

# Managing and Allocating Cluster Resources using Capacity Scheduler

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The Cloudera logo, featuring the word "CLOUDERA" in a bold, orange, sans-serif font. The letter "E" is stylized with a horizontal bar through its center.

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# Cluster Management with Capacity Scheduler

You can manage resources for the applications running on your cluster by allocating resources through scheduling, limiting CPU usage by configuring cgroups, and partitioning the cluster into subclusters using node labels.

## Using scheduling to allocate resources

You can allocate CPU, and memory among users and groups in a Hadoop cluster. You can use scheduling to allocate the best possible nodes for application containers.

The *CapacityScheduler* is responsible for scheduling. The *CapacityScheduler* is used to run Hadoop applications as a shared, multi-tenant cluster in an operator-friendly manner while maximizing the throughput and the utilization of the cluster.

The *ResourceCalculator* is part of the YARN *CapacityScheduler*. If you have only one type of resource, typically a CPU virtual core (vcore), use the *DefaultResourceCalculator*. If you have multiple resource types, use the *DominantResourceCalculator*.

### Related Information

[Enable Cgroups](#)

[Configure CPU scheduling and isolation](#)

[Configure GPU scheduling and isolation](#)

## YARN resource allocation

You can manage your cluster capacity using the Capacity Scheduler in YARN. You can use the Capacity Scheduler's *DefaultResourceCalculator* or the *DominantResourceCalculator* to allocate available resources.

The fundamental unit of scheduling in YARN is the queue. The capacity of each queue specifies the percentage of cluster resources available for applications submitted to the queue. You can set up queues in a hierarchy that reflects the database structure, resource requirements, and access restrictions required by the organizations, groups, and individuals who use the cluster resources.

You can use the default resource calculator when you want the resource calculator to consider only the available memory for resource calculation. When you use the default resource calculator (*DefaultResourceCalculator*), resources are allocated based on the available memory.

If you have multiple resource types, use the dominant resource calculator (*DominantResourceCalculator*) to enable CPU, GPU, and memory scheduling. The dominant resource calculator is based on the Dominant Resource Fairness (DRF) model of resource allocation. DRF is designed to fairly distribute CPU, and memory resources among different types of processes in a mixed-workload cluster.

For example, if User A runs CPU-heavy tasks and User B runs memory-heavy tasks, the DRF allocates more CPU and less memory to the tasks run by User A, and allocates less CPU and more memory to the tasks run by User B. In a single resource case, in which all jobs are requesting the same resources, the DRF reduces to max-min fairness for that resource.

## Use CPU scheduling

Cgroups with CPU scheduling helps you effectively manage mixed workloads.



**Note:** You should use CPU scheduling only in a Linux environment, because there is no isolation mechanism (cgroups equivalent) for Windows.

MapReduce jobs only

If you primarily run MapReduce jobs on your cluster, enabling CPU scheduling does not change performance much. The dominant resource for MapReduce is memory, so the DRF scheduler continues to balance MapReduce jobs in

a manner similar to the default resource calculator. In the case of a single resource, the DRF reduces to max-min fairness for that resource.

#### Mixed workloads

An example of a mixed workload is a cluster that runs both MapReduce and Storm on YARN. MapReduce is not CPU-constrained, but Storm on YARN is; its containers require more CPU than memory. As you add Storm jobs along with MapReduce jobs, the DRF scheduler tries to balance memory and CPU resources, but you might see some performance degradation in as a result. As you add more CPU-intensive Storm jobs, individual jobs start to take longer to run as the cluster CPU resources are consumed.

To solve this problem, you can use cgroups along with CPU scheduling. Using cgroups provides isolation for CPU-intensive processes such as Storm on YARN, thereby enabling you to predictably plan and constrain the CPU-intensive Storm containers.

You can also use node labels in conjunction with CPU scheduling and cgroups to restrict Storm on YARN jobs to a subset of cluster nodes.

## Configure CPU scheduling and isolation

You can configure CPU scheduling on your cluster to allocate the best possible nodes having the required CPU resources for application containers.

### Procedure

1. In Cloudera Manager, select the YARN service.
2. Click the Configuration tab.
3. Search for Resource Calculator Class.
4. Select the `org.apache.hadoop.yarn.util.resource.DominantResourceCalculator` option.
5. Search for `yarn.nodemanager.resource.cpu-vcores` and set the number of vcores to match the number of physical CPU cores on the NodeManager host by providing the number of physical cores.

### What to do next

Enable cgroups along with CPU scheduling. Cgroups is used as the isolation mechanism for CPU processes. With cgroups strict enforcement activated, each CPU process receives only the resources it requests. Without cgroups activated, the DRF scheduler attempts to balance the load, but unpredictable behavior may occur. For more information, see *Enable cgroups*.

### Related Information

[Using scheduling to allocate resources](#)

[Using GPU on YARN](#)

[Enable Cgroups](#)

[Limit CPU usage with Cgroups](#)

## Configure GPU scheduling and isolation

You can configure GPU scheduling and isolation on your cluster. Currently only Nvidia GPUs are supported in YARN.

### Before you begin

- YARN NodeManager must be installed with the Nvidia drivers.

### Procedure

1. In Cloudera Manager, navigate to **Hosts** **Hosts Configuration** . .
2. Search for cgroup.
3. Select the **Enable Cgroup-based Resource Management** checkbox.

4. Click Save Changes.
5. Navigate to YARN Configuration .
6. Search for cgroup.
7. Find the Use CGroups for Resource Management property and enable it for the applicable clusters.
8. Find the Always use Linux Container Executor property and enable it for the applicable clusters.
9. Search for gpu.
10. Find the Enable GPU Usage property and select the NodeManager Default Group checkbox.
11. Find the NodeManager GPU Devices Allowed property and define the GPU devices that are managed by YARN using one of the following ways.
  - Use the default value, auto, for auto detection of all GPU devices. In this case all GPU devices are managed by YARN.
  - Manually define the GPU devices that are managed by YARN.
12. Find the NodeManager GPU Detection Executable property and define the location of nvidia-smi. By default, this property has no value and it means that YARN checks the following paths to find nvidia-smi:
  - /usr/bin
  - /bin
  - /usr/local/nvidia/bin
13. Click Save Changes.
14. Click the Stale Configuration: Restart needed button on the top of the page.
15. Click Restart Stale Services.

Note that this step restarts all services with stale configurations.

16. Select Re-deploy client configuration and click Restart Now.

If the NodeManager fails to start, the following error is displayed:

```
INFO gpu.GpuDiscoverer (GpuDiscoverer.java:initialize(240)) - Trying to discover GPU information ... WARN gpu.GpuDiscoverer (GpuDiscoverer.java:initialize(247)) - Failed to discover GPU information from system, exception message :ExitCodeException exitCode=12: continue...
```

Fix the error by exporting the LD\_LIBRARY\_PATH in the yarn -env.sh using the following command:

```
export LD_LIBRARY_PATH=/usr/local/nvidia/lib:/usr/local/nvidia/lib64:
$LD_LIBRARY_PATH
```

### Related Information

[Using scheduling to allocate resources](#)

## Options to run distributed shell and GPU

You can run the distributed shell by specifying resources other than memory and vCores.

### Procedure

- Use the following command to run the distributed shell and GPU without a Docker container:

```
yarn jar </opt/cloudera/parcels/<CDH-version>/lib/hadoop-yarn/hadoop-yarn-applications-distributedshell.jar> \
-jar </opt/cloudera/parcels/<CDH-version>/lib/hadoop-yarn/hadoop-yarn-applications-distributedshell.jar> \
-shell_command /usr/local/nvidia/bin/nvidia-smi \
-container_resources memory-mb=3072,vcores=1,yarn.io/gpu=2 \
-num_containers 2
```

You receive output similar to the following:

```
+-----+
```

NVIDIA-SMI 375.66				Driver Version: 375.66			
GPU	Name	Persistence-M	Bus-Id	Disp.A	Volatile	Uncorr. ECC	
Fan	Temp	Perf	Pwr:Usage/Cap	Memory-Usage	GPU-Util	Compute M.	
0	Tesla P100-PCIE...	Off	0000:04:00.0	Off			0
N/A	30C	P0	24W / 250W	0MiB / 12193MiB	0%	Default	
1	Tesla P100-PCIE...	Off	0000:82:00.0	Off			0
N/A	34C	P0	25W / 250W	0MiB / 12193MiB	0%	Default	
Processes:							
GPU	PID	Type	Process name	GPU Memory Usage			
No running processes found							

## Limit CPU usage with Cgroups

You can use cgroups to limit CPU usage in a Hadoop Cluster.

You can use cgroups to isolate CPU-heavy processes in a Hadoop cluster. If you are using CPU Scheduling, you should also use cgroups to constrain and manage CPU processes. If you are not using CPU Scheduling, do not enable cgroups.

When you enable CPU Scheduling, queues are still used to allocate cluster resources, but both CPU and memory are taken into consideration using a scheduler that utilizes Dominant Resource Fairness (DRF). In the DRF model, resource allocation takes into account the dominant resource required by a process. CPU-heavy processes (such as Storm-on-YARN) receive more CPU and less memory. Memory-heavy processes (such as MapReduce) receive more memory and less CPU. The DRF scheduler is designed to fairly distribute memory and CPU resources among different types of processes in a mixed- workload cluster.

Cgroups compliments CPU Scheduling by providing CPU resource isolation. It enables you to set limits on the amount of CPU resources granted to individual YARN containers, and also lets you set a limit on the total amount of CPU resources used by YARN processes.

Cgroups represents one aspect of YARN resource management capabilities that includes CPU Scheduling, node labels, archival storage, and memory as storage. If CPU Scheduling is used, cgroups should be used along with it to constrain and manage CPU processes.

### Related Information

[Configure CPU scheduling and isolation](#)

### Enable Cgroups

You can enable CPU Scheduling to enable cgroups. You must configure certain properties in yarn-site.xml on the ResourceManager and NodeManager hosts to enable cgroups.

### About this task

cgroups is a Linux kernel feature. cgroups is supported on the following Linux operating systems:

- CentOS 6.9, 7.3
- RHEL 6.9, 7.3
- SUSE 12
- Ubuntu 16

At this time there is no cgroups equivalent for Windows. cgroups are not enabled by default on CDP. cgroups require that the CDP cluster be Kerberos enabled.



#### Important:

The yarn.nodemanager.linux-container-executor.cgroups.mount property must be set to false. Setting this value to true is not currently supported.

## Procedure

### Enable cgroups

The following commands must be run on every reboot of the NodeManager hosts to set up the cgroup hierarchy. Note that operating systems use different mount points for the cgroup interface. Replace `/sys/fs/cgroup` with your operating system equivalent.

```
mkdir -p /sys/fs/cgroup/cpu/yarn
chown -R yarn /sys/fs/cgroup/cpu/yarn
mkdir -p /sys/fs/cgroup/memory/yarn
chown -R yarn /sys/fs/cgroup/memory/yarn
mkdir -p /sys/fs/cgroup/blkio/yarn
chown -R yarn /sys/fs/cgroup/blkio/yarn
mkdir -p /sys/fs/cgroup/net_cls/yarn
chown -R yarn /sys/fs/cgroup/net_cls/yarn
mkdir -p /sys/fs/cgroup/devices/yarn
chown -R yarn /sys/fs/cgroup/devices/yarn
```

1. In Cloudera Manager, select the YARN service.
2. Click the Configuration tab.
3. Search for Always Use Linux Container Executor and select YARN-1 (Service-Wide) option.
4. Search for NodeManager Advanced Configuration and set the below property in the NodeManager Advanced Configuration Snippet (Safety Valve) for yarn-site.xml field.

```
Name: yarn.nodemanager.linux-container-executor.group
Value: hadoop
```

5. Search for CGroups and select YARN-1 (Service-Wide) option in the Use CGroups for Resource Management field.
6. Search for CGroups Hierarchy and set the NodeManager Default Group value to `/hadoop-yarn`.
7. Search for NodeManager Advanced Configuration and set the below property in the NodeManager Advanced Configuration Snippet (Safety Valve) for yarn-site.xml field.

```
Name: yarn.nodemanager.linux-container-executor.cgroups.mount
Value: false
```

```
Name: yarn.nodemanager.linux-container-executor.cgroups.mount-path
Value: /sys/fs/cgroup
```

8. (Optional) Set the percentage of CPU to be used by YARN. Search for Containers CPU Limit and set the value in the Containers CPU Limit Percentage field.

Set the percentage of CPU that can be allocated for YARN containers. In most cases, the default value of 100% should be used. If you have another process that needs to run on a node that also requires CPU resources, you can lower the percentage of CPU allocated to YARN to free up resources for the other process.

9. (Optional) Set flexible or strict CPU limits. Search for Strict CGroup Resource Usage and select the NodeManager Default Group field.

CPU jobs are constrained with CPU scheduling and cgroups enabled, but by default these are flexible limits. If spare CPU cycles are available, containers are allowed to exceed the CPU limits set for them. With flexible limits,



the amount of CPU resources available for containers to use can vary based on cluster usage -- the amount of CPU available in the cluster at any given time.

You can use cgroups to set strict limits on CPU usage. When strict limits are enabled, each process receives only the amount of CPU resources it requests. With strict limits, a CPU process will receive the same amount of cluster resources every time it runs.

Strict limits are not enabled (set to false) by default.



