

MySQL Cluster

Document Status

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Starting and stopping the cluster	Done	Stopping and Starting the Cluster
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Presentation

MySQL Cluster is a high availability solution for MySQL which:

- uses a clustered database engine called NDBCLUSTER or simply NDB. The commands used to manipulate the NDB engine data can be found [here](#),
- uses a different mysqld binary than that used by the standard MySQL,
- is compatible with Red Hat, Debian, SUSE, Oracle Linux, Mac OSX, Microsoft™ Windows®, Solaris and generic Linux - see [this link](#),
- can be downloaded from [this link](#),

The cluster contains several different types of nodes also called services:

Node	Short Name	Service	Function
Cluster Management Server Node	MGM node	ndb_mgmd	Contains the configuration data, starts and stops the cluster and performs backups
MySQL Server node	SQL node or API node	mysqld	Access the cluster data via mysqld with options -ndbcluster and -ndb-connectstring

Node	Short Name	Service	Function
Data node	S/O	ndbd	contain the cluster data



It is possible to have several types of nodes (services) installed on the same physical or virtual host. In this case we refer to a **cluster host**. However it is not a good idea to have several instances of the ndbd service on the **same** host.

Each node in the cluster obtains its configuration from the Cluster Management node. This node is also responsible for logging.

When the configuration is changed a *rolling restart* is initiated where each node is restarted, one after the other.

When data is saved to disk, we refer to a **checkpoint** :

- **Local Checkpoint** (LCP): Data is saved on the Data node's disk.
- **Global Checkpoint** (GCP): Transactions are synchronised on all disks.

High Availability

In a cluster with 4 Data nodes and 1 replica or copy the number of node groups is 4. This configuration is not recommended since high availability is not achieved.

In a cluster with 4 Data nodes and 2 replicas or copies the number of node groups is 2. This configuration is recommended to ensure high availability.

Node groups are formed automatically. The two lowest Data node IDs form the first group followed by the next two. For example if there are four data nodes with IDs 1,2,3 and 4 respectively and 2 replicas, the first node group will contain data node 1 and data node 2 whilst the second group will contain data node 3 and data node 4.

<note important> Each node group must have the same number of nodes. </note>

Data is partitioned into as many partitions as there are nodes.

Each node in a node group stores a **replica** (a copy of a partition). There are therefore as many replicas as there are nodes within the node group.



High availability is ensured as long as at least one node per node group is up.



Installation

Using a clean CentOS VM, create a full clone called **node1** using one processor and 512MB of RAM.

Attach a second .vmdk 2GB hard disk to the SATA controller of the **node1** VM, Call this disk **cluster**. Boot up the VM and create a partition on /dev/sdb :

```
[root@centos ~]# fdisk /dev/sdb
Device contains neither a valid DOS partition table, nor Sun, SGI or OSF disklabel
Building a new DOS disklabel with disk identifier 0xa6de8f27.
Changes will remain in memory only, until you decide to write them.
After that, of course, the previous content won't be recoverable.

Warning: invalid flag 0x0000 of partition table 4 will be corrected by w(rite)

WARNING: DOS-compatible mode is deprecated. It's strongly recommended to
switch off the mode (command 'c') and change display units to
sectors (command 'u').

Command (m for help): n
Command action
   e   extended
   p   primary partition (1-4)
p
Partition number (1-4): 1
First cylinder (1-261, default 1):
Using default value 1
```

```
Last cylinder, +cylinders or +size{K,M,G} (1-261, default 261):  
Using default value 261
```

```
Command (m for help): w  
The partition table has been altered!
```

```
Calling ioctl() to re-read partition table.  
Syncing disks.
```

Now create an Ext4 filesystem on /dev/sdb1 :

```
[root@centos ~]# mkfs.ext4 /dev/sdb1  
mke2fs 1.41.12 (17-May-2010)  
Filesystem label=  
OS type: Linux  
Block size=4096 (log=2)  
Fragment size=4096 (log=2)  
Stride=0 blocks, Stripe width=0 blocks  
131072 inodes, 524112 blocks  
26205 blocks (5.00%) reserved for the super user  
First data block=0  
Maximum filesystem blocks=536870912  
16 block groups  
32768 blocks per group, 32768 fragments per group  
8192 inodes per group  
Superblock backups stored on blocks:  
    32768, 98304, 163840, 229376, 294912  
  
Writing inode tables: done  
Creating journal (8192 blocks): done  
Writing superblocks and filesystem accounting information: done  
  
This filesystem will be automatically checked every 37 mounts or
```

180 days, whichever comes first. Use `tune2fs -c` or `-i` to override.

Mount `/dev/sdb1` on `/cluster` and edit `/etc/fstab` accordingly :

```
[root@redhat ~]# mkdir /cluster
[root@centos ~]# mount /dev/sdb1 /cluster
[root@centos ~]# blkid /dev/sdb1
/dev/sdb1: UUID="52a48f95-1310-4321-a217-0efb3365247e" TYPE="ext4"
[root@centos ~]# vi /etc/fstab
```

```
#
# /etc/fstab
# Created by anaconda on Fri Oct 25 09:32:46 2013
#
# Accessible filesystems, by reference, are maintained under '/dev/disk'
# See man pages fstab(5), findfs(8), mount(8) and/or blkid(8) for more info
#
UUID=c7b1d3e8-6471-4cba-947b-430db974e774 / ext4 defaults 1 1
UUID=d8988475-7dc7-4a61-8081-6153b7c9551b /boot ext4 defaults 1 2
UUID=a1d6a043-6f10-4f60-bb9c-aaaac9632c57 swap swap defaults 0 0
UUID=52a48f95-1310-4321-a217-0efb3365247e /cluster ext4 defaults 0 0
tmpfs /dev/shm tmpfs defaults 0 0
devpts /dev/pts devpts gid=5,mode=620 0 0
sysfs /sys sysfs defaults 0 0
proc /proc proc defaults 0 0
```

Now download the tarball **mysql-cluster-gpl-7.4.4-linux-glibc2.5-i686.tar.gz** from [this URL](#) and move it to `/cluster`. Untar the tarball and rename the directory to **mysql_cluster** :

```
[root@centos ~]# mv /home/trainee/Download/mysql-cluster-gpl-7.4.4-linux-glibc2.5-i686.tar.gz /cluster
[root@centos ~]# cd /cluster
[root@centos cluster]# ls
lost+found mysql-cluster-gpl-7.4.4-linux-glibc2.5-i686.tar.gz
[root@centos cluster]# tar xf mysql-cluster-gpl-7.4.4-linux-glibc2.5-i686.tar.gz
```

```
[root@centos cluster]# rm -rf mysql-cluster-gpl-7.4.4-linux-glibc2.5-i686.tar.gz
[root@centos cluster]# mv mysql-cluster-gpl-7.4.4-linux-glibc2.5-i686/ mysql_cluster
```

To facilitate our study of MySQL Cluster, we are going to remove anything that could cause problems. Firstly stop iptables and remove it using chkconfig :

```
[root@centos cluster]# service iptables stop
iptables: Setting chains to policy ACCEPT: filter      [ OK ]
iptables: Flushing firewall rules:                    [ OK ]
iptables: Unloading modules:                          [ OK ]
[root@centos cluster]# chkconfig --del iptables
```

Then put SELinux into permissive mode by editing **/etc/selinux/config** :

```
[root@centos cluster]# vi /etc/selinux/config
[root@centos cluster]# cat /etc/selinux/config

# This file controls the state of SELinux on the system.
# SELINUX= can take one of these three values:
#   enforcing - SELinux security policy is enforced.
#   permissive - SELinux prints warnings instead of enforcing.
#   disabled - No SELinux policy is loaded.
SELINUX=permissive
# SELINUXTYPE= can take one of these two values:
#   targeted - Targeted processes are protected,
#   mls - Multi Level Security protection.
SELINUXTYPE=targeted
```

Stop the VM and create 3 full clones as follows, each having **two** network interfaces. The first should be natted whilst the second should be in an internal network called **intnet**. Do NOT reinitialize the MAC address of each eth0 :

Clone	RAM
Node2	512 MB
Node3	1500 MB

Clone	RAM
Node4	1500 MB

Add a second network interface to node1 and put it into the intnet network.

Boot node1, node2, node3 and node4. Change the **/etc/inittab** file on node2, node3 and node4 so that they start up in runlevel 3. Configure eth1 as 192.168.22.105, 192.168.22.106, 192.168.22.107 et 192.68.22.108 respectively in each node. Make sure sshd is started on each node.

Open a terminal on node1 and type **/cluster/mysql_cluster/bin/ndb_setup.py**:

```
[root@node1 ~]# /cluster/mysql_cluster/bin/ndb_setup.py
Running out of install dir: /cluster/mysql_cluster/bin
Starting web server on port 8081
deathkey=433749
The application should now be running in your browser.
(Alternatively you can navigate to http://localhost:8081/welcome.html to start it)
```

In your browser, navigate to: <http://localhost:8081/welcome.html>:

The screenshot shows a web browser window titled "MySQL Cluster - Mozilla Firefox" displaying the "ORACLE MySQL Cluster Installer" page. The browser's address bar shows "localhost:8081/welcome.html". The page features a large blue background with the MySQL logo and a white box containing the following text:

Welcome to MySQL Cluster

This tool will aid cluster configuration. Please select an option below by clicking the appropriate icon.

Create New MySQL Cluster

Choose this option when you create your first MySQL Cluster configuration, or if you want to start from scratch.

Continue Previous Cluster Configuration

Continue working on the previous MySQL Cluster configuration.

The browser's taskbar at the bottom shows a terminal window with "root@node1:~" and the browser window.

Click on the link **Create New MySQL Cluster** and then fill in the top as follows:

Applications Places System **trainee** Sat Feb 28, 11:22 AM

Browse and run installed applications **MySQL Cluster - Mozilla Firefox**

MySQL Cluster

localhost:8081/content.html Google

ORACLE MySQL Cluster Installer

Define cluster > Define hosts > Define processes > Define parameters > Deploy configuration Settings ▾ Help ▾

Cluster Type and SSH Credentials

MySQL Cluster is able to operate in various configurations. Please specify the settings below to define the right cluster type that fits your use case. If you intend to use remote hosts for deploying MySQL Cluster, SSH must be enabled. Unless key based SSH is possible, you must submit your user name and password below.

Cluster property	Value
Cluster name [?]	MyCluster
Host list [?]	05,192.168.22.106,192.168.22.107,192.168.22.108
Application area [?]	simple testing ▾
Write load [?]	medium ▾

Previous Next Finish

root@node1: ~ MySQL Cluster - Mozill...

At the bottom of the page, untick **Key based SSH**, and input **root** and **fenestros**. Click on the **Next** button:

Applications Places System **trainee** Sat Feb 28, 11:29 AM

Browse and run installed applications **MySQL Cluster - Mozilla Firefox**

MySQL Cluster ✕ +

localhost:8081/content.html Google

ORACLE MySQL Cluster Installer

Define cluster > Define hosts > Define processes > Define parameters > Deploy configuration Settings Help

Cluster Type and SSH Credentials

MySQL Cluster is able to operate in various configurations. Please specify the settings below to define the right cluster type that fits your use case. If you intend to use remote hosts for deploying MySQL Cluster, SSH must be enabled. Unless key based SSH is possible, you must submit your user name and password below.

Write load [?] medium

SSH property	Value
Key based SSH [?]	<input type="checkbox"/>
User name [?]	root
Password [?]

Password for ssh login to the hosts running MySQL Cluster.

Previous Next Finish

root@node1: ~ MySQL Cluster - Mozill...

Your nodes should automatically be detected:

Define cluster > Define hosts > Define processes > Define parameters > Deploy configuration

Select and Edit Hosts

MySQL Cluster can be deployed on several hosts. Please select the desired hosts by pressing the *Add host* button below and enter a comma separated list of host names or ip addresses. Resource information is automatically retrieved from the added host if this is checked in the settings menu, and if the required SSH credentials have been submitted. When a host has been added, the corresponding information can be edited by double clicking a cell in the grid. If you want to apply the same changes to several hosts, multiple rows can be selected and the *Edit selected host(s)* button can be pressed, which shows a dialog where the editing can be done. Hosts can be deleted by selecting the corresponding rows in the table and pressing the *Remove selected host(s)* button. If a host is removed, processes configured to run on that host will also be removed from the configuration.

Host	Resource info	Platform	Memory (MB)	CPU cores	MySQL Cluster install directory	MySQL Cluster data directory
192.168.22.105	OK	Linux	370	1	/usr/local/bin/	/root/MySQL_Cluster/
192.168.22.106	OK	Linux	370	1	/usr/local/bin/	/root/MySQL_Cluster/

+ Add host ✖ Remove selected host(s) ✎ Edit selected host(s)

◀ Previous ▶ Next ▶ Finish

Change the directories as shown below for **all** the nodes and click on the **Next** button:

Define cluster > Define hosts > Define processes > Define parameters > Deploy configuration Settings ▾ Help ▾

Select and Edit Hosts

MySQL Cluster can be deployed on several hosts. Please select the desired hosts by pressing the *Add host* button below and enter a comma separated list of host names or ip addresses. Resource information is automatically retrieved from the added host if this is checked in the settings menu, and if the required SSH credentials have been submitted. When a host has been added, the corresponding information can be edited by double clicking a cell in the grid. If you want to apply the same changes to several hosts, multiple rows can be selected and the *Edit selected host(s)* button can be pressed, which shows a dialog where the editing can be done. Hosts can be deleted by selecting the corresponding rows in the table and pressing the *Remove selected host(s)* button. If a host is removed, processes configured to run on that host will also be removed from the configuration.

