Red Hat Enterprise Linux 7
High Availability Add-On Reference

Reference Document for the High Availability Add-On for Red Hat Enterprise Linux 7

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Abstract

Red Hat High Availability Add-On Reference provides reference information about installing, configuring, and managing the Red Hat High Availability Add-On for Red Hat Enterprise Linux 7.

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Chapter 1. Red Hat High Availability Add-On Configuration and Management Reference Overview

This document provides descriptions of the options and features that the Red Hat High Availability Add-On using Pacemaker supports. For a step-by-step basic configuration example, refer to *Red Hat High Availability Add-On Administration*.

You can configure a Red Hat High Availability Add-On cluster with the **pcs** configuration interface or with the **pcsd** GUI interface.

1.1. New and Changed Features

This section lists features of the Red Hat High Availability Add-On that are new since the initial release of Red Hat Enterprise Linux 7.

1.1.1. New and Changed Features for Red Hat Enterprise Linux 7.1

Red Hat Enterprise Linux 7.1 includes the following documentation and feature updates and changes.

- The **pcs resource cleanup** command can now reset the resource status and failcount for all resources, as documented in Section 5.11, “Cluster Resources Cleanup”.
- You can specify a **lifetime** parameter for the **pcs resource move** command, as documented in Section 7.1, “Manually Moving Resources Around the Cluster”.
- As of Red Hat Enteprise Linux 7.1, you can use the **pcs acl** command to set permissions for local users to allow read-only or read-write access to the cluster configuration by using access control lists (ACLs). For information on ACLs, see Section 3.3, “Setting User Permissions”.
- Section 6.2.3, “Ordered Resource Sets” and Section 6.3, “Colocation of Resources” have been extensively updated and clarified.
- Section 5.1, “Resource Creation” documents the **disabled** parameter of the **pcs resource create** command, to indicate that the resource being created is not started automatically.
- Section 3.1.6, “Configuring Quorum Options” documents the new **cluster quorum unblock** feature, which prevents the cluster from waiting for all nodes when establishing quorum.
- Section 5.1, “Resource Creation” documents the **before** and **after** parameters of the **pcs resource create** command, which can be used to configure resource group ordering.
- As of the Red Hat Enterprise Linux 7.1 release, you can backup the cluster configuration in a tarball and restore the cluster configuration files on all nodes from backup with the **backup** and **restore** options of the **pcs config** command. For information on this feature, see Section 2.8, “Backing Up and Restoring a Cluster Configuration”.
- Small clarifications have been made throughout this document.

1.1.2. New and Changed Features for Red Hat Enterprise Linux 7.2

Red Hat Enterprise Linux 7.2 includes the following documentation and feature updates and changes.

- You can now use the **pcs resource relocate run** command to move a resource to its preferred node, as determined by current cluster status, constraints, location of resources and other settings. For information on this command, see Section 7.1.2, “Moving a Resource to its Preferred Node”.
- Section 8.3, “Event Notification with Monitoring Resources” has been modified and expanded to better document how to configure the **ClusterMon** resource to execute an external program to determine what to do with cluster notifications.
- When configuring fencing for redundant power supplies, you now are only required to define each device once and to specify that both devices are required to fence the node. For information on configuring fencing for redundant power supplies, see Section 4.11, “Configuring Fencing for Redundant Power Supplies”.
- This document now provides a procedure for adding a node to an existing cluster in Section 3.2.3, “Adding Cluster Nodes”.
- The new **resource-discovery** location constraint option allows you to indicate whether Pacemaker should perform resource discovery on a node for a specified resource, as documented in Table 6.1, “Location Constraint Options”.
- Small clarifications and corrections have been made throughout this document.

1.2. Installing Pacemaker configuration tools

You can use the following **yum install** command to install the Red Hat High Availability Add-On software packages along with all available: fence agents from the High Availability channel.

```
# yum install pcs fence-agents-all
```

Alternately, you can install the Red Hat High Availability Add-On software packages along with only the fence agent that you require with the following command.

```
# yum install pcs fence-agents-model
```

The following command displays a listing of the available fence agents.

```
# rpm -q -a | grep fence
fence-agents-rhevm-4.0.2-3.el7.x86_64
fence-agents-ilo-mp-4.0.2-3.el7.x86_64
fence-agents-ipmilan-4.0.2-3.el7.x86_64
...
```

The **lvm2-cluster** and **gfs2-utils** packages are part of ResilientStorage channel. You can install them, as needed, with the following command.

```
# yum install lvm2-cluster gfs2-utils
```

Warning

After you install the Red Hat High Availability Add-On packages, you should ensure that your software update preferences are set so that nothing is installed automatically. Installation on a running cluster can cause unexpected behaviors.