**Note:** Irrespective of whether this property is true or false, at no point will total container CPU usage exceed the limit set in `yarn.nodemanager.resource.percentage-physical-cpu-limit`.



**Note:** CPU resource isolation leverages advanced features in the Linux kernel. At this time, setting `yarn.nodemanager.linux-container-executor.cgroups.strict-resource-usage` to true is not recommended due to known kernel panics. In addition, with some kernels, setting `yarn.nodemanager.resource.percentage-physical-cpu-limit` to a value less than 100 can result in kernel panics. If you require either of these features, you must perform scale testing to determine if the in-use kernel and workloads are stable. As a starting point, Linux kernel version 4.8.1 works with these features. However, testing the features with the desired workloads is very important.

### Related Information

[Using scheduling to allocate resources](#)

[Configure CPU scheduling and isolation](#)

### Using Cgroups

You can use strict cgroups CPU limits to constrain CPU processes in mixed workload clusters.

One example of a mixed workload is a cluster that runs both MapReduce and Storm-on-YARN. MapReduce is not CPU-constrained (MapReduce containers do not ask for much CPU). Storm-on-YARN is CPU-constrained: its containers ask for more CPU than memory. As you start adding Storm jobs along with MapReduce jobs, the DRF scheduler attempts to balance memory and CPU resources, but as more CPU-intensive Storm jobs are added, they may begin to take up the majority of the cluster CPU resources.

You can use cgroups along with CPU scheduling to help manage mixed workloads. cgroups provide isolation for CPU-heavy processes such as Storm-on-YARN, thereby enabling you to predictably plan and constrain the CPU-intensive Storm containers.

When you enable strict cgroup CPU limits, each resource gets only what it asks for, even if there is extra CPU available. This is useful for scenarios involving charge-backs or strict SLA enforcement, where you always need to know exactly what percentage of CPU is being used.

Also, enabling strict CPU limits would make job performance predictable, whereas without setting strict limits a CPU-intensive job would run faster when the cluster was not under heavy use, but slower when more jobs were running in the cluster. Strict CPU limits would therefore also be useful for benchmarking.

You can also use node labels in conjunction with cgroups and CPU scheduling to restrict Storm-on-YARN jobs to a subset of cluster nodes.

If you are using cgroups and want more information on CPU performance, you can review the statistics available in the `/cgroup/cpu/yarn/cpu.stat` file.

### Partition a cluster using node labels

You can use Node labels to partition a cluster into sub-clusters so that jobs run on nodes with specific characteristics.

You can use Node labels to run YARN applications on cluster nodes that have a specified node label. Node labels can be set as exclusive or shareable:

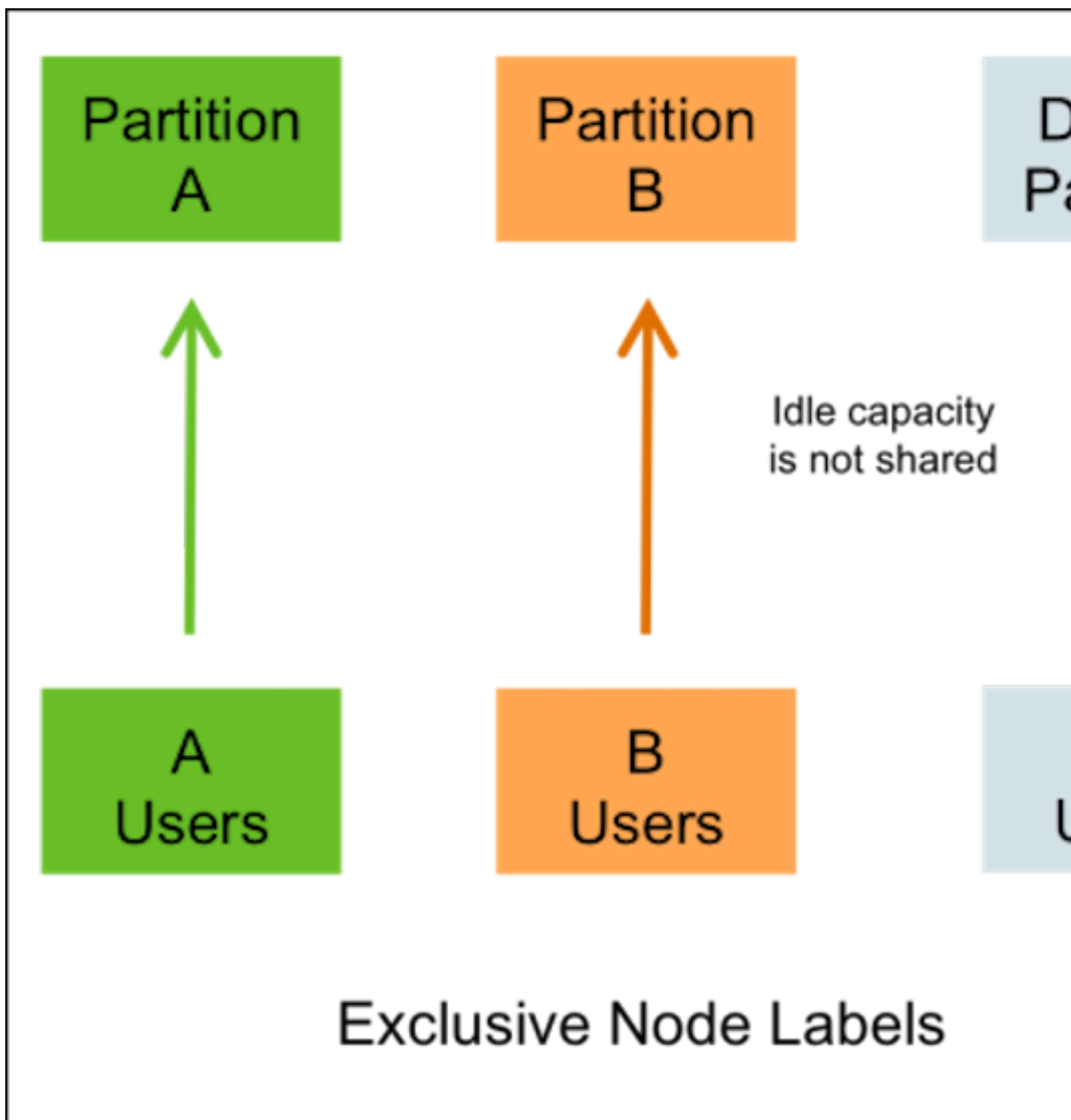
- **exclusive** -- Access is restricted to applications running in queues associated with the node label.
- **sharable** -- If idle capacity is available on the labeled node, resources are shared with all applications in the cluster.

The fundamental unit of scheduling in YARN is the queue. The capacity of each queue specifies the percentage of cluster resources that are available for applications submitted to the queue. Queues can be set up in a hierarchy that reflects the resource requirements and access restrictions required by the various organizations, groups, and users that utilize cluster resources.

Node labels enable you partition a cluster into sub-clusters so that jobs can be run on nodes with specific characteristics. For example, you can use node labels to run memory-intensive jobs only on nodes with a larger amount of RAM. Node labels can be assigned to cluster nodes, and specified as exclusive or shareable. You can then associate node labels with capacity scheduler queues. Each node can have only one node label.

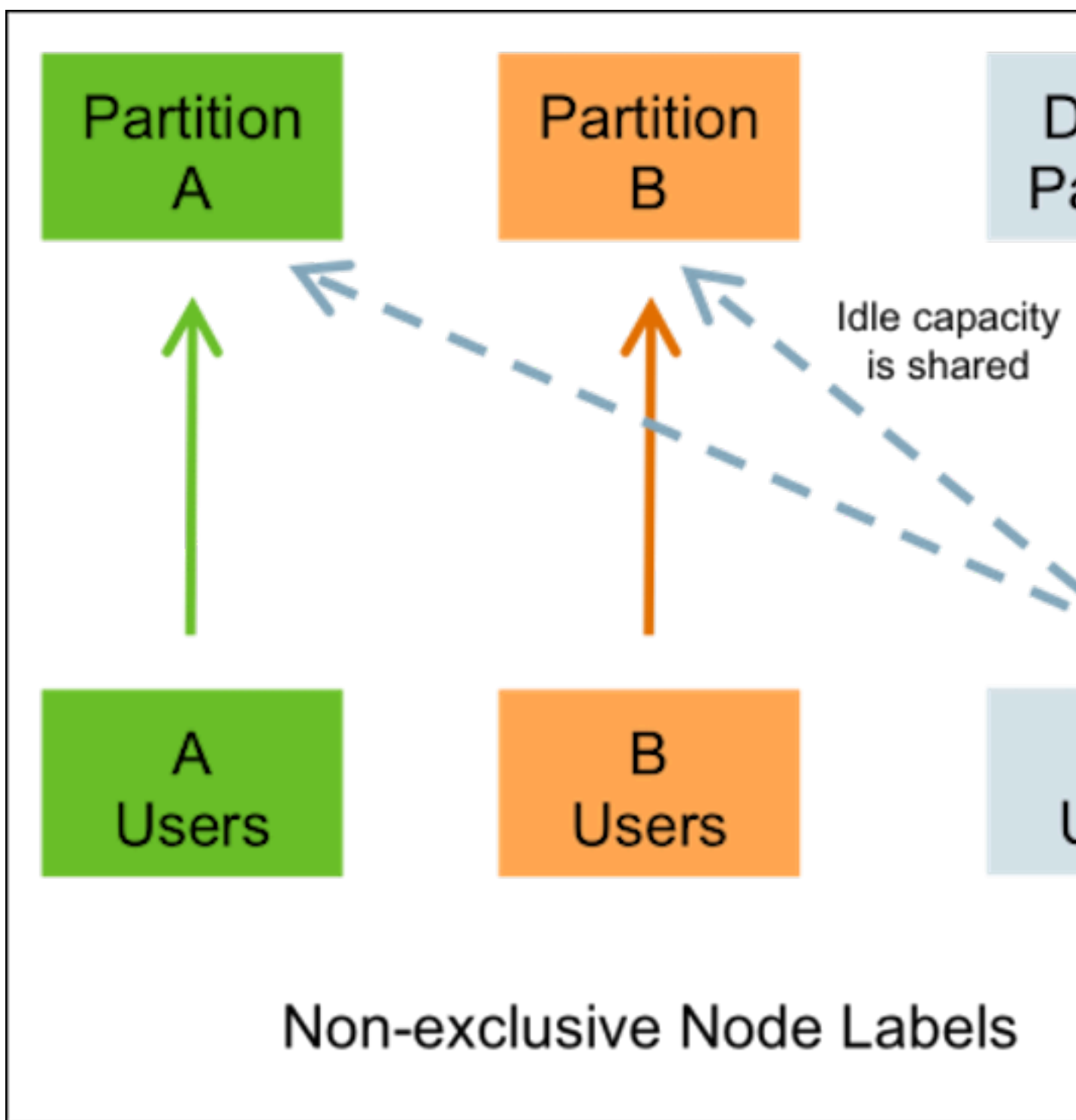
#### Exclusive Node Labels

When a queue is associated with one or more exclusive node labels, all applications submitted by the queue have exclusive access to nodes with those labels.



#### Shareable Node Labels

When a queue is associated with one or more shareable (non-exclusive) node labels, all applications submitted by the queue get first priority on nodes with those labels. If idle capacity is available on the labeled nodes, resources are shared with other non-labeled applications in the cluster. Non-labeled applications will be preempted if labeled applications request new resources on the labeled nodes.



#### Queues without Node Labels

If no node label is assigned to a queue, the applications submitted by the queue can run on any node without a node label, and on nodes with shareable node labels if idle resources are available.

#### Preemption

Labeled applications that request labeled resources preempt non-labeled applications on labeled nodes. If a labeled resource is not explicitly requested, the normal rules of preemption apply. Non-labeled applications cannot preempt labeled applications running on labeled nodes.

## Configure node labels

You can configure node labels on a cluster by making configuration changes on the YARN ResourceManager host.

### Enable Node Labels

To enable Node Labels on a cluster, make the following configuration changes on the YARN ResourceManager host.

#### 1. Create a Label Directory in HDFS

Use the following commands to create a "node-labels" directory in which to store the Node Labels in HDFS.

```
sudo su hdfs
hadoop fs -mkdir -p /yarn/node-labels
hadoop fs -chown -R yarn:yarn /yarn
hadoop fs -chmod -R 700 /yarn
```

-chmod -R 700 specifies that only the yarn user can access the "node-labels" directory.

You can then use the following command to confirm that the directory was created in HDFS.

```
hadoop fs -ls /yarn
```

The new node label directory should appear in the list returned by the following command. The owner should be yarn, and the permission should be drwx.

```
Found 1 items
drwx----- - yarn yarn 0 2014-11-24 13:09 /yarn/node-labels
```

Use the following commands to create a /user/<user\_name> directory that is required by the distributed shell.

```
hadoop fs -mkdir -p /user/<user_name>
hadoop fs -chown -R yarn:yarn /user/<user_name>
hadoop fs -chmod -R 700 /user/<user_name>
```

2. In Cloudera Manager, select the YARN service.
3. Click the Configuration tab.
4. Search for YARN Service Advanced Configuration.
5. In YARN Service Advanced Configuration Snippet (Safety Valve) for yarn-site.xml add the following:
  - Set the following property to enable Node Labels:

```
Name: yarn.node-labels.enabled
Value: true
```

- Set the following property to reference the HDFS node label directory

```
Name: yarn.node-labels.fs-store.root-dir
Value: hdfs:///
```

For example,

```
Name: yarn.node-labels.fs-store.root-dir
Value: hdfs://node-1.example.com:8020/yarn/node-labels/
```

6. Start or Restart the YARN ResourceManager.

## Add Node Labels

Use the following command format to add Node Labels. You should run these commands as the yarn user. Node labels must be added before they can be assigned to nodes and associated with queues.

```
sudo su yarn
yarn rmdadmin -addToClusterNodeLabels "<label1>(exclusive=<true|false>),<label2>(exclusive=<true|false>)"
```



### Note:

If exclusive is not specified, the default value is true.