Host	Resource info	Platform	Memory (MB)	CPU cores	MySQL Cluster install directory	MySQL Cluster data directory
192.168.22.105	OK	Linux	370	1	/cluster/mysql_cluster/	/cluster/MySQL_Cluster/
192.168.22.106	OK	Linux	370	1	/cluster/mysql_cluster/	/cluster/MySQL_Cluster/

+ Add host ✗ Remove selected host(s) ✎ Edit selected host(s)

◀ Previous ▶ Next ▶▶ Finish

Examine the physical topology of the cluster. Note how the installer has set up the high availability. Since we do not need them for this LAB, delete the API services and click on **Next** :

Applications Places System trainee Sat Feb 28, 11:34 AM

Browse and run installed applications MySQL Cluster - Mozilla Firefox

MySQL Cluster localhost:8081/content.html Google

ORACLE MySQL Cluster Installer

Define cluster > Define hosts > Define processes > Define parameters > Deploy configuration Settings Help

Define Processes and Cluster Topology

Various processes may be part of a MySQL Cluster configuration. Please refer to the [MySQL Cluster Documentation](#) for a description of the different process types. If you have added hosts previously, a default configuration will be suggested the first time you enter this page. This configuration may be modified by moving processes between hosts by drag and drop, or by adding and removing processes. You may also go back to the previous page and add more hosts before editing the topology. The special entry labelled *Any host* in the tree below represents an arbitrary host. On this special tree entry, only *API* processes can be moved or added. These processes will not be required to run on a particular host, but may execute anywhere.

MyCluster topology	Process property	Value
☆ Any host	Process name [?]	Management node 1
192.168.22.105	Process type [?]	Management node
Management node 1		

Add process Delete process

Previous Next Finish

root@node1:~ MySQL Cluster - Mozill...

Note that each node or service is associated with a node number. Examine the services and click on **Next** :

Applications Places System **trainee** Sat Feb 28, 11:37 AM

Browse and run installed applications **MySQL Cluster - Mozilla Firefox**

MySQL Cluster

localhost:8081/content.html Google

ORACLE MySQL Cluster Installer

Define cluster > Define hosts > Define processes > **Define parameters** > Deploy configuration Settings ▾ Help ▾

Define Processes Parameters

The processes in your MySQL Cluster configuration can be tuned by setting a number of configuration parameters. Please refer to the [MySQL Cluster Documentation](#) for a description of the different process parameters. This page allows you to define a subset of the configuration parameters. Below, you will see your processes to the left grouped by process type. If you select a process type entry in the tree, you may set parameters that will be applied to all instances of that process. However, if you want to set a parameter specifically for one process, you may do so by selecting the process instance in the tree and set the desired parameter. This tool suggests predefined settings for the different parameters based on the hardware resources and the cluster topology. The predefined settings may be overridden by pressing the *Override* button to the very right of the configuration parameter. If you want to cancel your setting, you may revert to the predefined value by pressing the *Revert* button which shows up when a parameter is overridden.

Process property	Value	Override
NodId [?]	49	
HostName [?]	192.168.22.105	
DataDir [?]	/cluster/MySQL_Cluster/49/	

MyCluster processes

- Management layer
 - Management node 1**

Show advanced configuration options

Previous Next Finish

root@node1:~ MySQL Cluster - Mozill...

Now click on **Deploy cluster**:

The screenshot shows a Mozilla Firefox browser window titled "MySQL Cluster - Mozilla Firefox" with the address bar set to "localhost:8081/content.html". The page content is the "ORACLE MySQL Cluster Installer" interface, specifically the "Deploy configuration" step. The breadcrumb navigation shows: "Define cluster > Define hosts > Define processes > Define parameters > Deploy configuration".

The main heading is "Deploy Configuration and start MySQL Cluster". Below it, a paragraph explains that the MySQL Cluster configuration can be reviewed, and users can select a process to view its startup command and configuration file. It notes that starting the cluster may take up to several minutes. A legend indicates process status icons: a gear for "unknown", a green circle for "connected or started", a yellow circle for "starting or shutting down", and a red circle for "not connected or stopped".

The interface features a "MyCluster processes" tree on the left with "Management layer" expanded to show "Management node 1". To the right, the "Startup command" and "Configuration file" fields are visible. The "Configuration file" field shows a path: "192.168.22.100 /cluster/MySQL_Cluster/40/". Below the tree, there are three buttons: "Deploy cluster", "Deploy and start cluster", and "Stop cluster". At the bottom right, there are "Previous", "Next", and "Finish" navigation buttons.

The browser's taskbar at the bottom shows the terminal window "root@node1: ~" and the browser window "MySQL Cluster - Mozill...".

Deploying the cluster can take upto 30 minutes:

Applications Places System trainee Sat Feb 28, 11:38 AM

Browse and run installed applications MySQL Cluster - Mozilla Firefox

MySQL Cluster localhost:8081/content.html Google

ORACLE MySQL Cluster Installer

Define cluster > Define hosts > Define processes > Define parameters > Deploy configuration Settings Help

Deploy Configuration and start MySQL Cluster

Your MySQL Cluster configuration can be reviewed below. To the left are the processes you have defined, ordered by their startup sequence. Please select a process to view its startup command(s) and configuration file. Note that some processes do not have configuration files. At the bottom of the center panel, there are buttons to *Deploy*, *Start* and *Stop* your cluster. Please note that starting the cluster may take up to several minutes depending on the configuration you have defined. In the process tree, the icons reflect the status of the process as reported by the management daemon: : *unknown* or if the management daemon does not reply, : *connected* or *started*, : *starting* or *shutting down*, and : *not connected* or *stopped*.

Deploying configuration

Creating directories

4%

MyCluster processes

- Management layer
- Management node 1

Deploy cluster Deploy and start cluster Stop cluster

Configuration file

Host 192.168.22.100

Path /cluster/MySQL_Cluster/40/

Previous Next Finish

root@node1:~ MySQL Cluster - Mozill...

Once the deployment has finished, you should see the following message:

Applications Places System trainee Sat Feb 28, 2:45 PM

Browse and run installed applications MySQL Cluster - Mozilla Firefox

MySQL Cluster Problem loading page

localhost:8081/content.html

ORACLE MySQL Cluster Installer

Define cluster > Define hosts > Define processes > Define parameters > Deploy configuration Settings Help

Deploy Configuration and start MySQL Cluster

Your MySQL Cluster configuration can be reviewed below. To the left are the processes that are part of the cluster. Some processes do not have configuration files. At the bottom of the center panel, you can see the configuration you have defined. In the process tree, the icons reflect the status of the processes: a green circle indicates that the process is starting or shutting down, and a red circle indicates that the process is not connected or stopped.

Select a process to view its startup command(s) and configuration file. Note that starting the cluster may take up to several minutes depending on the size of the cluster or if the management daemon does not reply, ● : connected or started, ● : not connected or stopped.

MyCluster processes

- Management layer
- Management node 1

Start 100%

Configuration file

Deploy cluster Deploy and start cluster Stop cluster

Previous Next Finish

root@node1:~ MySQL Cluster - Mozill...

Cluster Configuration

The cluster configuration is held in the `/cluster/MySQL_Cluster/` directory. The following shows the contents of the node1 host's configuration directory:

```
[root@node1 ~]# ls -lR /cluster/MySQL_Cluster/
/cluster/MySQL_Cluster/:
total 12
drwxr-xr-x. 2 root root 4096 Feb 28 14:42 49
drwxr-xr-x. 5 root root 4096 Feb 28 14:42 55
drwxr-xr-x. 5 root root 4096 Feb 28 14:42 56

/cluster/MySQL_Cluster/49:
total 4
-rw-r--r--. 1 root root 1426 Feb 28 14:42 config.ini

/cluster/MySQL_Cluster/55:
total 16
-rw-r--r--. 1 root root 346 Feb 28 14:42 my.cnf
drwxr-xr-x. 2 root root 4096 Feb 28 14:20 mysql
drwxr-xr-x. 2 root root 4096 Feb 28 14:19 test
drwxr-xr-x. 2 root root 4096 Feb 28 14:22 tmp

/cluster/MySQL_Cluster/55/mysql:
total 0

/cluster/MySQL_Cluster/55/test:
total 0

/cluster/MySQL_Cluster/55/tmp:
total 0

/cluster/MySQL_Cluster/56:
total 16
-rw-r--r--. 1 root root 346 Feb 28 14:42 my.cnf
drwxr-xr-x. 2 root root 4096 Feb 28 14:26 mysql
drwxr-xr-x. 2 root root 4096 Feb 28 14:24 test
drwxr-xr-x. 2 root root 4096 Feb 28 14:27 tmp
```

```
/cluster/MySQL_Cluster/56/mysql:
total 0

/cluster/MySQL_Cluster/56/test:
total 0

/cluster/MySQL_Cluster/56/tmp:
total 0
```

<note important> In the above example, we can see the configuration directories of the Cluster Management node (**49**) and the two Cluster SQL node (**55** and **56**). </note>

Node2's configuration is identical to that of node1, with the exception of the directory numbers:

```
[root@node2 ~]# ls -lR /cluster/MySQL_Cluster/
/cluster/MySQL_Cluster/:
total 12
drwxr-xr-x. 2 root root 4096 Feb 28 14:42 52
drwxr-xr-x. 5 root root 4096 Feb 28 14:42 57
drwxr-xr-x. 5 root root 4096 Feb 28 14:42 58

/cluster/MySQL_Cluster/52:
total 4
-rw-r--r--. 1 root root 1426 Feb 28 14:42 config.ini

/cluster/MySQL_Cluster/57:
total 16
-rw-r--r--. 1 root root 346 Feb 28 14:42 my.cnf
drwxr-xr-x. 2 root root 4096 Feb 28 14:31 mysql
drwxr-xr-x. 2 root root 4096 Feb 28 14:30 test
drwxr-xr-x. 2 root root 4096 Feb 28 14:32 tmp

/cluster/MySQL_Cluster/57/mysql:
total 0
```

```
/cluster/MySQL_Cluster/57/test:
total 0

/cluster/MySQL_Cluster/57/tmp:
total 0

/cluster/MySQL_Cluster/58:
total 16
-rw-r--r--. 1 root root 346 Feb 28 14:42 my.cnf
drwxr-xr-x. 2 root root 4096 Feb 28 14:37 mysql
drwxr-xr-x. 2 root root 4096 Feb 28 14:35 test
drwxr-xr-x. 2 root root 4096 Feb 28 14:38 tmp

/cluster/MySQL_Cluster/58/mysql:
total 0

/cluster/MySQL_Cluster/58/test:
total 0

/cluster/MySQL_Cluster/58/tmp:
total 0
```

Node3 and Node4's configuration are different in so much as they represent the services installed on them, Multi threaded data node 1 and Multi threaded data node 2 respectively:

```
[root@node3 ~]# ls -lR /cluster/MySQL_Cluster/
/cluster/MySQL_Cluster/:
total 4
drwxr-xr-x. 2 root root 4096 Feb 28 14:39 1

/cluster/MySQL_Cluster/1:
total 0
```

```
[root@node1 ~]# ls -lR /cluster/MySQL_Cluster/
```

```

/cluster/MySQL_Cluster/:
total 4
drwxr-xr-x. 2 root root 4096 Feb 28 14:41 2

/cluster/MySQL_Cluster/2:
total 0

```

The MySQL Cluster global configuration file is named **config.ini**, but only by convention. If the file does not exist, the configuration is read from the **configuration cache**. The location of this file has no default value and it can be placed in any location that can be read by `ndb_mgmd`. The location and name of the configuration file are specified using `-config-file=path_name`. The `config.ini` file uses the INI format where the content is split into [SECTIONS] containing parameter=value declarations which can either use the `=` or `:` characters as separators. One addition to the classic INI format is the use of a unique ID specified as a parameter within the section to specifically identify several nodes of the same type. Each node has a section in the `config.ini` file. In our case the cluster has two management nodes, so the configuration file contains two [NDB_MGMD] sections.

