Nitro 2.0

Administrator Guide

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Welcome

Welcome to the Administrator User Guide for Nitro 2.0.

The following chapters are provided to assist in understanding, getting started with, and using Nitro.

Chapter 1 Nitro Overview

Nitro is the Adaptive Computing High Throughput Computing (HTC) product designed to integrate with either High Performance Computing (HPC), such as Moab Workload Manager, or datacenter schedulers to schedule and run workloads consisting of large quantities (tens of thousands to millions) of small jobs (seconds to minutes to complete) without affecting the throughput of the HPC or datacenter scheduler.

In this chapter:

Nitro Origins and Purpose

This topic describes the motivation and purpose behind the creation of Nitro.

In this topic:

Origins

Until recently, Adaptive Computing's traditional market has been scheduling batch jobs for HPC systems, colloquially known as "supercomputers". These HPC systems are typically composed of hundreds to tens of thousands of "compute nodes" (servers designed for fast computations and large amounts of I/O), which are increasingly "off-the-shelf" servers. Part of scheduling workloads on such large HPC systems is optimizing the use of all the system's resources. This can be a complex process involving a large amount of computation which can take a significant amount of time.

Complicating the scheduling of HPC systems is the increasing use of workloads consisting of small jobs. These workloads do not need multiple servers but can execute on a single server or even on a single core, and may execute in a short amount of time, sometimes just seconds or even sub-seconds. Such workloads typically fall under the category of HTC and do not need the optimization performed by HPC schedulers.

When an HPC scheduler must schedule large quantities of HTC workloads, these workloads severely slow down the HPC scheduler and reduce its scheduling throughput. To counteract the effects of HTC workloads on HPC schedulers, Adaptive Computing created Nitro. Nitro schedules and runs HTC workloads on any HPC cluster or in any datacenter without affecting the throughput of the HPC or the datacenter scheduling software.

Nitro runs large quantities of HTC workloads as a single job submitted to any HPC or datacenter scheduler (it is scheduler-agnostic) using the resources allocated to it by the HPC or datacenter

scheduler. This permits the scheduler to operate normally and eliminates the impact the scheduling of thousands or millions of HTC workloads would have on it.

Purpose

Nitro runs workloads small enough to execute on a single compute node or server, regardless whether HTC in nature, with as little overhead as possible in order to speed up the execution of HTC-like workloads through the elimination of regular scheduler overhead. This is its primary intended purpose.

Nitro runs a single workload submitted to any HPC or datacenter scheduler and executes hundreds, thousands, or even millions of HTC-like workloads using the resources allocated to it by the HPC or datacenter scheduler. This permits the scheduler to operate normally by eliminating the impact that scheduling of thousands or millions of HTC workloads would have on the scheduler.

Workload Solutions and Use Cases

This topic provides an operational overview of workload solutions available with Nitro. Use cases are also provided to showcase some of the solutions and benefits with using Nitro.

In this topic:

Workloads

Nitro easily schedules and executes these typical workloads:

- Serial applications that use only a single core.
- Multi-threaded applications that run on a single host.
- Short-running applications.
- "Embarrassingly Parallel" applications such as Monte Carlo-based simulations.
- Serial or parallel applications that run on a single host.
- Regression testing.

Use Cases

This section contains use cases of Nitro workload solutions.

In this section:

Many Independent Short Workloads

Let's say a user wants to submit a workload of 50,000 HTC jobs to execute on a system, this means submitting each job separately to the system's scheduler. Submitting all 50,000 jobs at once to the work queue slows down the scheduler sufficiently that other users complain of reduced job response times (turnaround time between job submission and job completion). This reduced response time is due to the overhead the scheduler incurs scheduling so many HTC jobs and the overhead of starting and managing so many individual short jobs. In other words, the shorter the HTC job, the greater the percentage of the job's response time is consumed by job scheduling, startup, and management overhead.

Using Nitro, a user can submit a single "Nitro job" with the 50,000 HTC jobs (now referred to as Nitro tasks) to the system's scheduler. Nitro will quickly execute this workload using its very low scheduling overhead and very quick workload management. In other words, Nitro's low scheduling overhead provides improved response time for executing many short jobs when compared to a normal scheduler.

For example, let's look at a Nitro demonstration with an investment trading enterprise. The investment trading enterprise normally submitted a workload of 10,000 of its own HTC jobs to a commercial scheduler that took 110 seconds to execute the 10,000 jobs on ten 12-core hosts. Submitted as a single Nitro job to the same commercial scheduler, a very early version of Nitro took only 9 seconds to execute the same 10,000 jobs (again now called tasks) on the same ten 12-cores hosts. Resulting in a response time speedup of 12x!

Large Queues

Let's say an HPC cluster or a datacenter has a large job queue where a significant portion of the job queue consists of HTC workloads (thousands to millions of short jobs taking seconds to minutes to complete). This causes reduced job response times from the system scheduler.

However, by using Nitro, users can consolidate these workloads into a few Nitro jobs (tens or hundreds) to improve the system scheduler's job response times. Those Nitro jobs will execute the HTC workloads on the hosts the scheduler allocates to the Nitro jobs, thereby speeding their own workload turnarounds as well as improving the other users' job turnaround times due to a large reduction in the queue size.

For example, let's say a scheduler has a job queue containing 100,000 jobs and of those 95,000 can be consolidated into 95 Nitro jobs (each executing 1,000 tasks). By consolidating, the scheduler's job queue will drop from 100,000 jobs to 5,095 jobs, which the scheduler can process in 5% of the time required for processing 100,000 jobs, for a 20x scheduling cycle speedup. This speedup also benefits all the other jobs in the queue.

Multi-threaded HTC Applications

Let's say a user has a multi-threaded application that runs on a single host and wants to run the same application many times, but each time with different parameters or datasets. The user will either submit a single job that executes the application one instance at a time with the different parameters or datasets, or submits many jobs that execute the application only once, each with different parameters or datasets. The former method does not take advantage of the many available hosts on which many application instances can execute simultaneously for a shorter overall response time but does have the advantage of not affecting the system scheduler's scheduling time. The latter method has a greater potential for a shorter overall response time but has the disadvantage of affecting the system scheduler's job throughput.

Using Nitro, the user can run multiple instances of an application on the hosts the system scheduler allocates to the Nitro job without affecting the system scheduler's scheduling time or throughput. In addition, the Nitro job will usually execute all instances in a shorter time than the system scheduler could due to much lower overhead since Nitro's orientation and optimization quickly starts the next application instance as soon as an existing application instance completes.

Regression Testing

Let's say an institution performs large quantities of regression tests each night for the applications it develops. Many regression tests are similar and can execute independently of each other. The regression test framework submits the tests as individual jobs to the system scheduler, which means many jobs for it to schedule.

Using Nitro can increase the regression test throughput due to its much lower workload management overhead; that is, it can immediately start the next regression workload as soon as an existing workload completes without the overhead a system scheduler incurs communicating job completion, scheduling the next job to start, and then starting the next job.

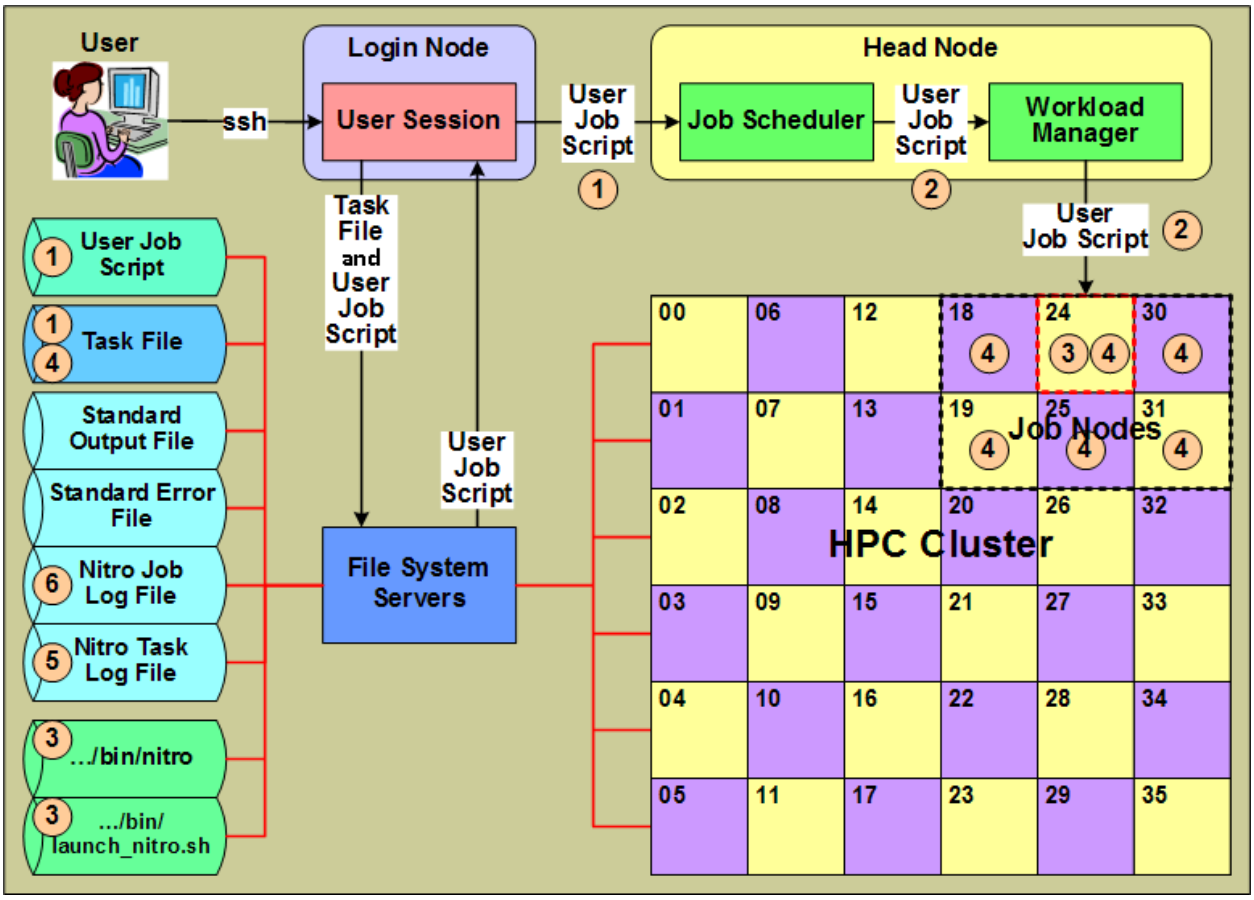
Theory of Operation

This topic identifies the various components of Nitro, describes their purpose, and illustrates how they interact with the user, the system scheduler, the system hardware, and each other.

In this topic:

Nitro High-Level Architecture and Flow

This section identifies Nitro components from a high-level Nitro product architecture perspective that most closely aligns with the perspective of a user submitting a Nitro job that uses the Nitro application to execute workloads with minimal scheduling overhead.

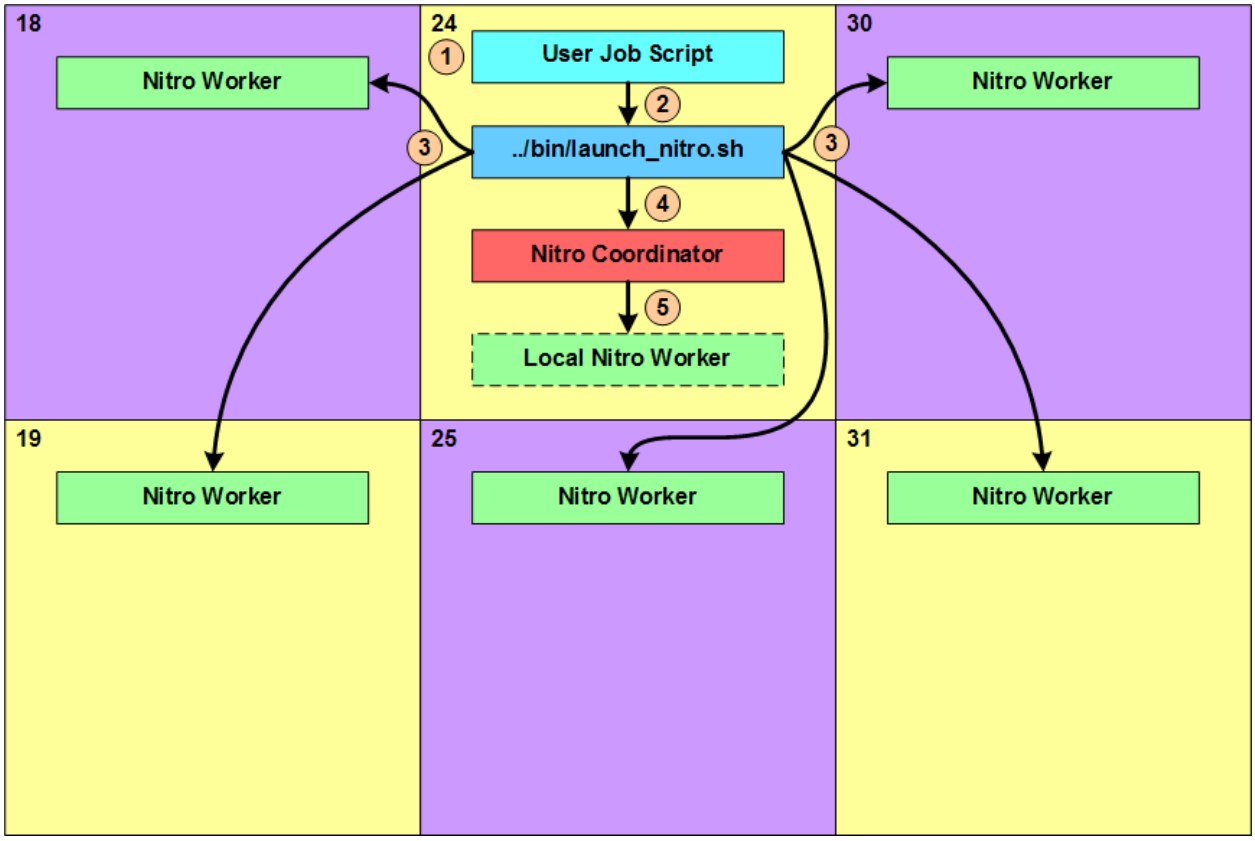


1. A user creates a "user job script" that executes Nitro with a task file (containing task definitions created by the user) that execute the user's workloads, and submits the job script to the system's job scheduler. The user job script can be scheduler-agnostic, which means the user can submit the same script to different schedulers on other systems or on the same system if its scheduler changes.
2. The scheduler allocates hosts to the Nitro job and, using a workload and/or resource manager, starts the execution of the job script on one of the job's allocated hosts.
3. The user job script executes Nitro (`.../bin/nitro`) using the Nitro launch script (`.../bin/launch_nitro.sh`). The Nitro launch script is scheduler-specific and allows the user job script to be scheduler-agnostic.
4. Nitro reads the task file containing the user-defined task definitions and then executes the tasks on its allocated hosts. A Nitro task definition is the equivalent of an HTC job running an application in that the user converts individual HTC jobs previously submitted to a scheduler into tasks executed by Nitro.
5. As tasks complete their execution, Nitro records information for each task in the Nitro task log file.
6. As Nitro processes task definitions from the task file and executes them, Nitro periodically updates the Nitro job log file with job progress and statistical task information to keep the user informed of its progress.

Also while Nitro executes, it records information about its environment and progress in the job's standard output file. Likewise, any unusual or unexpected errors it encounters it records in the job's standard error file.

Nitro Job Startup Architecture and Flow

This section identifies Nitro components from a job-level architecture perspective and indicates which Nitro components start and interact with other components during a Nitro job startup.

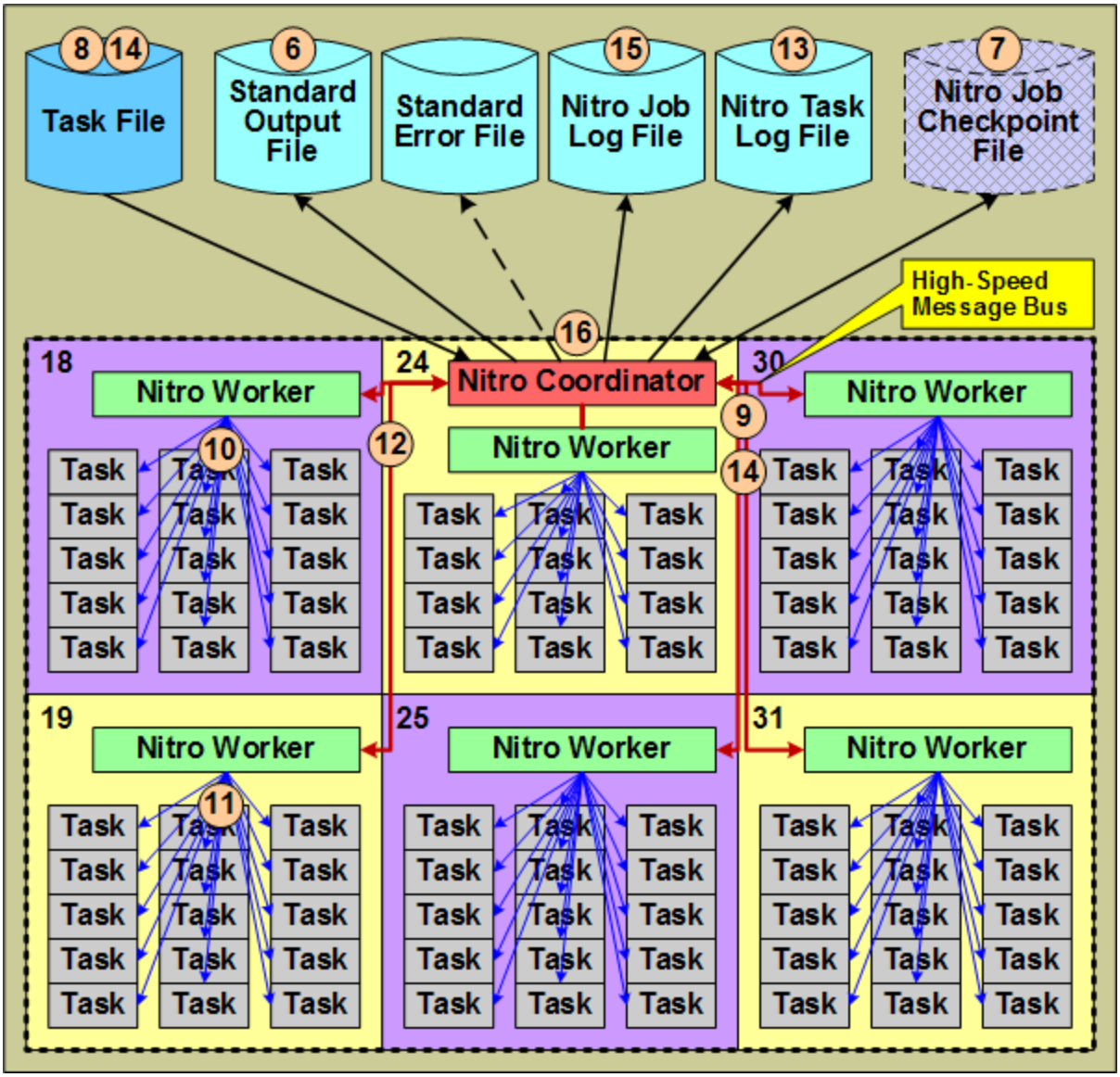


1. The user job script executes and does whatever the user specified. This can include things such as setting the Nitro environment variable for the task file path, setting other Nitro-recognized environment variables with values that affect Nitro's behavior, and performing any other preparatory work needed by the tasks Nitro will execute.
2. The last action performed by the user job script is to execute the Nitro launch script (`.../bin/launch_nitro.sh`) that starts up Nitro.
3. Using scheduler- or resource manager-specific commands, the Nitro launch script starts up one Nitro worker on each of the hosts allocated to the Nitro job.
4. Lastly, the Nitro launch script starts up the Nitro coordinator on the host on which it is executing.
5. If the user job script or the Nitro launch script specified the Nitro coordinator should start up a Nitro worker (Local Nitro Worker) on its host, the coordinator does so after it starts up.