For example, the following commands add the node label "x" as exclusive, and "y" as shareable (non-exclusive).

```
sudo su yarn
yarn rmdadmin -addToClusterNodeLabels "x(exclusive=true),y(exclusive=false)"
```

You can use the yarn cluster --list-node-labels command to confirm that Node Labels have been added:

```
[root@node-1 /]# yarn cluster --list-node-labels
15/07/11 13:55:43 INFO impl.TimelineClientImpl: Timeline service address: http://node-1.example.com:8188/ws/v1/timeline/
15/07/11 13:55:43 INFO client.RMPProxy: Connecting to ResourceManager at node-1.example.com/240.0.0.10:8032
Node Labels: <x:exclusivity=true>,<y:exclusivity=false>
```

You can use the following command format to remove Node Labels:

```
yarn rmdadmin -removeFromClusterNodeLabels "<label1>,<label2>"
```



### Note:

You cannot remove a node label if it is associated with a queue. For information about associating node labels with queues, see [Associate Node Labels with Queues](#) on page 35

## Confirm Node Label Assignments

You can use the following commands to view information about node labels.

- List all running nodes in the cluster: `yarn node -list`

Example:

```
[root@node-1 /]# yarn node -list
14/11/21 12:14:06 INFO impl.TimelineClientImpl: Timeline service address: http://node-1.example.com:8188/ws/v1/timeline/
14/11/21 12:14:07 INFO client.RMPProxy: Connecting to ResourceManager at node-1.example.com/240.0.0.10:8032
Total Nodes:3
Node-Id Node-State Node-Http-Address Number-of-Running-Containers
node-3.example.com:45454 RUNNING node-3.example.com:50060 0
node-1.example.com:45454 RUNNING node-1.example.com:50060 0
node-2.example.com:45454 RUNNING node-2.example.com:50060 0
```

- List all node labels in the cluster: `yarn cluster --list-node-labels`

Example:

```
[root@node-1 /]# yarn cluster --list-node-labels
15/07/11 13:55:43 INFO impl.TimelineClientImpl: Timeline service address: http://node-1.example.com:8188/ws/v1/timeline/
```

```
15/07/11 13:55:43 INFO client.RMProxy: Connecting to ResourceManager at node-1.example.com/240.0.0.10:8032
Node Labels: <x:exclusivity=true>,<y:exclusivity=false>
```

- List the status of a node (includes node labels): `yarn node -status <Node_ID>`

Example:

```
[root@node-1 /]# yarn node -status node-1.example.com:45454
14/11/21 06:32:35 INFO impl.TimelineClientImpl: Timeline service address:
http://node-1.example.com:8188/ws/v1/timeline/
14/11/21 06:32:35 INFO client.RMProxy: Connecting to ResourceManager at
node-1.example.com/240.0.0.10:8032
Node Report :
Node-Id : node-1.example.com:45454
Rack : /default-rack
Node-State : RUNNING
Node-Http-Address : node-1.example.com:50060
Last-Health-Update : Fri 21/Nov/14 06:32:09:473PST
Health-Report :
Containers : 0
Memory-Used : 0MB
Memory-Capacity : 1408MB
CPU-Used : 0 vcores
CPU-Capacity : 8 vcores
Node-Labels : x
```

Node labels are also displayed in the ResourceManager UI on the Nodes and Scheduler pages.

### Use node labels

You can use various methods to specify node labels when submitting jobs.

### Procedure

- Set Node Labels when Submitting Jobs

You can use the following methods to specify node labels when submitting jobs:

- `ApplicationSubmissionContext.setNodeLabelExpression(<node_label_expression>)` -- sets the node label expression for all containers of the application.
- `ResourceRequest.setNodeLabelExpression(<node_label_expression>)` -- sets the node label expression for individual resource requests. This will override the node label expression set in `ApplicationSubmissionContext.setNodeLabelExpression(<node_label_expression>)`.
- Specify `setAMContainerResourceRequest.setNodeLabelExpression` in `ApplicationSubmissionContext` to indicate the expected node label for the ApplicationMaster container.

You can use one of these methods to specify a node label expression, and `-queue` to specify a queue, when you submit YARN jobs using the distributed shell client. If the queue has a label that satisfies the label expression, it will run the job on the labeled node(s). If the label expression does not reference a label associated with the specified queue, the job will not run and an error will be returned. If no node label is specified, the job will run only on nodes without a node label, and on nodes with shareable node labels if idle resources are available.



#### Note:

You can only specify one node label in the `.setNodeLabelExpression` methods.

For example, the following commands run a simple YARN distributed shell "sleep for a long time" job. In this example we are asking for more containers than the cluster can run so we can see which node the job runs on. We are specifying that the job should run on queue "a1", which our user has permission to run jobs on. We are also using the `-node_label_expression` parameter to specify that the job will run on all nodes with label "x".

```
sudo su yarn
```

```
hadoop jar /opt/cloudera/parcels/CDH/lib/hadoop-yarn/hadoop-yarn-applications-distributedshell.jar
-shell_command "sleep 100" -jar /opt/cloudera/parcels/CDH/lib/hadoop-yarn/hadoop-yarn-applications-distributedshell.jar
-num_containers 30 -queue a1 -node_label_expression x
```

If we run this job on the example cluster we configured previously, containers are allocated on node-1, as this node has been assigned node label "x", and queue "a1" also has node label "x":

The following commands run the same job that we specified for node label "x", but this time we will specify queue "b1" rather than queue "a1".

```
sudo su yarn
hadoop jar /opt/cloudera/parcels/CDH/lib/hadoop-yarn/hadoop-yarn-applications-distributedshell.jar
-shell_command "sleep 100000" -jar /opt/cloudera/parcels/CDH/lib/hadoop-yarn/hadoop-yarn-applications-distributedshell.jar
-num_containers 30 -queue b1 -node_label_expression x
```

When we attempt to run this job on our example cluster, the job will fail with the following error message because label "x" is not associated with queue "b1".

```
14/11/24 13:42:21 INFO distributedshell.Client: Submitting application to ASM
14/11/24 13:42:21 FATAL distributedshell.Client: Error running Client
org.apache.hadoop.yarn.exceptions.InvalidResourceRequestException: Invalid resource request, queue=b1 doesn't have permission to access all labels in resource request. labelExpression of resource request=x. Queue labels=y
```

- MapReduce Jobs and Node Labels

Currently you cannot specify a node label when submitting a MapReduce job. However, if you submit a MapReduce job to a queue that has a default node label expression, the default node label will be applied to the MapReduce job.

Using default node label expressions tends to constrain larger portions of the cluster, which at some point starts to become counter-productive for jobs -- such as MapReduce jobs -- that benefit from the advantages offered by distributed parallel processing.

## Allocating Resources using YARN Queue Manager UI

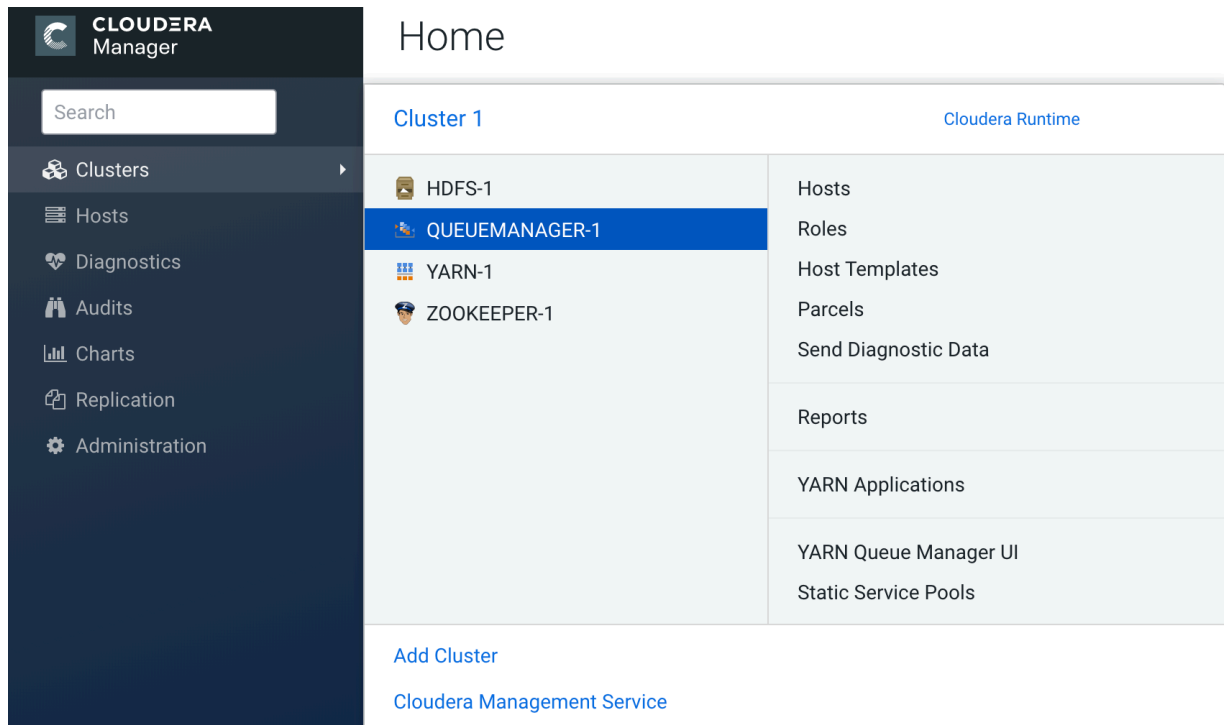
YARN Queue Manager is the queue management graphical user interface for Apache Hadoop YARN Capacity Scheduler. You can use YARN Queue Manager UI to manage your cluster capacity using queues to balance resource requirements of multiple applications from various users. Using YARN Queue Manager UI, you can set scheduler level properties and queue level properties. You can also view, sort, search, and filter queues using the YARN Queue Manager UI.

### Prerequisite

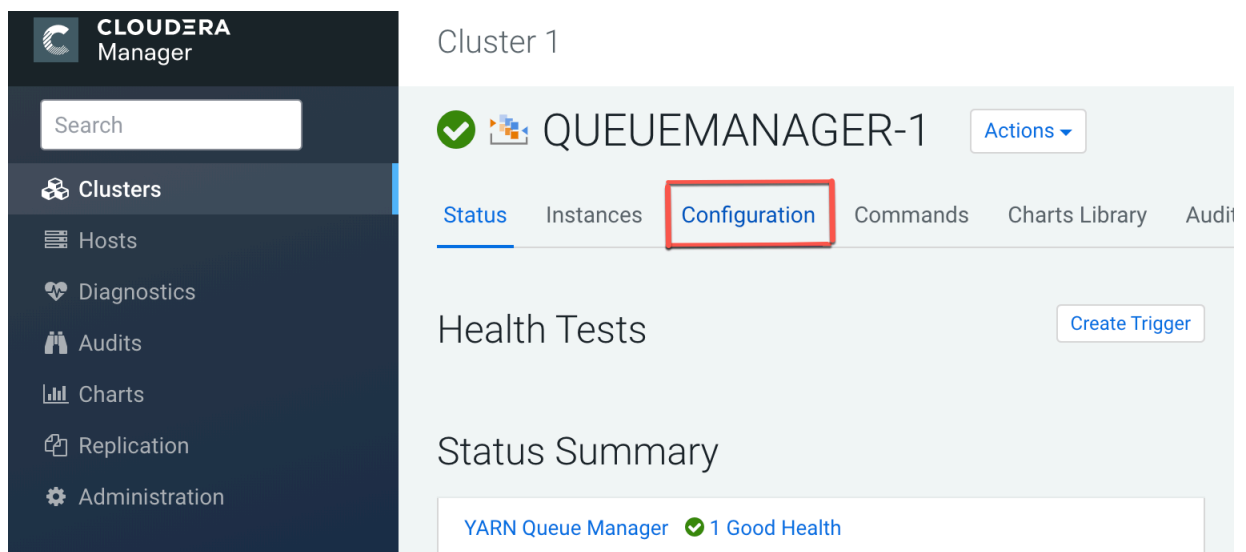
You must configure a Cloudera Manager user account with a minimum Configurator role for Queue Manager to access Cloudera Manager API.



1. In Cloudera Manager, select Clusters > QUEUEMANAGER-1 service.



2. Click the Configuration tab.



### 3. Search for Existing Cloudera Manager API Client Username.

Existing Cloudera Manager API Client Username <small>queuemanager_cm_api_client_logi n_name</small>	YARN Queue Manager Webapp Default Group <a href="#">Undo</a> <span>?</span>
	<input type="text"/>
	This field is required.