<note important> All Cluster parameter names are case-insensitive. </note>

The sections within this file are:

Section	Description
[NDB_MGMD DEFAULT]	Contains parameters that apply to all cluster management server nodes (MGM nodes)
[MGM] or [NDB_MGMD]	Defines a cluster management server node
[TCP] or [TCP DEFAULT]	Defines a TCP/IP connection between cluster nodes
[NDBD DEFAULT]	Contains parameters that apply to all data nodes (ndbd processes)
[NDBD]	Defines a cluster data node
[MYSQLD DEFAULT]	Contains parameters that apply to all MySQL server nodes (SQL or API nodes)
[MYSQLD]	Defines the cluster's MySQL server nodes

```

[root@node1 ~]# cat /cluster/MySQL_Cluster/49/config.ini
#
# Configuration file for MyCluster
#

[NDB_MGMD DEFAULT]
Portnumber=1186

```

[NDB_MGMD]

NodeId=49

HostName=192.168.22.105

DataDir=/cluster/MySQL_Cluster/49/

Portnumber=1186

[NDB_MGMD]

NodeId=52

HostName=192.168.22.106

DataDir=/cluster/MySQL_Cluster/52/

Portnumber=1186

[TCP DEFAULT]

SendBufferMemory=4M

ReceiveBufferMemory=4M

[NDBD DEFAULT]

BackupMaxWriteSize=1M

BackupDataBufferSize=16M

BackupLogBufferSize=4M

BackupMemory=20M

BackupReportFrequency=10

MemReportFrequency=30

LogLevelStartup=15

LogLevelShutdown=15

LogLevelCheckpoint=8

LogLevelNodeRestart=15

DataMemory=1M

IndexMemory=1M

MaxNoOfTables=4096

MaxNoOfTriggers=3500

NoOfReplicas=2

StringMemory=25

DiskPageBufferMemory=64M

```
SharedGlobalMemory=20M
LongMessageBuffer=32M
MaxNoOfConcurrentTransactions=16384
BatchSizePerLocalScan=512
FragmentLogFileSize=64M
NoOfFragmentLogFiles=16
RedoBuffer=32M
MaxNoOfExecutionThreads=2
StopOnError=false
LockPagesInMainMemory=1
TimeBetweenEpochsTimeout=32000
TimeBetweenWatchdogCheckInitial=60000
TransactionInactiveTimeout=60000
HeartbeatIntervalDbDb=15000
HeartbeatIntervalDbApi=15000
```

```
[NDBD]
```

```
NodeId=1
HostName=192.168.22.107
DataDir=/cluster/MySQL_Cluster/1/
```

```
[NDBD]
```

```
NodeId=2
HostName=192.168.22.108
DataDir=/cluster/MySQL_Cluster/2/
```

```
[MYSQLD DEFAULT]
```

```
[MYSQLD]
```

```
NodeId=55
HostName=192.168.22.105
```

```
[MYSQLD]
```

```
NodeId=56
```

```
HostName=192.168.22.105
```

```
[MYSQLD]
```

```
NodeId=57
```

```
HostName=192.168.22.106
```

```
[MYSQLD]
```

```
NodeId=58
```

```
HostName=192.168.22.106
```

```
[root@node2 ~]# cat /cluster/MySQL_Cluster/52/config.ini
```

```
#
```

```
# Configuration file for MyCluster
```

```
#
```

```
[NDB_MGMD DEFAULT]
```

```
Portnumber=1186
```

```
[NDB_MGMD]
```

```
NodeId=49
```

```
HostName=192.168.22.105
```

```
DataDir=/cluster/MySQL_Cluster/49/
```

```
Portnumber=1186
```

```
[NDB_MGMD]
```

```
NodeId=52
```

```
HostName=192.168.22.106
```

```
DataDir=/cluster/MySQL_Cluster/52/
```

```
Portnumber=1186
```

```
[TCP DEFAULT]
```

```
SendBufferMemory=4M
```

```
ReceiveBufferMemory=4M
```

```
[NDBD DEFAULT]
BackupMaxWriteSize=1M
BackupDataBufferSize=16M
BackupLogBufferSize=4M
BackupMemory=20M
BackupReportFrequency=10
MemReportFrequency=30
LogLevelStartup=15
LogLevelShutdown=15
LogLevelCheckpoint=8
LogLevelNodeRestart=15
DataMemory=1M
IndexMemory=1M
MaxNoOfTables=4096
MaxNoOfTriggers=3500
NoOfReplicas=2
StringMemory=25
DiskPageBufferMemory=64M
SharedGlobalMemory=20M
LongMessageBuffer=32M
MaxNoOfConcurrentTransactions=16384
BatchSizePerLocalScan=512
FragmentLogFileSize=64M
NoOfFragmentLogFiles=16
RedoBuffer=32M
MaxNoOfExecutionThreads=2
StopOnError=false
LockPagesInMainMemory=1
TimeBetweenEpochsTimeout=32000
TimeBetweenWatchdogCheckInitial=60000
TransactionInactiveTimeout=60000
HeartbeatIntervalDbDb=15000
HeartbeatIntervalDbApi=15000
```

```
[NDBD]
NodeId=1
HostName=192.168.22.107
DataDir=/cluster/MySQL_Cluster/1/
```

```
[NDBD]
NodeId=2
HostName=192.168.22.108
DataDir=/cluster/MySQL_Cluster/2/
```

```
[MYSQLD DEFAULT]
```

```
[MYSQLD]
NodeId=55
HostName=192.168.22.105
```

```
[MYSQLD]
NodeId=56
HostName=192.168.22.105
```

```
[MYSQLD]
NodeId=57
HostName=192.168.22.106
```

```
[MYSQLD]
NodeId=58
HostName=192.168.22.106
```

<note important> These two files are and must remain identical in order for the cluster to continue to function correctly. </note>

The definitions of the parameters in these files are as follows:

Section	Default Value	Parameter	Definition
---------	---------------	-----------	------------

Section	Default Value	Parameter	Definition
[NDB_MGMD DEFAULT]	1186	Portnumber=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-mgm-definition.html
[NDB_MGMD]	N/A	NodeId=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-mgm-definition.html
[NDB_MGMD]	N/A	HostName=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-mgm-definition.html
[NDB_MGMD]	Process CWD	DataDir=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-mgm-definition.html
[NDB_MGMD]	1186	Portnumber=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-mgm-definition.html
[TCP DEFAULT]	2GB	SendBufferMemory=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-tcp-definition.html#ndbparam-tcp-sendbuffermemory
[TCP DEFAULT]	2GB	ReceiveBufferMemory=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-tcp-definition.html#ndbparam-tcp-receivebuffermemory
[NDBD DEFAULT]	1MB	BackupMaxWriteSize=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-backupmaxwritesize
[NDBD DEFAULT]	16MB	BackupDataBufferSize=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-backupdatabuffersize
[NDBD DEFAULT]	16MB	BackupLogBufferSize=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-backuplogbuffersize
[NDBD DEFAULT]	N/A	BackupMemory=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-backupmemory
[NDBD DEFAULT]	0s	BackupReportFrequency=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-backupreportfrequency
[NDBD DEFAULT]	0s	MemReportFrequency=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-memreportfrequency
[NDBD DEFAULT]	1s	LogLevelStartup=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-loglevelstartup
[NDBD DEFAULT]	0s	LogLevelShutdown=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-loglevelshutdown
[NDBD DEFAULT]	0s	LogLevelCheckpoint=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-loglevelcheckpoint
[NDBD DEFAULT]	0s	LogLevelNodeRestart=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-loglevelnoderestart
[NDBD DEFAULT]	80MB	DataMemory=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-datamemory
[NDBD DEFAULT]	18M	IndexMemory=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-indexmemory
[NDBD DEFAULT]	128	MaxNoOfTables=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-maxnooftables
[NDBD DEFAULT]	768	MaxNoOfTriggers=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-maxnooftriggers

Section	Default Value	Parameter	Definition
[NDBD DEFAULT]	2	NoOfReplicas=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-noofreplicas
[NDBD DEFAULT]	25	StringMemory=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-stringmemory
[NDBD DEFAULT]	64M	DiskPageBufferMemory=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-diskpagebuffermemory
[NDBD DEFAULT]	128M	SharedGlobalMemory=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-sharedglobalmemory
[NDBD DEFAULT]	64M	LongMessageBuffer=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-longmessagebuffer
[NDBD DEFAULT]	4096	MaxNoOfConcurrentTransactions=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-maxnoofconcurrenttransactions
[NDBD DEFAULT]	256	BatchSizePerLocalScan=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-batchsizeperlocalscan
[NDBD DEFAULT]	16M	FragmentLogFileSize=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-fragmentlogfilesize
[NDBD DEFAULT]	16	NoOfFragmentLogFiles=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-nooffragmentlogfiles
[NDBD DEFAULT]	32M	RedoBuffer=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-redobuffer
[NDBD DEFAULT]	2	MaxNoOfExecutionThreads=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbmt-d-maxnoofexecutionthreads
[NDBD DEFAULT]	1	StopOnError=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-stoponerror
[NDBD DEFAULT]	0	LockPagesInMainMemory=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-lockpagesinmainmemory
[NDBD DEFAULT]	0	TimeBetweenEpochsTimeout=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-timebetweenepochstimeout
[NDBD DEFAULT]	6000ms	TimeBetweenWatchdogCheckInitial=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-timebetweenwatchdogcheckinitial
[NDBD DEFAULT]	4GB	TransactionInactiveTimeout=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-transactioninactivetimeout
[NDBD DEFAULT]	5000ms	HeartbeatIntervalDbDb=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-heartbeatintervaldbdb
[NDBD DEFAULT]	1500ms	HeartbeatIntervalDbApi	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html#ndbparam-ndbd-heartbeatintervaldbapi
[NDBD]	N/A	NodeId=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html
[NDBD]	N/A	HostName=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html
[NDBD]	N/A	DataDir=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-ndbd-definition.html
[MYSQLD]	N/A	NodeId=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-api-definition.html#ndbparam-api-nodeid

Section	Default Value	Parameter	Definition
[MYSQLD]	N/A	HostName=	http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-api-definition.html

MySQL Configuration

The four Cluster SQL nodes contain a **my.cnf** file:

```
[root@node1 ~]# cat /cluster/MySQL_Cluster/55/my.cnf
#
# Configuration file for MyCluster
# Generated by mcc
#
[mysqld]
log-error=mysqld.55.err
datadir="/cluster/MySQL_Cluster/55/"
tmpdir="/cluster/MySQL_Cluster/55/tmp"
basedir="/cluster/mysql_cluster/"
port=3306
ndbcluster=on
ndb-nodeid=55
ndb-connectstring=192.168.22.105:1186,192.168.22.106:1186,
socket="/cluster/MySQL_Cluster/55/mysql.socket"
[root@node1 ~]# cat /cluster/MySQL_Cluster/56/my.cnf
#
# Configuration file for MyCluster
# Generated by mcc
#
[mysqld]
log-error=mysqld.56.err
datadir="/cluster/MySQL_Cluster/56/"
tmpdir="/cluster/MySQL_Cluster/56/tmp"
basedir="/cluster/mysql_cluster/"
```

```
port=3307
ndbcluster=on
ndb-nodeid=56
ndb-connectstring=192.168.22.105:1186,192.168.22.106:1186,
socket="/cluster/MySQL_Cluster/56/mysql.socket"
```

```
[root@node2 ~]# cat /cluster/MySQL_Cluster/57/my.cnf
#
# Configuration file for MyCluster
# Generated by mcc
#
[mysqld]
log-error=mysqld.57.err
datadir="/cluster/MySQL_Cluster/57/"
tmpdir="/cluster/MySQL_Cluster/57/tmp"
basedir="/cluster/mysql_cluster/"
port=3306
ndbcluster=on
ndb-nodeid=57
ndb-connectstring=192.168.22.105:1186,192.168.22.106:1186,
socket="/cluster/MySQL_Cluster/57/mysql.socket"
[root@node2 ~]# cat /cluster/MySQL_Cluster/58/my.cnf
#
# Configuration file for MyCluster
# Generated by mcc
#
[mysqld]
log-error=mysqld.58.err
datadir="/cluster/MySQL_Cluster/58/"
tmpdir="/cluster/MySQL_Cluster/58/tmp"
basedir="/cluster/mysql_cluster/"
port=3307
ndbcluster=on
ndb-nodeid=58
```

```
ndb-connectstring=192.168.22.105:1186,192.168.22.106:1186,
socket="/cluster/MySQL_Cluster/58/mysql.socket"
```

<note important> All **my.cnf** parameter names are **case-sensitive**. </note>

As with a traditional my.cnf file, these parameters can be split out into different sections so that they apply only to specific cluster nodes, for example:

Section	Description	Example
[mysql_cluster]	Contains settings for all nodes	ndb-connectstring=192.168.22.105:1186,192.168.22.106:1186
[ndbd]	Contains settings specific to data nodes	ndb-connectstring=192.168.22.105:1186,192.168.22.106:1186
[ndb_mgm]	Contains settings specific to management nodes	ndb-connectstring=192.168.22.105:1186,192.168.22.106:1186
[mysqld]	Contains settings specific to SQL nodes	ndbcluster=on

The definitions of the non-standard MySQL parameters in these files are as follows:

Section	Parameter	Description
[mysqld]	ndbcluster=	Enables/disables the ndbcluster storage engine
[mysqld]	ndb-nodeid=	Sets the node's MySQL Cluster node ID.
[mysqld]	ndb-connectstring=	Stipulates the connection string for the management server hosts (default port = 1186)

Connection Strings

Each MySQL or API node must use a Connection String to connect to the Cluster Management node. The Connection String is defined either by the **bind-address** parameter or the **ndb-connectstring** parameter (used for backward compatibility) in **my.cnf** or in a file called **Ndb.cfg**, placed in the mysqld's startup directory.