Nitro Job Architecture and Processing Flow

This section identifies the other Nitro components used and/or produced by the Nitro coordinator from a job-level architecture perspective and shows their interactions.

This section continues the job-level perspective narrative relative to Nitro's operation shown in Nitro Job Startup Architecture and Flow on page 8.



6. The Nitro coordinator outputs information about its environment, including file path information, the job itself (with the job id), to the job's Standard Output File.
7. Nitro coordinator checks for the existence of a Nitro job checkpoint file. If it is present, the coordinator reads the checkpoint file and resumes the Nitro job; otherwise, the Nitro coordinator creates a checkpoint file for the Nitro job.

> A user can take advantage of restarting a Nitro job from where it left off if the user or an administrator cancelled the job or the scheduler preempted the job.

8. The Nitro coordinator opens and starts reading the task file in the user job script or via an environment variable. If the checkpoint file already exists, the coordinator resumes reading the task file from where it left off and reassigns any uncompleted tasks to workers for execution.
9. The Nitro coordinator processes the task definitions in the task file and creates task "assignments" from the task definitions in the task file that it sends to the Nitro workers via a message bus.
10. The Nitro workers each process their own task assignment and start up tasks using their "task launch" threads. Each task launch thread starts up and executes one task.
11. When a task finishes executing, the worker asynchronously uses the task launch thread to obtain statistical information about the task's execution.
12. When all tasks within a task assignment have completed, the worker returns the tasks' statistical information to the coordinator via the message bus and then starts processing its next task assignment.
13. The coordinator records the tasks' statistical information in the Nitro task Log file
14. The coordinator continues reading task definitions from the task file, creating task assignments, and sending the task assignments to the workers. To keep the workers busy (fully utilizing the hosts allocated to the Nitro job), the coordinator sends another task assignment to a worker when the worker processed a majority of the current task assignment (while worker still has tasks in its queue). This overlapping of task assignments keeps all host cores executing workload for a very high percentage of the time.
15. The coordinator periodically updates the Nitro job's statistical information in the Nitro job log file. The user can refer to the job log file to follow the Nitro job's progress.
16. When the coordinator has reached the end of the task file *and* the workers have executed all tasks, the coordinator shuts down the workers, deletes the checkpoint file, and then terminates itself. At this point the user job completes.

Nitro and System Scheduler Policies

Nitro is an HTC scheduler application executed by a job script just like any other application a user might execute. By design, Nitro does not and will not perform scheduling functions like a regular system scheduler, such as, enforcing per-user, per-group, and/or per-account resource or usage limit policies, supporting fair-share policies, maintaining separation between users in a multi-tenancy environment, etc. This means Nitro will not perform functions such as launching tasks from one Nitro job as different users, etc.

Nitro and Users

If users are subject to different constraints and policies, requiring the users to submit their own Nitro jobs and not combine the Nitro tasks allows the system scheduler to enforce policies on the

users, which is the system scheduler's responsibility. Thus with Nitro, the administrator will continue to use the system scheduler to enforce policies in the normal manner.

For example, if three users (A, B and C) each want to execute Nitro tasks that are the same application and perhaps even use the same data, they each must submit their own Nitro job with its own task file (could be the same file but the users must specify it for their own job). If they are each subject to different policies and constraints, the system scheduler enforces those constraints and, by design, Nitro is ignorant of the policies and constraints and will remain so.

Nitro and Host Resources

If a user wants to execute workloads that require certain hardware resources or constraints, the user must use the system scheduler's resource request capabilities to allocate or constrain such.

For example if a Nitro job will execute workloads that require an accelerator, such as NVIDIA/AMD GPU or Intel MIC (Xeon Phi), the user must request hosts with the required accelerator(s) for the Nitro job so the workloads have accelerator(s) available to them.

Key Terminology and Usage

This document includes a glossary of key terms used through this guide. This is to help simplify and clarify the information presented.

For example, instead of using terms specific to the traditional HPC (research, university, and government institutions) and commercial enterprise markets, such as "HPC cluster" and "datacenter" and their corresponding "compute node" and "server" terms, this guide uses the generic terms "system" and "host", respectively. Also this guide uses the term "workload" to represent an arbitrary amount of work to execute on a system while "job" refers to workload submitted by a user to a system's scheduler for eventual execution on one or more of the system's hosts.

Refer often to Glossary on page 82 for a complete list of terms used in this guide.

Chapter 2 Installation and Configuration

This chapter provides Nitro installation and configuration instructions. This chapter is designed for system administrators.

In this chapter:

Understand and Plan Your System Environment

This topic provides information that is important to understand before you begin your Nitro installation.

In this topic:

Nitro Licenses and Licensing

Nitro is a licensed software product that requires licenses conveyed via a license file and managed by the RLM license server in order to execute. Adaptive Computing must generate a license file for your Nitro product and you must install the license file onto the RLM server where the RLM license daemon can read it. Without the proper installation of the license file, Nitro will not execute.

Adaptive Computing licenses Nitro in two mutually-exclusive ways, by node and by core.

- Sites running parallel jobs that request multiple whole host systems (HPC compute nodes or servers) will want to license Nitro by node since their schedulers often allocates job resources by whole hosts for speed.
- Sites running mainly serial (single-core) jobs that request one or a few cores will want to license Nitro by core since their schedulers tend to fragment host system resources such that it may be very difficult for a Nitro job to obtain whole host systems.

The Nitro license file indicates the license model, by-node or by-core, the Nitro product will operate under.

Nitro Product Packaging

Adaptive Computing provides two methods for installing Nitro components, manual (install each tarball individually) or using an RPM (download a bundle of all the tarballs).

With Nitro 2.0, you will need access to an RLM Server for licensing. A Nitro Web Services interface is also introduced with 2.0.

> Currently, Nitro Web Services is only applicable if you are using Torque as your resource manager. In addition, you will also need to license and install Moab Viewpoint.

Depending on your system configuration, you may need some or all of the components.

To support the 2.0 changes, the Nitro Download page includes these files for the different components.

- Nitro Product – nitro-<*version*>-<*OS*>.tar.gz
- Nitro Web Services – nitro-web-services-<*version*>-<*OS*>.tar.gz
- RLM Server – ac-rlm-<*version*>-<*OS*>.tar.gz
- The nitro-<*version*>-<*OS*>.rpm bundles all three components.

> The RLM Server is included as a courtesy. If your company already has access to an RLM (for example, you installed one as part of your Remote Visualization package), you will not need to install another RLM Server.

Default Installation Directory and Subdirectories

Nitro will be installed to the `/opt/nitro` directory by default. This directory includes the following subdirectories.

```
# cd /opt/nitro
# ls -l
drwxr-xr-x. 2 root root 4096 Jun  9 16:20 bin
drwxr-xr-x. 6 root root 4096 Jun  9 16:20 scripts
drwxr-xr-x. 1 root root 4096 Jun  9 16:20 etc
```

- The bin directory contains the binary executable program files and executable scripts that make up the Nitro product for your site.
- The scripts directory contains reference launch_nitro.sh scripts for different job schedulers and resource managers, which include Cray ALPS with Torque or Slurm, Platform LSF, Slurm, and Torque (Moab and Maui schedulers).
- The etc directory contains the nitro.cfg file. Nitro has some default settings that can be changed by setting values in the /opt/nitro/etc/nitro.cfg file. See Nitro Configuration File on page 69 for more information.

System Requirements

This topic identifies the system requirements for your Nitro installation.

In this topic:

Hardware Requirements

- Nitro requires one or more multi-core processors per host. Generally the more processors (sockets) and/or OS cores a host has, the more tasks Nitro can execute simultaneously on each host; although this will be application-dependent.
- It is recommended that hosts should have sufficient memory to execute as many applications as possible so that Nitro can run them at a rate of one application instance per OS core (especially if they are not multi-threaded). This eliminates the need for users to have to request memory in their Nitro task definitions.

See Task File on page 76 for more information on specifying memory requirements.

Supported Operating Systems

Nitro supports these operating systems:

- CentOS 6.x, 7.x
- Red Hat 6.x, 7.x
- Scientific Linux 6.x, 7.x
- SUSE Linux Enterprise Server 11, 12

SUSE Linux Enterprise Server (SLES) 11 is not available as an RPM installation method.

Reprise License Manger Server Requirements

As of version 2.0, Nitro is a licensed software product that requires the Reprise License Manager (RLM) software to check out and check in Nitro licenses. The RLM web server/license daemon software must execute on a central server accessible by all host systems on which Nitro will execute.

The RLM software itself is extremely light-weight and does not require its own server. Meaning that you can install the RLM server on the same host as your job scheduler or resource manager server.

If your company does not already utilize an RLM, you will need to install one. See the RLM Installation documentation available from the Nitro download site (http://www.adaptivecomputing.com/support/download-center/nitro/).

Software Requirements

Nitro is built with all needed libraries statically linked. This provides for a quick and simple installation and helps avoid troublesome library mismatches. No additional packages need to be installed on the compute nodes.

However, users running the nitrostat utility require Python 2.6.6 or later on the system from which they are running it.

Manual Installation and Upgrade

This section provides installation, configuration, and upgrading information using the Manual Installation method.

In this section:

Preparing for Manual Installation or Upgrade

This topic contains instructions on how to download and unpack the Nitro Tarball Bundle for all the hosts in your configuration.

> Whether you are installing tarballs on one host or on several hosts, each host (physical machine) on which a server is installed (RLM Server, Nitro, Nitro Web Servcies) *must* have the Nitro Tarball Bundle.

Set Up Proxies

If your site uses a proxy to connect to the Internet, do the following:

```
export http_proxy=http://<proxy_server_id>:<port>
export https_proxy=http://<proxy_server_id>:<port>
```

Download and Unpack the Nitro Tarball Bundle

The Nitro Tarball Bundle contains all the tarballs available for Nitro. However, not every tarball may be installed on the same host.

On each host (physical machine), do the following:

1. Using a web browser, navigate to the Adaptive Computing Nitro Download website (http://www.adaptivecomputing.com/support/download-center/nitro/).

2. Download the Nitro Tarball Bundle `nitro-tarball-bundle-<version>-<OS>.tar.gz`.

   The variable marked <version> indicates the build's version, revision, and changeset information. The variable marked <OS> indicates the OS for which the build was designed.

3. Unpack the Nitro Tarball Bundle.

```
[root]# tar xzvf nitro-tarball-bundle-<version>-<OS>.tar.gz
```

Installing

Installing RLM Server

Access to a Reprise License Manager (RLM) server is required when using Nitro.

This topic contains instructions on how to install an RLM Server.

If your company already uses an RLM Server, you can skip this procedure and follow the instructions in 0Installing Nitro on page 20.

In this topic:

Open Necessary Ports

If your site is running firewall software on its hosts, you will need to configure the firewall to allow connections to the necessary ports.

This section contains the instructions to open the RLM Server (5053) and RLM Web Interface (5054) ports.

On the RLM Server, open the necessary ports.

- Red Hat 6-based systems using iptables

```
[root]# iptables -A INPUT -p tcp --dport 5053 -j ACCEPT
[root]# iptables -A INPUT -p tcp --dport 5054 -j ACCEPT
[root]# service iptables save
```

- Red Hat 7-based systems using firewalld

```
[root]# firewall-cmd --add-port=5053/tcp --permanent
[root]# firewall-cmd --add-port=5054/tcp --permanent
[root]# firewall-cmd --reload
```

- SUSE 11-based systems using SuSEfirewall2

```
[root]# vi /etc/sysconfig/SuSEfirewall2

FW_SERVICES_EXT_TCP="5053 5054"

[root]# service SuSEfirewall2_setup restart
```

- SUSE 12-based systems using SuSEfirewall2

```
[root]# vi /etc/sysconfig/SuSEfirewall2

FW_SERVICES_EXT_TCP="5053 5054"

[root]# service SuSEfirewall2 restart
```

Install the RLM Server

If your configuration uses firewalls, you *must also* open the necessary ports before installing Nitro. See Open Necessary Ports on page 17.

On the host where the RLM Server will reside, do the following:

1. If you have not already do so, complete the steps to prepare the host. See Preparing for Manual Installation or Upgrade on page 16.
2. Identify the RLM tarball (`ac-rlm-<version>.tar.gz`).
3. Create a non-root user and group (rlm is used in the example).

```
[root]# groupadd -r rlm
[root]# useradd -r -g rlm -d /opt/rlm -c "A non-root user under which to run
Reprise License Manager" rlm
```

4. Create a directory and install the tarball files in that location (we are using /opt/rlm as the install location in the example).

```
[root]# mkdir -p -m 0744 /opt/rlm
[root]# cd /opt/rlm
[root]# tar -xzvf /tmp/ac-rlm-<version>.tar.gz --strip-components=1
[root]# chown -R rlm:rlm /opt/rlm
```

The `--strip-components=1` removes the "ac-rlm-<*version*>/" from the relative path so that they are extracted into the current directory.

5. Install the startup scripts.

If you are using a user:group other than rlm:rlm or a location other than /opt/rlm, then edit the following files to reflect those changes after copying them.

- Red Hat 6-based or SUSE 11-based systems

```
[root]# cp init.d/rlm /etc/init.d
```

- Red Hat 7-based or SUSE 12-based systems

```
[root]# cp systemd/rlm.service /etc/systemd/system
```

6. Start the services and configure the RLM Server to start automatically at system reboot.
   - Red Hat 6-based or SUSE 11-based systems

```
[root]# chkconfig --add rlm
[root]# chkconfig rlm on
[root]# service rlm start
```

   - Red Hat 7-based or SUSE 12-based systems

```
[root]# systemctl start rlm.service
[root]# systemctl enable rlm.service
```

Change the Default Passwords

The RLM Web interface includes two usernames (admin and user) by default. These usernames have the default password "changeme!".

If you do not change this password, RLM, and Remote Visualization, will not be secure. For tips on choosing a good password, see https://www.us-cert.gov/ncas/tips/ST04-002.

Do the following for both the user and the admin usernames:

1. Using a web browser, navigate to your RLM instance. (http://<*RLM_host*>:5054; where <*RLM_host*> is the IP address or name of the RLM Server Host).
2. Log in.
3. Select **Change Password** and change the password according to your password security process.

Licensing Nitro

This topic provides instructions on how to obtain and install the Nitro license.

These instructions assume you already have access to an RLM Server. See Installing RLM Server on page 17

Do the following:

1. On the RLM server, obtain the hostid and hostname.
   - hostid

```
/opt/rlm/rlmhostid
```

You should see output similar to the following.

```
# /opt/rlm/rlmhostid
rlmhostid v12.0
Copyright (C) 2006-2015, Reprise Software, Inc. All rights reserved.

Hostid of this machine: 00259096f004
```

- hostname

```
/opt/rlm/rlmhostid host
```

You should see output similar to the following.

```
rlmhostid v12.0
Copyright (C) 2006-2015, Reprise Software, Inc. All rights reserved.

Hostid of this machine: host=<your-host-name>
```

2. Email licenses@adaptivecomputing.com for a license and include the hostid and hostname you just obtained.
3. Adaptive Computing will generate the license and send you the Nitro license file (.lic) file in a return email.
4. As a root user on the RLM server, do the following:
   a. Download and install the license file.

```
cd /opt/rlm
chown rlm:rlm <licenseFileName>.lic
```

   b. Perform a reread to update the RLM Server with you license.

```
/opt/rlm/rlmreread
```

5. Copy the license file to each compute node (coordinator). On each compute node, or the shared file system, do the following:

```
cp <licenseFileName>.lic /opt/nitro/bin/
```

0Installing Nitro

This topic contains instructions on to install can configure Nitro

These instructions assume you already have installed the Nitro license on an RLM Server. See Licensing Nitro on page 19 for detailed instructions.

Nitro

- needs to be available to all of the nodes that will be used as part of the Nitro job.
- can be installed either to each node individually *or* to a shared file system that each node can access.

- can be installed to integrate with a scheduler, such as Moab Workload Manager, or without (Nitro standalone). The instructions are the same.

In this topic:

Open Necessary Ports

Nitro uses several ports for communication between the workers and the coordinator.

The default port is 47000, and up to four ports are used in running Nitro (ports 47000-47003).

On each compute node (coordinator), open the necessary ports.

- Red Hat 6-based systems using iptables

```
[root]# iptables-save > /tmp/iptables.mod
[root]# vi /tmp/iptables.mod

# Add the following lines immediately *before* the line matching
# "-A INPUT -j REJECT --reject-with icmp-host-prohibited"
-A INPUT -p tcp --dport 47000 -j ACCEPT
-A INPUT -p tcp --dport 47001 -j ACCEPT
-A INPUT -p tcp --dport 47002 -j ACCEPT
-A INPUT -p tcp --dport 47003 -j ACCEPT

[root]# iptables-restore < /tmp/iptables.mod
[root]# service iptables save
```

- Red Hat 7-based systems using firewalld

```
[root]# firewall-cmd --add-port=47000/tcp --permanent
[root]# firewall-cmd --add-port=47001/tcp --permanent
[root]# firewall-cmd --add-port=47002/tcp --permanent
[root]# firewall-cmd --add-port=47003/tcp --permanent
[root]# firewall-cmd --reload
```

- SUSE 11-based systems using SuSEfirewall2

```
[root]# vi /etc/sysconfig/SuSEfirewall2

FW_SERVICES_EXT_TCP="47000 47001 47002 47003"

[root]# service SuSEfirewall2_setup restart
```

- SUSE 12-based systems using SuSEfirewall2

```
[root]# vi /etc/sysconfig/SuSEfirewall2

FW_SERVICES_EXT_TCP="47000 47001 47002 47003"

[root]# service SuSEfirewall2 restart
```

Install Nitro

> If your configuration uses firewalls, you *must also* open the necessary ports before installing Nitro. See Open Necessary Ports on page 21.

On the host where Nitro will reside, do the following:

1. If you have not already do so, complete the steps to prepare the host. See Preparing for Manual Installation or Upgrade on page 16.
2. Identify the Nitro product tarball (nitro-<*version*>-<*OS*>.tar.gz).
3. As the root user, run each of the following commands in order.

```
mkdir /opt/nitro
tar xzvpf  nitro-<version>-<OS>.tar.gz - C /opt/nitro --strip-components=1
```

4. Identify the launch_nitro.sh script version for your resource manager. This script will be copied to the bin directory from where user job scripts will execute Nitro. See Default Installation Directory and Subdirectories on page 14 for more information.

   Reference scripts are provided in `/opt/nitro/scripts`.

```
# find . -name launch_nitro.sh
./scripts/lsf/launch_nitro.sh
./scripts/torque/launch_nitro.sh
./scripts/slurm/launch_nitro.sh
./scripts/alps/torque/launch_nitro.sh
./scripts/alps/slurm/launch_nitro.sh
```

5. Copy the launch script to the bin directory. (This example uses the Torque-based launch script.)

```
# cp /opt/nitro/scripts/torque/launch_nitro.sh /opt/nitro/bin/launch_nitro.sh
```

   > This is a "copy" file operation and not a "move" operation. This allows you to customize your version of the script and always have the factory version available for consultation and/or comparison.