Existing Cloudera Manager API Client Password <small>queuemanager_cm_api_client_logi n_password</small>	YARN Queue Manager Webapp Default Group <a href="#">Undo</a> <span>?</span>
	<input type="password"/>
	This field is required.

4. Enter the existing Cloudera Manager user account details in the username and password fields.

5. Click Save Changes.

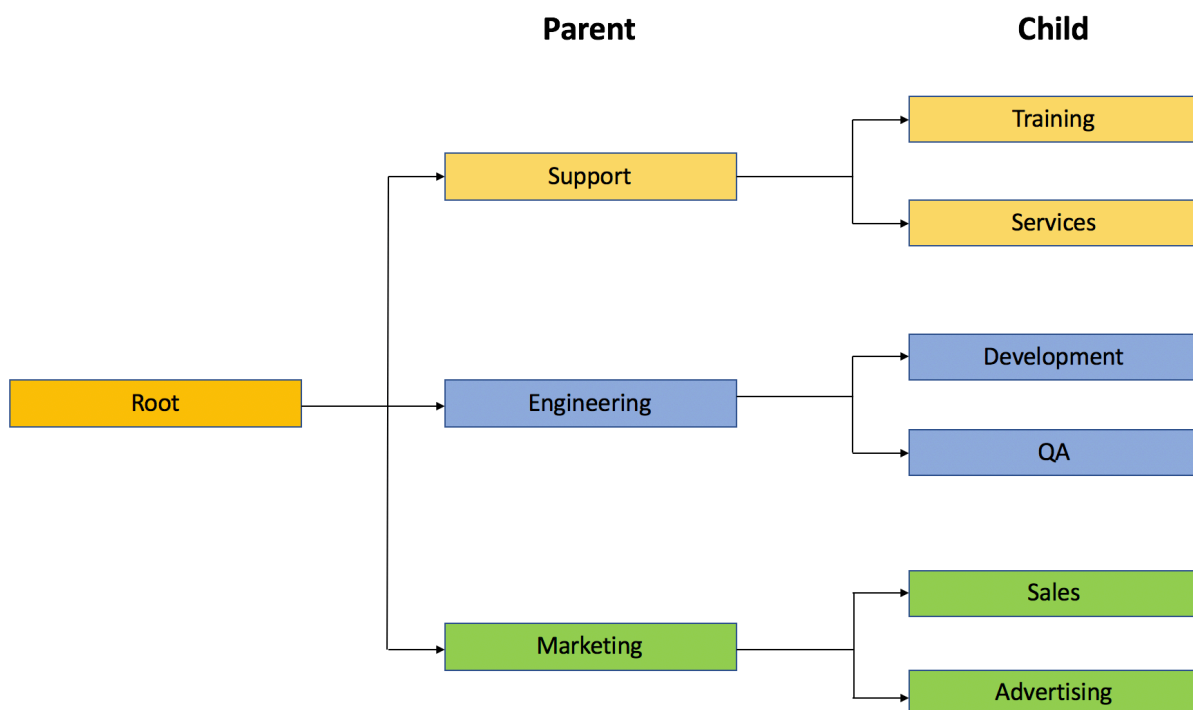
For more information about assigning users to a role in Cloudera Manager, see [Cloudera Manager User Roles](#)

## Set up Queues

Capacity Scheduler queues can be set up in a hierarchy that reflects the database structure, resource requirements, and access restrictions required by the various organizations, groups, and users that utilize cluster resources.

The fundamental unit of scheduling in YARN is a queue. The capacity of each queue specifies the percentage of cluster resources that are available for applications submitted to the queue.

For example, suppose that a company has three organizations: Engineering, Support, and Marketing. The Engineering organization has two sub-teams: Development and QA. The Support organization has two sub-teams: Training and Services. And finally, the Marketing organization is divided into Sales and Advertising. The following image shows the queue hierarchy for this example:



Each child queue is tied to its parent queue and the top-level "support", "engineering", and "marketing" queues would be tied to the "root" queue.

## Add queues using YARN Queue Manager UI

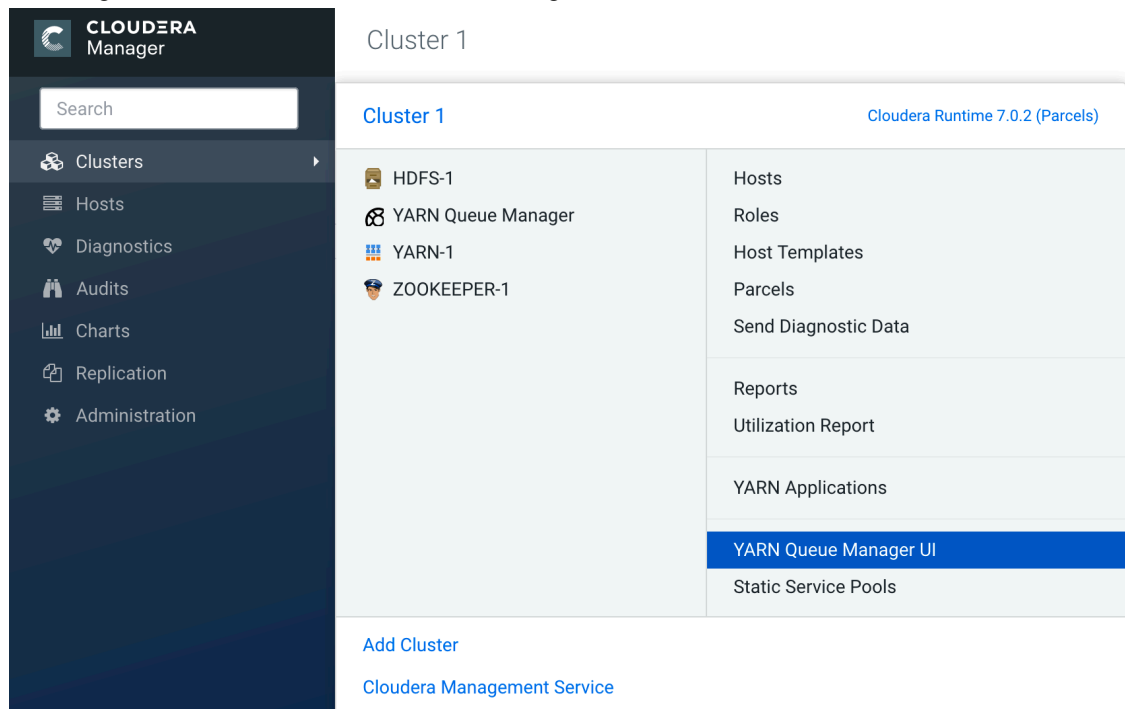
The Capacity Scheduler has a predefined queue called root. All queues in the system are children of the root queue. Each child queue is tied to its parent queue but children queues do not inherit properties directly from the parent queue unless otherwise specified.

### About this task

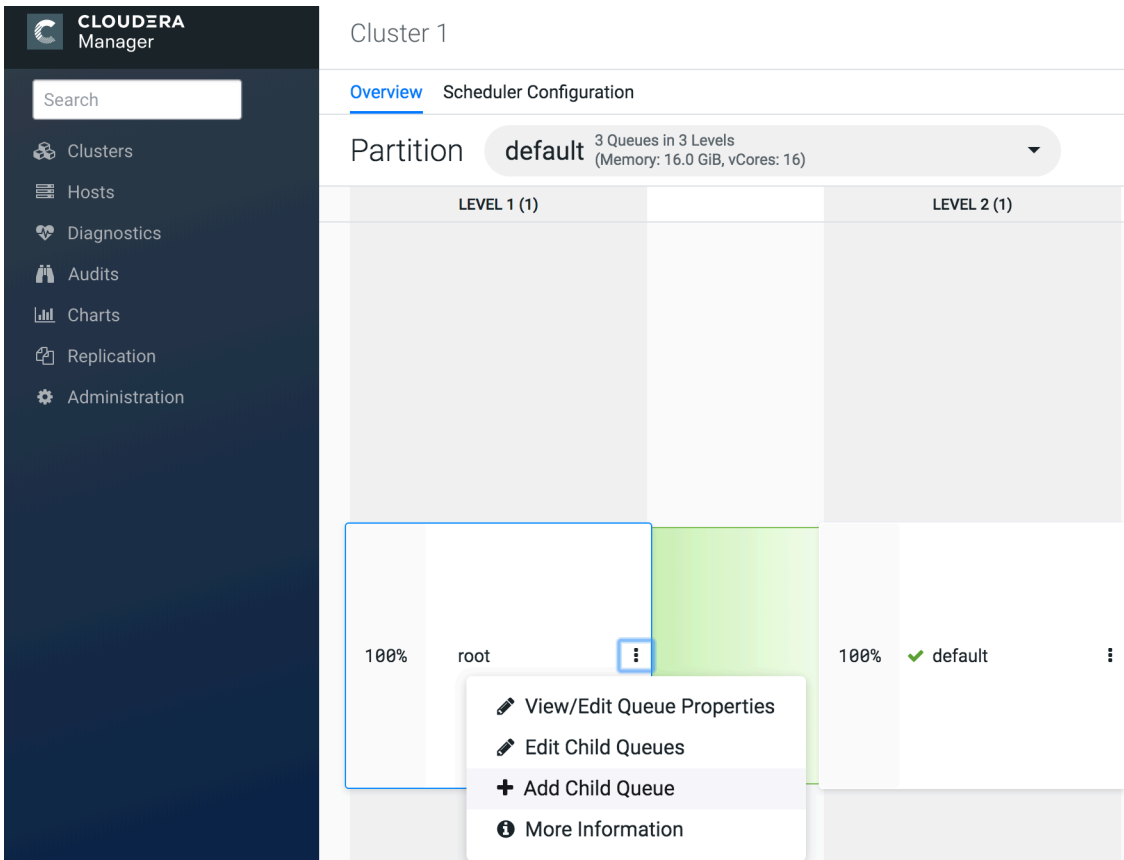
In Cloudera Manager, you can use the YARN Queue Manager UI service to add queues.

### Procedure

1. In Cloudera Manager, select Clusters > YARN Queue Manager UI service.



2. Click on the three vertical dots on the root and select the Add Child Queue option.



3. Enter the name of the queue, Configured Capacity, and Maximum Capacity values for the queue.

root

×

Memory: 16.0 GiB; vCores: 16

CONFIGURED CAPACITY	MAXIMUM CAPACITY	
<div>40</div> <div>%</div>	<div>100</div> <div>%</div>	<div>✓ default</div> <div>Memory: 16.0 GiB; vCores: 16</div>
<div>60</div> <div>%</div>	<div>100</div> <div>%</div>	<div>Support</div>

Additional queue properties can be set later by clicking **View/Edit Queue Properties** on the new queue's menu.

Total Configured Capacity: 100%

Cancel

Save

#### 4. Click Save.

Repeat the above steps to add more parent and child queues.

## Hierarchical queue characteristics

You must consider the various characteristics of the Capacity Scheduler hierarchical queues before setting them up.

- There are two types of queues: parent queues and child queues.
- Parent queues enable the management of resources across organizations and sub- organizations. They can contain more parent queues or leaf queues. They do not themselves accept any application submissions directly.
- Leaf queues are the queues that live under a parent queue and accept applications. Leaf queues do not have any child queues, and therefore do not have any configuration property that ends with ".queues".
- There is a top-level parent root queue that does not belong to any organization, but instead represents the cluster itself.
- Using parent and leaf queues, administrators can specify capacity allocations for various organizations and sub-organizations.

## Scheduling Among Queues

Hierarchical queues ensure that guaranteed resources are first shared among the sub-queues of an organization before any remaining free resources are shared with queues belonging to other organizations. This enables each organization to have control over the utilization of its guaranteed resources.

- At each level in the hierarchy, every parent queue keeps the list of its child queues in a sorted manner based on demand. The sorting of the queues is determined by the currently used fraction of each queue's capacity (or the full-path queue names if the reserved capacity of any two queues is equal).
- The root queue understands how the cluster capacity needs to be distributed among the first level of parent queues and invokes scheduling on each of its child queues.
- Every parent queue applies its capacity constraints to all of its child queues.
- Leaf queues hold the list of active applications (potentially from multiple users) and schedules resources in a FIFO (first-in, first-out) manner, while at the same time adhering to capacity limits specified for individual users.

## Configure Scheduler Properties

You can configure the scheduler properties to define the behaviour of all the queues. All parent and children queues inherit the properties set using the Scheduler Properties.

### About this task

In Cloudera Manager, you can use the Scheduler Properties to configure the scheduler properties.

### Procedure

1. In Cloudera Manager, select Clusters > YARN Queue Manager UIservice.

The screenshot shows the Cloudera Manager interface. On the left is a dark sidebar with the Cloudera Manager logo and a search bar. Below the search bar is a menu with options: Clusters, Hosts, Diagnostics, Audits, Charts, Replication, and Administration. The main content area is titled 'Cluster 1' and shows the 'YARN Queue Manager' configuration for 'Cluster 1' (Cloudera Runtime 7.0.2 (Parcels)). The configuration is divided into two columns. The left column lists services: HDFS-1, YARN Queue Manager, YARN-1, and ZOOKEEPER-1. The right column lists components: Hosts, Roles, Host Templates, Parcels, Send Diagnostic Data, Reports, Utilization Report, YARN Applications, YARN Queue Manager UI (highlighted in blue), and Static Service Pools. Below the configuration area are links for 'Add Cluster' and 'Cloudera Management Service'.