An example of the most complete form of a Connection String is:

```
nodeid=55,mymanagementhost:1186,192.168.22.105:1186,192.168.22.106:1186, . . .
```

In the above example the MySQL Cluster Data node or API node will poll each host until a connection to a Cluster Management node is successful. As a result there is a Cluster Management node redundancy. In the example shown, the line can be split as follows:

```
NodeId, host-definition, host_definition, host-definition
```

<note important> If the Connection String is not defined, the default value of **localhost:1186** is used. </note>

The bind-address Parameter

If a bind address is defined before the host definitions, the same bind address is used for all of the host definitions:

```
bind-address=192.168.22.105, server1:1186, server2:1186
```

In order to poll two servers, the format of the line becomes:

```
server1:1186;bind-address=192.168.22.105, server2:1186;bind-address=192.168.22.106
```

Starting the Cluster

Starting the cluster consists firstly of starting the Cluster Management service on node1 and node2. The Cluster Management daemon **ndb_mgmd** can be invoked with many command line switches as shown below:

```
[root@node1 ~]# /cluster/mysql_cluster/bin/ndb_mgmd --help
MySQL Cluster Management Server mysql-5.6.23 ndb-7.4.4
Usage: /cluster/mysql_cluster/bin/ndb_mgmd [OPTIONS]
MySQL distrib mysql-5.6.23 ndb-7.4.4, for linux-glibc2.5 (i686)
```

Default options are read from the following files in the given order:

```
/etc/my.cnf /etc/mysql/my.cnf /usr/local/mysql/etc/my.cnf ~/.my.cnf
```

The following groups are read: `mysql_cluster` `ndb_mgmd`

The following options may be given as the first argument:

```
--print-defaults      Print the program argument list and exit.
--no-defaults         Don't read default options from any option file,
```

```
                except for login file.
--defaults-file=#      Only read default options from the given file #.
--defaults-extra-file=# Read this file after the global files are read.
--defaults-group-suffix=#
                        Also read groups with concat(group, suffix)
--login-path=#        Read this path from the login file.

-?, --usage           Display this help and exit.
-?, --help            Display this help and exit.
-V, --version         Output version information and exit.
-c, --ndb-connectstring=name
                        Set connect string for connecting to ndb_mgmd. Syntax:
                        "[nodeid=<id>;][host=]<hostname>[:<port>]". Overrides
                        specifying entries in NDB_CONNECTSTRING and my.cnf
--ndb-mgmd-host=name  same as --ndb-connectstring
--ndb-nodeid=#        Set node id for this node. Overrides node id specified in
                        --ndb-connectstring.
--ndb-optimized-node-selection
                        Select nodes for transactions in a more optimal way
                        (Defaults to on; use --skip-ndb-optimized-node-selection to disable.)
-c, --connect-string=name
                        same as --ndb-connectstring
--core-file           Write core on errors.
--character-sets-dir=name
                        Directory where character sets are.
-f, --config-file=name
                        Specify cluster configuration file
-P, --print-full-config
                        Print full config and exit
-d, --daemon          Run ndb_mgmd in daemon mode (default)
                        (Defaults to on; use --skip-daemon to disable.)
--interactive         Run interactive. Not supported but provided for testing
                        purposes
```

```

--no-nodeid-checks Do not provide any node id checks
--nodaemon        Don't run as daemon, but don't read from stdin
--mycnf           Read cluster config from my.cnf
--bind-address=name Local bind address
--configdir=name  Directory for the binary configuration files (alias for
--config-dir)
--config-dir=name Directory for the binary configuration files
--config-cache    Enable configuration cache and change management
                  (Defaults to on; use --skip-config-cache to disable.)
-v, --verbose     Write more log messages
--reload          Reload config from config.ini or my.cnf if it has changed
                  on startup
--initial         Delete all binary config files and start from config.ini
                  or my.cnf
--log-name=name   Name to use when logging messages for this node
--nowait-nodes=name Nodes that will not be waited for during start

```

Variables (--variable-name=value)

and boolean options {FALSE|TRUE} Value (after reading options)

```

-----
ndb-connectstring (No default value)
ndb-mgmd-host     (No default value)
ndb-nodeid        0
ndb-optimized-node-selection TRUE
connect-string   (No default value)
core-file        FALSE
character-sets-dir (No default value)
config-file      (No default value)
print-full-config FALSE
daemon           TRUE
interactive      FALSE
no-nodeid-checks FALSE
nodaemon        FALSE
mycnf           FALSE

```

```
bind-address          (No default value)
configdir             /usr/local/mysql/mysql-cluster
config-dir           /usr/local/mysql/mysql-cluster
config-cache         TRUE
verbose              FALSE
reload               FALSE
initial              FALSE
log-name             MgmtSrvr
nowait-nodes         (No default value)
```

<note important> At the end of the above output we can see the default values for some of the switches. </note>

Starting the Cluster Management Nodes

Start the Management service on node1 by stipulating the `-initial` switch such that the `config.ini` and `my.cnf` files are read:

```
[root@node1 ~]# /cluster/mysql_cluster/bin/ndb_mgmd --initial --ndb-nodeid=49 --config-
dir=/cluster/MySQL_Cluster/49/ --config-file=/cluster/MySQL_Cluster/49/config.ini
MySQL Cluster Management Server mysql-5.6.23 ndb-7.4.4
```

Start the Management service on node2 by stipulating the `-initial` switch such that the `config.ini` and `my.cnf` files are read:

```
[root@node2 ~]# /cluster/mysql_cluster/bin/ndb_mgmd --initial --ndb-nodeid=52 --config-
dir=/cluster/MySQL_Cluster/52/ --config-file=/cluster/MySQL_Cluster/52/config.ini
MySQL Cluster Management Server mysql-5.6.23 ndb-7.4.4
```

Starting the SQL Nodes

Start the SQL node on node3:

```
[root@node3 ~]# /cluster/mysql_cluster/bin/ndbmtdd --ndb-nodeid=1 --ndb-
```

```
connectstring=192.168.22.105:1186,192.168.22.106:1186
2015-03-02 09:26:14 [ndbd] INFO      -- Angel connected to '192.168.22.105:1186'
2015-03-02 09:26:14 [ndbd] INFO      -- Angel allocated nodeid: 1
```

Start the SQL node on node4:

```
[root@node4 ~]# /cluster/mysql_cluster/bin/ndbmtld --ndb-nodeid=2 --ndb-
connectstring=192.168.22.105:1186,192.168.22.106:1186
2015-03-02 09:26:49 [ndbd] INFO      -- Angel connected to '192.168.22.105:1186'
2015-03-02 09:26:49 [ndbd] INFO      -- Angel allocated nodeid: 2
```

<note important> Note that **ndbmtld** is the multi-threaded version of **ndbd**, used on host computers having multiple CPU cores. For further information about the differences between **ndbm** and **ndbmtld**, consult this

<http://dev.mysql.com/doc/refman/5.6/en/mysql-cluster-programs-ndbmtld.html> [link] </note>

We now need to create the MySQL Server system tables on node1 and node2. In order to achieve this, Oracle supplies a bash script called **mysql_install_db** which can be found in **/cluster/mysql_cluster/scripts/** :

```
[root@node1 ~]# /cluster/mysql_cluster/scripts/mysql_install_db --no-defaults --basedir=/cluster/mysql_cluster/ -
--datadir=/cluster/MySQL_Cluster/55/ --user=root --explicit_defaults_for_timestamp
WARNING: The host 'node1.fenestros.loc' could not be looked up with /cluster/mysql_cluster//bin/resolveip.
This probably means that your libc libraries are not 100 % compatible
with this binary MySQL version. The MySQL daemon, mysqld, should work
normally with the exception that host name resolving will not work.
This means that you should use IP addresses instead of hostnames
when specifying MySQL privileges !
```

```
Installing MySQL system tables...2015-03-02 09:30:29 30822 [Note] InnoDB: Using mutexes to ref count buffer pool
pages
2015-03-02 09:30:29 30822 [Note] InnoDB: The InnoDB memory heap is disabled
2015-03-02 09:30:29 30822 [Note] InnoDB: Mutexes and rw_locks use InnoDB's own implementation
2015-03-02 09:30:29 30822 [Note] InnoDB: Memory barrier is not used
2015-03-02 09:30:29 30822 [Note] InnoDB: Compressed tables use zlib 1.2.3
2015-03-02 09:30:29 30822 [Note] InnoDB: Using Linux native AIO
```

```
2015-03-02 09:30:29 30822 [Note] InnoDB: Not using CPU crc32 instructions
2015-03-02 09:30:29 30822 [Note] InnoDB: Initializing buffer pool, size = 128.0M
2015-03-02 09:30:29 30822 [Note] InnoDB: Completed initialization of buffer pool
2015-03-02 09:30:29 30822 [Note] InnoDB: The first specified data file ./ibdata1 did not exist: a new database to
be created!
2015-03-02 09:30:29 30822 [Note] InnoDB: Setting file ./ibdata1 size to 12 MB
2015-03-02 09:30:29 30822 [Note] InnoDB: Database physically writes the file full: wait...
2015-03-02 09:30:30 30822 [Note] InnoDB: Setting log file ./ib_logfile101 size to 48 MB
2015-03-02 09:30:31 30822 [Note] InnoDB: Setting log file ./ib_logfile1 size to 48 MB
2015-03-02 09:30:32 30822 [Note] InnoDB: Renaming log file ./ib_logfile101 to ./ib_logfile0
2015-03-02 09:30:32 30822 [Warning] InnoDB: New log files created, LSN=45781
2015-03-02 09:30:32 30822 [Note] InnoDB: Doublewrite buffer not found: creating new
2015-03-02 09:30:32 30822 [Note] InnoDB: Doublewrite buffer created
2015-03-02 09:30:32 30822 [Note] InnoDB: 128 rollback segment(s) are active.
2015-03-02 09:30:32 30822 [Warning] InnoDB: Creating foreign key constraint system tables.
2015-03-02 09:30:32 30822 [Note] InnoDB: Foreign key constraint system tables created
2015-03-02 09:30:32 30822 [Note] InnoDB: Creating tablespace and datafile system tables.
2015-03-02 09:30:32 30822 [Note] InnoDB: Tablespace and datafile system tables created.
2015-03-02 09:30:32 30822 [Note] InnoDB: Waiting for purge to start
2015-03-02 09:30:32 30822 [Note] InnoDB: 5.6.23 started; log sequence number 0
2015-03-02 09:30:33 30822 [Note] Binlog end
2015-03-02 09:30:33 30822 [Note] InnoDB: FTS optimize thread exiting.
2015-03-02 09:30:33 30822 [Note] InnoDB: Starting shutdown...
2015-03-02 09:30:35 30822 [Note] InnoDB: Shutdown completed; log sequence number 1625977
OK
```

```
Filling help tables...2015-03-02 09:30:35 30845 [Note] InnoDB: Using mutexes to ref count buffer pool pages
2015-03-02 09:30:35 30845 [Note] InnoDB: The InnoDB memory heap is disabled
2015-03-02 09:30:35 30845 [Note] InnoDB: Mutexes and rw_locks use InnoDB's own implementation
2015-03-02 09:30:35 30845 [Note] InnoDB: Memory barrier is not used
2015-03-02 09:30:35 30845 [Note] InnoDB: Compressed tables use zlib 1.2.3
2015-03-02 09:30:35 30845 [Note] InnoDB: Using Linux native AIO
2015-03-02 09:30:35 30845 [Note] InnoDB: Not using CPU crc32 instructions
2015-03-02 09:30:35 30845 [Note] InnoDB: Initializing buffer pool, size = 128.0M
```

```
2015-03-02 09:30:35 30845 [Note] InnoDB: Completed initialization of buffer pool
2015-03-02 09:30:35 30845 [Note] InnoDB: Highest supported file format is Barracuda.
2015-03-02 09:30:35 30845 [Note] InnoDB: 128 rollback segment(s) are active.
2015-03-02 09:30:35 30845 [Note] InnoDB: Waiting for purge to start
2015-03-02 09:30:35 30845 [Note] InnoDB: 5.6.23 started; log sequence number 1625977
2015-03-02 09:30:36 30845 [Note] Binlog end
2015-03-02 09:30:36 30845 [Note] InnoDB: FTS optimize thread exiting.
2015-03-02 09:30:36 30845 [Note] InnoDB: Starting shutdown...
2015-03-02 09:30:37 30845 [Note] InnoDB: Shutdown completed; log sequence number 1625987
OK
```

To start mysqld at boot time you have to copy support-files/mysql.server to the right place for your system

PLEASE REMEMBER TO SET A PASSWORD FOR THE MySQL root USER !

To do so, start the server, then issue the following commands:

```
/cluster/mysql_cluster//bin/mysqladmin -u root password 'new-password'
/cluster/mysql_cluster//bin/mysqladmin -u root -h node1.fenestros.loc password 'new-password'
```

Alternatively you can run:

```
/cluster/mysql_cluster//bin/mysql_secure_installation
```

which will also give you the option of removing the test databases and anonymous user created by default. This is strongly recommended for production servers.