6. Customize the bin/launch_nitro.sh script as needed for your site's administrative policies. For example, to enable the Nitro coordinator's host to always execute a local Nitro worker, modify the bin/launch_nitro.sh script version to always pass the --run-local-worker command line option to the coordinator. See Launch Scripts on page 47 for more information on editing the launch script.
7. If you are not using a shared file system, copy the Nitro installation directory to all hosts.

   Only the Nitro bin directory with its proper path is required to run Nitro jobs. This means that you only need to copy the Nitro bin directory to the other hosts.

```
# scp -r /opt/nitro/bin root@host002:/opt/nitro
nitrostat                                     100%   12KB  12.0KB/s   00:00
launch_nitro.sh                               100% 6890     6.7KB/s   00:00
nitro                                         100%   15MB  14.9MB/s   00:00
```

Verify Network Communication

Verify that the nodes that will be running Nitro are able to communicate with the Nitro ports *and* that the nodes are able to communicate with one another.

Installing Nitro Web Services

This topic contains instructions on how to install Nitro Web Services.

Currently, Nitro Web Services is only applicable if you are using Torque as your resource manager. In addition, you will also need to license and install Moab Viewpoint.

SUSE 11 is not supported on all the hosts on which you can install Adaptive Computing Software (for example, the host on which Moab Viewpoint Server resides) or on all database hosts.

Do the following in the order presented:

1. Open the MongoDB Database Port (27017) on page 23
2. Install MongoDB on page 24
3. Install and Configure Nitro Web Services on page 26
4. Configure Viewpoint for Nitro Web Services on page 27
5. Configure Nitro Compute Nodes on page 28

Open the MongoDB Database Port (27017)

Nitro Web Services requires access to a MongoDB database. Depending on your system configuration, your MongoDB databases may not be installed on the same host as their corresponding component servers. For example, you may choose to install the Nitro Web Services MongoDB on the same host where you have installed other MongoDB databases.

Do the following, as needed:

- If you have chosen to install the Nitro Web Services MongoDB database on the *same* host you installed other MongoDB databases, confirm the firewall port (27017) is already opened on that host.
- If you have chosen to install the Nitro Web Services MongoDB database on a *different* host from other MongoDB databases, you will need to open the Nitro Web Services MongoDB database port in firewall for that host. To open the port in the firewall, do the following:
    - Red Hat 6-based systems using iptables

```
[root]# iptables-save > /tmp/iptables.mod
[root]# vi /tmp/iptables.mod

# Add the following lines immediately *before* the line matching
# "-A INPUT -j REJECT --reject-with icmp-host-prohibited"

-A INPUT -p tcp --dport 27017 -j ACCEPT

[root]# iptables-restore < /tmp/iptables.mod
[root]# service iptables save
```

- Red Hat 7-based systems using firewalld

```
[root]# firewall-cmd --add-port=27017/tcp --permanent
[root]# firewall-cmd --reload
```

- SUSE 11-based systems using SuSEfirewall2

```
[root]# vi /etc/sysconfig/SuSEfirewall2

FW_SERVICES_EXT_TCP="27017"

[root]# service SuSEfirewall2_setup restart
```

- SUSE 12-based systems using SuSEfirewall2

```
[root]# vi /etc/sysconfig/SuSEfirewall2

FW_SERVICES_EXT_TCP="27017"

[root]# service SuSEfirewall2 restart
```

Install MongoDB

To install and enable MongoDB on the Nitro Web Services Host, do the following:

1. Install MongoDB.
   - Red Hat 6-based or Red Hat 7-based systems

```
[root]# cat > /etc/yum.repos.d/mongodb.repo <<End-of-file
[mongodb]
name=MongoDB Repository
baseurl=http://downloads-distro.mongodb.org/repo/redhat/os/x86_64
gpgcheck=0
enabled=1
exclude=mongodb-org mongodb-org-server
End-of-file
[root]# yum install mongo-10gen-server
```

   - SUSE 11-based systems

```
[root]# zypper ar --refresh -r
http://download.opensuse.org/repositories/server:/database/SLE_11_
SP3/server:database.repo
[root]# zypper install mongodb
```

   - SUSE 12-based systems

```
[root]# zypper ar --refresh -r
http://download.opensuse.org/repositories/server:/database/SLE_
12/server:database.repo
[root]# zypper install mongodb
```

2. Start MongoDB

> There may be a short delay (approximately 3 minutes) for Mongo to start the first time.

- Red Hat 6-based or SUSE 11-based systems

```
[root]# chkconfig mongod on
[root]# service mongod start
```

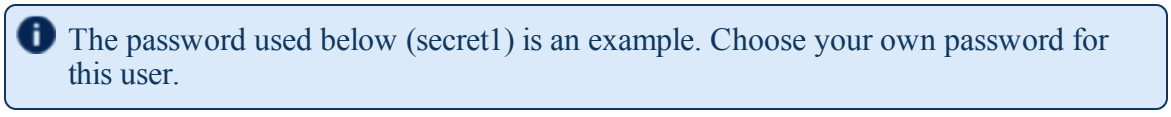
- Red Hat 7-based systems

```
[root]# cat > /usr/lib/systemd/system/mongodb.service <<End-of-file
[Unit]
Description=High-performance, schema-free document-oriented database
After=syslog.target network.target

[Service]
Type=forking
User=mongod
Group=mongod
Environment=CONFIG=/etc/mongod.conf
Environment=OPTIONS=
EnvironmentFile=-/etc/sysconfig/mongod
ExecStart=/usr/bin/mongod -f \$CONFIG \$OPTIONS
PrivateTmp=true
LimitNOFILE=65536
TimeoutStartSec=180
StandardOutput=syslog
StandardError=syslog

[Install]
WantedBy=multi-user.target
End-of-file
[root]# rm -f /etc/init.d/mongod
[root]# systemctl enable mongodb.service
[root]# systemctl start mongodb.service
[root]# systemctl daemon-reload
```

- SUSE 12-based systems

```
[root]# systemctl enable mongodb.service
[root]# systemctl start mongodb.service
[root]# systemctl daemon-reload
```

3. Prepare the MongoDB database by doing the following:
   a. Add the required MongoDB users.




```
[root]# mongo
> use admin;
> db.addUser("admin_user", "secret1");
> db.auth ("admin_user", "secret1");
> exit
```

> Because the `admin_user` has read and write rights to the `admin` database, it also has read and write rights to all other databases. See Control Access to MongoDB Instances with Authentication (http://docs.mongodb.org/manual/tutorial/control-access-to-mongodb-with-authentication/) for more information.

b. Enable authentication in MongoDB.

- Red Hat 6-based systems

```
[root]# vi /etc/mongod.conf
auth = true
[root]# service mongod restart
```

- Red Hat 7-based systems

```
[root]# vi /etc/mongod.conf
auth = true
[root]# systemctl restart mongodb.service
```

- SUSE 11-based or SUSE 12-based systems

  MongoDB authentication is already enabled. No further action is needed.

Install and Configure Nitro Web Services

> You *must* complete the tasks earlier in this topic before installing Nitro Web Services.

On the host where Nitro Web Services will reside, do the following:

1. If you have not already do so, complete the steps to prepare the host. See Preparing for Manual Installation or Upgrade on page 16.
2. Identify and unpack the Nitro Web Services tarball (nitro-web-services-<*version*>-<*OS*>.tar.gz). This step assumes the Nitro Web Services tarball was downloaded to /tmp.

```
[root] cd /tmp
# The nitro-web-services tarball must be extracted to "/"
[root] tar -zxvf nitro-web-services*.tar.gz --directory /
```

3. Install Nitro Web Services.

```
[root] cd /opt/nitro-web-services
[root] ./install.sh
```

4. Understand and edit the configuration files. The installation provides these two configuration files:

   - /opt/nitro-web-services/etc/nitro.cfg
   - /opt/nitro-web-services/etc/zmq-job-status-adapter.cfg

   For example, the zmq_job_status_adapter.cfg file contains the msg port number that you will need to define on the Nitro compute nodes.

You will need to edit both of these cfg files for your system configuration.

> Typically, you will only need to edit the passwords to change them from the default value to your specified passwords.

5. Start the services and configure Nitro Web Services to start automatically at system boot.
   - Red Hat 6-based or SUSE 11-based systems

```
[root] chkconfig --add nitro-web-services
[root] chkconfig --add nitro-zmq-job-status-adapter
[root] service nitro-web-services start
[root] service nitro-zmq-job-status-adapter start
```

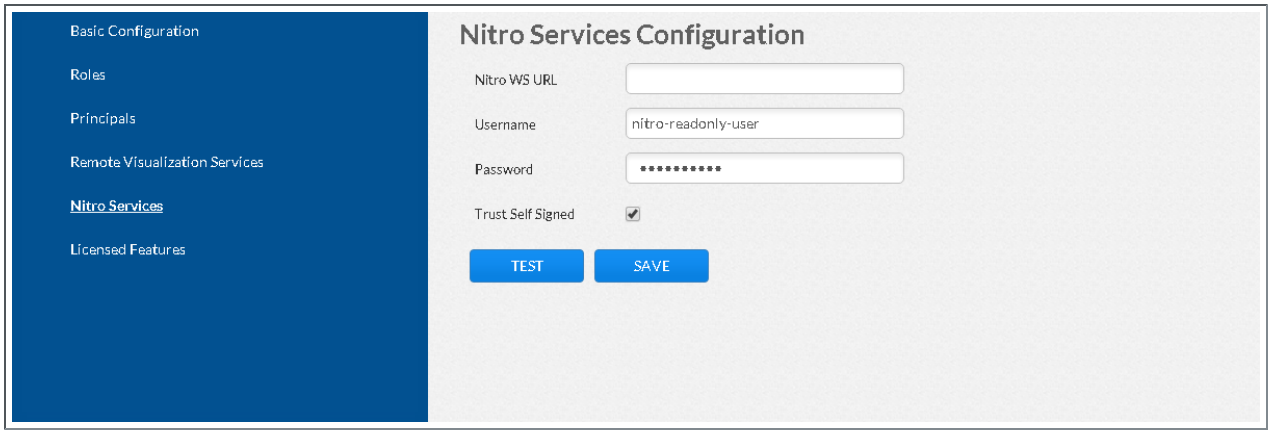
   - Red Hat 7-based or SUSE 12-based systems

```
[root] systemctl enable nitro-web-services.service
[root] systemctl enable nitro-zmq-job-status-adapter.service
[root] systemctl daemon-reload
[root] systemctl start nitro-web-services.service
[root] systemctl start nitro-zmq-job-status-adapter.service
```

Configure Viewpoint for Nitro Web Services

Do the following:

1. Using a web browser, navigate to your Viewpoint instance (`http://<server>:8081`) and then log in as the MWS administrative user (moab-admin, by default).
2. Click **Configuration** from the menu and then click **Nitro Services** from the left pane. The following is an example of the Nitro Services Configuration page.



3. Enter the configuration information. The following table describes the required information.

Field	Description
Nitro WS URL	Hostname (or IP address) and port number for the host on which you installed Nitro Web Services. For example, https://<*hostname*>:9443
Username	Name of the user. This typically nitro-readonly-user.
Password	The user's password.
Trust Self Signed	Indicates whether Nitro Web Services was set up using self-signed certificates.

4. Click **TEST** to confirm the settings are correct. This confirms whether Nitro Web Services is up and receiving connections.
5. Click **SAVE**.
6. (Recommended) Use curl to test Nitro Web Services connectivity.

```
curl --insecure --data '{"username": "nitro-admin", "password": "ChangeMe2!"}' \
 https://<hostname>:9443/auth
```

You should get something similar to the following in the response:

```
{
  "status": 200,
  "data": {
    "nitro-key": "3e0fb95e9a0e44ae91daef4deb500dcc67a3714880e851d781512a49",
    "user": {
      "username": "nitro-admin",
      "last_updated": "2016-02-26 23:34:55.604000",
      "name": "Nitro Admin",
      "created": "2016-02-26 23:34:55.604000",
      "auth": {
        "job": [
          "read",
          "write",
          "delete"
        ],
        "user": [
          "read",
          "write",
          "delete"
        ]
      }
    }
  }
}
```

Configure Nitro Compute Nodes

You need to configure the Nitro coordinators to send job status updates to the Nitro Web Services's ZMQ Job Status Adapter. The ZMQ Job Status Adapter is responsible for reading job status updates off of the ZMQ bus and persisting them to Mongo. Nitro Web Services can then be used to access Nitro job status.

Each Nitro job has a Nitro Coordinator. Nitro Coordinators can be configured to publish job status updates to ZMQ by setting the "nws-connector-address" configuration option in Nitro's nitro.cfg file. Each compute node allocated/scheduled to a Nitro Job can play the role of a Nitro coordinator. Therefore, you must update the "nws-connector-address" in each compute node's nitro.cfg file.

> Configuring nws-connector-address is simplified if each node is sharing Nitro's configuration over a shared filesystem. If you are not using a shared filesystem, update the Nitro configuration on each compute node.

Do the following:

1. If you have not already done so, on the Nitro Web Services Host, locate the msg_port number in the `/opt/nitro-web-services/etc/zmq_job_status_adapter.cfg` file. This is the port number you need to specify for the nws-connector-address.
2. On *each* Nitro compute note (Torque MOM Host), specify the nws-connector-address in the `/opt/nitro/etc/nitro.cfg` file .

```
...
# Viewpoint connection allows Nitro to communicate job status information
# to viewpoint.  This option indicates name and port of the remote server
# in the form: <host>:<port>
nws-connector-address <nitro-web-services-hostname>:47100
...
```

Upgrading

Upgrading Nitro

> You must be a root user when installing or upgrading Nitro.

This topic contains the steps and procedures to follow to upgrade Nitro using the Manual upgrade method.

In this topic:

Upgrade from a Version Prior to 2.0

The following steps are required if you are upgrading a Nitro version prior to 2.0.

1. Install or obtain access to an RLM server. See Installing RLM Server on page 17.

   > Beginning with Nitro 2.0, the licensing procedure changed to use an RLM server. If your company already uses an RLM Server, you can skip this procedure.

2. Obtain and install the Nitro license. This requires access the an RLM server. See Licensing Nitro on page 19.

Upgrade Nitro

On the host where Nitro resides, do the following:

1. If you installed Nitro on its own host *or* if Nitro is the first component being upgraded on a host with other manual installations, complete the steps to prepare the host. See Preparing for Manual Installation or Upgrade on page 16.
2. Identify the Nitro product tarball (nitro-<*version*>-<*OS*>.tar.gz).
3. As the root user, run each of the following commands in order.

```
mkdir /opt/nitro
tar xzvpf  nitro-<version>-<OS>.tar.gz - C /opt/nitro --strip-components=1
```

4. Identify the `launch_nitro.sh` script version for your resource manager.

   Reference scripts are provided in `/opt/nitro/scripts`.

```
# find . -name launch_nitro.sh
./scripts/lsf/launch_nitro.sh
./scripts/torque/launch_nitro.sh
./scripts/slurm/launch_nitro.sh
./scripts/alps/torque/launch_nitro.sh
./scripts/alps/slurm/launch_nitro.sh
```

5. Copy the latest launch script to the bin directory. (This example uses the Torque-based launch script.)

```
# cp /opt/nitro/scripts/torque/launch_nitro.sh /opt/nitro/bin/launch_nitro.sh
```

   > This is a "copy" file operation and not a "move" operation. This allows you to customize your version of the script and always have the factory version available for consultation and/or comparison.

6. Merge any customizations from your existing `launch_nitro.sh` script into the script you just copied to the bin directory.
7. If you are not using a shared file system, copy the updated Nitro installation directory to all hosts.

   Only the Nitro bin directory with its proper path is required to run Nitro jobs. This means that you only need to copy the Nitro bin directory to the other hosts.

```
# scp -r /opt/nitro/bin root@host002:/opt/nitro
nitrostat                                     100%   12KB  12.0KB/s   00:00
launch_nitro.sh                               100% 6890     6.7KB/s   00:00
nitro                                         100%   15MB  14.9MB/s   00:00
```

RPM Installation and Upgrade

This section provides installation, configuration, and upgrading information using the RPM Installation method.

The RPM Installation method is not applicable for SUSE 11-based systems.

In this section:

- Preparing for RPM Installation or Upgrade on page 31
- Install
  - Installing RLM Server on page 33
  - Licensing Nitro on page 35
  - Installing Nitro on page 36
  - Installing Nitro Web Services on page 38
- Upgrade
  - Upgrading Nitro on page 45

Preparing for RPM Installation or Upgrade

This topic contains instructions on how to download the Nitro RPM Bundle and enable the Adaptive Computing repository for all the hosts in your configuration.

Whether you are installing or upgrading RPMs on one host or on several hosts, each host (physical machine) on which a server is installed (RLM Server, Nitro, Nitro Web Servcies) *must* have the Adaptive Computing Package Repository enabled.

Set Up Proxies

If your site uses a proxy to connect to the Internet, do the following:

```
export http_proxy=http://<proxy_server_id>:<port>
export https_proxy=http://<proxy_server_id>:<port>
```

Enable the Adaptive Computing Package Repository

The Nitro RPM Bundle contains all the RPMs for Nitro. However, not every RPM may be installed on the same host.

On each host (physical machine), do the following:

1. Download the Nitro 2.0 RPM Bundle from the Adaptive Computing website.
2. Untar the Nitro RPM bundle.

```
[root]# tar zxf nitro-rpm-bundle-<version>-<OS>.tar.gz
```

3. Change directories into the untarred directory.

> Consider reviewing the README file for additional details on using the RPM distribution tarball.

4. Install the suite repositories. The `-y` option installs with the default settings for the RPM suite.

> For a description of the options of the repository installer script, run:
>
> ```
> [root]# ./install-rpm-repos.sh -h
> ```

```
[root]# ./install-rpm-repos.sh [<repository-directory>] [-y]
```

> If the installation returns the following warning line:
>
> `Warning: RPMDB altered outside of yum.`
>
> This is normal and can safely be ignored.

The [<*repository-directory*>] option is the directory where you want to copy the RPMs. If no argument is given, run "`install-rpm-repos.sh -h`" to view usage information and identify the default directory location. If the [<*repository-directory*>] already exists, RPMs will be added to the existing directory. No files are overwritten in [<*repository-directory*>].

A repository file is also created and points to the [<*repository-directory*>] location. For Red Hat 6-based or Red Hat 7-based systems, the repository file is created in `/etc/yum.repos.d/`. For SUSE 12-based systems, the repository files is created in `/etc/zypp/repos.d/`.

For ease in repository maintenance, the install script fails if Adaptive Computing RPMs are copied to different directories. If a non-default [<*repository-directory*>] is specified, please use the same directory for future updates.

The script installs the `createrepo` package and its dependencies. You must answer "y" to all the questions in order for the RPM install of the suite to work.

Additionally, the script installs:

- The EPEL and 10gen repositories on Red Hat 6-based and Red Hat 7-based systems.
- The openSUSE Apache:Modules, devel:languages:python, devel:languages:perl, and server:database repositories on SUSE 12-based systems.

5. Test the repository.
   - Red-Hat 6-based or Red Hat 7-based systems

     ```
     [root]# yum search nitro
     ```

   - SUSE 12-based systems

     ```
     [root]# zypper search nitro
     ```

   If no error is given, the repository is correctly installed. The following is an example of the output after verifying the repository.

   > The RPM file may contain multiple components. It is recommended that you do a search in the repository for Nitro to limit the results.

   ```
   Loaded plugins: fastestmirror, security
   Loading mirror speeds from cached hostfile
    *epel: linux.mirrors.es.net
   ================================================ N/S Matched: nitro
   ================================================
   nitro.x86_64 : Adaptive Nitro for High Throughput Computing
   nitro-web-services.x86_64 : Nitro Web Services
   ```

Installing

Installing RLM Server

Access to a Reprise License Manager (RLM) server is required when using Nitro.