2. In the YARN Queue Manager window, click on the Scheduler Configuration tab.

The screenshot shows the Cloudera Manager Scheduler Configuration window for 'Cluster 1'. The 'Scheduler Configuration' tab is selected and circled in red. The window displays a 'Partition' dropdown set to 'default' with a summary '3 Queues in 3 Levels (Memory: 16.0 GiB, vCores: 16)'. Below this, there are two main sections: 'LEVEL 1 (1)' and 'LEVEL 2 (1)'. Under 'LEVEL 1 (1)', there is a table with one row: '100%' in the first column, 'root' in the second column, and a vertical ellipsis in the third column. Under 'LEVEL 2 (1)', there is a table with one row: '100%' in the first column, '✓ default' in the second column, and a vertical ellipsis in the third column.

3. In the Scheduler Configuration window, enter the value of the property and click Save.

## Scheduler Configuration

PROPERTY	VALUE
Queue Mappings	<input type="text"/>
Override Queue Mappings	<input type="checkbox"/> Disabled
Maximum Application Priority	<input type="text"/>
Enable Queue Preemption	<input type="checkbox"/> Disabled
Enable Intra Queue Preemption	<input type="checkbox"/> Disabled
Maximum Applications	<input type="text" value="10000"/>
Maximum AM Resource Limit	<input type="text" value="0.2"/>
Enable Asynchronous Scheduler	<input checked="" type="checkbox"/> Enabled

[Save](#)

## Define Queue Mapping Policies

Administrators can define a default mapping policy to specify that applications submitted by users are automatically submitted to queues.

With a default mapping policy, users are not required to specify the queue name when submitting their applications. The default mapping policy can be configured to be overridden if the queue name is specified for the submitted application.

Queue mapping is defined using a comma-separated list of mapping assignments. The order of the mapping assignments list is important -- in cases where multiple mapping assignments are used, the Capacity Scheduler processes the mapping assignments in left-to-right order to determine which mapping assignment to use first.

Queue mapping assignments can be defined for a user (using "u") or for a group of users (using "g"). Each mapping assignment type is described in the following sections.

### Configure queue mapping for users and groups to specific queues

Specifies that all applications submitted by a specific user are submitted to a specific queue.

- You can specify that all applications submitted by a specific user are submitted to a specific queue using the following mapping assignment.

```
u:user1:queueA
```

This defines a mapping assignment for applications submitted by the "user1" user to be submitted to queue "queueA" by default.

- To specify that all applications submitted by a specific group of users are submitted to a specific queue, use the following mapping assignment:

```
g:group1:queueB
```

This defines a mapping assignment for applications submitted by any user in the group "group1" to be submitted to queue "queueB" by default.

The Queue Mapping definition can consist of multiple assignments, in order of priority.

To configure queue mapping (yarn.scheduler.capacity.queue-mappings) for users and groups to specific queues based on this example, perform the following:

1. In Cloudera Manager, select Clusters > YARN Queue Manager UI service. A list of existing queues is displayed.
2. Click on the Scheduler Configuration tab.
3. Add u:maria:engineering,g:webadmins:weblog in the Queue Mappings text box.
4. Click Save.

In this example, there are two queue mapping assignments. The u:maria:engineering mapping will be respected first, which means all applications submitted by the user "maria" will be submitted to the "engineering" queue. The g:webadmins:weblog mapping will be processed after the first mapping -- thus, even if user "maria" belongs to the "webadmins" group, applications submitted by "maria" will still be submitted to the "engineering" queue. In this scenario, the mappings will be evaluated from left to right, and the first valid mapping will be used.

### Configure Queue Mapping for Users and Groups to Queues with the Same Name

Specifies that all applications are submitted to the queue with the same name as a group.

- To specify that all applications are submitted to the queue with the same name as a group, use this mapping assignment:

```
u:%user:%primary_group
```

Consider the following example configuration. On this cluster, there are two groups: "marketing" and "engineering". Each group has the following users:

In "marketing", there are 3 users: "angela", "rahul", and "dmitry".

In "engineering", there are 2 users: "maria" and "greg".

To configure queue mapping (yarn.scheduler.capacity.queue-mappings) for users and groups to queues with the same name based on this example, perform the following:

1. In Cloudera Manager, select Clusters > YARN Queue Manager UI service. A list of existing queues is displayed.
2. Click on the Scheduler Configuration tab.
3. Enter u:%user:%primary\_group in the Queue Mappings text box.
4. Click Save.

With this queue mapping, any application submitted by members of the "marketing" group -- "angela", "rahul", or "dmitry" -- will be submitted to the "marketing" queue. Any application submitted by members of the "engineering" group -- "maria" or "greg" -- will be submitted to the "engineering" queue.

To specify that all applications are submitted to the queue with the same name as a user, use this mapping assignment:  
u:%user:%user

This requires that queues are set up with the same name as the users. With this queue mapping, applications submitted by user "greg" will be submitted to the queue "greg".

### Enable override of default queue mappings

You can override default queue mappings (yarn.scheduler.capacity.queue-mappings-override.enable) and submit applications that are specified for queues, other than those defined in the default queue mappings.



## Procedure

1. In Cloudera Manager, select Clusters > YARN Queue Manager UI service. A list of existing queues is displayed.
2. Click on the Scheduler Configuration tab.
3. Select the Override Queue Mappings check-box to disable the queue mapping.
4. Click Save.

You must select the Override Queue Mappings to override the default queue mapping.

Consider the following example in the case where queue mapping override has been enabled.

The value of the Queue Mappings is set to u:maria:engineering,g:webadmins:weblog. If user "maria" explicitly submits an application to the "marketing" queue, the default queue assignment of "engineering" is overridden, and the application is submitted to the "marketing" queue.

## Configure queue mapping to use the user name from the application tag using Cloudera Manager

You can configure queue mapping to use the user name from the application tag instead of the proxy user who submitted the job. For example, when a user runs Hive queries, HiveServer2 submits the query in the queue mapped from an end user instead of a hive user.

### How to configure queue mapping

1. In Cloudera Manager, select the YARN service.
2. Click the Configuration tab.
3. Search for ResourceManager. In the Filters pane, under Scope, select ResourceManager.
4. In ResourceManager Advanced Configuration Snippet (Safety Valve) for yarn-site.xml add the following:
  - a. Enable the application-tag-based-placement property to enable application placement based on the user ID passed using the application tags.

```
Name: yarn.resourcemanager.application-tag-based-placement.enable
Value: true
Description: Set to "true" to enable application placement based on the
user ID passed using the application tags. When it is enabled, it chec
ks for the userid=<userId> pattern and if found, the application will be
placed onto the found user's queue, if the original user has the requir
ed rights on the passed user's queue.
```

- b. Add the list of users in the allowlist who can use application tag based placement. The applications when the submitting user is included in the allowlist, will be placed onto the queue defined in the yarn.scheduler.capacity.queue-mappings property defined for the user from the application tag. If there is no user defined, the submitting user will be used.

```
Name: yarn.resourcemanager.application-tag-based-placement.username.whit
elist
Value: <Hive process user(s)>
Description: Comma separated list of users who can use the application t
ag based placement, if "yarn.resourcemanager.application-tag-based-place
ment.enable" is enabled.
```



**Note:** Check the Hive system user value(s) and add the value(s) to the allowlist:

1. In Cloudera Manager, navigate to Hive Configuration .
2. Search for System User.
3. Note down the value(s) set as process username(s), and add the value(s) to the allowlist.
5. Restart the ResourceManager service for the changes to apply.

## Set Application Priority

You can use Priority Scheduling to run YARN applications at higher priority, regardless of other applications that are already running in the cluster. YARN allocates more resources to applications running at a higher priority over those running at a lower priority. Priority Scheduling enables you to set an application's priority both at the time of submission and dynamically at run time.

### About this task

Priority Scheduling works only with the FIFO (First In, First Out) ordering policy. FIFO is the default Capacity Scheduler ordering policy.

To set application priority (`yarn.cluster.max-application-priority`), perform the following:

### Procedure

1. In Cloudera Manager, select Clusters > YARN Queue Manager UI service. A list of existing queues is displayed.
2. Click on the Scheduler Configuration tab.
3. Enter the priority in the Maximum Application Priority text box.
4. Click Save.

## Configure Queue Preemption

Capacity Scheduler Preemption allows higher-priority applications to preempt lower-priority applications.

### About this task

A scenario can occur in which a queue has a guaranteed level of cluster resources, but must wait to run applications because other queues are utilizing all of the available resources. If Preemption is enabled, higher-priority applications do not have to wait because lower priority applications have taken up the available capacity. With Preemption enabled, under-served queues can begin to claim their allocated cluster resources almost immediately, without having to wait for other queues' applications to finish running.

To configure Queue Preemption (`yarn.resourcemanager.scheduler.monitor.enable`) on all queues, perform the following:

### Procedure

1. In Cloudera Manager, select Clusters > YARN Queue Manager UI service. A list of existing queues is displayed.
2. Click on the Scheduler Configuration tab.
3. Select the Enable Queue Preemption checkbox.
4. Click Save.

For information about configuring preemption for a specific queue, see [Configure preemption for a specific queue](#).

## Configure Intra-Queue Preemption

Intra-queue preemption prevents resource imbalances in a queue.

### About this task

Intra-queue preemption helps in effective distribution of resources within a queue based on configured user limits or application priorities.

To configure Intra-Queue Preemption (`yarn.resourcemanager.monitor.capacity.preemption.intra-queue-preemption.enabled`) on all queues, perform the following:

### Procedure

1. In Cloudera Manager, select Clusters > YARN Queue Manager UI service. A list of existing queues is displayed.

2. Click on the Scheduler Configuration tab.
3. Select the Enable Intra Queue Preemption checkbox.
4. Click Save.

For information about configuring intra-queue preemption for a specific queue, see [Configure Intra-Queue Preemption for a specific queue](#).

## Set Application Limits

To avoid system-thrash due to an unmanageable load -- caused either by malicious users, or by accident -- the Capacity Scheduler enables you to place a static, configurable limit on the total number of concurrently active (both running and pending) applications at any one time.

You can set the maximum applications limit (`yarn.scheduler.capacity.maximum-applications`) using this configuration property. The default value is 10,000.

1. In Cloudera Manager, select Clusters > YARN Queue Manager UI service. A list of existing queues is displayed.
2. Click on the Scheduler Configuration tab.
3. Enter the maximum application limit in the Maximum Applications text box.
4. Click Save.

For information about overriding this limit on a per-queue basis, see [Set Application limit for a specific queue](#).

## Set Application Master Resource Limit

The Application Master (AM) resource limit that can be used to set a maximum percentage of cluster resources allocated specifically to Application Masters. This property has a default value of 10%, and exists to avoid cross-application deadlocks where significant resources in the cluster are occupied entirely by the Containers running ApplicationMasters.

### About this task

The Maximum AM Resource Limit (`yarn.scheduler.capacity.maximum-am-resource-percent`) property also indirectly controls the number of concurrent running applications in the cluster, with each queue limited to a number of running applications proportional to its capacity.

### Procedure

1. In Cloudera Manager, select Clusters > YARN Queue Manager UI service. A list of existing queues is displayed.
2. Click on the Scheduler Configuration tab.
3. Enter the maximum AM resource limit in the Maximum AM Resource Limit text box.
4. Click Save.

For information about overriding this limit on a per-queue basis, see [Configure Application Master resource limit for a specific queue](#).

## Configure Asynchronous Scheduler

Asynchronous scheduler decouples the CapacityScheduler scheduling from Node Heartbeats. This improves the latency significantly.

### About this task

To enable asynchronous scheduling (`yarn.scheduler.capacity.schedule-asynchronously.enable`), perform the following:

### Procedure

1. In Cloudera Manager, select Clusters > YARN Queue Manager UI service. A list of existing queues is displayed.
2. Click on the Scheduler Configuration tab.

3. Select the Enable Asynchronous Scheduler check-box.
4. Click Save.

## Configuring Cluster Capacity with Queues

You can manage your cluster capacity using queues to balance resource requirements of multiple applications from various users.

You can use the Capacity Scheduler to share cluster resources using FIFO (first in, first out) queues. YARN allows you to configure queues to own a fraction of the capacity of each cluster, and this specific queue capacity is fulfilled dynamically from the available nodes.

Users can submit applications to different queues at multiple levels in the queue hierarchy if the capacity is available on the nodes in the cluster. Because total cluster capacity can vary, capacity configuration values are expressed using percentages.

Specify the capacity property to allocate a floating-point percentage values of cluster capacity to a queue. The following configurations divide the cluster resources between the "engineering", "support", and "marketing" organizations in a 6:1:3 ratio (60%, 10%, and 30%).

To specify the capacity property based on the above example, perform the following:

1. In Cloudera Manager, select Clusters > YARN Queue Manager UI service. A list of existing queues is displayed.
2. Click on the three vertical dots on the root and select Edit Child Queues option.
3. Enter the Configured Capacity of "engineering" to 60, "support" to 10, and "marketing" to 30.
4. Click Save.

## Configure Queue Properties

Queue properties contain the settings that define the behavior of the queue. Using queue properties, you can define the setting that need not inherit properties directly from the parent queue and define the setting specific to the queue.