See the manual for more instructions.

You can start the MySQL daemon with:

```
cd . ; /cluster/mysql_cluster//bin/mysqld_safe &
```

You can test the MySQL daemon with `mysql-test-run.pl`

```
cd mysql-test ; perl mysql-test-run.pl
```

Please report any problems at <http://bugs.mysql.com/>

The latest information about MySQL is available on the web at

```
http://www.mysql.com
```

Support MySQL by buying support/licenses at <http://shop.mysql.com>

WARNING: Found existing config file `/cluster/mysql_cluster//my.cnf` on the system.
Because this file might be in use, it was not replaced,
but was used in bootstrap (unless you used `--defaults-file`)
and when you later start the server.
The new default config file was created as `/cluster/mysql_cluster//my-new.cnf`,
please compare it with your file and take the changes you need.

WARNING: Default config file `/etc/my.cnf` exists on the system
This file will be read by default by the MySQL server
If you do not want to use this, either remove it, or use the
`--defaults-file` argument to `mysqld_safe` when starting the server

```
[root@node1 ~]# /cluster/mysql_cluster/scripts/mysql_install_db --no-defaults --basedir=/cluster/mysql_cluster/ -  
-datadir=/cluster/MySQL_Cluster/56/ --user=root --explicit_defaults_for_timestamp  
WARNING: The host 'node1.fenestros.loc' could not be looked up with /cluster/mysql_cluster//bin/resolveip.  
This probably means that your libc libraries are not 100 % compatible  
with this binary MySQL version. The MySQL daemon, mysqld, should work  
normally with the exception that host name resolving will not work.  
This means that you should use IP addresses instead of hostnames  
when specifying MySQL privileges !
```

```
Installing MySQL system tables...2015-03-02 09:31:54 30876 [Note] InnoDB: Using mutexes to ref count buffer pool
```

```
pages
2015-03-02 09:31:54 30876 [Note] InnoDB: The InnoDB memory heap is disabled
2015-03-02 09:31:54 30876 [Note] InnoDB: Mutexes and rw_locks use InnoDB's own implementation
2015-03-02 09:31:54 30876 [Note] InnoDB: Memory barrier is not used
2015-03-02 09:31:54 30876 [Note] InnoDB: Compressed tables use zlib 1.2.3
2015-03-02 09:31:54 30876 [Note] InnoDB: Using Linux native AIO
2015-03-02 09:31:54 30876 [Note] InnoDB: Not using CPU crc32 instructions
2015-03-02 09:31:54 30876 [Note] InnoDB: Initializing buffer pool, size = 128.0M
2015-03-02 09:31:55 30876 [Note] InnoDB: Completed initialization of buffer pool
2015-03-02 09:31:55 30876 [Note] InnoDB: The first specified data file ./ibdata1 did not exist: a new database to
be created!
2015-03-02 09:31:55 30876 [Note] InnoDB: Setting file ./ibdata1 size to 12 MB
2015-03-02 09:31:55 30876 [Note] InnoDB: Database physically writes the file full: wait...
2015-03-02 09:31:55 30876 [Note] InnoDB: Setting log file ./ib_logfile101 size to 48 MB
2015-03-02 09:31:57 30876 [Note] InnoDB: Setting log file ./ib_logfile1 size to 48 MB
2015-03-02 09:31:59 30876 [Note] InnoDB: Renaming log file ./ib_logfile101 to ./ib_logfile0
2015-03-02 09:31:59 30876 [Warning] InnoDB: New log files created, LSN=45781
2015-03-02 09:31:59 30876 [Note] InnoDB: Doublewrite buffer not found: creating new
2015-03-02 09:31:59 30876 [Note] InnoDB: Doublewrite buffer created
2015-03-02 09:31:59 30876 [Note] InnoDB: 128 rollback segment(s) are active.
2015-03-02 09:31:59 30876 [Warning] InnoDB: Creating foreign key constraint system tables.
2015-03-02 09:31:59 30876 [Note] InnoDB: Foreign key constraint system tables created
2015-03-02 09:31:59 30876 [Note] InnoDB: Creating tablespace and datafile system tables.
2015-03-02 09:31:59 30876 [Note] InnoDB: Tablespace and datafile system tables created.
2015-03-02 09:31:59 30876 [Note] InnoDB: Waiting for purge to start
2015-03-02 09:31:59 30876 [Note] InnoDB: 5.6.23 started; log sequence number 0
2015-03-02 09:31:59 30876 [Note] Binlog end
2015-03-02 09:31:59 30876 [Note] InnoDB: FTS optimize thread exiting.
2015-03-02 09:31:59 30876 [Note] InnoDB: Starting shutdown...
2015-03-02 09:32:01 30876 [Note] InnoDB: Shutdown completed; log sequence number 1625977
OK

Filling help tables...2015-03-02 09:32:01 30899 [Note] InnoDB: Using mutexes to ref count buffer pool pages
2015-03-02 09:32:01 30899 [Note] InnoDB: The InnoDB memory heap is disabled
```

```
2015-03-02 09:32:01 30899 [Note] InnoDB: Mutexes and rw_locks use InnoDB's own implementation
2015-03-02 09:32:01 30899 [Note] InnoDB: Memory barrier is not used
2015-03-02 09:32:01 30899 [Note] InnoDB: Compressed tables use zlib 1.2.3
2015-03-02 09:32:01 30899 [Note] InnoDB: Using Linux native AIO
2015-03-02 09:32:01 30899 [Note] InnoDB: Not using CPU crc32 instructions
2015-03-02 09:32:01 30899 [Note] InnoDB: Initializing buffer pool, size = 128.0M
2015-03-02 09:32:01 30899 [Note] InnoDB: Completed initialization of buffer pool
2015-03-02 09:32:01 30899 [Note] InnoDB: Highest supported file format is Barracuda.
2015-03-02 09:32:01 30899 [Note] InnoDB: 128 rollback segment(s) are active.
2015-03-02 09:32:01 30899 [Note] InnoDB: Waiting for purge to start
2015-03-02 09:32:01 30899 [Note] InnoDB: 5.6.23 started; log sequence number 1625977
2015-03-02 09:32:01 30899 [Note] Binlog end
2015-03-02 09:32:01 30899 [Note] InnoDB: FTS optimize thread exiting.
2015-03-02 09:32:01 30899 [Note] InnoDB: Starting shutdown...
2015-03-02 09:32:03 30899 [Note] InnoDB: Shutdown completed; log sequence number 1625987
OK
```

To start mysqld at boot time you have to copy
support-files/mysql.server to the right place for your system

PLEASE REMEMBER TO SET A PASSWORD FOR THE MySQL root USER !
To do so, start the server, then issue the following commands:

```
/cluster/mysql_cluster//bin/mysqladmin -u root password 'new-password'
/cluster/mysql_cluster//bin/mysqladmin -u root -h node1.fenestros.loc password 'new-password'
```

Alternatively you can run:

```
/cluster/mysql_cluster//bin/mysql_secure_installation
```

which will also give you the option of removing the test
databases and anonymous user created by default. This is
strongly recommended for production servers.

See the manual for more instructions.

You can start the MySQL daemon with:

```
cd . ; /cluster/mysql_cluster//bin/mysqld_safe &
```

You can test the MySQL daemon with `mysql-test-run.pl`

```
cd mysql-test ; perl mysql-test-run.pl
```

Please report any problems at <http://bugs.mysql.com/>

The latest information about MySQL is available on the web at

```
http://www.mysql.com
```

Support MySQL by buying support/licenses at <http://shop.mysql.com>

WARNING: Found existing config file `/cluster/mysql_cluster//my.cnf` on the system. Because this file might be in use, it was not replaced, but was used in bootstrap (unless you used `--defaults-file`) and when you later start the server. The new default config file was created as `/cluster/mysql_cluster//my-new.cnf`, please compare it with your file and take the changes you need.

WARNING: Default config file `/etc/my.cnf` exists on the system. This file will be read by default by the MySQL server. If you do not want to use this, either remove it, or use the `--defaults-file` argument to `mysqld_safe` when starting the server.

```
[root@node2 ~]# /cluster/mysql_cluster/scripts/mysql_install_db --no-defaults --basedir=/cluster/mysql_cluster/ -  
-datadir=/cluster/MySQL_Cluster/57/ --user=root --explicit_defaults_for_timestamp  
[root@node2 ~]# /cluster/mysql_cluster/scripts/mysql_install_db --no-defaults --basedir=/cluster/mysql_cluster/ -  
-datadir=/cluster/MySQL_Cluster/58/ --user=root --explicit_defaults_for_timestamp
```

Now we need to start the SQL nodes on node1:

```
[root@node1 ~]# /cluster/mysql_cluster/bin/mysqld --defaults-file=/cluster/MySQL_Cluster/55/my.cnf --
basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/55/ --user=root --
explicit_defaults_for_timestamp &
[1] 31287
[root@node1 ~]# /cluster/mysql_cluster/bin/mysqld --defaults-file=/cluster/MySQL_Cluster/56/my.cnf --
basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/56/ --user=root --
explicit_defaults_for_timestamp &
[2] 31319
[root@node1 ~]# ps aux | grep mysqld
root      31287  6.2  0.4 811932 1728 pts/1    Sl   10:22   0:01 /cluster/mysql_cluster/bin/mysqld --defaults-
file=/cluster/MySQL_Cluster/55/my.cnf --basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/55/ --
user=root --explicit_defaults_for_timestamp
root      31319 12.4 73.9 812040 280812 pts/1    Sl   10:22   0:00 /cluster/mysql_cluster/bin/mysqld --defaults-
file=/cluster/MySQL_Cluster/56/my.cnf --basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/56/ --
user=root --explicit_defaults_for_timestamp
root      31352  0.0  0.1  4352   732 pts/1    S+   10:22   0:00 grep mysqld
```

Equally we need to do the same on node2:

```
[root@node2 ~]# /cluster/mysql_cluster/bin/mysqld --defaults-file=/cluster/MySQL_Cluster/57/my.cnf --
basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/57/ --user=root --
explicit_defaults_for_timestamp &
[1] 24817
[root@node2 ~]# /cluster/mysql_cluster/bin/mysqld --defaults-file=/cluster/MySQL_Cluster/58/my.cnf --
basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/58/ --user=root --
explicit_defaults_for_timestamp &
[2] 24847
[root@node2 ~]# ps aux | grep mysqld
root      24817  4.1  7.0 811728 26688 pts/0    Sl   10:25   0:01 /cluster/mysql_cluster/bin/mysqld --defaults-
file=/cluster/MySQL_Cluster/57/my.cnf --basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/57/ --
user=root --explicit_defaults_for_timestamp
root      24847  3.0 56.4 288124 214500 pts/0    D    10:25   0:00 /cluster/mysql_cluster/bin/mysqld --defaults-
```

```
file=/cluster/MySQL_Cluster/58/my.cnf --basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/58/ --
user=root --explicit_defaults_for_timestamp
root      24851  0.3  0.1  4352  504 pts/0    S+   10:26   0:00 grep mysqld
```

<note important> You can find more information about the **-explicit_defaults_for_timestamp** switch [here](#). </note>

Check the Cluster Status

You can use the NDB Cluster Management Client, **ndb_mgm**, from either node1 or node2 to check the cluster status:

```
[root@node1 ~]# /cluster/mysql_cluster/bin/ndb_mgm
-- NDB Cluster -- Management Client --
ndb_mgm> SHOW
Connected to Management Server at: localhost:1186
Cluster Configuration
-----
[ndbd(NDB)] 2 node(s)
id=1      @192.168.22.107 (mysql-5.6.23 ndb-7.4.4, Nodegroup: 0, *)
id=2      @192.168.22.108 (mysql-5.6.23 ndb-7.4.4, Nodegroup: 0)

[ndb_mgmd(MGM)] 2 node(s)
id=49     @192.168.22.105 (mysql-5.6.23 ndb-7.4.4)
id=52     @192.168.22.106 (mysql-5.6.23 ndb-7.4.4)

[mysqld(API)] 4 node(s)
id=55     @192.168.22.105 (mysql-5.6.23 ndb-7.4.4)
id=56     @192.168.22.105 (mysql-5.6.23 ndb-7.4.4)
id=57     @192.168.22.106 (mysql-5.6.23 ndb-7.4.4)
id=58     @192.168.22.106 (mysql-5.6.23 ndb-7.4.4)

ndb_mgm> exit
[root@node1 ~]#
```

```
[root@node2 ~]# /cluster/mysql_cluster/bin/ndb_mgm
-- NDB Cluster -- Management Client --
ndb_mgm> SHOW
Connected to Management Server at: localhost:1186
Cluster Configuration
-----
[ndbd(NDB)] 2 node(s)
id=1      @192.168.22.107 (mysql-5.6.23 ndb-7.4.4, Nodegroup: 0, *)
id=2      @192.168.22.108 (mysql-5.6.23 ndb-7.4.4, Nodegroup: 0)

[ndb_mgmd(MGM)] 2 node(s)
id=49     @192.168.22.105 (mysql-5.6.23 ndb-7.4.4)
id=52     @192.168.22.106 (mysql-5.6.23 ndb-7.4.4)

[mysqld(API)] 4 node(s)
id=55     @192.168.22.105 (mysql-5.6.23 ndb-7.4.4)
id=56     @192.168.22.105 (mysql-5.6.23 ndb-7.4.4)
id=57     @192.168.22.106 (mysql-5.6.23 ndb-7.4.4)
id=58     @192.168.22.106 (mysql-5.6.23 ndb-7.4.4)

ndb_mgm> exit
[root@node2 ~]#
```