This topic contains instructions on how to install an RLM Server.

> If your company already uses an RLM Server, you can skip this procedure and follow the instructions in Installing Nitro on page 36.

In this topic:

Open Necessary Ports

If your site is running firewall software on its hosts, you will need to configure the firewall to allow connections to the necessary ports.

This section contains the instructions to open the RLM Server (5053) and RLM Web Interface (5054) ports.

On the RLM Server, open the necessary ports.

- Red Hat 6-based systems using iptables

```
[root]# iptables -A INPUT -p tcp --dport 5053 -j ACCEPT
[root]# iptables -A INPUT -p tcp --dport 5054 -j ACCEPT
[root]# service iptables save
```

- Red Hat 7-based systems using firewalld

```
[root]# firewall-cmd --add-port=5053/tcp --permanent
[root]# firewall-cmd --add-port=5054/tcp --permanent
[root]# firewall-cmd --reload
```

- SUSE 12-based systems using SuSEfirewall2

```
[root]# vi /etc/sysconfig/SuSEfirewall2

FW_SERVICES_EXT_TCP="5053 5054"

[root]# service SuSEfirewall2 restart
```

Install the RLM Server

If your configuration uses firewalls, you *must also* open the necessary ports before installing the RLM Server . See Open Necessary Ports on page 33.

On the host where the RLM Server will reside, do the following:

1. If you are installing RLM Server on its own host *or* on a host that does not have another RPM installation, complete the steps to prepare the host. See Preparing for RPM Installation or Upgrade on page 31.
2. Install the RPM.
   - Red Hat 6-based or Red Hat 7-based systems

```
[root]# yum install ac-rlm
```

   - SUSE 12-based systems

```
[root]# zypper install ac-rlm
```

Change the Default Passwords

The RLM Web interface includes two usernames (admin and user) by default. These usernames have the default password "changeme!".

If you do not change this password, RLM will not be secure. For tips on choosing a good password, see https://www.us-cert.gov/ncas/tips/ST04-002.

Do the following for both the user and the admin usernames:

1. Using a web browser, navigate to your RLM instance. (http://<*RLM_host*>:5054; where <*RLM_host*> is the IP address or name of the RLM Server Host).

2. Log in.
3. Select **Change Password** and change the password according to your password security process.

Licensing Nitro

This topic provides instructions on how to obtain and install the Nitro license.

These instructions assume you already have access to an RLM Server. See Installing RLM Server on page 33.

Do the following:

1. On the RLM server, obtain the hostid and hostname.
   - hostid

     ```
     /opt/rlm/rlmhostid
     ```

     You should see output similar to the following.

     ```
     # /opt/rlm/rlmhostid
     rlmhostid v12.0
     Copyright (C) 2006-2015, Reprise Software, Inc. All rights reserved.

     Hostid of this machine: 00259096f004
     ```

   - hostname

     ```
     /opt/rlm/rlmhostid host
     ```

     You should see output similar to the following.

     ```
     rlmhostid v12.0
     Copyright (C) 2006-2015, Reprise Software, Inc. All rights reserved.

     Hostid of this machine: host=<your-host-name>
     ```

2. Email licenses@adaptivecomputing.com for a license and include the hostid and hostname you just obtained.
3. Adaptive Computing will generate the license and send you the Nitro license file (.lic) file in a return email.
4. As a root user on the RLM server, do the following:
   a. Download and install the license file.

      ```
      cd /opt/rlm
      chown rlm:rlm <licenseFileName>.lic
      ```

   b. Perform a reread to update the RLM Server with you license.

      ```
      /opt/rlm/rlmreread
      ```

5. Copy the license file to each compute node (coordinator). On each compute node, or the shared file system, do the following:

```
cp <licenseFileName>.lic /opt/nitro/bin/
```

Installing Nitro

This topic contains instructions on to install and configure Nitro.

> These instructions assume you have installed the Nitro license on an RLM Server. See Licensing Nitro on page 35 for detailed instructions.

Nitro

- needs to be available to all of the nodes that will be used as part of the Nitro job.
- can be installed either to each node individually *or* to a shared file system that each node can access.
- can be installed to integrate with a scheduler, such as Moab Workload Manager, or without (Nitro standalone). The instructions are the same.

In this topic:

Open Necessary Ports

Nitro uses several ports for communication between the workers and the coordinator.

The default port is 47000, and up to four ports are used in running Nitro (ports 47000-47003).

On each compute node (coordinator), open the necessary ports.

- Red Hat 6-based systems using iptables

```
[root]# iptables-save > /tmp/iptables.mod
[root]# vi /tmp/iptables.mod

# Add the following lines immediately *before* the line matching
# "-A INPUT -j REJECT --reject-with icmp-host-prohibited"
-A INPUT -p tcp --dport 47000 -j ACCEPT
-A INPUT -p tcp --dport 47001 -j ACCEPT
-A INPUT -p tcp --dport 47002 -j ACCEPT
-A INPUT -p tcp --dport 47003 -j ACCEPT

[root]# iptables-restore < /tmp/iptables.mod
[root]# service iptables save
```

- Red Hat 7-based systems using firewalld

```
[root]# firewall-cmd --add-port=47000/tcp --permanent
[root]# firewall-cmd --add-port=47001/tcp --permanent
[root]# firewall-cmd --add-port=47002/tcp --permanent
[root]# firewall-cmd --add-port=47003/tcp --permanent
[root]# firewall-cmd --reload
```

- SUSE 12-based systems using SuSEfirewall2

```
[root]# vi /etc/sysconfig/SuSEfirewall2

FW_SERVICES_EXT_TCP="47000 47001 47002 47003"

[root]# service SuSEfirewall2 restart
```

Install Nitro

If your configuration uses firewalls, you *must also* open the necessary ports before installing Nitro. See Open Necessary Ports on page 36.

On the host where Nitro will reside, do the following:

1. If you are installing Nitro on its own host *or* on a host that does not have another RPM installation, complete the steps to prepare the host. See Preparing for RPM Installation or Upgrade on page 31.
2. Install the RPM.
   - Red Hat 6-based or Red Hat 7-based systems

     ```
     [root] # yum install nitro
     ```

   - SUSE 12-based systems

     ```
     [root] # zypper install nitro
     ```

3. Identify the launch_nitro.sh script version for your resource manager. This script will be copied to the bin directory from where user job scripts will execute Nitro. See Default Installation Directory and Subdirectories on page 14 for more information.

   Reference scripts are provided in `/opt/nitro/scripts`.

   ```
   # find . -name launch_nitro.sh
   ./scripts/lsf/launch_nitro.sh
   ./scripts/torque/launch_nitro.sh
   ./scripts/slurm/launch_nitro.sh
   ./scripts/alps/torque/launch_nitro.sh
   ./scripts/alps/slurm/launch_nitro.sh
   ```

4. Copy the launch script to the bin directory. (This example uses the Torque-based launch script.)

   ```
   # cp /opt/nitro/scripts/torque/launch_nitro.sh /opt/nitro/bin/launch_nitro.sh
   ```

> This is a "copy" file operation and not a "move" operation. This allows you to customize your version of the script and always have the factory version available for consultation and/or comparison.

5. Customize the bin/launch_nitro.sh script as needed for your site's administrative policies. For example, to enable the Nitro coordinator's host to always execute a local Nitro worker, modify the bin/launch_nitro.sh script version to always pass the --run-local-worker command line option to the coordinator. See Launch Scripts on page 47 for more information on editing the launch script.
6. If you are not using a shared file system, copy the Nitro installation directory to all hosts.

   Only the Nitro bin directory with its proper path is required to run Nitro jobs. This means that you only need to copy the Nitro bin directory to the other hosts.

```
# scp -r /opt/nitro/bin root@host002:/opt/nitro
nitrostat                                     100%   12KB  12.0KB/s   00:00
launch_nitro.sh                               100% 6890     6.7KB/s   00:00
nitro                                         100%   15MB  14.9MB/s   00:00
```

Verify Network Communication

Verify that the nodes that will be running Nitro are able to communicate with the Nitro ports *and* that the nodes are able to communicate with one another.

Installing Nitro Web Services

This topic contains instructions on how to install Nitro Web Services.

> Currently, Nitro Web Services is only applicable if you are using Torque as your resource manager. In addition, you will also need to license and install Moab Viewpoint.

Do the following in the order presented:

1. Open the MongoDB Database Port (27017) on page 38
2. Install MongoDB on page 39
3. Install and Configure Nitro Web Services on page 41
4. Configure Viewpoint for Nitro Web Services on page 42
5. Configure Nitro Compute Nodes on page 44

Open the MongoDB Database Port (27017)

> Nitro Web Services requires access to a MongoDB database. Depending on your system configuration, your MongoDB databases may not be installed on the same host as their corresponding component servers. For example, you may choose to install the Nitro Web Services MongoDB on the same host where you have installed other MongoDB databases instead of on the Moab Server Host.

Do the following, as needed:

- If you have chosen to install the Nitro Web Services MongoDB database on the *same* host you installed other MongoDB databases, confirm the firewall port (27017) is already opened on that host.
- If you have chosen to install the Nitro Web Services MongoDB database on a *different* host from other MongoDB databases, you will need to open the Nitro Web Services MongoDB database port in the firewall for that host. To open the port in the firewall, do the following:
  - Red Hat 6-based systems using iptables

```
[root]# iptables-save > /tmp/iptables.mod
[root]# vi /tmp/iptables.mod

# Add the following lines immediately *before* the line matching
# "-A INPUT -j REJECT --reject-with icmp-host-prohibited"

-A INPUT -p tcp --dport 27017 -j ACCEPT

[root]# iptables-restore < /tmp/iptables.mod
[root]# service iptables save
```

  - Red Hat 7-based systems using firewalld

```
[root]# firewall-cmd --add-port=27017/tcp --permanent
[root]# firewall-cmd --reload
```

  - SUSE 12-based systems using SuSEfirewall2

```
[root]# vi /etc/sysconfig/SuSEfirewall2

FW_SERVICES_EXT_TCP="27017"

[root]# service SuSEfirewall2 restart
```

Install MongoDB

To install and enable MongoDB on the Moab Server Host, do the following:

1. Install MongoDB.
   - Red Hat 6-based or Red Hat 7-based systems

```
[root]# cat > /etc/yum.repos.d/mongodb.repo <<End-of-file
[mongodb]
name=MongoDB Repository
baseurl=http://downloads-distro.mongodb.org/repo/redhat/os/x86_64
gpgcheck=0
enabled=1
exclude=mongodb-org mongodb-org-server
End-of-file
[root]# yum install mongo-10gen-server
```

- SUSE 12-based systems

```
[root]# zypper ar --refresh -r
http://download.opensuse.org/repositories/server:/database/SLE_
12/server:database.repo
[root]# zypper install mongodb
```

2. Start MongoDB

- Red Hat 6-based systems

```
[root]# chkconfig mongod on
[root]# service mongod start
```

- Red Hat 7-based systems

```
[root]# cat > /usr/lib/systemd/system/mongodb.service <<End-of-file
[Unit]
Description=High-performance, schema-free document-oriented database
After=syslog.target network.target

[Service]
Type=forking
User=mongod
Group=mongod
Environment=CONFIG=/etc/mongod.conf
Environment=OPTIONS=
EnvironmentFile=-/etc/sysconfig/mongod
ExecStart=/usr/bin/mongod -f \$CONFIG \$OPTIONS
PrivateTmp=true
LimitNOFILE=65536
TimeoutStartSec=180
StandardOutput=syslog
StandardError=syslog

[Install]
WantedBy=multi-user.target
End-of-file
[root]# rm -f /etc/init.d/mongod
[root]# systemctl enable mongodb.service
[root]# systemctl start mongodb.service
[root]# systemctl daemon-reload
```

- SUSE 12-based systems

```
[root]# systemctl enable mongodb.service
[root]# systemctl start mongodb.service
[root]# systemctl daemon-reload
```

3. Prepare the MongoDB database by doing the following:
   a. Add the required MongoDB users.

   > The password used below (secret1) is an example. Choose your own password for this user.

   ```
   [root]# mongo
   > use admin;
   > db.addUser("admin_user", "secret1");
   > db.auth ("admin_user", "secret1");
   > exit
   ```

   > Because the `admin_user` has read and write rights to the `admin` database, it also has read and write rights to all other databases. See Control Access to MongoDB Instances with Authentication (http://docs.mongodb.org/manual/tutorial/control-access-to-mongodb-with-authentication/) for more information.

   b. Enable authentication in MongoDB.
      - Red Hat 6-based systems

      ```
      [root]# vi /etc/mongod.conf
      auth = true
      [root]# service mongod restart
      ```

      - Red Hat 7-based systems

      ```
      [root]# vi /etc/mongod.conf
      auth = true
      [root]# systemctl restart mongodb.service
      ```

      - SUSE 12-based systems

        MongoDB authentication is already enabled. No further action is needed.

Install and Configure Nitro Web Services

> You *must* complete the tasks earlier in this topic before installing Nitro Web Services.

On the host where Nitro Web Services will reside, do the following:

1. If you have not already do so, complete the steps to prepare the host. See Preparing for RPM Installation or Upgrade on page 31.
2. Install the Nitro Web Services RPM.
   - Red 6-based or Red Hat 7-based systems

   ```
   [root] yum install -y nitro-web-services
   ```

- SUSE 12-based systems

```
[root] zypper --non-interactive install nitro-web-services
```

3. Understand and edit the configuration files. The installation provides these two configuration files:
   - /opt/nitro-web-services/etc/nitro.cfg
   - /opt/nitro-web-services/etc/zmq-job-status-adapter.cfg

   For example, the zmq_job_status_adapter.cfg file contains the msg port number that you will need to define on the Nitro compute nodes.

   You will need to edit both of these cfg files for your system configuration.

   > Typically, you will only need to edit the passwords to change them from the default value to your specified passwords.

4. Start the services and configure Nitro Web Services to start automatically at system boot.
   - Red Hat 6-based systems

```
[root] chkconfig --add nitro-web-services
[root] chkconfig --add nitro-zmq-job-status-adapter
[root] service nitro-web-services start
[root] service nitro-zmq-job-status-adapter start
```

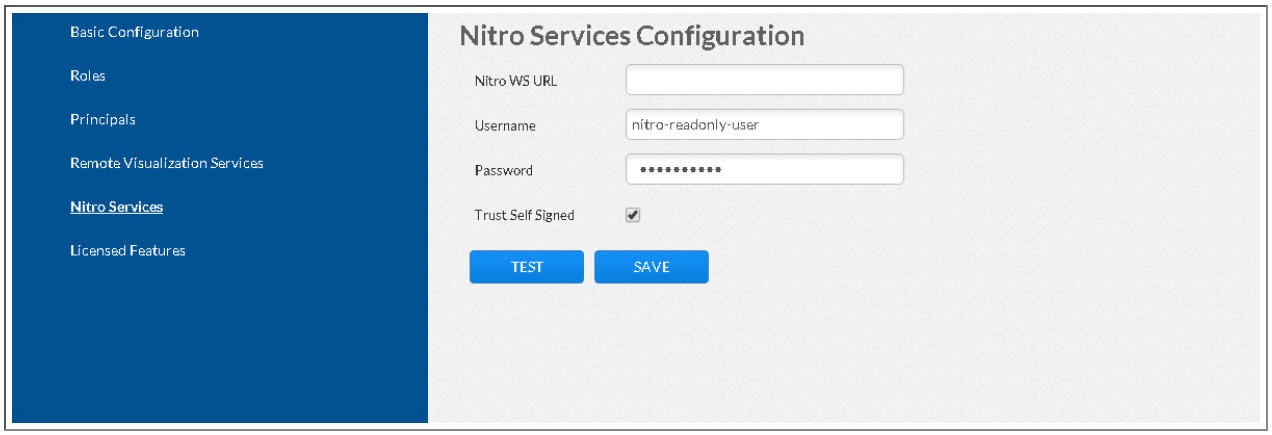
   - Red Hat 7-based or SUSE 12-based systems

```
[root] systemctl enable nitro-web-services.service
[root] systemctl enable nitro-zmq-job-status-adapter.service
[root] systemctl daemon-reload
[root] systemctl start nitro-web-services.service
[root] systemctl start nitro-zmq-job-status-adapter.service
```

Configure Viewpoint for Nitro Web Services

Do the following:

1. Using a web browser, navigate to your Viewpoint instance (`http://<server>:8081`) and then log in as the MWS administrative user (moab-admin, by default).
2. Click **Configuration** from the menu and then click **Nitro Services** from the left pane. The following is an example of the Nitro Services Configuration page.



3. Enter the configuration information. The following table describes the required information.

Field	Description
Nitro WS URL	Hostname (or IP address) and port number for the host on which you installed Nitro Web Services. For example, https://<*hostname*>:9443
Username	Name of the user. This typically nitro-readonly-user.
Password	The user's password.
Trust Self Signed	Indicates whether Nitro Web Services was set up using self-signed certificates.

4. Click **TEST** to confirm the settings are correct. This confirms whether Nitro Web Services is up and receiving connections.
5. Click **SAVE**.
6. (Recommended) Use curl to test Nitro Web Services connectivity.

```
curl --insecure --data '{"username": "nitro-admin", "password": "ChangeMe2!"}' \
 https://<hostname>:9443/auth
```

You should get something similar to the following in the response:

```
{
  "status": 200,
  "data": {
    "nitro-key": "3e0fb95e9a0e44ae91daef4deb500dcc67a3714880e851d781512a49",
    "user": {
      "username": "nitro-admin",
      "last_updated": "2016-02-26 23:34:55.604000",
      "name": "Nitro Admin",
      "created": "2016-02-26 23:34:55.604000",
      "auth": {
        "job": [
          "read",
          "write",
          "delete"
        ],
        "user": [
          "read",
          "write",
          "delete"
        ]
      }
    }
  }
}
```

Configure Nitro Compute Nodes

You need to configure the Nitro coordinators to send job status updates to the Nitro Web Services's ZMQ Job Status Adapter. The ZMQ Job Status Adapter is responsible for reading job status updates off of the ZMQ bus and persisting them to Mongo. Nitro Web Services can then be used to access Nitro job status.

Each Nitro job has a Nitro Coordinator. Nitro Coordinators can be configured to publish job status updates to ZMQ by setting the "nws-connector-address" configuration option in Nitro's nitro.cfg file. Each compute node allocated/scheduled to a Nitro Job can play the role of a Nitro coordinator. Therefore, you must update the "nws-connector-address" in each compute node's nitro.cfg file.

Configuring nws-connector-address is simplified if each node is sharing nitro's configuration over a shared filesystem. If you are not using a shared filesystem, update the nitro configuration on each compute node.

Do the following:

1. If you have not already done so, on the Moab Server Host, locate the msg_port number in the `/opt/nitro-web-services/etc/zmq_job_status_adapter.cfg` file. This is the port number you need to specify for the nws-connector-address.
2. On *each* Nitro compute note (Torque MOM Host), specify the nws-connector-address in the `/opt/nitro/etc/nitro.cfg` file .

```
...
# Viewpoint connection allows Nitro to communicate job status information
# to viewpoint.  This option indicates name and port of the remote server
# in the form: <host>:<port>
nws-connector-address <nitro-web-services-hostname>:47100
...
```

Upgrading

Upgrading Nitro

> You must be a root user when installing or upgrading Nitro.

This topic contains the steps and procedures to follow to upgrade Nitro using the RPM upgrade method.