### About this task

In Cloudera Manager, you can use the Queue Properties to view and configure the queue properties.

### Procedure

1. In Cloudera Manager, select Clusters > YARN Queue Manager UI service.

The screenshot shows the Cloudera Manager interface. On the left is a dark sidebar with the Cloudera Manager logo and a search bar. Below the search bar is a menu with icons and labels: Clusters, Hosts, Diagnostics, Audits, Charts, Replication, and Administration. The main content area is titled 'Cluster 1' and 'Cloudera Runtime 7.0.2 (Parcels)'. It displays a list of services: HDFS-1, YARN Queue Manager, YARN-1, and ZOOKEEPER-1. To the right of these services is a list of links: Hosts, Roles, Host Templates, Parcels, Send Diagnostic Data, Reports, Utilization Report, YARN Applications, YARN Queue Manager UI (highlighted in blue), and Static Service Pools. At the bottom of the main content area are links for 'Add Cluster' and 'Cloudera Management Service'.

2. Click on the three vertical dots on the queue and select the View/Edit Queue Properties option.

The screenshot shows the Cloudera Manager interface with the 'Scheduler Configuration' page selected. The left sidebar is the same as in the previous screenshot. The main content area is titled 'Cluster 1' and 'Scheduler Configuration'. It shows a table with columns for 'LEVEL 1 (1)', 'LEVEL 2 (1)', and 'LEVEL 3 (1)'. The first row shows '100%' and 'root'. The second row shows '100%' and 'default'. The third row shows '100%' and 'Development'. A context menu is open over the 'Development' queue, showing options: View/Edit Queue Properties (highlighted), Add Child Queue, Delete Queue, Stop Queue, and More Information.

3. In the Queue Properties window, enter the value of the property and click Save.

Queue Properties
×

root.default.Development

Resource Allocation^

Minimum User Limit
%

User Limit Factor

Application Limits^

Maximum Applications

Maximum AM Resource Limit
%

Queue Permissions^

Submit Application ACL

Queue Administer ACL

Cancel Save

## Set User Limits

Set a minimum percentage of resources allocated to each leaf queue user.

The `MinimumUser Limit (minimum-user-limit-percent)` property can be used to set the minimum percentage of resources allocated to each leaf queue user. For example, to enable equal sharing of the "services" leaf queue capacity among five users, you would set the minimum user limit percentage to 20%.

To configure user limits based on this example, perform the following:

1. In Cloudera Manager, select **Clusters > YARN Queue Manager UI** service. A list of existing queues is displayed.
2. Click on the three vertical dots on the **Services** queue and select **View/Edit Queue Properties** option.
3. In the Queue Properties dialog-box, enter 20 in the **Minimum User Limit** text box.
4. Click **Save**.

This setting determines the minimum limit that any user's share of the queue capacity can shrink to. Irrespective of this limit, any user can come into the queue and take more than his or her allocated share if there are idle resources available.

The following table shows how the queue resources are adjusted as users submit jobs to a queue with a minimum user limit percentage is set to 20%:

- Queue resources are adjusted in the same manner for a single user submitting multiple jobs in succession. If no other users are requesting queue resources, the first job would receive 100% of the queue capacity. When the user submits a second job, each job receives 50% of queue capacity. When the user submits a third job, each job receives 33% of queue capacity. If a fourth user then submits a job, each job would receive 25% of queue capacity. When the number of jobs submitted by all users reaches a total of five, each job will receive 20% of queue capacity, and subsequent users must wait for queue capacity to free up (assuming preemption is not enabled).
- The Capacity Scheduler also manages resources for decreasing numbers of users. As users' applications finish running, other existing users with outstanding requirements begin to reclaim that share.
- Note that despite this sharing among users, the FIFO application scheduling order of Capacity Scheduler does not change. This guarantees that users cannot monopolize queues by submitting new applications continuously. Applications (and thus the corresponding users) that are submitted first always get a higher priority than applications that are submitted later.

Capacity Scheduler's leaf queues can also use the `user-limit-factor` property to control user resource allocations. This property denotes the fraction of queue capacity that any single user can consume up to a maximum value, regardless of whether or not there are idle resources in the cluster.

To configure the maximum limit (`user-limit-factor`) based on this example, perform the following:

1. In Cloudera Manager, select Clusters > YARN Queue Manager UI service. A list of existing queues is displayed.
2. Click on the three vertical dots on the queue you want to set limit and select View/Edit Queue Properties option.
3. In the Queue Properties dialog-box, enter 1 in the User Limit Factor text box.
4. Click Save.

The default value of "1" means that any single user in the queue can at maximum only occupy the queue's configured capacity. This prevents users in a single queue from monopolizing resources across all queues in a cluster. Setting the value to "2" would restrict the queue's users to twice the queue's configured capacity. Setting it to a value of 0.5 would restrict any user from using resources beyond half of the queue capacity.

## Set application limit for a specific queue

To avoid system-thrash due to an unmanageable load -- caused either by malicious users, or by accident -- the Capacity Scheduler enables you to place a static, configurable limit on the total number of concurrently active (both running and pending) applications at any one time.

### About this task

You can set the `maximum-application-limit` property using the Maximum Application queue property. The limit for running applications in any specific queue is a fraction of this total limit, proportional to its capacity. This is a hard limit, which means that once this limit is reached for a queue, any new applications to that queue will be rejected, and clients will have to wait and retry later.

To set the application limit (`yarn.scheduler.capacity.<queue-path>.maximum-applications`) on a specific queue, perform the following:

### Procedure

1. In Cloudera Manager, select Clusters > YARN Queue Manager UI service. A list of existing queues is displayed.
2. Click on the three vertical dots on the queue and select View/Edit Queue Properties option.
3. In the Queue Properties dialog-box, enter the maximum application limit in the Maximum Application text box.

#### 4. Click Save.

For information about setting application limits on all the queues, see [Set Application Limits](#).

### Set Application Master resource limit for a specific queue

The Application Master (AM) resource limit can be used to set a maximum percentage of cluster resources allocated specifically to Application Masters. The default value is 10% and exists to avoid cross-application deadlocks where significant resources in the cluster are occupied entirely by the Containers running Application Masters.

#### About this task

This property also indirectly controls the number of concurrent running applications in the cluster, with each queue limited to a number of running applications proportional to its capacity.

To set the maximum Application Masters resource limit (`yarn.scheduler.capacity.maximum-am-resource-percent`) for a specific queue:

#### Procedure

1. In Cloudera Manager, select Clusters > YARN Queue Manager UI service. A list of existing queues is displayed.
2. Click on the three vertical dots on the queue and select View/Edit Queue Properties option.
3. In the Queue Properties dialog-box, enter the limit in the Maximum AM Resource Limit text box.
4. Click Save.

For information about setting Application Master resource limits on all the queues, see [Set Application Master Resource Limit](#).

### Control access to queues using ACLs

Use Access-control lists (ACLs) to control access rights to users and administrators to the Capacity Scheduler queues.

Application submission can really only happen at the leaf queue level, but an ACL restriction set on a parent queue will be applied to all of its descendant queues.

In the Capacity Scheduler, ACLs are configured by granting queue access to a list of users and groups with the Submit Application ACL parameter. The format of the list is "user1,user2 group1,group2" -- a comma-separated list of users, followed by a space, followed by a comma-separated list of groups.



**Note:** The default value of Submit Application ACL for a root queue is `yarn`, which means that only the default `yarn` user can submit applications to that queue. Therefore, to provide specific users and groups with access to the queue, you must explicitly set the value of Submit Application ACL to those users and groups.

The value of Submit Application ACL (`acl_submit_applications`) can also be set to "\*" (asterisk) to allow access to all users and groups, or can be set to " " (space character) to block access to all users and groups.

As mentioned previously, ACL settings on a parent queue are applied to all of its descendant queues. Therefore, if the parent queue uses the "\*" (asterisk) value (or is not specified) to allow access to all users and groups, its child queues cannot restrict access. Similarly, before you can restrict access to a child queue, you must first set the parent queue to " " (space character) to block access to all users and groups.

For example, the following properties would set the root Submit Application ACL value to " " (space character) to block access to all users and groups, and also restrict access to its child "support" queue to the users "sherlock" and "john" and the members of the "cfo-group" group:

Each child queue is tied to its parent queue with the configuration property. The top-level "support", "engineering", and "marketing" queues would be tied to the "root" queue.

To set the ACLs based on this example, perform the following:

1. In Cloudera Manager, select Clusters > YARN Queue Manager UI service. A list of existing queues is displayed.
2. Click on the three vertical dots on the queue you want to set ACL and select View/Edit Queue Properties option.
3. In the Queue Properties dialog-box, add `sherlock,john cfo-group` in the Submit Application ACL text box.



#### 4. Click Save.

A separate ACL can be used to control the administration of queues at various levels. Queue administrators can submit applications to the queue, kill applications in the queue, and obtain information about any application in the queue (whereas normal users are restricted from viewing all of the details of other users' applications).

If the Queue Administer ACL value is set to " " (space character), it blocks access to all users and groups. If the ACL is set to `sherlock,john cfo-group`, it allows access to the users "sherlock" and "john" and the members of the "cfo-group" group.

## Configure preemption for a specific queue

Capacity Scheduler Preemption allows higher-priority applications to preempt lower-priority applications.

### About this task

A scenario can occur in which a queue has a guaranteed level of cluster resources, but must wait to run applications because other queues are utilizing all of the available resources. If Preemption is enabled, higher-priority applications do not have to wait because lower priority applications have taken up the available capacity. With Preemption enabled, under-served queues can begin to claim their allocated cluster resources almost immediately, without having to wait for other queues' applications to finish running.



**Note:** If the preemption policy is disabled in the scheduler configurations, you cannot enable preemption for a specific queue. For information about setting scheduler level preemption, see [Configure Queue Preemption](#) on page 26.

You can disable the queue preemption (`yarn.resourcemanager.scheduler.monitor.enable`) for a specific queue.

### Procedure

1. In Cloudera Manager, select Clusters > YARN Queue Manager UI service. A list of existing queues is displayed.
2. Click on the three vertical dots on the queue and select View/Edit Queue Properties option.
3. In the Queue Properties dialog-box, uncheck the Enable Preemption checkbox.
4. Click Save.

## Configure Intra-Queue Preemption for a specific queue

Intra-queue preemption prevents resource imbalances in a queue.

### About this task

Intra-queue preemption helps in effective distribution of resources within a queue based on configured user limits or application priorities.



**Note:** If the intra-queue preemption policy is disabled in the scheduler configurations, you cannot enable intra-queue preemption for a specific queue. For information about setting scheduler level intra-queue preemption, see [Configure Intra-Queue Preemption](#).

To disable Intra-Queue Preemption (`yarn.resourcemanager.monitor.capacity.preemption.intra-queue-preemption.enabled`) for a specific queue

### Procedure

1. In Cloudera Manager, select Clusters > YARN Queue Manager UI service. A list of existing queues is displayed.
2. Click on the three vertical dots on the queue and select View/Edit Queue Properties option.
3. In the Queue Properties dialog-box, uncheck the Enable Intra Queue Preemption checkbox.
4. Click Save.

## Set Flexible Scheduling Policies

Set FIFO (First In, First Out) or Fair scheduling policies in Capacity Scheduler depending on your requirements.

The default ordering policy in Capacity Scheduler is FIFO (First In, First Out). FIFO generally works well for predictable, recurring batch jobs, but sometimes not as well for on-demand or exploratory workloads. For these types of jobs, Fair Scheduling is often a better choice. Flexible scheduling policies enable you to assign FIFO or Fair ordering policies for different types of workloads on a per-queue basis.

### Examples FIFO and Fair Sharing Policies

Both FIFO (First In, First Out) and Fair scheduling policies work differently in batch jobs and ad hoc jobs.

#### Batch Example

In the below example, two queues have the same resources available. One uses the FIFO ordering policy, and the other uses the Fair Sharing policy. A user submits three jobs to each queue one after another, waiting just long enough for each job to start. The first job uses 6x the resource limit in the queue, the second 4x, and last 2x.

- In the FIFO queue, the 6x job would start and run to completion, then the 4x job would start and run to completion, and then the 2x job. They would start and finish in the order 6x, 4x, 2x.
- In the Fair queue, the 6x job would start, then the 4x job, and then the 2x job. All three would run concurrently, with each using 1/3 of the available application resources. They would typically finish in the following order: 2x, 4x, 6x.

#### Ad Hoc Plus Batch Example

In this example, a job using 10x the queue resources is running. After the job is halfway complete, the same user starts a second job needing 1x the queue resources.

- In the FIFO queue, the 10x job will run until it no longer uses all queue resources (map phase complete, for example), and then the 1x job will start.
- In the Fair queue, the 1x job will start, run, and complete as soon as possible – picking up resources from the 10x job by attrition.

### Configure Queue Ordering Policies

You can configure the property for queue ordering policies (`yarn.scheduler.capacity.<queue-path>.ordering-policy`) to FIFO or Fair. The default setting is FIFO.

#### Procedure

1. In Cloudera Manager, select Clusters > YARN Queue Manager UI service. A list of existing queues is displayed.
2. Click on the three vertical dots on the queue you want to configure queue ordering policies and select the View/Edit Queue Properties option.
3. In the Queue Properties dialog-box, select the ordering policy as FIFO or Fair using the Ordering Policy drop-down box .
4. Click Save.