The ndb_mgm command can also be used as follows:

```
[root@node1 ~]# ndb_mgm -e "SHOW"
-bash: ndb_mgm: command not found
[root@node1 ~]# /cluster/mysql_cluster/bin/ndb_mgm -e "SHOW"
Connected to Management Server at: localhost:1186
Cluster Configuration
-----
[ndbd(NDB)] 2 node(s)
id=1      @192.168.22.107 (mysql-5.6.23 ndb-7.4.4, Nodegroup: 0, *)
id=2      @192.168.22.108 (mysql-5.6.23 ndb-7.4.4, Nodegroup: 0)
```

```
[ndb_mgmd(MGM)] 2 node(s)
id=49 @192.168.22.105 (mysql-5.6.23 ndb-7.4.4)
id=52 @192.168.22.106 (mysql-5.6.23 ndb-7.4.4)

[mysqld(API)] 4 node(s)
id=55 @192.168.22.105 (mysql-5.6.23 ndb-7.4.4)
id=56 @192.168.22.105 (mysql-5.6.23 ndb-7.4.4)
id=57 @192.168.22.106 (mysql-5.6.23 ndb-7.4.4)
id=58 @192.168.22.106 (mysql-5.6.23 ndb-7.4.4)

[root@node1 ~]# /cluster/mysql_cluster/bin/ndb_mgm --execute "SHOW"
Connected to Management Server at: localhost:1186
Cluster Configuration
-----
[ndbd(NDB)] 2 node(s)
id=1 @192.168.22.107 (mysql-5.6.23 ndb-7.4.4, Nodegroup: 0, *)
id=2 @192.168.22.108 (mysql-5.6.23 ndb-7.4.4, Nodegroup: 0)

[ndb_mgmd(MGM)] 2 node(s)
id=49 @192.168.22.105 (mysql-5.6.23 ndb-7.4.4)
id=52 @192.168.22.106 (mysql-5.6.23 ndb-7.4.4)

[mysqld(API)] 4 node(s)
id=55 @192.168.22.105 (mysql-5.6.23 ndb-7.4.4)
id=56 @192.168.22.105 (mysql-5.6.23 ndb-7.4.4)
id=57 @192.168.22.106 (mysql-5.6.23 ndb-7.4.4)
id=58 @192.168.22.106 (mysql-5.6.23 ndb-7.4.4)
```

The command line switches of the ndb_mgm command are:

```
[root@node2 ~]# /cluster/mysql_cluster/bin/ndb_mgm --help
Usage: /cluster/mysql_cluster/bin/ndb_mgm [OPTIONS] [hostname [port]]
MySQL distrib mysql-5.6.23 ndb-7.4.4, for linux-glibc2.5 (i686)
```

```
Default options are read from the following files in the given order:
/etc/my.cnf /etc/mysql/my.cnf /usr/local/mysql/etc/my.cnf ~/.my.cnf
The following groups are read: mysql_cluster ndb_mgm
The following options may be given as the first argument:
--print-defaults      Print the program argument list and exit.
--no-defaults        Don't read default options from any option file,
                    except for login file.
--defaults-file=#     Only read default options from the given file #.
--defaults-extra-file=# Read this file after the global files are read.
--defaults-group-suffix=#
                    Also read groups with concat(group, suffix)
--login-path=#       Read this path from the login file.

-?, --usage          Display this help and exit.
-?, --help           Display this help and exit.
-V, --version        Output version information and exit.
-c, --ndb-connectstring=name
                    Set connect string for connecting to ndb_mgmd. Syntax:
                    "[nodeid=<id>][host=]<hostname>[:<port>]". Overrides
                    specifying entries in NDB_CONNECTSTRING and my.cnf
--ndb-mgmd-host=name
                    same as --ndb-connectstring
--ndb-nodeid=#       Set node id for this node. Overrides node id specified in
                    --ndb-connectstring.
--ndb-optimized-node-selection
                    Select nodes for transactions in a more optimal way
                    (Defaults to on; use --skip-ndb-optimized-node-selection to disable.)
-c, --connect-string=name
                    same as --ndb-connectstring
--core-file          Write core on errors.
--character-sets-dir=name
                    Directory where character sets are.
-e, --execute=name   execute command and exit
-t, --try-reconnect=#
```

```

Specify number of tries for connecting to ndb_mgmd (0 =
infinite)
-v, --verbose=# Control the amount of printout

```

```

Variables (--variable-name=value)
and boolean options {FALSE|TRUE} Value (after reading options)
-----

```

```

ndb-connectstring (No default value)
ndb-mgmd-host (No default value)
ndb-nodeid 0
ndb-optimized-node-selection TRUE
connect-string (No default value)
core-file FALSE
character-sets-dir (No default value)
execute (No default value)
try-reconnect 3
verbose 1

```

Stopping and Starting the Cluster

Graceful Shutdown

To perform a graceful shutdown of the cluster, we need to use the **ndb-adm** command on a host running a management node. This command causes the `ndb_mgm`, `ndb_mgmd`, and any `ndbd` or `ndbmt` processes to terminate gracefully as shown below:

```

[root@node1 ~]# /cluster/mysql_cluster/bin/ndb_mgm -e shutdown
Connected to Management Server at: localhost:1186
4 NDB Cluster node(s) have shutdown.
Disconnecting to allow management server to shutdown.

```

Note however that the `mysqld` servers are not shutdown:

```
[root@node1 ~]# ps aux | grep ndb_mgmd
root      3410  0.0  0.1  4352   732 pts/0    S+   13:37   0:00 grep ndb_mgmd
[root@node1 ~]# ps aux | grep mysqld
root      2983  1.7  0.7 812036  2908 pts/0    Sl   12:41   1:01 /cluster/mysql_cluster/bin/mysqld --defaults-
file=/cluster/MySQL_Cluster/55/my.cnf --basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/55/ --
user=root --explicit_defaults_for_timestamp
root      3016  1.7 37.8 811548 143712 pts/0    Sl   12:41   1:00 /cluster/mysql_cluster/bin/mysqld --defaults-
file=/cluster/MySQL_Cluster/56/my.cnf --basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/56/ --
user=root --explicit_defaults_for_timestamp
root      3412  0.0  0.1  4352   732 pts/0    S+   13:38   0:00 grep mysqld
```

```
[root@node2 ~]# ps aux | grep ndb_mgmd
root      2726  0.0  0.1  4352   724 pts/1    S+   13:39   0:00 grep ndb_mgmd
[root@node2 ~]# ps aux | grep mysqld
root      2348  1.8  0.8 832032  3128 ?        Sl   12:41   1:04 /cluster/mysql_cluster/bin/mysqld --defaults-
file=/cluster/MySQL_Cluster/57/my.cnf --basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/57/ --
user=root --explicit_defaults_for_timestamp
root      2382  1.8  1.1 811524  4456 ?        Sl   12:42   1:03 /cluster/mysql_cluster/bin/mysqld --defaults-
file=/cluster/MySQL_Cluster/58/my.cnf --basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/58/ --
user=root --explicit_defaults_for_timestamp
root      2729  0.0  0.1  4356   736 pts/1    S+   13:39   0:00 grep mysqld
```

As opposed to the ndbd nodes which have been shutdown:

```
[root@node3 ~]# ps aux | grep ndbdtd
root      2870  0.0  0.0  4352   724 pts/0    S+   13:42   0:00 grep ndbdtd
```

```
[root@node4 ~]# ps aux | grep ndbdtd
root      2887  0.0  0.0  4352   724 pts/0    S+   13:43   0:00 grep ndbdtd
```

It therefore necessary to manually shutdown the mysqld nodes as shown below:

```
[root@node1 ~]# /cluster/mysql_cluster/bin/mysqladmin --socket='/cluster/MySQL_Cluster/55/mysql.socket' shutdown
```

```
[1]- Done /cluster/mysql_cluster/bin/mysqld --defaults-file=/cluster/MySQL_Cluster/55/my.cnf
--basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/55/ --user=root --
explicit_defaults_for_timestamp
[root@node1 ~]# /cluster/mysql_cluster/bin/mysqladmin --socket='/cluster/MySQL_Cluster/56/mysql.socket' shutdown
[2]+ Done /cluster/mysql_cluster/bin/mysqld --defaults-file=/cluster/MySQL_Cluster/56/my.cnf
--basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/56/ --user=root --
explicit_defaults_for_timestamp
[root@node1 ~]# ps aux | grep mysqld
root      3454  0.0  0.1  4352  728 pts/0    S+   13:49   0:00 grep mysqld
```

```
[root@node2 ~]# /cluster/mysql_cluster/bin/mysqladmin --socket='/cluster/MySQL_Cluster/57/mysql.socket' shutdown
[root@node2 ~]# ps aux | grep mysqld
root      2382  2.0  1.1 811524  4456 ?        Sl   12:42   1:28 /cluster/mysql_cluster/bin/mysqld --defaults-
file=/cluster/MySQL_Cluster/58/my.cnf --basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/58/ --
user=root --explicit_defaults_for_timestamp
root      2779  0.0  0.1  4356  736 pts/1    S+   13:53   0:00 grep mysqld
[root@node2 ~]# /cluster/mysql_cluster/bin/mysqladmin --socket='/cluster/MySQL_Cluster/58/mysql.socket' shutdown
[root@node2 ~]# ps aux | grep mysqld
root      2784  0.0  0.1  4352  728 pts/1    S+   13:53   0:00 grep mysqld
```

Starting the Cluster

Starting the cluster consists of first starting the Management nodes:

```
[root@node1 ~]# /cluster/mysql_cluster/bin/ndb_mgmd -f /cluster/MySQL_Cluster/49/config.ini --config-
dir=/cluster/MySQL_Cluster/49/
MySQL Cluster Management Server mysql-5.6.23 ndb-7.4.4
[root@node1 ~]# /cluster/mysql_cluster/bin/ndb_mgm -e SHOW
Connected to Management Server at: localhost:1186
Cluster Configuration
-----
[ndbd(NDB)] 2 node(s)
id=1 (not connected, accepting connect from 192.168.22.107)
```

```
id=2 (not connected, accepting connect from 192.168.22.108)
```

```
[ndb_mgmd(MGM)] 2 node(s)
```

```
id=49 @192.168.22.105 (mysql-5.6.23 ndb-7.4.4)
```

```
id=52 (not connected, accepting connect from 192.168.22.106)
```

```
[mysqld(API)] 4 node(s)
```

```
id=55 (not connected, accepting connect from 192.168.22.105)
```

```
id=56 (not connected, accepting connect from 192.168.22.105)
```

```
id=57 (not connected, accepting connect from 192.168.22.106)
```

```
id=58 (not connected, accepting connect from 192.168.22.106)
```

```
[root@node2 ~]# /cluster/mysql_cluster/bin/ndb_mgmd -f /cluster/MySQL_Cluster/52/config.ini --config-dir=/cluster/MySQL_Cluster/52/
```

```
MySQL Cluster Management Server mysql-5.6.23 ndb-7.4.4
```

```
[root@node2 ~]# /cluster/mysql_cluster/bin/ndb_mgm -e SHOW
```

```
Connected to Management Server at: localhost:1186
```

```
Cluster Configuration
```

```
-----
```

```
[ndbd(NDB)] 2 node(s)
```

```
id=1 (not connected, accepting connect from 192.168.22.107)
```

```
id=2 (not connected, accepting connect from 192.168.22.108)
```

```
[ndb_mgmd(MGM)] 2 node(s)
```

```
id=49 @192.168.22.105 (mysql-5.6.23 ndb-7.4.4)
```

```
id=52 @192.168.22.106 (mysql-5.6.23 ndb-7.4.4)
```

```
[mysqld(API)] 4 node(s)
```

```
id=55 (not connected, accepting connect from 192.168.22.105)
```

```
id=56 (not connected, accepting connect from 192.168.22.105)
```

```
id=57 (not connected, accepting connect from 192.168.22.106)
```

```
id=58 (not connected, accepting connect from 192.168.22.106)
```

We now need to start the Data nodes:

```
[root@node3 ~]# /cluster/mysql_cluster/bin/ndbmysqld --ndb-connectstring=192.168.22.105:1186,192.168.22.106:1186
2015-03-02 14:41:18 [ndbd] INFO      -- Angel connected to '192.168.22.105:1186'
2015-03-02 14:41:18 [ndbd] INFO      -- Angel allocated nodeid: 1
```

```
[root@node4 ~]# /cluster/mysql_cluster/bin/ndbmysqld --ndb-connectstring=192.168.22.105:1186,192.168.22.106:1186
2015-03-02 14:41:22 [ndbd] INFO      -- Angel connected to '192.168.22.105:1186'
2015-03-02 14:41:22 [ndbd] INFO      -- Angel allocated nodeid: 2
```