In this topic:

Upgrade from a Version Prior to 2.0

The following steps are required if you are upgrading a Nitro version prior to 2.0.

1. Install or obtain access to an RLM server. See Installing RLM Server on page 33.

   > Beginning with Nitro 2.0, the licensing procedure changed to use an RLM server. If your company already uses an RLM Server, you can skip this procedure.

2. Obtain and install the Nitro license. This requires access the an RLM server. See Licensing Nitro on page 35.

Upgrade Nitro

On the host where Nitro resides, do the following:

1. If you are installing Nitro on its own host *or* if Nitro is the first component being upgraded on a host with other RPM installations, complete the steps to prepare the host. See Preparing for RPM Installation or Upgrade on page 31.
2. Install the RPM.
   - Red Hat 6-based or Red Hat 7-based systems

     ```
     [root] # yum install nitro
     ```

   - SUSE 12-based systems

     ```
     [root] # zypper install nitro
     ```

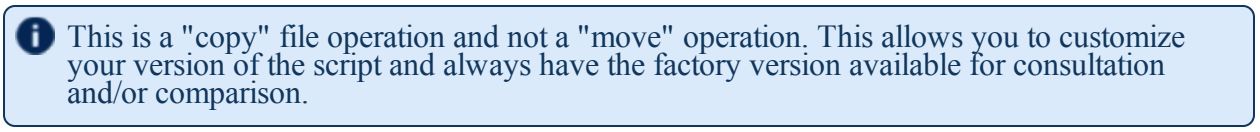
Identify the `launch_nitro.sh` script version for your resource manager.

Reference scripts are provided in `/opt/nitro/scripts`.

```
# find . -name launch_nitro.sh
./scripts/lsf/launch_nitro.sh
./scripts/torque/launch_nitro.sh
./scripts/slurm/launch_nitro.sh
./scripts/alps/torque/launch_nitro.sh
./scripts/alps/slurm/launch_nitro.sh
```

Copy the latest launch script to the bin directory. (This example uses the Torque-based launch script.)

```
# cp /opt/nitro/scripts/torque/launch_nitro.sh /opt/nitro/bin/launch_nitro.sh
```



Merge any customizations from your existing `launch_nitro.sh` script into the script you just copied to the bin directory.

If you are not using a shared file system, copy the updated Nitro installation directory to all hosts.

Only the Nitro bin directory with its proper path is required to run Nitro jobs. This means that you only need to copy the Nitro bin directory to the other hosts.

```
# scp -r /opt/nitro/bin root@host002:/opt/nitro
nitrostat                                     100%   12KB  12.0KB/s   00:00
launch_nitro.sh                               100% 6890     6.7KB/s   00:00
nitro                                         100%   15MB  14.9MB/s   00:00
```

Chapter 3 System Administration

This chapter provides additional configuration and resources, including troubleshooting, for system administrators.

In this chapter:

Scheduler and Resource Manager Integration

This topic provides information on the scripts used to integrate with your resource manager. It also provides additional configuration instructions if your installation uses a directory other than the default.

In this topic:

Launch Scripts

The `/opt/nitro/scripts` directory contains a set of launch scripts for different job schedulers and resource managers, which include Cray ALPS with Torque or Slurm, Platform LSF, Slurm, and Torque (Moab and Maui schedulers). See Resource Manager Launch Scripts on page 70.

The purpose of these scripts is to provide an interface between the job scheduler or resource manager and Nitro that supplies Nitro with information about the job and resources.

Customizing the Launch Scripts

The launch scripts may be customized for your installation. The launch script needs to accomplish the following:

1. Get a list of nodes allocated to the job.
2. Get the job ID.
3. Translate environment variables to command line options.

   Users can set the environment variables NITRO_OPTIONS (applied to both the worker and coordinator command lines), NITRO_WORKER_OPTIONS (applied only to the worker command line), and NITRO_COORD_OPTIONS (applied only to the coordinator command line). See Submit a Nitro Job to a Scheduler on page 57.
4. Launch the workers on all but the first node allocated to the job.
5. Launch the coordinator on the first node allocated to the job.

Additional Configuration

All of the scripts have a line setting the "NITRO" script variable to the Nitro default installation location.

If you installed Nitro to a directory other than the default `/opt/nitro/bin` installation directory, you will need to change the launch scripts to run Nitro from your installation location.

For example, if you have installed Nitro on a shared file system called "/sharedfs/opt/nitro", then make the following change to your copy of the launch script.

change:

```
NITRO=/opt/nitro/bin/nitro
```

to:

```
NITRO=/sharedfs/opt/nitro/bin/nitro
```

File System Configuration

This topic provides details regarding the file system configuration.

Users will normally submit Nitro jobs to a scheduler. A Nitro job runs in the user's workspace on the nodes allocated to the job by the scheduler. There are two Nitro output file locations (task log and job log) that *must* be available to the hosts running the workers and coordinator.

In this topic:

Nitro Launch Script Location

The Nitro launch script must be installed in a shared file location or a location that is accessible to the users that will be running Nitro jobs. While users won't need to run the Nitro application itself, they should have read access to the Nitro launch script.

Task File Location

The task file a Nitro job will use must be accessible to the job. Most schedulers will copy the user job script, but will not copy the task file the user must provide. Users may need to stage this task file into a location accessible to Nitro job hosts. Nitro only needs read access to this file.

Job Output Directory

If the user does not specify a Nitro job directory (using "--job-dir" command line option), Nitro defaults to the `$HOME/nitro/<job id>` directory.

This directory contains the Nitro job and task log files, Nitro diagnostic log files, and temporary files Nitro uses to recover a canceled job. Users' home directories on these hosts should be mapped to a shared file location accessible to the users either from the system's login hosts, or outside of the cluster. Nitro will need to create directories and files in the Nitro job directory.

Recommended NFS Settings

If the job directory and task file are located on an NFS, then depending on the NFS cache settings, system administrators and users should be aware of the following:

- Job Directory - Users may not see job progress for several seconds after Nitro writes the files.
- Task File - If using Nitro in *linger mode*, Nitro may not recognize that new tasks have been added to the task file for up to 30 seconds.
- System Configuration (caching/tuning) - Add "lookupcache=none" to the NFS file system mount options in /etc/fstab for all the hosts using the NFS to prevent caching delays.

Related Topics

- Resource Manager Launch Scripts on page 70
- Command Line Flags, Options, and Positional Parameters on page 72
- Linger Mode on page 67

Run Nitro Without a Scheduler

Nitro works well running as a job invoked via a scheduler and/or resource manager.

However, if you have a set of hosts that are dedicated to high-throughput computing and would like to run Nitro jobs on these machines, or have Nitro always waiting (ready to run tasks at any time), you can run Nitro without the use of a scheduler.

This topic explains how to run Nitro without the use of a scheduler (also referred to Nitro standalone).

In this topic:

Selecting a Job ID

Since you do not have a scheduler to supply a job ID, Nitro will create a default job ID based on the current date and time in the format "YYYMMDDHHMMSS". Since the workers and coordinator will be started separately, it is recommended that you designate a job ID and set the "--job-id <*job id*>" command line option on the worker and coordinator command lines with that job ID. Setting the job ID provides consistency between the workers and the coordinator when referencing the job; for example, when viewing job output and log files.

Starting Workers

You must start a worker on each host you want to execute Nitro tasks by starting it manually on a terminal on that host, or by running a remote command through ssh.

A worker command line must include an "--coord" argument that lists the host name and port number (if other than default port "47000") of the coordinator.

When each worker connects to the coordinator, it identifies itself using the `--name` option. If `--name` is not supplied, the worker's identification is the worker node's name.

> The name supplied to the coordinator via `--workers` or `--workers-file` must match the `--name` argument specified on the worker's command line.

For example, if you have the coordinator running on host "node001" and a worker running on host "node002", then the command line to start the worker would look like the following:

```
/opt/nitro/bin/nitro --mode=worker --job-id MyJob01 --coord node001 --name node002
```

Alternately, to run the worker using ssh (assuming ssh keys have been exchanged between the coordinator and worker), it would look like the following:

```
ssh user@node002 '/opt/nitro/bin/nitro --mode=worker --job-id MyJob01 --coord node001
--name node002'
```

Starting the Coordinator

The coordinator requires either a list of worker names or a session key that workers will use to attach to the coordinator. When supplying a list of worker names, these workers will be the only workers authorized to connect to the coordinator and receive workload assignments. If you specify a session key, any worker with the session key will be able to attach and receive workload.

Using Worker Names

A list of worker names can be specified on the command line, with worker names separated by the plus symbol (+). For example:

```
/opt/nitro/bin/nitro --mode=coord --job-id MyJob01 --workers
node002+node003+node004+node005 ~/taskfile.txt
```

Alternately if it is a large list, it may be written to a file with one name per line, where the name is what the worker identifies itself as to the coordinator. For example:

```
echo -e "node001\nnode002\nnode003\nnode004\nnode005" > nodelist.txt
/opt/nitro/bin/nitro mode=coord --job-id MyJob01 --workers-file nodelist.txt
~/taskfile.txt
```

host node001 is the coordinator and hosts node002-node005 are workers.

Using a Session Key

To start the coordinator with a session key, use the `--key <keyvalue>` command line option instead of the `--workers` or `--workers-file` command line options. Any worker that is started with the `--key` command line option with the correct <*keyvalue*> will be able to attach to the coordinator. For example:

```
/opt/nitro/bin/nitro --mode=worker --coord node01 --job-id MyJob01 --key password1234
/opt/nitro/bin/nitro --mode=coord --name=node01 --job-id MyJob01 --key password1234
~/taskfile.txt
```

(Optional) Changing the Job Directory

The default job directory (the location to which Nitro will write the job and task log files) is `$HOME/nitro/<job id>`.

If you want to store results in a different directory, use the "--job-dir" command line option on both the coordinator and workers.

Related Topics

- Command Line Flags, Options, and Positional Parameters on page 72

Chapter 4 Using Nitro

This chapter provides information and instructions on using Nitro.

In this chapter:

Prepare a Nitro Job

This topic provides information on the Nitro job's task file and performance tuning information.

In this topic:

Task File

The task file is a single file that contains a list of tasks to execute. Each line of the task file should contain only *one* task. You can add comments to your task file to help describe the tasks being performed, the data required, or other information that is pertinent to describing the tasks. Nitro also provides the capability to use task names and labels to help you organize your tasks.

Most of the tasks you create for a task file will probably run to completion fairly quickly, but it is possible that a task gets stuck in a loop or needs to run for a certain amount of time. Nitro by default limits tasks to 3,600 seconds (1 hour), but you can specify the limit to apply to the task by using the "maxtime" token. Time limits are specified in seconds. The following is an example of a task definition that limits a task to 30 seconds.

```
name=S23T01 maxtime=30 cmd=/opt/framemaker/bin/framegen -i /shared/scene23.def -tindex
1
```

Tasks

A task line can be as simple as the command you want to execute. For example, if you want to run a program called "framegen", input a file from a shared directory, and process the frame starting at time index "0" (zero), the command line might look like as follows.

```
/opt/framemaker/bin/framegen -i /shared/scene23.def -tindex 0
```

Nitro uses name/value pairs before the command line that you want to execute to define Nitro-specific information, such as, specifying a task name, task labels (that you can use to categorize the task), maximum time a task will run, and the command to execute to run the tasks itself. The key words for these name/value pairs are:

```
"cores=<count>"
"env=<name=value>[,<name=value>,...]"
"labels=<label>[,<label>,...]"
"name=<task name>"
"maxtime=<time limit in seconds>"
"memory=<amount>"
"shell=[default | none | <shell path>]"
"cmd=<command line>"
```

The optional name/value pairs must be prepended to the line containing the task command line. As soon as Nitro sees something that isn't a name/value pair, the task line parsing stops and the rest is assumed to be part of the command line to execute.

To make it clear where the task options end and your command line begins, include "cmd=" before your task's command line. This token is optional but helps to make the task definition easier to read when you are specifying other options. The following is an example command line with the "cmd=" token.

```
cmd=/opt/framemaker/bin/framegen -i /shared/scene23.def -tindex 0
```

Nitro organizes the tasks for tracking.

Nitro tracks tasks by a task ID and line number. Nitro automatically generates a task ID for each task definition in the task file. The first task definition receives task ID "1".

Only a task definition will increment the task ID. Because a task file can have empty or comment lines, the task ID and the line number in the task file may not be the same for the task.

Nitro will create a report of all tasks run and will include the task ID and line number in this report. The task ID is passed to the task via the **$NITROTASKID** environment variable.

To make Nitro tasks easier to track, or to search for specific tasks in the task completion report, add a unique task name to your task definition. Task names don't have to be unique, but creating a unique task name helps you identify specific tasks.

You can use any naming scheme you want, as long as the name does not include spaces (which would indicate an end to the name/value pair).

For example, if you are processing data for scenes 21, 22, and 23, you can name the tasks according to scene and time index.

```
name=S21T00 cmd=/opt/framemaker/bin/framegen -i /shared/scene21.def -tindex 0
name=S21T01 cmd=/opt/framemaker/bin/framegen -i /shared/scene21.def -tindex 1
name=S22T00 cmd=/opt/framemaker/bin/framegen -i /shared/scene22.def -tindex 0
name=S22T01 cmd=/opt/framemaker/bin/framegen -i /shared/scene22.def -tindex 1
name=S23T00 cmd=/opt/framemaker/bin/framegen -i /shared/scene23.def -tindex 0
name=S23T01 cmd=/opt/framemaker/bin/framegen -i /shared/scene23.def -tindex 1
```

Nitro makes the task name available to the task via the **$NITROTASKNAME** environment variable when it executes the task. If the task command line includes the environment variable, it is substituted by its value before the command executes.

You can also use task labels to organize or identify the tasks. You can use multiple labels to describe a task. Multiple label values are separated by a comma between them; spaces are not allowed.

For example, if scene 22 contains a green screen that needs additional processing after this job completes, you can include the label "green" on all of the tasks for this scene.

```
name=S21T00 cmd=/opt/framemaker/bin/framegen -i /shared/scene21.def -tindex 0
name=S21T01 cmd=/opt/framemaker/bin/framegen -i /shared/scene21.def -tindex 1
name=S22T00 labels=green /opt/framemaker/bin/framegen -i /shared/scene22.def -tindex 0
name=S22T01 labels=green /opt/framemaker/bin/framegen -i /shared/scene22.def -tindex 1
name=S23T00 cmd=/opt/framemaker/bin/framegen -i /shared/scene23.def -tindex 0
name=S23T01 cmd=/opt/framemaker/bin/framegen -i /shared/scene23.def -tindex 1
```

Performance Tuning

Assignment Size

Each set of tasks that a coordinator sends to a worker is called an assignment. Nitro is most efficient when it can send a large enough assignment to each worker to keep the worker busy for at least 10 seconds before requesting more work. On the other hand, if you have a heterogeneous set of hosts with a wide variance in performance characteristics, you don't want one worker taking a very long time completing its assignment after all of the other workers have finished.

> You can specify an assignment size as small as "1" (which could be useful for tasks that need to use all of the available OS cores) and as large as "1000" (useful to keep worker cores busy with tasks of extremely short duration).

> Assignment sizes don't need to be evenly divisible by the number of OS cores available. Nitro will try to send the worker a second assignment when the worker gets about half way done with the current assignment so the second assignment will start running tasks as soon as an OS core becomes idle from the previous assignment.

Nitro uses a default assignment size of 250 tasks. If this is too many or two few tasks per assignment for your configuration, you can change it by using the --assignment-size command line option for the coordinator.

For example, if your nodes are all running 16 OS cores and each task takes 2 seconds to complete, each assignment of default size will take 31.25 seconds to complete (250 tasks at 2 seconds each divided by 16 OS cores), so you might want to change the assignment size to "80" to get an assignment time of closer to 10 seconds with the command line option.

> Adaptive Computing recommends a 10-20 second assignment duration to optimize node utilization and to prevent "tailing" jobs (job where at its end there is only one or a few workers executing a large assignment and other workers are idle).

```
--assignment-size 80
```

If submitting a job to a job scheduler, you can change the assignment size by setting the **NITRO_COORD_OPTIONS** environment variable so it contains the --assignment-size command line option.

Thread Control

Nitro typically runs one task per available OS core on each worker. However, you can configure Nitro to run more tasks than OS cores (over-subscription), fewer tasks than OS cores (under-subscription) or a specific number of OS cores. You might want to over-subscribe the available OS cores if you are not utilizing the full capacity of the host. You may need to under-subscribe cores if

background tasks are running on the nodes. To over- or under-subscribe, use the --thread-ratio command line option.

```
--thread-ratio <ratio>
```

<ratio> only applies to worker nodes. However, if you are using the –run-local-worker command line option, then the thread ratio will be passed on to the coordinator's local worker.

--thread-ratio also lets you specify over- or under-subscription properly in a heterogeneous host environment where hosts have different numbers of processors, cores, or threads. For example, if your hosts are all single socket, oct-core with hyper-threading enabled (16 total OS cores), but you want to over-subscribe by a factor of 1.5x, you could accomplish this by adding "--thread-ratio 1.5" to the worker command line to give each worker the ability to run 24 concurrent tasks. Alternately, if your tasks are all designed to use 2 OS cores each (multi-threaded application), you could use "--thread-ratio 0.5".

There may also be cases where you want to specify the *exact* number of OS cores to be used by the worker, such as when you have tasks that will use all available OS cores. In that case, you would use the --thread-count command line option to specify a thread count of 1 (--thread-count 1).

Run a Worker on the Coordinator Node

In configurations where you will be running less than 20 worker hosts, the coordinator node may be underutilized. To remedy this situation you may want to run a worker on the coordinator host so you can use its resources more effectively. To run a worker on the coordinator host, include the --run-local-worker flag on the coordinator's command line *or* you can explicitly start a worker Nitro process on the host.

Nitro will calculate the number of threads that the local worker should run so the coordinator is not starved for CPU cycles; causing it to slow down all the other workers.

Task Execution Environment Variables

Nitro will pass several environment variables to your tasks when it executes them.

Valid environment variables:

- $NITROJOBID – Job ID of the Nitro job.
- $NITROJOBDIR – Job directory to which Nitro writes log files. This directory can be used to store output files from your tasks.
- $NITROTASKCORES – Number of cores allocated to the task.
- $NITROTASKID – Task ID of the task. The task ID is a number that starts at 1 and increments by 1 for each task definition (valid or invalid) in the task file. Commented and empty lines are not counted; if the task file contains such, the task ID and the line number will diverge.
- $NITROTASKMEMORY – Amount of memory (in MB) allocated to the task.
- $NITROTASKNAME – Task name, if provided by the task definition.
- $NITROTASKTIME – Task time limit, specified by "maxtime" in the task definition.
- $NITRO_TASK_FILE - Can be used with normal file names that do not use spaces, but **MUST** be used if the user submits more than one task file.

- $NITRO_LONG_TASK_FILE - Can be used with normal file names that do contain spaces, but **MUST** be used if the file name contains spaces. This variable can only contain one file name. You cannot submit multiple file names containing spaces.

Nitro reads a portion of the task file at a time. While the Nitro job is running, do *not* add or remove any task definitions or comment lines in the task file. Changes to the task file could cause line numbers to be changed and jobs to not run or be accidentally rerun.

Related Topics

- Command Line Flags, Options, and Positional Parameters on page 72

Submit a Nitro Job to a Scheduler

This topic provides information about submitting a Nitro job and executing Nitro. The user creates the user job script and the system administrator sets up and configures the Nitro launch script, which the user job script executes to run Nitro.