### Best Practices for Ordering Policies

You must consider factors related to applications and resource availability in queues while configuring ordering policies.

- Ordering policies are configured on a per-queue basis, with the default ordering policy set to FIFO. Fairness is usually best for on-demand, interactive, or exploratory workloads, while FIFO can be more efficient for predictable, recurring batch processing. You should segregate these different types of workloads into queues configured with the appropriate ordering policy.
- In queues supporting both large and small applications, large applications can potentially "starve" (not receive sufficient resources). To avoid this scenario, use different queues for large and small jobs, or use size-based weighting to reduce the natural tendency of the ordering logic to favor smaller applications.
- Use the Maximum AM Resource Limit scheduler property to restrict the number of concurrent applications running in the queue to avoid a scenario in which too many applications are running simultaneously. Limits on

each queue are directly proportional to their queue capacities and user limits. This property is specified as a float, for example: 0.5 = 50%. The default setting is 0.1=10%. This property can be set for all queues by setting the [Maximum AM Resource Limit](#) property at the root level, and can also be overridden on a per-queue basis by setting the [Maximum AM Resource LimitSet Application Master Resource Limit](#) on page 27 property at the queue level.

## Associate Node Labels with Queues

You can use Node labels to partition a cluster into sub-clusters so that jobs run on nodes with specific characteristics. You can use Node labels to run YARN applications on cluster nodes that have a specified node label.

### Before you begin

Before associating node labels, you must add node labels and assign node labels to cluster nodes. For more information about adding and assigning node labels see, [Configure node labels](#) on page 13 .

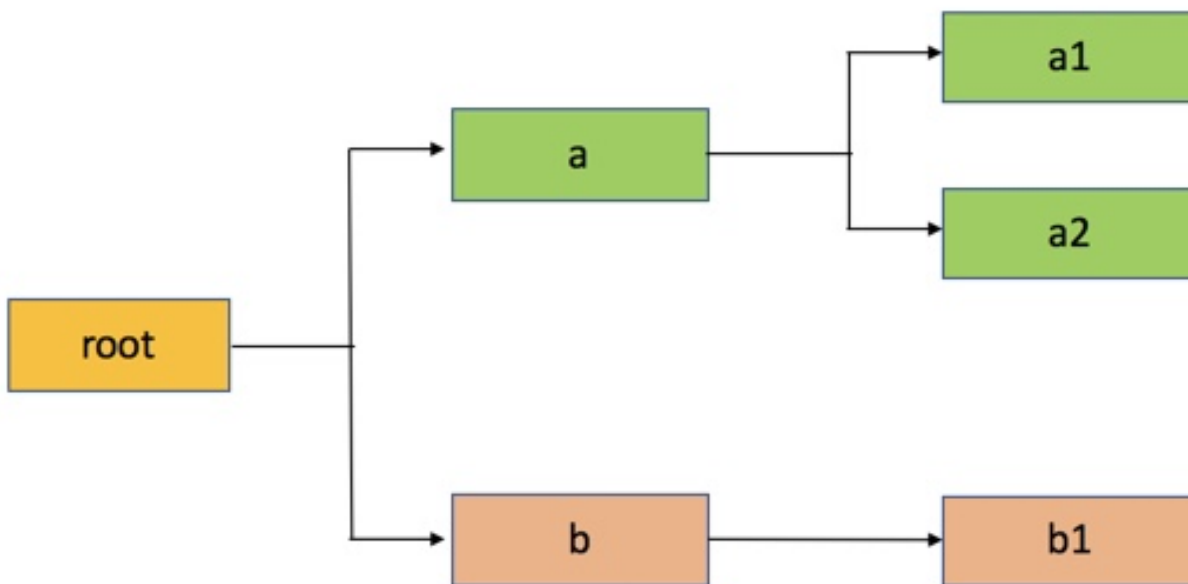
### About this task

After you create labels and assign node labels to cluster nodes, use the Queue Manager to assign node labels (`yarn.scheduler.capacity.<queue-path>.accessible-node-labels`) to queues and configure capacity to that queue for the specified label. You must specify capacity on each node label of each queue, and also ensure that the sum of capacities of each node-label of direct children of a parent queue at every level is equal to 100%. Node labels that a queue can access (accessible Node Labels of a queue) must be the same as, or a subset of, the accessible Node Labels of its parent queue.

### Example

Assume that a cluster has a total of 8 nodes. The first 3 nodes (n1-n3) have node label=x, the next 3 nodes (n4-n6) have node label=y, and the final 2 nodes (n7, n8) do not have any Node Labels. Each node can run 10 containers.

The queue hierarchy is as follows:



Assume that queue “a” can access Node Labels “x” and “y”, and queue “b” can only access node label “y”. By definition, nodes without labels can be accessed by all queues.

Consider the following example label configuration for the queues:

`capacity(a) = 40, capacity(a, label=x) = 100, capacity(a, label=y) = 50; capacity(b) = 60, capacity(b, label=y) = 50`

This means that:

- Queue “a” can access 40% of the resources on nodes without any labels, 100% of the resources on nodes with label=x, and 50% of the resources on nodes with label=y.
- Queue “b” can access 60% of the resources on nodes without any labels, and 50% of the resources on nodes with label=y.

You can also see that for this configuration:

$\text{capacity(a)} + \text{capacity(b)} = 100$

$\text{capacity(a, label=x)} + \text{capacity(b, label=x)}$  (b cannot access label=x, it is 0) = 100

$\text{capacity(a, label=y)} + \text{capacity(b, label=y)} = 100$

For child queues under the same parent queue, the sum of the capacity for each label should equal 100%.

Similarly, we can set the capacities of the child queues a1, a2, and b1:

a1 and a2:  $\text{capacity(a.a1)} = 40$ ,  $\text{capacity(a.a1, label=x)} = 30$ ,  $\text{capacity(a.a1, label=y)} = 50$   $\text{capacity(a.a2)} = 60$ ,  $\text{capacity(a.a2, label=x)} = 70$ ,  $\text{capacity(a.a2, label=y)} = 50$ ;

b1:  $\text{capacity(b.b1)} = 100$ ,  $\text{capacity(b.b1, label=y)} = 100$

You can see that for the a1 and a2 configuration:

$\text{capacity(a.a1)} + \text{capacity(a.a2)} = 100$

$\text{capacity(a.a1, label=x)} + \text{capacity(a.a2, label=x)} = 100$

$\text{capacity(a.a1, label=y)} + \text{capacity(a.a2, label=y)} = 100$

How many resources can queue a1 access?

Resources on nodes without any labels: Resource = 20 (total containers that can be allocated on nodes without a label, in this case n7, n8) \* 40% (a.capacity) \* 40% (a.a1.capacity) = 3.2 (containers)

Resources on nodes with label=x

Resource = 30 (total containers that can be allocated on nodes with label=x, in this case n1-n3) \* 100% (a.labelx.capacity) \* 30% = 9 (containers)

To implement this example configuration, perform the following

1. In Cloudera Manager, select Clusters > YARN Queue Manager UI service. A graphical queue hierarchy is displayed in the Overview tab.
2. Click on the three vertical dots on a queue and select the View/Edit Queue Properties option.

3. In the Queue Properties dialog-box , select the x label from the Accessible Node Labels drop-down box, click +, again select the y label from the Accessible Node Labels drop-down box and click Save.

## Queue Properties ✕

root.a

Queue Permissions ^

Submit Application ACL

Queue Administer ACL

Ordering Policy ^

Ordering Policy

Utilization

Node Labels ^

Accessible Node Labels

Select  
Default  
All  
None  
✓ x  
y

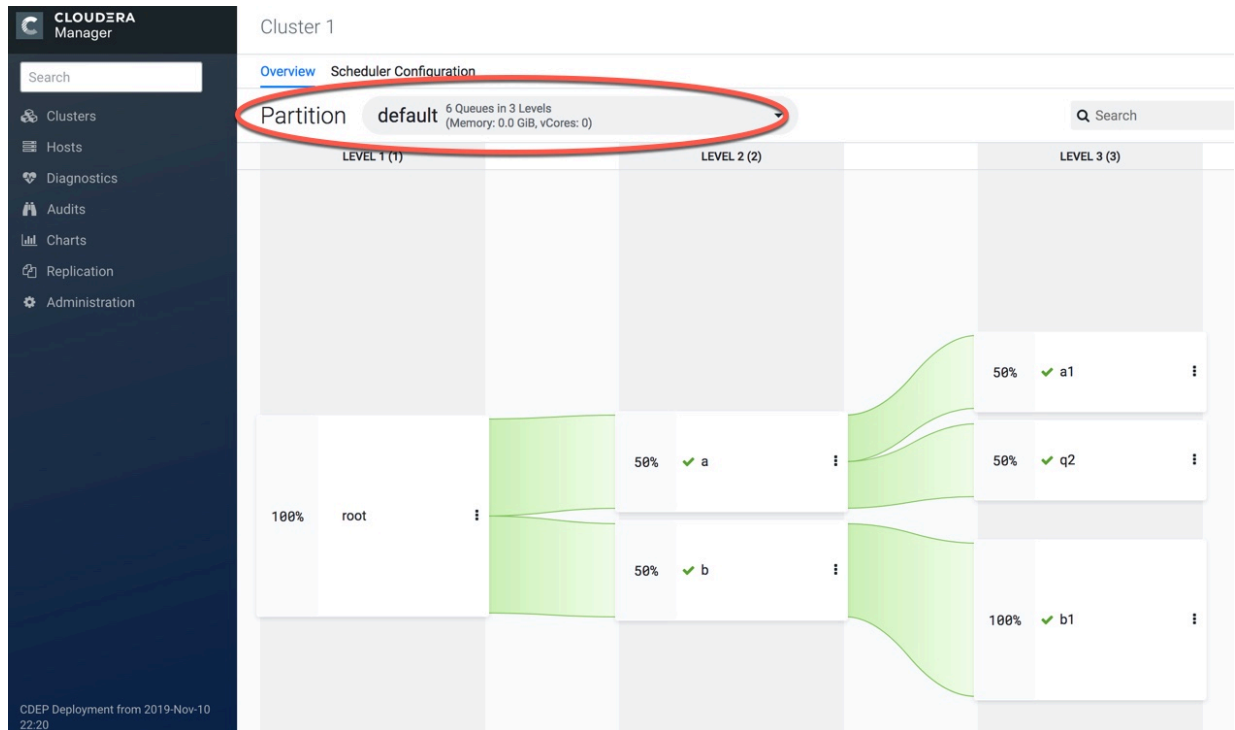
+

Cancel

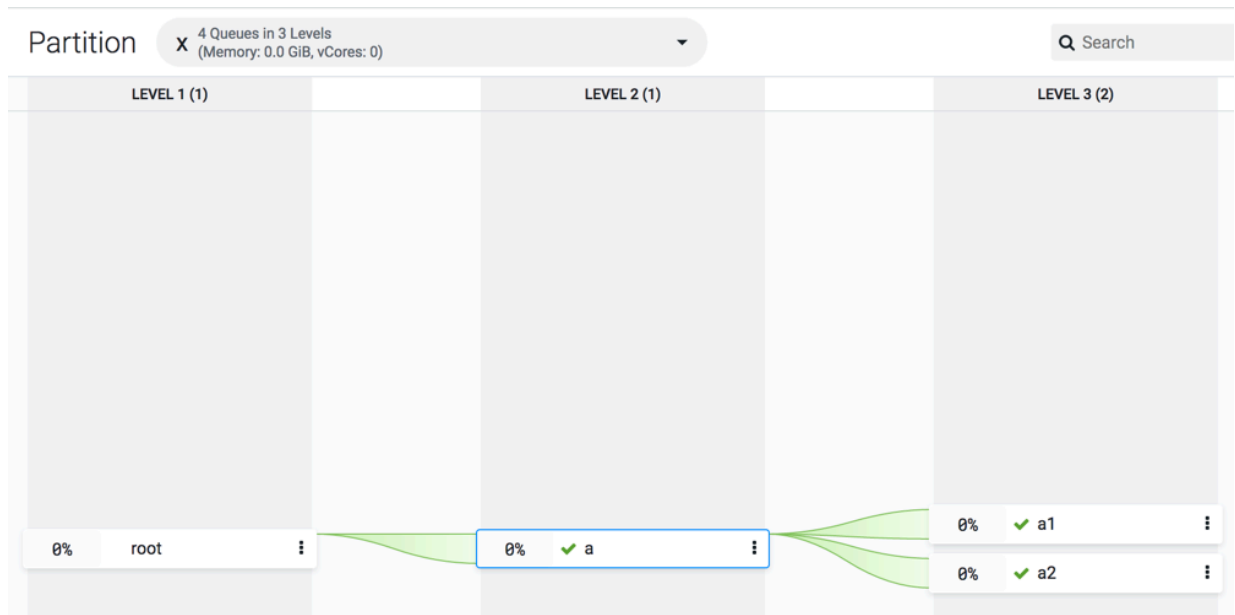
Save

4. Repeat the above steps to assign x label for a1 and a2 queues.
5. Click on the three vertical dots on b queue and select the View/Edit Queue Properties option.
6. In the Queue Properties dialog-box, select the y label from the Accessible Node Labels drop-down box, click +, and click Save.
7. Repeat the above steps to assign y label for b1, a, a1, and a2 queue.