Now we can check the cluster status from the node4 host:

```
[root@node4 ~]# /cluster/mysql_cluster/bin/ndb_mgm --ndb-connectstring=192.168.22.105:1186,192.168.22.106:1186 -e
SHOW
Connected to Management Server at: 192.168.22.105:1186
Cluster Configuration
-----
[ndbd(NDB)] 2 node(s)
id=1      @192.168.22.107  (mysql-5.6.23 ndb-7.4.4, Nodegroup: 0)
id=2      @192.168.22.108  (mysql-5.6.23 ndb-7.4.4, Nodegroup: 0, *)

[ndb_mgmd(MGM)] 2 node(s)
id=49     @192.168.22.105  (mysql-5.6.23 ndb-7.4.4)
id=52     @192.168.22.106  (mysql-5.6.23 ndb-7.4.4)

[mysqld(API)] 4 node(s)
id=55 (not connected, accepting connect from 192.168.22.105)
id=56 (not connected, accepting connect from 192.168.22.105)
id=57 (not connected, accepting connect from 192.168.22.106)
id=58 (not connected, accepting connect from 192.168.22.106)
```

Finally we need to start the SQL nodes:

```
[root@node1 ~]# /cluster/mysql_cluster/bin/mysqld --defaults-file=/cluster/MySQL_Cluster/55/my.cnf --
basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/55/ --user=root --
```

```
explicit_defaults_for_timestamp &
[1] 4134
[root@node1 ~]# /cluster/mysql_cluster/bin/mysqld --defaults-file=/cluster/MySQL_Cluster/56/my.cnf --
basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/56/ --user=root --
explicit_defaults_for_timestamp &
[2] 4167
[root@node1 ~]# ps aux | grep mysqld
root      4134  4.3  0.5 812040  2020 pts/0    Sl   14:43   0:01 /cluster/mysql_cluster/bin/mysqld --defaults-
file=/cluster/MySQL_Cluster/55/my.cnf --basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/55/ --
user=root --explicit_defaults_for_timestamp
root      4167  4.9 74.6 812040 283320 pts/0    Sl   14:43   0:00 /cluster/mysql_cluster/bin/mysqld --defaults-
file=/cluster/MySQL_Cluster/56/my.cnf --basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/56/ --
user=root --explicit_defaults_for_timestamp
root      4200  0.0  0.1  4352   728 pts/0    S+  14:44   0:00 grep mysqld
[root@node1 ~]# /cluster/mysql_cluster/bin/ndb_mgm -e SHOW
Connected to Management Server at: localhost:1186
Cluster Configuration
-----
[ndbd(NDB)] 2 node(s)
id=1      @192.168.22.107 (mysql-5.6.23 ndb-7.4.4, Nodegroup: 0)
id=2      @192.168.22.108 (mysql-5.6.23 ndb-7.4.4, Nodegroup: 0, *)

[ndb_mgmd(MGM)] 2 node(s)
id=49     @192.168.22.105 (mysql-5.6.23 ndb-7.4.4)
id=52     @192.168.22.106 (mysql-5.6.23 ndb-7.4.4)

[mysqld(API)] 4 node(s)
id=55     @192.168.22.105 (mysql-5.6.23 ndb-7.4.4)
id=56     @192.168.22.105 (mysql-5.6.23 ndb-7.4.4)
id=57 (not connected, accepting connect from 192.168.22.106)
id=58 (not connected, accepting connect from 192.168.22.106)

[root@node2 ~]# /cluster/mysql_cluster/bin/mysqld --defaults-file=/cluster/MySQL_Cluster/57/my.cnf --
basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/57/ --user=root --
```

```
explicit_defaults_for_timestamp &
[1] 2987
[root@node2 ~]# /cluster/mysql_cluster/bin/mysqld --defaults-file=/cluster/MySQL_Cluster/58/my.cnf --
basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/58/ --user=root --
explicit_defaults_for_timestamp &
[2] 3019
[root@node2 ~]# ps aux | grep mysqld
root      2987  4.2  0.8 812040 3384 pts/1    Sl   14:45   0:01 /cluster/mysql_cluster/bin/mysqld --defaults-
file=/cluster/MySQL_Cluster/57/my.cnf --basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/57/ --
user=root --explicit_defaults_for_timestamp
root      3019  7.0 80.5 812040 305976 pts/1    Sl   14:45   0:00 /cluster/mysql_cluster/bin/mysqld --defaults-
file=/cluster/MySQL_Cluster/58/my.cnf --basedir=/cluster/mysql_cluster/ --datadir=/cluster/MySQL_Cluster/58/ --
user=root --explicit_defaults_for_timestamp
root      3052  0.5  0.1  4352   748 pts/1    S+  14:45   0:00 grep mysqld
[root@node2 ~]# /cluster/mysql_cluster/bin/ndb_mgm -e SHOW
Connected to Management Server at: localhost:1186
Cluster Configuration
-----
[ndbd(NDB)] 2 node(s)
id=1      @192.168.22.107 (mysql-5.6.23 ndb-7.4.4, Nodegroup: 0)
id=2      @192.168.22.108 (mysql-5.6.23 ndb-7.4.4, Nodegroup: 0, *)

[ndb_mgmd(MGM)] 2 node(s)
id=49     @192.168.22.105 (mysql-5.6.23 ndb-7.4.4)
id=52     @192.168.22.106 (mysql-5.6.23 ndb-7.4.4)

[mysqld(API)] 4 node(s)
id=55     @192.168.22.105 (mysql-5.6.23 ndb-7.4.4)
id=56     @192.168.22.105 (mysql-5.6.23 ndb-7.4.4)
id=57     @192.168.22.106 (mysql-5.6.23 ndb-7.4.4)
id=58     @192.168.22.106 (mysql-5.6.23 ndb-7.4.4)
```

<note important> It is obviously possible to perform a **rolling restart** to ensure high availability. This process is detailed [here](#) </note>

Logging and Debugging

MySQL Logs

These are generated in their respective node directories. They are of a traditional MySQL format and detail both successful operations and errors:

```
[root@node1 ~]# tail /cluster/MySQL_Cluster/55/mysqld.55.err
2015-03-02 14:43:47 4134 [Note] NDB Binlog: starting log at epoch 5130/3
2015-03-02 14:43:47 4134 [Note] NDB Binlog: Got first event
2015-03-02 14:43:47 4134 [Note] NDB Binlog: ndb tables writable
2015-03-02 14:43:47 4134 [Note] NDB Binlog: Startup and setup completed
2015-03-02 14:44:09 4134 [Note] NDB Schema dist: Data node: 1 reports subscribe from node 56, subscriber bitmask
10000000
2015-03-02 14:44:09 4134 [Note] NDB Schema dist: Data node: 2 reports subscribe from node 56, subscriber bitmask
10000000
2015-03-02 14:45:32 4134 [Note] NDB Schema dist: Data node: 1 reports subscribe from node 57, subscriber bitmask
30000000
2015-03-02 14:45:32 4134 [Note] NDB Schema dist: Data node: 2 reports subscribe from node 57, subscriber bitmask
30000000
2015-03-02 14:45:50 4134 [Note] NDB Schema dist: Data node: 1 reports subscribe from node 58, subscriber bitmask
70000000
2015-03-02 14:45:50 4134 [Note] NDB Schema dist: Data node: 2 reports subscribe from node 58, subscriber bitmask
70000000
[root@node1 ~]# tail /cluster/MySQL_Cluster/56/mysqld.56.err
2015-03-02 14:44:10 4167 [Note] NDB Binlog: starting log at epoch 5140/19
2015-03-02 14:44:10 4167 [Note] NDB Binlog: Got first event
2015-03-02 14:44:10 4167 [Note] NDB Binlog: ndb tables writable
2015-03-02 14:44:10 4167 [Note] NDB Binlog: Startup and setup completed
2015-03-02 14:44:10 4167 [Note] NDB Schema dist: Data node: 2 reports subscribe from node 55, subscriber bitmask
80000000
2015-03-02 14:44:10 4167 [Note] NDB Schema dist: Data node: 1 reports subscribe from node 55, subscriber bitmask
80000000
```

```
2015-03-02 14:45:32 4167 [Note] NDB Schema dist: Data node: 1 reports subscribe from node 57, subscriber bitmask 28000000
2015-03-02 14:45:32 4167 [Note] NDB Schema dist: Data node: 2 reports subscribe from node 57, subscriber bitmask 28000000
2015-03-02 14:45:50 4167 [Note] NDB Schema dist: Data node: 1 reports subscribe from node 58, subscriber bitmask 68000000
2015-03-02 14:45:50 4167 [Note] NDB Schema dist: Data node: 2 reports subscribe from node 58, subscriber bitmask 68000000
```

```
[root@node2 ~]# tail /cluster/MySQL_Cluster/57/mysqld.57.err
2015-03-02 14:45:32 2987 [Note] NDB Binlog: starting log at epoch 5180/16
2015-03-02 14:45:32 2987 [Note] NDB Binlog: Got first event
2015-03-02 14:45:32 2987 [Note] NDB Binlog: ndb tables writable
2015-03-02 14:45:32 2987 [Note] NDB Binlog: Startup and setup completed
2015-03-02 14:45:32 2987 [Note] NDB Schema dist: Data node: 1 reports subscribe from node 56, subscriber bitmask 10000000
2015-03-02 14:45:32 2987 [Note] NDB Schema dist: Data node: 1 reports subscribe from node 55, subscriber bitmask 18000000
2015-03-02 14:45:32 2987 [Note] NDB Schema dist: Data node: 2 reports subscribe from node 56, subscriber bitmask 10000000
2015-03-02 14:45:32 2987 [Note] NDB Schema dist: Data node: 2 reports subscribe from node 55, subscriber bitmask 18000000
2015-03-02 14:45:50 2987 [Note] NDB Schema dist: Data node: 1 reports subscribe from node 58, subscriber bitmask 58000000
2015-03-02 14:45:50 2987 [Note] NDB Schema dist: Data node: 2 reports subscribe from node 58, subscriber bitmask 58000000
[root@node2 ~]# tail /cluster/MySQL_Cluster/58/mysqld.58.err
2015-03-02 14:45:51 3019 [Note] NDB Binlog: starting log at epoch 5189/15
2015-03-02 14:45:51 3019 [Note] NDB Binlog: Got first event
2015-03-02 14:45:51 3019 [Note] NDB Binlog: ndb tables writable
2015-03-02 14:45:51 3019 [Note] NDB Binlog: Startup and setup completed
2015-03-02 14:45:51 3019 [Note] NDB Schema dist: Data node: 1 reports subscribe from node 57, subscriber bitmask 20000000
2015-03-02 14:45:51 3019 [Note] NDB Schema dist: Data node: 1 reports subscribe from node 56, subscriber bitmask
```

```
30000000
2015-03-02 14:45:51 3019 [Note] NDB Schema dist: Data node: 1 reports subscribe from node 55, subscriber bitmask
38000000
2015-03-02 14:45:51 3019 [Note] NDB Schema dist: Data node: 2 reports subscribe from node 57, subscriber bitmask
20000000
2015-03-02 14:45:51 3019 [Note] NDB Schema dist: Data node: 2 reports subscribe from node 56, subscriber bitmask
30000000
2015-03-02 14:45:51 3019 [Note] NDB Schema dist: Data node: 2 reports subscribe from node 55, subscriber bitmask
38000000
```

Cluster Logs

By default the cluster log is saved to a file named `ndb_<node_id>_cluster.log` situated in the Management node's data directory:

```
[root@node1 ~]# locate *_cluster.log
/cluster/MySQL_Cluster/49/ndb_49_cluster.log
```

```
[root@node2 ~]# locate *_cluster.log
/cluster/MySQL_Cluster/52/ndb_52_cluster.log
```

<note important> This location can be changed by the [DataDir](#) parameter. The use of Syslog is made possible by the [LogDestination](#) parameter. The cluster log provides logging information for the entire cluster in a single location. </note>