Adaptive Computing's objective for Nitro is two-fold; first, allow the user to use the same job script for a Nitro job regardless of the scheduler used by a system to schedule jobs and, second, allow the administrator to customize Nitro for the system based on the scheduler and/or resource manager the system uses. This means the user job script can be scheduler-agnostic while the Nitro launch script (executed by the user job script) must be scheduler- or resource manager-specific.

In this topic:

User Job Script

Typically, the system administrator provides a sample Nitro job script to users to customize as needed.

A sample user job script is located in the Nitro installation's "samples" subdirectory.

Users can set launch script environment variables at the user job script-level to affect Nitro's behavior. See Launch Script Environment Variables on page 58 for a list of available variables.

The user job script also contains the information to execute the Nitro launch script (`/opt/nitro/bin/launch_nitro.sh`).

Nitro Launch Script

Adaptive Computing provides a configured Nitro launch script for different schedulers or resource managers. You can also build a new script. See Resource Manager Launch Scripts on page 70.

During the installation of Nitro, the system administrator copies the Nitro launch script (`/opt/nitro/scripts` directory) to the directory (`/opt/nitro/bin`) from where the user job script executes it.

Customize the Nitro Launch Script

The system administrator may customize the Nitro launch script to suit the needs of the system. The Nitro launch script may examine and modify, or simply pass through, the command line options specified by the environment variables set by the user job script. The command line options are then passed via the environment variables to the Nitro workers and coordinator that are started by the Nitro launch script.

Launch Script Environment Variables

The Nitro launch script looks for several environment variables. Users can also customize these variables in the user job script.

- NITRO_TASK_FILE
- NITROJOBID
- NITRO_OPTIONS
- NITRO_COORD_OPTIONS
- NITRO_WORKER_OPTIONS.

NITRO_TASK_FILE

The NITRO_TASK_FILE environment variable must contain the path to the task file, and the task file must be accessible to the coordinator host that will run the job.

Users should put the task file in a shared location accessible by any host in the system.

NITROJOBID

The NITROJOBID environment variable is created automatically by the launch script, based on the resource manager's job ID, if the user job script does not provide one.

Unless you are restarting a job that partially completed and was canceled, you don't need to set this environment variable. If you specify this environment variable in the job's submission, it will override the resource manager job ID and Nitro will use the value you supplied.

If your job scheduler and resource manager use different numbering systems, the job ID that Nitro will use is the one that it gets from the resource manager. You may want to submit the job directly to the resource manager in this case to avoid confusion. Check with your system administrator to find out if your job scheduler's and resource manager's job ids are synchronized.

NITRO_OPTIONS, NITRO_COORD_OPTIONS, or _NITRO_WORKER_OPTIONS

Any command line options the user job script needs to pass to Nitro must be contained in either the NITRO_OPTIONS, NITRO_COORD_OPTIONS, or NITRO_WORKER_OPTIONS environment variables.

Moab/Torque Customization Commands and Options

If using Moab/Torque, be aware of the following:

- Nitro will consume all available OS cores on the hosts on which it runs.
    - If Nitro is running exclusively on hosts, you may want to configure your system to run a single job per host (for example, in Moab, set NODEACCESSPOLICY to SINGLEJOB in the moab.cfg file).
    - If you will run other workload on the system that may run multiple jobs per host, you will need to provide a script or instruct users on how to specify their Nitro jobs to run with a single task per host configuration. In Moab and Torque the jobs should be submitted (using either msub or qsub) with the "`-l nodes=<node count>:tpn=1`" command line option.

Examples

The sample launch_nitro.sh job scripts provided in `/opt/nitro/scripts/<resource manager>/` all expect environment variables. You can set environment variables for the Nitro launch script at job submission or define them in the user job script.

Example: Setting Environment Variables at Job Submission

The "-v" option in Moab's msub command sets environment variables before calling the user job script. The user job script inherits these environment variables.

The user job script can add to or overwrite any environment variable defined in msub's "-v" option.

- User job script (/home/jdoe/user_job_script.sh)

  This script must exist on the host where you execute the msub command. In this example, this user job script exists in jdoe's home directory.

```
exec /opt/nitro/bin/launch_nitro.sh
```

- msub example

```
msub -lnodes=5 -ltpn=1 -lwalltime=600 -v "NITRO_TASK_
FILE=/home/jdoe/nitro/monte_sim.txt,NITRO_OPTIONS=--job-dir
/home/jdoe/monte01,NITRO_COORD_OPTIONS=--run-local-worker" /home/jdoe/user_job_
script.sh
```

    - The task file monte_sim.txt contains the list of task command lines that you want to execute.
    - The "--job-dir" sets the path to which Nitro will write the job and task logs.
    - The last parameter is the path of the user job script.

Example: Setting Environment Variables In the User Job Script

- User job script (/home/jdoe/user_job_script.sh)

  This script must exist on the host where you execute the msub command. In this example, this user job script exists in jdoe's home directory.

```
NITRO_TASK_FILE=/home/jdoe/nitro/monte_sim.txt
NITRO_OPTIONS="--job-dir /home/jdoe/monte01"
NITRO_COORD_OPTIONS=--run-local-worker
exec /opt/nitro/bin/launch_nitro.sh
```

- msub example

```
msub -lnodes=5 -ltpn=1 -lwalltime=600 /home/jdoe/user_job_script.sh
```

  - The task file monte_sim.txt contains the list of task command lines that you want to execute.
  - The "--job-dir" sets the path to which Nitro will write the job and task logs.
  - The last parameter is the path of the user job script.
  - NITRO_TASK_FILE, NITRO_OPTIONS and NITRO_COORD_OPTIONS are set in the user job script.

Track Job Progress

This topic provides information on viewing job progress and output.

In this topic:

Introduction on How Nitro Tracks the Job

Nitro will print some job information to stdout, such as what workers attached, how many tasks have been run, if any tasks failed, etc.

If your Nitro job is submitted through a scheduler, you may not see any of this until the job has completed and the resource manager has copied the job output to your job's submission directory.

However, Nitro provides a tool called nitrostat to display status information while the job is running. nitrostat is located in the `nitro/bin` directory where Nitro was installed.

Nitro creates two files that you can use to stay up-to-date on the progress of your job.

- nitro_<*jobid*>.joblog.txt - Information about the job in general.
- nitro_<*jobid*>.tasklog.txt - Listing of individual tasks that have completed along with performance statistics collected from running the task (duration and memory usage) and the task output to stdout and/or stderr.

> Both files are written to the job directory that you provide using the `--job-dir` command line option when submitting your job, or to the default job directory `$HOME/nitro/<jobid>`.

Job Log

To see job status using nitrostat, you will need the job ID. The job ID is the job ID reported to you when you submitted the job to the schuleder *or* that you set manually via the `--job-id` command line option in the NITRO_OPTIONS environment variable or via the NITROJOBID environment variable.

- The default location for the job and task logs are in your "`$HOME/nitro/<jobID>`" directory.
- You can also use the "--job-dir" command line option to specify a different job directory if you are not using the default location.

Nitro Job Progress Report

The Nitro job progress reports lets you see the current contents of a job log file.

For example, let's say you have a job that was run by your resource manager as job "23576", running "/opt/nitro/bin/nitrostat 23576"shows you the job's progress.

```
Nitro Job Progress Report

Start Time  : 2016-02-10 09:10:11-0600
Current Time: 2016-02-10 09:10:42-0600
Elapsed Time: 31 seconds (00:00:31)

Job Id      : 23576
Coordinator : node01
Task Log    : /home/jdoe/jobs/23576/nitro_23576.tasklog.txt
Task File   : /home/jdoe/jobs/survey03.tasks
  File Size : 123366
  Est Tasks : 3016
  Processed : 75%

Tasks
------------
Pending     : 500
In Progress : 500
Completed   : 1250
  Success   : 1250
  Failure   : 0
  InsufRes  : 0
  Timeout   : 0
  Invalid   : 0
  Tasks/sec : 40.3
Total Tasks : 2250

Workers
-------
Host   Pid    Thrds Status  Assigned Running Completed  Success  Failure  InsufRes
Timeout Tasks/sec AsgmtDur
node02 6851     12  running     1250     250      1000     1000        0         0
  0      36.0      8.0
node03 14988     4  running      500     250       250      250        0         0
  0       9.3     27.0
```

The following describes the fields and their output descriptions.

- Start Time – Date and time the coordinator started running.
- Current Time – Current date and time the report was generated (reports are generated every 5 seconds).

- Elapsed Time – Amount of time the coordinator has been working on the tasks.
- Job Id – Job ID that Nitro was passed on its command line. Typically assigned by the resource manager, but can be assigned by the user.
- Coordinator – Host name on which the coordinator is running.
- Task Log – Path and file name of the task log file that is generated by the coordinator.
- Task File – Path and file name of the task file.
- File Size – File size of the task file.
- Est Tasks – Number of tasks the coordinator estimates in the task file. Since Nitro doesn't read the entire task file on startup, an estimate is given based on lines read from the file so far.
- Processed– Percentage of the task file that has been read by the coordinator.
- Tasks Section: Lists the counts of tasks in each category
    - Pending – Number of tasks that have been put into assignments and are waiting to be sent to a worker.
    - In Progress– Number of tasks in assignments sent to the workers for which workers have not yet returned results.
    - Completed – Number of tasks in assignments that have been completed (workers have returned results).
    - Success – Number of completed tasks that were successful (the task returned an exit code of 0).
    - Failure – Number of completed tasks that returned an exit code other than 0.
    - InsufRes – Number of tasks that could not be run because the requested resources for the task was not available.
    - Timeout – Number of completed tasks that ran longer than the task "maxtime" parameter and were terminated by the worker.
    - Invalid – Number of task definitions that contained errors and could not be run.
    - Tasks/sec – Number of tasks per second based on the time that the coordinator sends the first assignment until the time the report is generated. If in *linger mode*, this will only be calculated for the last 60 seconds.
    - Total Tasks – Total number of tasks including completed and invalid tasks.
- Workers Section: List by worker
    - Host – Host name and port (if not the default port) of the worker.
    - Pid – Process ID of the worker.
    - Thrds –Number of task launch threads the worker is using to run tasks.
    - Status – Status of the worker. This may be "unconnected", "running", "unresponsive", "closing", or "closed".

- Assigned – Number of tasks assigned to this worker so far.
- Running – Number of tasks in assignments currently allocated to the worker.
- Completed – Number of tasks in assignments the worker has completed.
- Success – Number of successfully completed tasks.
- Failure – Number of tasks that returned an exit code other than 0.
- InsufRes – Number of tasks that could not be run because the requested resources for the task was not available.
- Timeout – Number of tasks that exceeded the tasks "maxtime" threshold and were terminated by the worker.
- Tasks/sec – Number of tasks per second that the worker has completed so far. In *linger mode* this is only calculated for the last 60 seconds.
- AsgmtDur – Average assignment duration in seconds.

Job Completed Report

Once the job has completed, the job report will show "(final)" on the end of the first line of the report and Current Time is replaced with Finish Time (after Start Time). The following example is based on the previous example for job "23576" .

```
Nitro Job Progress Report (final)

Start Time  : 2016-02-10 09:10:11-0600
Finish Time : 2016-02-10 09:11:36-0600
Elapsed Time: 85 seconds (00:01:25)

Job Id      : 23576
Task Log    : /home/jdoe/jobs/23576/nitro_23576.tasklog.txt
Task File   : /home/jdoe/jobs/survey03.tasks

Tasks
------------
Pending     : 0
Running     : 0
Completed   : 3000
  Success   : 3000
  Failure   : 0
  InsufRes  : 0
  Timeout   : 0
  Invalid   : 0
  Tasks/sec : 35.3
Total Tasks : 3000

Coordinator
-----------
Host    : node01
Threads : 8

Worker Resources
----------------
Workers : 2
Threads : 16

Workers
-------
Host   Pid    Thrds Status Assigned Running Completed  Success  Failure  InsufRes
Timeout Tasks/sec AsgmtDur
node02 6851     12  closed     2250       0      2250     2250        0         0
 0      29.2      8.3
node03 14988     4  closed      750       0       750      750        0         0
 0       8.8     35.7
```

Task Log

The task log file contains a listing of all tasks that have been completed and some statistics about the tasks duration and memory consumption. This file is named `nitro_<JobID>.tasklog.txt` and is located in the same directory as the job log file.

The task log file is tab-delimited, so you can easily import it into a spreadsheet or database, or process it using another program. You can also view the task log using the nitrostat utility.

```
JobID  TaskID  Line Name        Status  ExitCode Hostname          StartTime
          Duration UserCPU SystemCPU VirtualMem PhysicalMem Labels
Output
foo    1       1    task001     Success 0        localhost:10004   2015-06-18_
15:26:52.954-0600     1.005   0.000     0.000    7364608      630784
foo,foobar,foobaz,xyz
foo    2       2    task002     Success 0        localhost:10004   2015-06-18_
15:26:52.954-0600           1.007   0.000     0.000   87834368      630784 foo,foobar,xyz
foo    3       3    task003     Success 0        localhost:10004   2015-06-18_
15:26:52.954-0600           1.005   0.000     0.000   71728640      901120 foo,xyz
foo    4       4    task004     Success 0        localhost:10004   2015-06-18_
15:26:52.955-0600     1.005   0.000     0.000   38837504      630784
foo,foobar,foobaz,abc
foo    5       5    task005     Success 0        localhost:10004   2015-06-18_
15:26:53.960-0600           1.004   0.000     0.000  405946368      630784 foo,foobar,abc
foo    6       6    task006     Success 0        localhost:10004   2015-06-18_
15:26:53.961-0600     1.005   0.000     0.000  405946368      946176 foo,abc
foo    7       7    task007     Success 0        localhost:10004   2015-06-18_
15:26:53.961-0600           1.003   0.000     0.000  405946368      630784
foo    8       8    task008     Success 0        localhost:10004   2015-06-18_
15:26:53.966-0600           1.003   0.000     0.000  405946368      700416
foo    9       9    task009     Success 0        localhost:10004   2015-06-18_
15:26:54.965-0600           1.005   0.000     0.000  405946368      630784
foo    10      10   task010     Success 0        localhost:10004   2015-06-18_
15:26:54.965-0600           1.003   0.000     0.000  405946368      630784
foo    11      11   task011     Success 0        localhost:10004   2015-06-18_
15:26:55.973-0600           1.005   0.000     0.000    7364608      630784
foo    12      12               Success 0        localhost:10004   2015-06-18_
15:26:55.973-0600           1.004   0.000     0.000  405946368      626688
foo    13      14   fail        Failure 1        localhost:10004   2015-06-18_
15:26:55.973-0600           0.005   0.000     0.000       8192        4096
foo    14      16   stderr      Success 0        localhost:10004   2015-06-18_
15:26:55.974-0600           0.005   0.000     0.000  405946368      536576
foo    15      18   stderr_fail Failure 1        localhost:10004   2015-06-18_
15:26:55.979-0600           0.005   0.000     0.000  405946368     1228800
      ERROR MESSAGE
foo    16      20   overtime    Timeout -9       localhost:10004   2015-06-18_
15:26:55.980-0600          2.006   0.000     0.000  405946368      970752
      maxtime exceeded, process was killed
foo    17      21               Success 0        localhost:10004   2015-06-18_
15:26:55.985-0600           1.002   0.000     0.000  405946368      626688
foo    19      23               Success 0        localhost:10004   2015-06-18_
15:26:56.979-0600           1.007   0.000     0.000  405946368      970752
foo    20      24               Success 0        localhost:10004   2015-06-18_
15:26:56.988-0600           1.003   0.000     0.000  405946368      724992
foo    21      25               Success 0        localhost:10004   2015-06-18_
15:26:57.986-0600           1.005   0.000     0.000  405946368      724992
foo    22      26               Success 0        localhost:10004   2015-06-18_
15:26:57.988-0600           1.005   0.000     0.000  405946368      970752
foo    23      27               Success 0        localhost:10004   2015-06-18_
15:26:57.988-0600           1.005   0.000     0.000  405946368      630784
foo    24      28               Success 0        localhost:10004   2015-06-18_
15:26:57.995-0600           1.005   0.000     0.000  405946368      630784
foo    25      29               Success 0        localhost:10004   2015-06-18_
15:26:58.993-0600           1.005   0.000     0.000  405946368      974848
foo    26      30               Success 0        localhost:10004   2015-06-18_
15:26:58.994-0600           1.004   0.000     0.000  405946368      626688
```

The task log contains the following fields.

- JobID – Job ID that was passed to Nitro using the "--job-id" command line option.
- TaskID – Task number within the Nitro job.
- Line – Line number in the task file of the task definition.

- Name – Task name supplied in the task definition by the "name=<*name*>" option.
- Status – One of "Success", "Failure", "InsufRes", "Timeout", or "Invalid".
- ExitCode – Numerical exit code returned by the task.
- Hostname – Name of the worker that executed the task.
- StartTime – Date and time the worker actually started the task.
- Duration – Number of seconds the task ran (millisecond resolution).
- UserCPU – Number of seconds the task ran in user mode (millisecond resolution).
- SystemCPU – Number of seconds the task run system calls (millisecond resolution).
- VirtualMem – Maximum virtual memory allocated to the task in bytes.

  The operating system may allocate shared memory and may charge a proportion of this shared memory to random tasks.

- PhysicalMem – Maximum physical memory allocated to the task in bytes.
- Labels – Optional task labels specified by the task definition.
- Output – stdout and/or stderr. If a task outputs to both stdout and stderr, both are displayed in the format <*stdout*>/<*stderr*>.

Related Topics

- Command Line Flags, Options, and Positional Parameters on page 72
- nitrostat on page 79

Dynamic Workload

This topic identifies activities pertaining to dynamic workload.

Nitro jobs are flexible in the number of resources they can use to accomplish the tasks given them. Worker nodes can be added to a job or taken away without any adverse consequences (other than the job running more slowly). You can also add workload by appending the task file.

In this topic:

Removing Worker Nodes

If nodes are needed for a more important task, the workers can be killed, and their assignments will be returned to the coordinator.

Killing the worker with a SIGTERM signal will allow the worker to send a partial assignment completion report to the coordinator. Be aware that if a worker is killed, the tasks that are running, may be run again when the assignment is given to a different worker to complete. Therefore, it is important to program your tasks to exit if the work has already been completed or overwrite the previous result.

Adding Worker Nodes to a Running Job

While the workload is being executed, workers can be added to the coordinator. The coordinator requires either a list of worker names or a session key that workers will use to attach to the coordinator to receive workload assignments. If you specify a list of worker names, only those workers will be authorized to connect to the coordinator. If you specify a session key, any worker with the session key will be able to connect to the coordinator.

Once the coordinator exits, the job is finished and workers won't be able to connect.

Linger Mode

If you need to keep a coordinator up continually to respond to workload that could be added at any time, you can use the "--linger" command line option on the workers and coordinator to allow Nitro to stay resident and not exit when the tasks are completed.

Nitro provides a message-based process to dynamically add workload to Nitro. Contact Adaptive Computing Professional Services for more information on dynamically adding workload.

Chapter 5 References

This chapter provides additional information for system administrators and users.

In this chapter:

Nitro Configuration File

The nitro.cfg file is available to system administrators.

Nitro looks for this configuration file in the `/opt/nitro/etc` directory, which must be a peer to the `/opt/nitro/bin` directory. If found, Nitro will load configuration options specified in the nitro.cfg file.

nitro.cfg Configuration Options

These configuration options are available to customize the nitro.cfg file:

- `assignment-size <size>` – Sets the default assignment size.
- `coord-threads <count>` – Indicates to the coordinator how many threads to reserve for the coordinator when allocating cores to a local worker (when using "--run-local-worker" on the coordinator command line). Default is 2. Adaptive Computing recommends setting the <*count*> value to 1 if all jobs will use less than 20 nodes and setting the <*count*> value to 4 if the jobs require a large number of nodes (greater than 50) to run.