8. In the Overview tab, click on the Partition drop-down box and select label x.

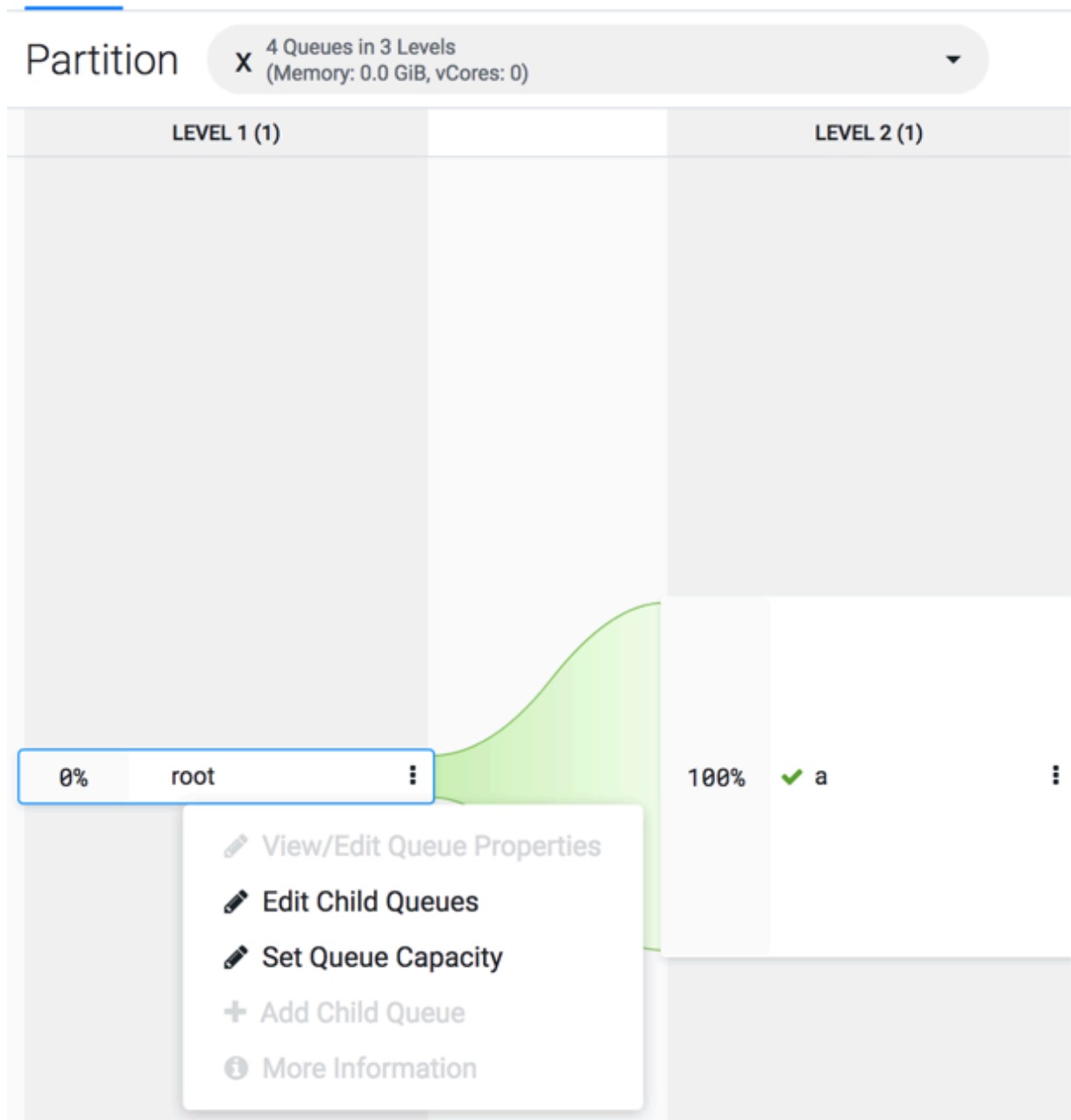


9. Click on the three vertical dots on the a queue and select the Edit Child Queues option.



10. Enter the Configured Capacity of a1 to 40 and a2 to 60.  
 11. Click on the three vertical dots on the root queue and select the Edit Child Queues option.  
 12. Enter the Configured Capacity of a to 100 and Click Save.

13. Click on the three vertical dots on the root queue and select the Set Queue Capacity option.



14. In the Overview tab, click on the Partition drop-down box and select label y.

15. Click on the three vertical dots on the a queue and select the Edit Child Queues option.

16. Enter the Configured Capacity of a1 to 50 and a2 to 50 and Click Save.

17. Click on the three vertical dots on the b queue and select the Edit Child Queues option.

18. Enter the Configured Capacity of b1 to 100 and Click Save.

19. Click on the three vertical dots on the root queue and select the Edit Child Queues option.

20. Enter the Configured Capacity of a to 50 and b to 50 and Click Save.

21. Click on the three vertical dots on the root queue and select the Set Queue Capacity option.

## Application Reservations

For a resource-intensive application, the Capacity Scheduler creates a reservation on a cluster node if the node's free capacity can meet the particular application's requirements. This ensures that the resources are utilized only by that particular application until the application reservation is fulfilled.

The Capacity Scheduler is responsible for matching free resources in the cluster with the resource requirements of an application. Many times, a scheduling cycle occurs such that even though there are free resources on a node, they are not sized large enough to satisfy the application waiting for a resource at the head of the queue. This typically happens with high-memory applications whose resource demand for Containers is much larger than the typical application running in the cluster. This mismatch can lead to starving these resource-intensive applications.

The Capacity Scheduler reservations feature addresses this issue as follows:

- When a node reports in with a finished Container, the Capacity Scheduler selects an appropriate queue to utilize the newly available resources based on capacity and maximum capacity settings.
- Within that selected queue, the Capacity Scheduler looks at the applications in a FIFO order along with the user limits. Once a needy application is found, the Capacity Scheduler tries to see if the requirements of that application can be met by the node's free capacity.
- If there is a size mismatch, the Capacity Scheduler immediately creates a reservation on the node for the application's required Container.
- Once a reservation is made for an application on a node, those resources are not used by the Capacity Scheduler for any other queue, application, or Container until the application reservation is fulfilled.
- The node on which a reservation is made reports back when enough Containers finish running such that the total free capacity on the node now matches the reservation size. When that happens, the Capacity Scheduler marks the reservation as fulfilled, removes it, and allocates a Container on the node.
- In some cases another node fulfills the resources required by the application, so the application no longer needs the reserved capacity on the first node. In this situation, the reservation is simply cancelled.

To prevent the number of reservations from growing in an unbounded manner, and to avoid any potential scheduling deadlocks, the Capacity Scheduler maintains only one active reservation at a time on each node.

## Resource Distribution Workflow

During scheduling, queues at any level in the hierarchy are sorted in the order of their current used capacity, and the available resources are distributed among them starting with queues that are currently the most under-served.

With respect to capacities alone, the resource scheduling has the following workflow:

- The more under-served a queue is, the higher the priority it receives during resource allocation. The most under-served queue is the queue with the least ratio of used capacity as compared to the total cluster capacity.
  - The used capacity of any parent queue is defined as the aggregate sum of used capacity of all of its descendant queues, recursively.
  - The used capacity of a leaf queue is the amount of resources used by the allocated Containers of all of the applications running in that queue.
- Once it is decided to give a parent queue the currently available free resources, further scheduling is done recursively to determine which child queue gets to use the resources -- based on the previously described concept of used capacities.
- Further scheduling happens inside each leaf queue to allocate resources to applications in a FIFO order.
  - This is also dependent on locality, user level limits, and application limits.
  - Once an application within a leaf queue is chosen, scheduling also happens within the application. Applications may have different priorities of resource requests.
- To ensure elasticity, capacity that is configured but not utilized by any queue due to lack of demand is automatically assigned to the queues that are in need of resources.



## Resource Distribution Process - Example

To understand the resource distribution workflow, consider the example of a 100-node cluster, each with 10 GB of memory allocated for YARN containers, for a total cluster capacity of 1000 GB (1 TB).

According to the previously described configuration, the "engineering" organization is assigned 60% of the cluster capacity, i.e., an absolute capacity of 600 GB. Similarly, the "support" organization is assigned 100 GB, and the "marketing" organization gets 300 GB.

Under the "engineering" organization, capacity is distributed between the "development" team and the "qa" team in a 1:4 ratio. So "development" gets 120 GB, and 480 GB is assigned to "qa".

Now consider the following timeline of events:

- Initially, the entire "engineering" queue is free with no applications running, while the "support" and "marketing" queues are utilizing their full capacities.
- Users Sid and Hitesh first submit applications to the "development" leaf queue. Their applications are elastic and can run with either all of the resources available in the cluster, or with a subset of cluster resources (depending upon the state of the resource-usage).
  - Even though the "development" queue is allocated 120 GB, Sid and Hitesh are each allowed to occupy 120 GB, for a total of 240 GB.
  - This can happen despite the fact that the "development" queue is configured to be run with a capacity of 120 GB. Capacity Scheduler allows elastic sharing of cluster resources for better utilization of available cluster resources. Since there are no other users in the "engineering" queue, Sid and Hitesh are allowed to use the available free resources.
- Next, users Jian, Zhijie and Xuan submit more applications to the "development" leaf queue. Even though each is restricted to 120 GB, the overall used capacity in the queue becomes 600 GB -- essentially taking over all of the resources allocated to the "qa" leaf queue.
- User Gupta now submits an application to the "qa" queue. With no free resources available in the cluster, the user's application must wait.
  - Given that the "development" queue is utilizing all of the available cluster resources, Gupta may or may not be able to immediately get back the guaranteed capacity of his "qa" queue -- depending upon whether or not preemption is enabled.
- As the applications of Sid, Hitesh, Jian, Zhijie, and Xuan finish running and resources become available, the newly available Containers will be allocated to Gupta's application.

This will continue until the cluster stabilizes at the intended 1:4 resource usage ratio for the "development" and "qa" queues.

From this example, you can see that it is possible for abusive users to submit applications continuously, and thereby lock out other queues from resource allocation until Containers finish running or get preempted. To avoid this scenario, Capacity Scheduler supports limits on the elastic growth of any queue. For example, you can restrict the "development" queue from monopolizing the "engineering" queue capacity by setting the maximum capacity property.

To set the maximum capacity property based on this example, perform the following:

1. In Cloudera Manager, select Clusters > YARN Queue Manager UI service. A list of existing queues is displayed.
2. Click on the three vertical dots on the development queue and select Edit Child Queues option.
3. Enter 40 in the Configured Value field.
4. Click Save.

Once this is set, users of the "development" queue can still go beyond their capacity of 120 GB, but they will not be allocated any more than 40% of the "engineering" parent queue's capacity (i.e., 40% of 600 GB = 240 GB).

The capacity and maximum-capacity properties can be used to control sharing and elasticity across the organizations and sub-organizations utilizing a YARN cluster. Administrators should balance these properties to avoid strict limits that result in a loss of utilization, and to avoid excessive cross-organization sharing.

## Start and Stop Queues

Queues in YARN can be in two states: `RUNNING` or `STOPPED`. A `RUNNING` state indicates that a queue can accept application submissions, and a `STOPPED` queue does not accept application submissions. The default state of any configured queue is `RUNNING`.

In Capacity Scheduler, parent queues and leaf queues can be stopped. For an application to be accepted at any leaf queue, all the queues in the hierarchy all the way up to the root queue must be running. This means that if a parent queue is stopped, all of the descendant queues in that hierarchy are inactive, even if their own state is `RUNNING`.

### To stop a queue:

1. In Cloudera Manager, select **Clusters > YARN Queue Manager UI service**. A graphical queue hierarchy is displayed in the Overview tab.
2. Click on the three vertical dots on the queue and select **Stop Queue**.
3. You will be prompted for a confirmation. Click **OK** to stop the queue.

### To start a queue:

1. In Cloudera Manager, select **Clusters > YARN Queue Manager UI service**. A graphical queue hierarchy is displayed in the Overview tab.
2. Click on the three vertical dots on the queue and select **Start Queue**.
3. You will be prompted for a confirmation. Click **OK** to start the queue.

Administrators can use the ability to stop and drain applications in a queue for a number of reasons, such as when decommissioning a queue and migrating its users to other queues. Administrators can stop queues at run-time, so that while current applications run to completion, no new applications are accepted. Existing applications can continue until they finish running, and thus the queue can be drained gracefully without any end-user impact.

## Delete Queues

You must first stop the queue before deleting the queue. You can delete a single queue and also parent queue and its children if all the queues in the hierarchy are stopped.

In Capacity Scheduler, parent queues, child queues, and the root queue can all be stopped. For an application to be accepted at any child queue, all the queues in the hierarchy all the way up to the root queue must be running. This means that if a parent queue is stopped, all of the descendant queues in that hierarchy are inactive, even if their own state is `RUNNING`.

1. In Cloudera Manager, select **Clusters > YARN Queue Manager UI service**. A graphical queue hierarchy is displayed in the Overview tab.
2. Click on the three vertical dots on the queue and select **Delete Queue**.

You can use the **Delete Queues and its Children** option to delete both parent queue and its children queues.

3. You will be prompted for a confirmation. Click **OK** to stop the queue.