For example:

```
[root@node1 ~]# tail /cluster/MySQL_Cluster/49/ndb_49_cluster.log
2015-03-02 15:39:37 [MgmtSrvr] INFO      -- Node 2: Data usage is 71%(23 32K pages of total 32)
2015-03-02 15:39:37 [MgmtSrvr] INFO      -- Node 2: Index usage is 12%(20 8K pages of total 160)
2015-03-02 15:40:03 [MgmtSrvr] INFO      -- Node 1: Data usage is 71%(23 32K pages of total 32)
2015-03-02 15:40:03 [MgmtSrvr] INFO      -- Node 1: Index usage is 12%(20 8K pages of total 160)
2015-03-02 15:40:08 [MgmtSrvr] INFO      -- Node 2: Data usage is 71%(23 32K pages of total 32)
2015-03-02 15:40:08 [MgmtSrvr] INFO      -- Node 2: Index usage is 12%(20 8K pages of total 160)
2015-03-02 15:40:34 [MgmtSrvr] INFO      -- Node 1: Data usage is 71%(23 32K pages of total 32)
```

```
2015-03-02 15:40:34 [MgmtSrvr] INFO -- Node 1: Index usage is 12%(20 8K pages of total 160)
2015-03-02 15:40:38 [MgmtSrvr] INFO -- Node 2: Data usage is 71%(23 32K pages of total 32)
2015-03-02 15:40:38 [MgmtSrvr] INFO -- Node 2: Index usage is 12%(20 8K pages of total 160)
```

```
[root@node2 ~]# tail /cluster/MySQL_Cluster/52/ndb_52_cluster.log
2015-03-02 15:39:37 [MgmtSrvr] INFO -- Node 2: Data usage is 71%(23 32K pages of total 32)
2015-03-02 15:39:37 [MgmtSrvr] INFO -- Node 2: Index usage is 12%(20 8K pages of total 160)
2015-03-02 15:40:03 [MgmtSrvr] INFO -- Node 1: Data usage is 71%(23 32K pages of total 32)
2015-03-02 15:40:03 [MgmtSrvr] INFO -- Node 1: Index usage is 12%(20 8K pages of total 160)
2015-03-02 15:40:07 [MgmtSrvr] INFO -- Node 2: Data usage is 71%(23 32K pages of total 32)
2015-03-02 15:40:07 [MgmtSrvr] INFO -- Node 2: Index usage is 12%(20 8K pages of total 160)
2015-03-02 15:40:34 [MgmtSrvr] INFO -- Node 1: Data usage is 71%(23 32K pages of total 32)
2015-03-02 15:40:34 [MgmtSrvr] INFO -- Node 1: Index usage is 12%(20 8K pages of total 160)
2015-03-02 15:40:38 [MgmtSrvr] INFO -- Node 2: Data usage is 71%(23 32K pages of total 32)
2015-03-02 15:40:38 [MgmtSrvr] INFO -- Node 2: Index usage is 12%(20 8K pages of total 160)
```

Node Logs

Node logs are specific to each node and are held in the DataDir:

```
[root@node1 ~]# locate _out.log
/cluster/MySQL_Cluster/49/ndb_49_out.log
```

```
[root@node2 ~]# locate *_out.log
/cluster/MySQL_Cluster/52/ndb_52_out.log
```

```
[root@node3 ~]# locate _out.log
/cluster/MySQL_Cluster/1/ndb_1_out.log
```

```
[root@node4 ~]# locate _out.log
/cluster/MySQL_Cluster/2/ndb_2_out.log
```

For example:

```
[root@node1 ~]# tail /cluster/MySQL_Cluster/49/ndb_49_out.log
==INITIAL==
==CONFIRMED==
==INITIAL==
==CONFIRMED==
Node 52 failed
stop checker 0
==CONFIRMED==
```

```
[root@node2 ~]# tail /cluster/MySQL_Cluster/52/ndb_52_out.log
==INITIAL==
==CONFIRMED==
==INITIAL==
==CONFIRMED==
stop checker 0
==CONFIRMED==
```

```
[root@node3 ~]# tail /cluster/MySQL_Cluster/1/ndb_1_out.log
2015-03-02 14:41:26 [ndbd] INFO      -- NDB start phase 7 completed
2015-03-02 14:41:26 [ndbd] INFO      -- Start phase 8 completed
2015-03-02 14:41:26 [ndbd] INFO      -- Phase 8 enabled foreign keys and waited forall nodes to complete start up
to this point
2015-03-02 14:41:26 [ndbd] INFO      -- Start phase 9 completed
2015-03-02 14:41:26 [ndbd] INFO      -- Phase 9 enabled APIs to start connecting
2015-03-02 14:41:26 [ndbd] INFO      -- Start phase 101 completed
2015-03-02 14:41:26 [ndbd] INFO      -- Phase 101 was used by SUMA to take over responsibility for sending some of
the asynchronous change events
2015-03-02 14:41:26 [ndbd] INFO      -- Node started
2015-03-02 14:41:26 [ndbd] INFO      -- Prepare arbitrator node 49 [ticket=0c5c000100a3b073]
2015-03-02 14:43:47 [ndbd] INFO      -- Allocate event buffering page chunk in SUMA, 16 pages, first page ref =
3594
```

```
[root@node4 ~]# tail /cluster/MySQL_Cluster/2/ndb_2_out.log
2015-03-02 14:41:26 [ndbd] INFO      -- Grant nodes to start phase: 9, nodes: 00000000000000006
2015-03-02 14:41:26 [ndbd] INFO      -- Start phase 9 completed
2015-03-02 14:41:26 [ndbd] INFO      -- Phase 9 enabled APIs to start connecting
2015-03-02 14:41:26 [ndbd] INFO      -- Grant nodes to start phase: 10, nodes: 00000000000000006
2015-03-02 14:41:26 [ndbd] INFO      -- Start phase 101 completed
2015-03-02 14:41:26 [ndbd] INFO      -- Phase 101 was used by SUMA to take over responsibility for sending some of
the asynchronous change events
2015-03-02 14:41:26 [ndbd] INFO      -- Grant nodes to start phase: 102, nodes: 00000000000000006
2015-03-02 14:41:26 [ndbd] INFO      -- Node started
2015-03-02 14:41:27 [ndbd] INFO      -- Started arbitrator node 49 [ticket=0c5c000100a3b073]
2015-03-02 14:43:47 [ndbd] INFO      -- Allocate event buffering page chunk in SUMA, 16 pages, first page ref =
3720
```

The ndbinfo MySQL Cluster Information Database

It is possible to interrogate the cluster in real time by using the ndbinfo database.

For example, we can connect to the first SQL node on the node1 host as follows:

```
[root@node1 ~]# /cluster/mysql_cluster/bin/mysql --socket="/cluster/MySQL_Cluster/55/mysql.socket"
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 2
Server version: 5.6.23-ndb-7.4.4-cluster-gpl MySQL Cluster Community Server (GPL)

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affiliates. Other names may be trademarks of their respective
owners.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.
```

```
mysql>
```

We first check that the ndbinfo support is active:

```
mysql> SHOW PLUGINS;
```

Name	Status	Type	Library	License
binlog	ACTIVE	STORAGE ENGINE	NULL	GPL
mysql_native_password	ACTIVE	AUTHENTICATION	NULL	GPL
mysql_old_password	ACTIVE	AUTHENTICATION	NULL	GPL
sha256_password	ACTIVE	AUTHENTICATION	NULL	GPL
MEMORY	ACTIVE	STORAGE ENGINE	NULL	GPL
MRG_MYISAM	ACTIVE	STORAGE ENGINE	NULL	GPL
CSV	ACTIVE	STORAGE ENGINE	NULL	GPL
MyISAM	ACTIVE	STORAGE ENGINE	NULL	GPL
ndbcluster	ACTIVE	STORAGE ENGINE	NULL	GPL
ndbinfo	ACTIVE	STORAGE ENGINE	NULL	GPL
ndb_transid_mysql_connection_map	ACTIVE	INFORMATION SCHEMA	NULL	GPL
FEDERATED	DISABLED	STORAGE ENGINE	NULL	GPL
ARCHIVE	ACTIVE	STORAGE ENGINE	NULL	GPL
InnoDB	ACTIVE	STORAGE ENGINE	NULL	GPL
INNODB_TRX	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_LOCKS	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_LOCK_WAITS	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_CMP	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_CMP_RESET	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_CMPMEM	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_CMPMEM_RESET	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_CMP_PER_INDEX	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_CMP_PER_INDEX_RESET	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_BUFFER_PAGE	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_BUFFER_PAGE_LRU	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_BUFFER_POOL_STATS	ACTIVE	INFORMATION SCHEMA	NULL	GPL

INNODB_METRICS	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_FT_DEFAULT_STOPWORD	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_FT_DELETED	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_FT_BEING_DELETED	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_FT_CONFIG	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_FT_INDEX_CACHE	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_FT_INDEX_TABLE	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_SYS_TABLES	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_SYS_TABLESTATS	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_SYS_INDEXES	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_SYS_COLUMNS	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_SYS_FIELDS	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_SYS_FOREIGN	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_SYS_FOREIGN_COLS	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_SYS_TABLESPACES	ACTIVE	INFORMATION SCHEMA	NULL	GPL
INNODB_SYS_DATAFILES	ACTIVE	INFORMATION SCHEMA	NULL	GPL
BLACKHOLE	ACTIVE	STORAGE ENGINE	NULL	GPL
PERFORMANCE_SCHEMA	ACTIVE	STORAGE ENGINE	NULL	GPL
partition	ACTIVE	STORAGE ENGINE	NULL	GPL

-----+-----+-----+-----+-----+
 45 rows in set (0.11 sec)

mysql>

Now we use the ndbinfo database:

```
mysql> SHOW DATABASES;
+-----+
| Database          |
+-----+
| information_schema |
| mysql             |
| ndbinfo           |
| performance_schema |
```

```
| test          |
| tmp          |
+-----+
6 rows in set (0.06 sec)
```

```
mysql> USE ndbinfo;
Reading table information for completion of table and column names
You can turn off this feature to get a quicker startup with -A
```

Database changed

```
mysql> SHOW TABLES;
```

```
+-----+
| Tables_in_ndbinfo          |
+-----+
| arbitrator_validity_detail |
| arbitrator_validity_summary |
| blocks                     |
| cluster_operations         |
| cluster_transactions       |
| config_params              |
| counters                   |
| dict_obj_types             |
| disk_write_speed_aggregate |
| disk_write_speed_aggregate_node |
| disk_write_speed_base      |
| diskpagebuffer             |
| logbuffers                  |
| logspaces                   |
| membership                  |
| memory_per_fragment        |
| memoryusage                 |
| nodes                       |
| operations_per_fragment    |
| resources                   |
+-----+
```

```
| restart_info          |
| server_operations    |
| server_transactions  |
| threadblocks         |
| threadstat           |
| transporters         |
+-----+
26 rows in set (0.01 sec)

mysql>
```

We are now able to query this database for real time statistics such as the memory usage:

```
mysql> SELECT * FROM memoryusage;
+-----+-----+-----+-----+-----+-----+
| node_id | memory_type          | used   | used_pages | total   | total_pages |
+-----+-----+-----+-----+-----+-----+
| 1       | Data memory         | 753664 | 23         | 1048576 | 32          |
| 1       | Index memory        | 163840 | 20         | 1310720 | 160         |
| 1       | Long message buffer | 262144 | 1024       | 33554432 | 131072      |
| 2       | Data memory         | 753664 | 23         | 1048576 | 32          |
| 2       | Index memory        | 163840 | 20         | 1310720 | 160         |
| 2       | Long message buffer | 393216 | 1536       | 33554432 | 131072      |
+-----+-----+-----+-----+-----+-----+
6 rows in set (0.02 sec)

mysql>
```

Backing Up MySQL Cluster

A backup of MySQL Cluster is a snapshot of the database. The snapshot consists of three main parts:

- **Metadata** - The names and definitions of all database tables
 - File name format: BACKUP-backup_id.node_id.ctl
- **Table records** - The data stored in the database tables
 - File name format: BACKUP-backup_id-0.node_id.data
- **Transaction log** - A sequential record of how and when data was stored in the database
 - File name format: BACKUP-backup_id.node_id.log

The backup is started by using the **ndb_mgm** command with one of the following options:

- **NOWAIT** - ndb_mgm immediately returns a prompt
- **STARTED** - ndb_mgm returns a prompt after the backup has started
- **COMPLETED** - ndb_mgm returns a prompt after the backup has completed

A snapshot option can also be stipulated:

- **SNAPSHOTSTART** - the snapshot reflects the status at the start of the backup process
- **SNAPSHOTEND** - the snapshot reflects the status at the end of the backup process

For example:

```
[root@node1 ~]# /cluster/mysql_cluster/bin/ndb_mgm
-- NDB Cluster -- Management Client --
ndb_mgm> START BACKUP SNAPSHOTEND WAIT COMPLETED
Connected to Management Server at: localhost:1186
Waiting for completed, this may take several minutes
Node 1: Backup 2 started from node 49
Node 1: Backup 2 started from node 49 completed
  StartGCP: 10336 StopGCP: 10339
  #Records: 2054 #LogRecords: 0
  Data: 50696 bytes Log: 0 bytes
ndb_mgm>

[root@node2 ~]# /cluster/mysql_cluster/bin/ndb_mgm
-- NDB Cluster -- Management Client --
ndb_mgm> START BACKUP SNAPSHOTEND WAIT COMPLETED
```

```
Connected to Management Server at: localhost:1186
Waiting for completed, this may take several minutes
Node 1: Backup 3 started from node 52
Node 1: Backup 3 started from node 52 completed
  StartGCP: 12310 StopGCP: 12313
  #Records: 2054 #LogRecords: 0
  Data: 50696 bytes Log: 0 bytes
ndb_mgm>
```

Backups are saved to the directory/BACKUP stipulated by the value of the **BackupDataDir** parameter on the data node hosts which defaults to DataDir/BACKUP:

```
[root@node3 ~]# ls /cluster/MySQL_Cluster/1/BACKUP
BACKUP-1  BACKUP-2
```

```
[root@node4 BACKUP-1]# ls /cluster/MySQL_Cluster/2/BACKUP
BACKUP-1
```

~~DISCUSSION:off~~

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