  > There is also a "--coord-threads" command line option, that if set, overrides the <*count*> specified here (nitro.cfg file).

- `default-shell <shell path>` – Allows the configuration of the default shell used by Nitro to launch tasks. The default value is "/bin/bash". In high throughput usages where many very small tasks need to be launched as quickly as possible, it may be beneficial to use a more compact shell such as the Bourne shell or Korn shell. To set this value, specify the fully qualified path to the shell such as "/bin/sh".

- `default-shell-command <command>` – Allows configuration of the command line parameter to the shell that Nitro uses when launching a task. The default shell command is "-c" so that Nitro will execute "/bin/bash -c <*task command line*>". Set this value if you need to customize the launch command or are using a shell that uses a different command line option to launch a command line.
- `disable-affinity` – Instructs the workers that they should not track and set the task's affinity.

  
  There is also a "--disable-affinity" command line option, that if set, overrides the setting here (nitro.cfg file).

- `max-cpu-threshold <value>` – Causes Nitro to reduce task threads when the threshold is reached. The <value> is a percentage of system load, where 100% is equivalent to the number of cores in the node and is measured by the 60 second load average.
- `maxtime-limit <period>` – Lets you set the maxtime option's upper limit for all Nitro job task definitions. If this option is not specified, the coordinator will use its default of 1 day (86400 seconds). This value can be specified as a number of seconds, or by using the Days:Hours:Minutes:Seconds format (ie: 7:0:0:0 = 7 days).
- `min-memory-threshold <threshold MB>` – If set to a value other than 0 (zero), causes Nitro to check the workers available physical memory before starting tasks. If the available physical memory drops below this value, Nitro will stop running tasks until available memory rises above the threshold. This can be used to throttle tasks or account for background activity that is consuming memory and causing the system to swap memory to disk. It is important to select a threshold that will allow the system to throttle before swapping starts to happen. 2GB (2000MB) is a good threshold to start with.
- `throttle-period <period>` – Sets the amount of time (in seconds) that Nitro will wait before checking for throttling conditions (such as the memory threshold). Nitro defaults to checking every 2 seconds. Setting this to 0 (zero) causes Nitro to check when tasks complete, or 1 second whichever comes first.
- `task-output-limit <value>` – Sets the number of bytes that will be captured by stdout and stderr (each) and written to the task log file. The default value is 512 bytes. Nitro captures the stdout and stderr strings output by tasks, but only retains the last n characters as set by the limit to reduce communication and storage overhead.

Resource Manager Launch Scripts

Launch scripts have been provided for Torque, SLURM, LSF, and Cray resource managers or environments. The launch scripts can be found in the `/opt/nitro/scripts` directory. If you use another resource manager, you may need to build a new script. Also, if you want to change the basic configuration or paths used with your installation, you may want to customize the launch script that the users of your system will use to start Nitro.

There are several basic points that a launch script needs to cover to interface the resource manager with Nitro.

1. Getting the resource manager job ID and passing it to Nitro. See Resource Manager Job ID on page 71.
2. Specifying the location of the Nitro binary. See Location of the Nitro Binary on page 71.
3. Getting the list of nodes that Nitro is to run on for the current job. See List of Job Nodes on page 71.
4. Launching the Nitro workers and coordinator. Launch Nitro Workers and Coordinator on page 72.
5. Customize the command line parameters of workers and/or coordinator. See Customize Command Line Parameters on page 72.

Resource Manager Job ID

Nitro uses the job ID to customize the output files so if several copies of Nitro are running at the same time they don't corrupt each other's information. Torque, for example, defines the `$PBS_JOBID` environment variable that contains a job ID as defined by Torque.

The provided launch scripts add the "`--job-id <job id>`" parameter to Nitro's command line parameters (to the workers and the coordinator) if a job ID is provided, or if no job ID is found, then it defaults to a job ID with the format "YYYYMMDDHHMMSS" containing the date and time the Nitro launch script runs.

Location of the Nitro Binary

The launch script assumes the Nitro binary will be found in the `/opt/nitro/bin` directory. This requires that Nitro has been installed to each node, or that the `/opt/nitro` directory has been mapped to a remote file system.

If you have installed Nitro to a directory other than the default, you need to customize the Nitro launch script with this location. For example, if you installed Nitro to `/mysharedfs/nitro`, you need to change the line of the Nitro launch script

from

```
NITRO=/opt/nitro/bin/nitro
```

to

```
NITRO=/mysharedfs/nitro/bin/nitro
```

List of Job Nodes

Resource managers typically send the job to one node in the allocated set of nodes. The script then executes work on any of the remote nodes within the job allocation. The Nitro launch script then launches a Nitro worker on each of the remote nodes before launching the coordinator.

The coordinator only accepts a connection from the list of workers provided via the `--workers` or `--workers-file` parameter *or* by using the `--key` command line option to specify a session key "<*keyvalue*>".

Resource managers typically have an environment variable set with the list of nodes allocated to the job. For example, in Torque, this environment variable is "`$PBS_NODEFILE`" and contains the file that is accessible to the job containing the list of nodes allocated to the job.

The file containing the list of nodes is typically a file with a single node name per line, such as:

```
node01
node02
node03
```

Launch Nitro Workers and Coordinator

The Nitro launch script needs to remotely start up Nitro workers and return control to the script.

- Torque uses the "pbsdsh" command.
- SLURM uses the "srun" command.
- LSF uses the "blaunch" command.
- Cray systems use the "aprun" command.

> Please refer to your resource manager's documentation for instructions and options to run the remote command.

The workers are started first in the Nitro launch script so the coordinator can be executed last using "exec". This is so the coordinator gains control of the process. The Nitro launch script currently uses (and assumes) the first node in the nodes list as the coordinator and all other nodes as workers.

Customize Command Line Parameters

If all your user's jobs are expected to use less than 20 nodes, you may want to add the option to the script to run a local worker on the coordinator node to maximize task throughput. Users can already do this by adding the "`--run-local-worker`" flag to the NITRO_COORD_OPTIONS environment variable at job submission or in the user job script, but you may elect to add this to the Nitro launch script to reduce the parameters necessary for a user to configure. See Submit a Nitro Job to a Scheduler on page 57.

If you want to add command line parameters to Nitro, the best way is to prepend the option to the beginning of either the NITRO_OPTIONS, NITRO_COORD_OPTIONS, or NITRO_WORKER_OPTIONS environment variable(s), as appropriate. For example, if you wanted to add the "`--run-local-worker`" flag to the coordinator command line, add the following line to the Nitro launch script after the line containing the NITRO_OPTIONS.

```
NITRO_OPTIONS="--job-id ${NITROJOBID} ${NITRO_OPTIONS}"
NITRO_COORD_OPTIONS="--run-local-worker ${NITRO_COORD_OPTIONS}"
```

Command Line Flags, Options, and Positional Parameters

This topic identifies the individual command line flags, options, and positional parameters recognized and/or required by Nitro.

In this topic:

Flags

- **Disable Affinity** – Instructs a worker that it should not track and set the task's affinity.

  This option overrides --disable-affinity in the nitro.cfg file.

```
--disable-affinity
```

- **Linger** – Tells Nitro to keep running after the initial tasks have completed. The <*timeout*> specifies the number of seconds that must pass after the last completed task file before Nitro closes (shuts down). A <*timeout*> value of -1 indicates an indefinite period of time; Nitro will not close until a signal is given to close.

```
--linger <timeout>
```

- **Run Local Worker** – Runs a local worker on the coordinator's host.

```
--run-local-worker
```

- **Trust Workers** – Allows any worker to attach to Nitro and accept workload. Without this flag, the coordinator will only connect workers that were specified with the --workers, --workers-file, or --key ccommand line option.

```
--trust-workers
```

Options

- **Mode** – Required command line parameter that indicates the role (coord/worker) of Nitro when started on a host.

```
--mode=[coord | worker]
```

- **Coordinator Host** – Specifies the coordinator to connect to when Nitro is running in worker mode (`--mode=worker`).

```
--coord <HOST[:PORT]>
```

- **Session Key** – Specifies a session key that can be used to authenticate workers to the coordinator. The session key must be provided on the workers and coordinator command lines. Any worker reporting in to the coordinator will be required to provide this key to be able to connect and receive workload. The session key is any string that does not contain spaces or any characters which the shell will interpret.

```
--key <keyvalue>
```

- **Key File** – File containing a passphrase that can be used to authenticate workers to a coordinator. If the file contains newline or tab characters, these will be removed from the passphrase.

```
--key-file <file>
```

- **Worker Hosts** – "+"-separated list of the host names of the worker hosts the job scheduler allocated to the Nitro job for its exclusive use.

```
--workers <hostlist>
```

- **Worker Hosts File** – File containing a list of the host names, one per line, the job scheduler allocated to the Nitro job for its exclusive use.

```
--workers-file <filename>
```

- **Name** – Name the worker uses to reference itself when communicating with the coordinator. For the coordinator, this is the name to which the workers will connect. If not specified, Nitro defaults to the node's name.

> The name supplied to the coordinator via `--workers` or `--workers-file` must match `--name`. If using `--trust-workers` or `--key`, any unique value can be used for `--name`. Workers' names must be unique within a coordinator group.

```
--name <name>
```

- **Port Base** – Base port number for port assignments (default 47000); used to override first port assignment by Nitro process. Valid range of ports is 47000-65535.

  Each Nitro coordinator process requires four ports. A coordinator process will bind a range of four ports starting with the start port specified by this option as the starting point for port assignments.

```
-p <port>
--port1 <port>
```

- **Thread Count** – The quantity of threads the Nitro workers should use when executing tasks. This option is mutually-exclusive with the Thread Ratio option.

  If this option and the Thread Ratio option are not given, a worker uses one task launch thread per OS core to which it is pinned.

  The primary reason for this option is to explicitly specify a task-launch thread count for Nitro running a specific single application, usually on homogeneous hosts.

```
--thread-count <num>
```

- **Thread Ratio** – The ratio of task launch threads-to-OS "cores" the Nitro workers should use when creating task launch threads. This option is mutually exclusive with the Thread Count option.

  If this option and the Thread Count option are not given, the ratio is "1.0", meaning a worker uses one task launch thread per OS core to which it is pinned.

  Ratio is a positive real number (e.g., 1.5, 0.5, etc) that when multiplied with the count of OS cores to which a worker is pinned yields a count of the task launch threads it will use. The worker rounds the count to the nearest integer, with a minimum value of 1.

The primary reason for this option is to allow a user to over-subscribe or under-subscribe the task-launch thread count appropriately relative to the OS core count of heterogeneous hosts (e.g., 1.5 means 6 threads for a quad-core host and 24 threads for a 16-core host).

```
--thread-ratio <ratio>
```

- **Assignment Size** – The quantity of tasks the Nitro coordinator should pass to a Nitro worker at one time; default is 250.

```
--assignment-size <num>
```

- **Job Directory** – Specifies the path for the directory where Nitro will place its Job Progress Log and Completed Task Log files.

```
--job-dir <path>
```

- **Job ID** – Specifies the job ID for a specific Nitro run. The job ID may be used to create the job directory and certain file paths.

```
--job-id <jobID>
```

- **Coordinator Threads** – Indicates to the coordinator how many threads to reserve for the coordinator when allocating cores to a local worker (when using "--run-local-worker" on the coordinator command line). Default is 2. Adaptive Computing recommends setting the <*count*> value to 1 if all jobs will use less than 20 nodes and setting the <*count*> value to 4 if the jobs require a large number of nodes (greater than 50) to run.

  This option overrides the --coord-threads setting in the nitro.cfg file.

```
--coord-threads <count>
```

- **Task Environment** – Specifies the environment variables to set in the task's execution environment. This is used by the worker but is also needed on the coordinator's command line if running a local worker. Multiple values can be specified by separating name/value pairs with a comma.

```
--task-env <ENVVARNAME=value[,...]>
```

- **Debug Log File** – The path for the optional "debug log" file the Nitro coordinator can produce. If the path is not defined, the coordinator will use the default path `$NITROJOBDIR/nitro_$NITROJOBID-hostname_pid.log`.

```
--logfile <path>
```

- **Debug Log Level** – The level of debug log information the Nitro coordinator will output when tracing/logging. The default is "3" (information). The highest level allowed is "7" (debug).

```
--loglevel <num>
```

Positional Parameters

- **Task File Name** – Path of text file containing Nitro task definitions. This must be the last parameter on the coordinator's command line.

```
path
```

Command Line Options per Nitro Mode

The table that follows identifies which command line options Nitro uses in worker or coordinator mode. Some command line options are used in both modes and are listed in this table in the "Both" row.

Nitro Mode	Command Line Option
Coordinator	--assignment-size --coord-threads (if using --run-local-worker with the coordinator) --port1 --run-local-worker --trust-workers --workers --workers-file --key-file
Worker	--coord --disable-affinity (if *not* using --run-local-worker with the coordinator) --name --task-env (if *not* using --run-local-worker with the coordinator) --thread-count (if *not* using --run-local-worker with the coordinator) --thread-ratio (if *not* using --run-local-worker with the coordinator)
Both	--disable-affinity (if using --run-local-worker with the coordinator) --job-dir --job-id --key --linger --logfile --loglevel --mode --task-env (if using --run-local-worker with the coordinator) --thread-count (if using --run-local-worker with the coordinator) --thread-ratio (if using --run-local-worker with the coordinator)

Task File

A task file contains a list of Nitro task definitions (task execution options) along with the task command line Nitro will execute. Since the Nitro coordinator will be running on one of the nodes allocated to the Nitro job, the task file must be accessible to the node on which the coordinator will run.

The task file is a text file where each task definition must be contained on a single line. Lines of text may be terminated by either a Linux-style line ending (LF or '\n' new line character) or a Windows-style line ending (CR/LF - '\r\n' carriage return/line feed combination). The line number is reported in the task log so that errors in the task file can be quickly located and fixed.

The task file allows comment and empty lines. A hash symbol (#) in the first column of a line identifies a comment line.

Each task will be assigned a task ID, which will start at 1 and increment with each task line (comment and empty lines are not assigned a task ID). This task ID is passed to the task in the NITROTASKID environment variable.

Task Options

Task options are name/value pairs that are listed before the task's command line of the form "<*option*>=<*value*>". Task options must be specified *before* the task's command line to be executed. As Nitro parses the line, it will stop looking for name/value pairs as soon as it finds a character string that does not include the name/value delimiter (=) or is the "cmd" option. Everything after the "cmd=" option or the first string that is not delimited as a name/value pair will be considered part of the task command line.

Task definitions that contain errors (such as a misspelled option) are considered "invalid" tasks and will be reported in the task log along with an explanation of the error in the line. Examples of valid command lines are as follows:

```
# Commented line
/opt/framemaker/bin/assemble_frame --input /shared/scene23.def --time-index 0
cmd=/opt/framemaker/bin/assemble_frame --input /shared/scene23.def --time-index 0

name=Scene23Time0 /opt/framemaker/bin/assemble_frame --input /shared/scene23.def --
time-index 0
name=Scene23Time0 maxtime=30 cmd=/opt/framemaker/bin/assemble_frame --input
/shared/scene23.def --time-index 0
```

The following describes the various task options.

- **Application Command** – The coordinator considers everything immediately after the equal sign (= in "cmd=") as the task's "application" command line, which a worker will execute. There must be at least one non-whitespace character immediately after the "=" or the coordinator declares the task definition invalid. The application command line permits standard I/O redirection and environment variable substitution.

  ```
  cmd=<xxx -y zzz>
  ```

  Do not place any task options after the command line or the coordinator will not parse them; assumes they are part of the command line.

- **Labels** – Specifies the labels assigned to a task.

  This is optional and there is no default value.

If given, a label must be composed of letters, digits, underscore, hyphen, and/or period. Use a comma to separate multiple labels.

If the option's value violates the conditions above, the coordinator will declare the task definition invalid and will not send the task to a worker.

When the coordinator logs the task in the Completed Tasks Log file, it outputs this option's value "as is", meaning without alternation and with no substitution of commas with spaces.

```
labels=<list>
```

- **Maximum Time** – Maximum time (in seconds) a task may execute after which the worker will terminate it. This is optional; the default value is 3,600 seconds (1 hour).

  If given, the value must be less than the `maxtime-limit <period>` value. See Nitro Configuration File on page 69 for more information on the `maxtime-limit` configuration option.

  > If the option's value is non-numeric, non-decimal, or outside the allowed range, the coordinator will declare the task definition invalid and will not send the task to a worker.

  ```
  maxtime=<nn>
  ```

- **Name** – Unique name assigned to your task definition. Task names do not have to be unique, but creating a unique task name will help to identify tasks.

  ```
  name=<task name>
  ```

- **Task Cores** – Number of OS cores that the task requires. Nitro will allocate the number of cores requested and set the affinity of the task to the available cores.

  ```
  cores=<count>
  ```

  > The command line options "--thread-count" or "--thread-ratio" affect the number of available cores. If you use either of these options and they specify more cores than the node has available, Nitro will not pin the task to a specific core. If a task is specified to require more cores than the node that receives the task assignment, the task will not run.

  > Users should submit their jobs so that tasks can run on any of the nodes that are allocated to the job. If, for example, you have some tasks that require 20 processors, but there are some 16 core nodes in the cluster, the job should be submitted so that it only allows 20 proc nodes to be allocated to the job. If a Nitro worker is assigned a job with requirements that it cannot fulfill (either too many cores, or too much memory) the task will be counted as failed, and Nitro will show the status of "InsufRes" for that task in the task log file.

- **Task Environment Variables** – Specifies a list of user supplied environment variables that will be set in the context of the task. The list of environment variables can be one or more name/value pairs separated by commas. Environment variable name value pairs cannot contain spaces.

```
env=<name=value>[,<name=value>,...]
```

- **Task Memory** – Maximum amount of memory that the task requires. Nitro determines the amount of physical memory available on the system and uses this number as the limit that can be allocated by concurrent tasks. If no units are specified, GB is assumed. Available unit specifications include "GB" (10^9 bytes), "GiB" (2^30 bytes), "MB" (10^6 bytes), and "MiB" (2^20 bytes). Nitro uses MB units in debug logs.

```
memory=<amount>
```

Users should submit their jobs so that tasks can run on any of the nodes that are allocated to the job. If, for example, you have some tasks that require 32 GB, but there are some 16 GB nodes in the cluster, the job should be submitted so that it only allows 32 GB nodes to be allocated to the job. If a Nitro worker is assigned a job with requirements that it cannot fulfill (either too many cores, or too much memory) the task will be counted as failed, and Nitro will show the status of "InsufRes" for that task in the task log file.

- **Task Shell** – Specifies the task shell, if any, to use. Tasks are normally executed by running "/bin/bash -c <*task command line*>".

```
shell=[default | none | <shell path>]
```

  - The default shell provides translation of environment variables into command line options and other command line processing benefits.
  - In high-throughput environments performance gains can be realized by using a lighter weight shell such as the Bourne shell or Korn shell.
  - If no command line processing is needed, the task can be run without a shell.
  - Executing a task directly instead of using the shell can speed task invocation by more than 50% over the default shell.

  When specifying a shell other than the default shell, the fully qualified path should be used. For example, if you want to use the Bourne shell you should specify the shell as "/bin/sh" as opposed to just "sh".

nitrostat

nitrostat is a utility found in the `/opt/nitro/bin` directory that will display the status of a Nitro job or of individual tasks. nitrostat lets you quickly find specific tasks or list all failed, invalid, or timed out tasks. nitrostat also offers a "wait" mode that will monitor the task log for tasks matching the specified criteria until the job completes.

Running nitrostat

To run nitrostat, you'll need to know the job ID of the job you want to monitor. For example, if you have a job with ID "3145", you can monitor the job progress with the following command:

```
/opt/nitro/bin/nitrostat 3145 -w
```

nitrostat assumes that the job information can be found in `$HOME/nitro/<job id>`.

If you have specified a different location for the job directory using the Nitro "`--job-dir`" command line option, then you'll need to specify the same location using the nitrostat "`--job-dir`" command line option.

For example, if your job directory is in `$HOME/projects/survey03` then use the following command:

```
/opt/nitro/bin/nitrostat 3145 --job-dir $HOME/projects/survey03 -w
```

nitrostat will show the following information when job status is requested:

```
Nitro Job Progress Report

Start Time  : 2015-06-17 09:10:11-0600
Current Time: 2015-06-17 09:10:42-0600
Elapsed Time: 31 seconds (00:00:31)

Job Id      : 23576
Coordinator : node01
Task Log    : /home/jdoe/projects/survey03/23576/nitro_23576.tasklog.txt
Task File   : /home/jdoe/projects/survey03/survey03.tasks
  File Size : 123366
  Est Tasks : 3016
  Processed : 75%

Tasks
------------
Pending     : 500
Running     : 500
Completed   : 1250
  Success   : 1250
  Failure   : 0
  InsufRes  : 0
  Timeout   : 0
  Invalid   : 0
  Tasks/sec : 40.3
Total Tasks : 2250

Workers
-------
Host   Port  Pid    Thrds Status  Assigned Running Completed  Success  Failure
InsufRes Timeout Tasks/sec AsgmtDur
node02 47000 6851     12  running     1250     250      1000     1000        0
0       0      36.0      8.0
node03 47000 14988     4  running      500     250       250      250        0
0       0       9.3     27.0
```

Searching for Task Records

You can use nitrostat to search the task log by task name, task ID, or label using regular expressions. You can also combine criteria to further refine your search.

For example, if you want to search for tasks containing the task name "Survey03" and the label "NYC" you can specify the command line as follows:

```
/opt/nitro/bin/nitrostat Job01 --name Survey03 --label NYC
```

The following identifies the nitrostat command line options.

- `--all`, `-a` – Shows all tasks.
- `--completed`, `-c` – Shows completed tasks.
- `--failed`, `-f` – Shows failed tasks.
- `--invalid`, `-i` – Shows invalid tasks.
- `--timedout`, `-o` – Shows tasks that timed out (exceeded maxtime).
- `--wait`, `-w` – Continues updating results until entire job is completed.
- `--name`, `-n <task name>` – Shows task(s) with the specified task name.
- `--task`, `-t <task id>` – Shows the task with the specified task ID.
- `label`, `-l <label list>` – Shows all tasks that contain the specified label. <*label list*> is a comma-separated list of labels that may *not* contain spaces.
- `--working-dir`, `-d <directory>` — Uses the specified working directory to locate the job and task log files. The default working directory is `$HOME/nitro`.
- `--regex` – If set, uses regular expression as the matching mode for <*task name*>, <*task id*>, and <*label list*>. The default is literal (exact string).

Job Recovery

Jobs run under a scheduler can, depending on job priority and settings, be preempted by a higher priority job, or even canceled by the user or administrator, or may fail due to hardware failure. Depending on the scheduler's configuration, a preempted job may be restarted later by the scheduler using the same job ID as the original job.

The job ID is the key to recovering jobs since Nitro uses the job ID as part of the path to the files associated with that job. Nitro tracks its progress by storing a checkpoint file that indicates which tasks have been completed and which have not. When Nitro is restarted, it looks for a checkpoint file and will continue from where it left off if one is found. If a job was canceled or preempted without a restart policy, then you will need to restart the job manually. Again, the key to restarting the job is to use the job ID of the original job.

The job ID is usually the ID that was returned when the job was submitted. There can be some differences between the scheduler's job ID and the resource manager's job ID depending on scheduler and resource manager settings. When you submitted your Nitro job, you may have set a Nitro job directory. If you didn't, it defaults to `$HOME/nitro/<jobid>`. This directory will contain the job log and task log files, along with checkpoint and Nitro log files. You can therefore use the directory name that Nitro created as the job directory with which to resubmit the job by passing the `--job-dir` option with the directory name through the NITRO_OPTIONS environment variable.

To restart the job you must set the NITROJOBID environment variable to the original job ID. Setting this environment variable will override the job ID provided by the resource manager and Nitro will resume from the line number of the task file described in the checkpoint file.

The checkpoint file is updated periodically when assignments are completed by workers and are returned to the coordinator. If a job is canceled, the workers will do their best to respond to the

coordinator with the tasks that have been completed so far, but depending on how quickly the resource manager forces the applications to close, the checkpoint file may or may not be fully updated. Therefore, it is possible that restarting a job will result in a particular task or set of tasks being run a second time. Users should take this into account and program their tasks so that if running the task a second time would cause a problem, transactions are recorded by the task that would prevent the second run.

If a job is canceled for reasons of task failure (for example, because of a typo in the task command line), you may want to submit the job as a new job instead of trying to resume the job with failed tasks.

Failed and invalid tasks are marked as complete in the checkpoint file; they won't be re-run if the job is just restarted.

Coordinator Resiliency

Nitro has the ability to detect workers that have become unresponsive due to hardware, network, or software failure. During normal operation, workers periodically send an update to the coordinator. If the coordinator doesn't receive a status update after 45 seconds, the worker is deemed to be unresponsive, and any outstanding assignments will be revoked and reassigned to responsive workers. However, if the worker reports back to the coordinator before the assignment has been assigned to another worker, the assignment will be recovered and completed by that originally-assigned worker.

Glossary

Compute Node
Term for a computer (see Server) designed for high-performance computing and managed by an HPC administrator as part of an HPC cluster (see Host)

Coordinator
Nitro component responsible for scheduling Nitro tasks to the Worker components for execution, recording the tasks' information in the Task Log file and job information in the Nitro Job Log file, and checkpointing the Nitro job's state information in the Nitro Checkpoint file.

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.

CPU
See Processor, Core, Thread, OS Core, and Virtual Core. CPU is too generic, ambiguous, or context-specific for utilization in this manual.

Datacenter
A non-HPC cluster system composed of many "servers" that typically are not used for high performance computing.

High Performance Computing
The use of highly parallel and/or specialized "supercomputers" for executing parallel workloads such as large simulations, solving problems that require very complex and extensive calculations, computations that require very long running calculations, etc. Such workloads are characterized by their use of many "compute nodes" (servers or hosts), often in the thousands, to work on a single problem and have execution times ranging from minutes to months. HPC systems often execute from one to a few dozen or hundreds of simultaneous workloads and have a job (workload) queue with a few hundred to several thousands of pending jobs. In HPC systems, the performance of individual workloads within a time interval is the primary objective and therefore HPC schedulers attempt to optimize their use of an HPC system's resources regardless of the scheduling overhead incurred to do so (within reason).

High Throughput Computing
Describes workloads that often execute on just a single core and may have execution times ranging from sub-seconds to minutes and perhaps hours. HTC systems often execute hundreds to tens of thousands of simultaneous workloads. In HTC systems, the quantity of workloads processed per time interval is the primary objective and therefore HTC schedulers attempt to minimize scheduling overhead in order to maximize workload throughput.

Host
Generic reference to an HPC system's "compute node" or a datacenter's "server".

HPC
See High Performance Computing.

HPC Cluser
HPC industry's term for a "supercomputer". It is somewhat analogous to a "datacenter", except for the sometimes specialized nature of its hardware.

HT
See Hyper-Threading.

HTC
See High Throughput Computing.

Hyper-Threading
Term used by Intel for its Simultaneous Multi-Threading (SMT) capabillity in its Atom, Core, Itanium, Pentium 4, Xeon, and Xeon Phi processor families. See also Simultaneous Multi-Threading.

Job
HPC term for workload submitted by a user to a scheduler for the purpose of scheduling resources on which the workload executes when started up by the scheduler. This document will use this term to identify workload, in whatever form, submitted to a scheduler that schedules the workload for execution on a system (HPC cluster or commercial datacenter). 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". The user also gives information identifying the types of resources, typically one or more hosts and optionally other hardware (such as GPU or MIC accelerators) or software and/or software licenses, required by the workload to execute, either in the job script itself or at the time of job submission (for example, via command line options or web portal form). The scheduler schedules the job for the requested resources and when they are available allocates them to the job and then starts the job by executing the script on one of the allocated hosts. The script executes the workload(s)/application(s) that then use the resources allocated to the job by the scheduler.

Job Scheduler
HPC term for a scheduler that manages submitted workloads (called "jobs") for an HPC cluster. See Scheduler.

Multi-threading
The use of multiple software threads, which may or may not be pinned to hardware threads (core affinity), to implement processing in parallel. There are multiple implementations of multi-threading, such as Linux "pthreads", etc.

Nitro
HTC task scheduler application offered by Adaptive Computing, Inc.

Node
Shorthand term for "compute node". See Compute Node.

OS Core
Term that refers to what the operating system considers an individual hardware-based computation unit, often called a "core" or a 'CPU". In actuality, the "OS core" can be a hardware-based core (see "Core") or a hardware-based thread (see "Thread"). This guide uses this term to refer to the basic hardware-based computational unit allocatable by an operating system to a process.

Process
An individual executing program managed by an operating system. It has its own resources and memory address space, independent of all other executing processes managed by the operating system. A process may itself be multi-threaded, which means the operating system can execute simultaneously different software execution threads of the process.

Processor
A physical hardware chip (sometimes called a "socket"); regardless of whether it supports a single core or multiple cores ("multi-core" processor). Socket is a strong, unambiguous synonym for processor while CPU (see CPU) is an ambiguous synonym individuals and/or processor vendor documentation may use. In addition, people and literature sometimes use the term processor to refer to a hardware core (see Core) or hardware thread (see Thread). This guide uses the term "processor" to refer to the physical hardware chip.

Scheduler
Term used generically in the guide for the specialized software between the user and the HPC cluster-/datacenter system that manages submitted workloads or "jobs". Such management includes queuing jobs, prioritizing queued jobs for execution, scheduling and allocating requested resources for each job, and starting jobs when their requested resources become available and the jobs have the highest priority. This guide uses the term "system scheduler" to refer to the scheduler that schedules jobs for your system, regardless whether it is an HPC cluster or datacenter.

Server
Term for a (typically) "headless" computer used in a data center and managed by a system administrator in an IT department. See Host.

Simultaneous Multi-Threading
Processor core's ability to execute (in hardware) instructions from multiple, independent, software execution threads and track their states simultaneously.

SMT
See Simultaneous Multi-Threading.

Task
A single unit of work (HTC job) defined by Nitro task definitions in a user task file (list of HTC jobs now referred to as tasks) that Nitro can schedule and launch for execution as a single OS process.

Task file
The file containing the list of tasks that Nitro should execute.

Task Launch Thread
A Nitro worker "software execution thread" capable of launching one Nitro "task". Unless modified by a Nitro worker command line option, the worker's quantity of task launch threads is identical to the quantity of host OS cores made available to the worker by the system scheduler.

Thread
In SMT or hyper-threading, refers to a hardware-based thread execution capability. For example, the consumer-oriented Intel Core i7 processor has four cores, each of which has hardware that can simultaneously track two software execution thread states and execute the other thread when one thread blocks waiting on a memory access; thus increasing the utilization of each core's computational capability and yielding 8 hardware-based threads for the entire processor. The server-oriented Intel Xeon processor documentation refers to threads as "logical processors". Cray documentation uses the term threads relative to the SMT capability of the Intel Xeon processors in its XC systems. Regardless of vendor terminology, one thread in the context of SMT refers to the hardware capability for tracking and executing one software execution thread. The term threads used in the context of a processor core refers to the quantity of software execution threads the core can simultaneously track; e.g., 2 threads per Intel Xeon E5-2650 v3 core and 20 threads per Intel Xeon E5-2650 v3 processor. BIOS settings enable or disable the SMT capability of SMT-capable processors and therefore determine at boot time whether a processor has only one thread per core or multiple threads per core. See Core and OS Core.

Virtual Core
Term often used to refer to a hardware-based thread of a core that is not the first thread (thread 0) within a core. If a processor has SMT or hyper-threading enabled, "thread 0" represents the core and the other threads 1-N represent "virtual cores". The only way to execute using just a core that has SMT/hyper-threading enabled is to use only thread 0 of the core and expressly enforce the non-use of the core's other threads or "virtual cores" through a CPUset or control-group (cgroup).

Worker
Nitro component responsible for executing the user's workloads specified by the task definitions in the Task file.

Workload
Generic term used in this guide to refer to some amount of work to be done, typically by executing one or more software applications.

Chapter 6 Troubleshooting

This chapter provides troubleshooting information.

In this topic:

Related Topics

- Track Job Progress on page 60
- nitrostat on page 79

Sources of Troubleshooting Information

These are common sources of reference for troubleshooting:

- **Job Output Files** - Any errors that Nitro reports should be reported on stderr and will be captured to your job's output files (if running Nitro through a job scheduler).
- **Job and Task Log Files in the Job Directory** -
  - Nitro writes a job log indicating the startup parameters, input files, configuration, and the main worker events and statistics. You can review the job log to determine if any tasks failed, timed out, or were invalid (an error parsing the task line).
  - The task log contains a listing of all task results from the job and includes stdout and/or stderr output.
- **Nitro debug logs** - In the job directory you will also find a "logs" directory with worker and coordinator logs. The logs are named according to the role (worker or coordinator), host, job, and process ID so that logs being written to the same directory will not overwrite logs from another Nitro job or worker with the same process ID.

  The default log level that Nitro logs at is level 3 (information), but this can be raised as high as 7 (debug) to gather much more information about the messages that Nitro is sending between the workers and coordinator, and the actions Nitro is taking (very large log file).

  You can use the "--loglevel" command line parameter to set the log level independently on the workers and coordinator.

Related Topics

- Troubleshooting on page 87

Troubleshooting Task Errors

The Nitro job log, and the stdout output from the Nitro coordinator, lists the number of tasks completed, tasks successfully completed (exit code of 0), failed tasks (exit code other than 0), tasks that timed out (exceeded the "maxtime" task option), invalid tasks (tasks that the coordinator could not parse without errors), and tasks with insufficient resources.

If you encounter a problem you are unable to solve, forward the log files according to your company's escalation process.

In this topic:

Task Command Line Errors

If the command line that you use to specify the task's command line contains an error (for example, the path is incorrect or you are attempting to run a script with noexecute permissions set), then the shell will output an error message to stderr that will be captured and stored in the task log file.

For example, if the task's command line references a binary that doesn't exist, you would see the following error in the task log file.

```
Job ID Task ID Line # Task Name Status  Ret  Hostname Start time   Duration UserCPU
SysCPU VirtMem PhysMem Labels  Output
------ ------- ------ --------- ------- ---- -------- ------------ -------- ------- --
---- ------- ------- ------- ------
EX01   3       3      S07T2303  Failure 127  node02   07:58:07.868    0.005   0.000
0.000       0       0         bash: /opt/framemaker/bin/framegen: No such file or
directory
EX01   4       4      S07T2304  Failure 127  node02   07:58:07.872    0.007   0.000
0.000       0       0         bash: /opt/framemaker/bin/framegen: No such file or
directory
EX01   5       5      S07T2305  Failure 127  node02   07:58:07.878    0.003   0.000
0.000       0       0         bash: /opt/framemaker/bin/framegen: No such file or
directory
```

Failed Tasks

Failed tasks were tasks that the worker executed, but have failed because the command line was not valid, or the task ran and returned an exit code other than 0. To diagnose the error, examine the task log file located in the job directory. See Track Job Progress on page 60.

You can also use nitrostat to list failed tasks. See nitrostat on page 79. To list failed tasks using nitrostat use the following command line.

```
/opt/nitro/bin/nitrostat <job id> -f
```

The following is an example of information provided by nitrostat showing failed tasks.

```
Job ID Task ID Line # Task Name Status  Ret  Hostname Start time   Duration UserCPU
SysCPU VirtMem PhysMem Labels  Output
------ ------- ------ --------- ------- ---- -------- ------------ -------- ------- --
---- ------- ------- ------- ------
EX01   3       3      S07T2303  Failure 127  node02   07:58:07.868    0.005   0.000
0.000       0       0         bash: /opt/framemaker/bin/framegen: No such file or
directory
EX01   4       4      S07T2304  Failure 127  node02   07:58:07.872    0.007   0.000
0.000       0       0         bash: /opt/framemaker/bin/framegen: No such file or
directory
EX01   5       5      S07T2305  Failure 127  node02   07:58:07.878    0.003   0.000
0.000       0       0         bash: /opt/framemaker/bin/framegen: No such file or
directory
```

The line number of the failed task in the task file is listed so you can easily identify which lines in the task file generated errors. If you need to verify the path to the task file used by Nitro you will find it both in the job log file and in the stdout output from the coordinator, which may also be recorded in the output files provided by your scheduler.

```
Nitro Environment
-----------------
Job Id       : EX01
Job path     : /home/jdoe/jobs/EX01
Job log      : /home/jdoe/jobs/EX01/nitro_EX01.joblog.txt
Task log     : /home/jdoe/jobs/EX01/nitro_EX01.tasklog.txt
Task file    : /home/jdoe/jobs/example1.tasks
Worker hosts : node02
```

If Nitro cannot access the task file, you will receive an error from the coordinator on stderr indicating that the task file was not found or is not accessible.

Invalid Tasks

Invalid tasks are lines in the task file that Nitro could not parse without errors. Parsing errors usually include misspelling a task option name. If your task line doesn't contain any task options, you should prepend the "cmd=" option to your command line. The "cmd" option indicates that Nitro should stop parsing the task line and accept the rest of the line as the command line to be executed. The following example shows an invalid task.

```
Job ID Task ID Line # Task Name Status   Ret      Output
------ ------- ------ --------- -------- ---- ... ------
EX01   14      14               Invalid           Unrecognized option name: walltime
```

In this case an invalid option "walltime" was used in a task definition instead of "maxtime".

```
# invalid line:
name=S07T2314 walltime=30 cmd=/opt/framemaker/bin/framegen -i /shared/scene07.def -
tindex 2314

# valid line:
name=S07T2314 maxtime=30 cmd=/opt/framemaker/bin/framegen -i /shared/scene07.def -
tindex 2314
```

The task file may also be rejected if you have any binary data in the file. The task file should only include ASCII text and each task must be on a separate line. The task file allows comment and empty lines. A hash symbol (#) in the first column of a line identifies a comment line.

Insufficient Resources Tasks

If workers are not able to fulfill resource requirements for tasks with cores or memory specifications, an insufficient resources error is logged. The following example show a task with insufficient resources.

```
JobID   TaskID  Line Name       Status   ExitCode       Hostname        StartTime                  Du
UserCPU SystemCPU VirtualMem  PhysicalMem       Labels  Output
425     1       13              Success  0              node02          2016-02-16_17:58:07.052-
0700    0.030   0.010    0.000   130211840      1077248          1 1000000 3.142116000
425     2       14              Success  0              node02          2016-02-16_17:58:07.052-
0700    0.030   0.010    0.000   130211840      1081344          2 1000000 3.141296000
425     3       15              Success  0              node02          2016-02-16_17:58:07.083-
0700    0.021   0.010    0.000   275505152      1679360          3 1000000 3.139544000
425     4       16              InsufRes -1             node02          2016-02-16_17:58:07.083-
0700    0.000   0.000    0.000           0            0                                 Error: worker
to 2 threads, task is requesting 3 threads
```

Related Topics

- Track Job Progress on page 60
- nitrostat on page 79
- Troubleshooting on page 87