1.3. Configuring the iptables Firewall to Allow Cluster Components

The Red Hat High Availability Add-On requires that the following ports be enabled for incoming traffic:

- For TCP: Ports 2224, 3121, 21064
- For UDP: Ports 5405
- For DLM (if using the DLM lock manager with clvm/GFS2): Port 21064

You can enable these ports by means of the **firewalld** daemon by executing the following commands.

```
# firewall-cmd --permanent --add-service=high-availability
# firewall-cmd --add-service=high-availability
```

1.4. The Cluster and Pacemaker Configuration Files

The configuration files for the Red Hat High Availability add-on are **corosync.conf** and **cib.xml**. Do not edit these files directly; use the **pcs** or **pcsd** interface instead.

The **corosync.conf** file provides the cluster parameters used by **corosync**, the cluster manager that Pacemaker is built on.

The **cib.xml** file is an XML file that represents both the cluster's configuration and current state of all resources in the cluster. This file is used by Pacemaker's Cluster Information Base (CIB). The contents of the the CIB are automatically kept in sync across the entire cluster

Chapter 2. The pcs Command Line Interface

The **pcs** command line interface controls and configures **corosync** and Pacemaker by providing an interface to the **corosync.conf** and **cib.xml** files.

The general format of the **pcs** command is as follows.

```
pcs [-f file] [-h] [commands]...
```

2.1. The pcs Commands

The **pcs** commands are as follows.

- **cluster**

  Configure cluster options and nodes. For information on the **pcs cluster** command, see Chapter 3, *Cluster Creation and Administration*.

- **resource**

  Create and manage cluster resources. For information on the **pcs cluster** command, see Chapter 5, *Configuring Cluster Resources*, Chapter 7, *Managing Cluster Resources*, and Chapter 8, *Advanced Resource types*.

- **stonith**

  Configure fence devices for use with Pacemaker. For information on the **pcs stonith** command, see Chapter 4, *Fencing: Configuring STONITH*.

- **constraint**

  Manage resource constraints. For information on the **pcs constraint** command, see Chapter 6, *Resource Constraints*.

- **property**

  Set Pacemaker properties. For information on seeting properties with the **pcs property** command, see Chapter 10, *Pacemaker Cluster Properties*.

- **status**

  View current cluster and resource status. For information on the **pcs status** command, see Section 2.5, “Displaying Status”.

- **config**

  Display complete cluster configuration in user-readable form. For information on the **pcs config** command, see Section 2.6, “Displaying the Full Cluster Configuration”.

2.2. pcs Usage Help Display

You can use the **-h** option of **pcs** to display the parameters of a **pcs** command and a description of those parameters. For example, the following command displays the parameters of the **pcs resource** command. Only a portion of the output is shown.

```
# pcs resource -h
```

```
Usage: pcs resource [commands]...
Manage pacemaker resources
Commands:
   show [resource id] [--all]
      Show all currently configured resources or if a resource is specified
      show the options for the configured resource.  If --all is specified
      resource options will be displayed

   start <resource id>
      Start resource specified by resource_id
...
```

2.3. Viewing the Raw Cluster Configuration

Although you should not edit the cluster configuration file directily, you can view the raw cluster configuration with the **pcs cluster cib** command.

You can save the raw cluster configuration to a specified file with the **pcs cluster cib *filename*** as described in Section 2.4, “Saving a Configuration Change to a File”.

2.4. Saving a Configuration Change to a File

When using the **pcs** command, you can use the **-f** option to save a configuration change to a file without affecting the active CIB.

If you have previously configured a cluster and there is already an active CIB, you use the following command to save the raw xml a file.

```
pcs cluster cib filename
```

For example, the following command saves the raw xml from the CIB into a file name **testfile**.

```
pcs cluster cib testfile
```

The following command creates a resource in the file **testfile1** but does not add that resource to the currently running cluster configuration.

```
# pcs -f testfile1 resource create VirtualIP ocf:heartbeat:IPaddr2 ip=192.168.0.120
cidr_netmask=24 op monitor interval=30s
```

You can push the current content of **testfile** to the CIB with the following command.

```
pcs cluster cib-push filename
```

2.5. Displaying Status

You can display the status of the cluster and the cluster resources with the following command.

```
pcs status commands
```

If you do not specify a *commands* parameter, this command displays all information about the cluster and the resources. You display the status of only particular cluster components by specifying **resources**, **groups**, **cluster**, **nodes**, or **pcsd**.

2.6. Displaying the Full Cluster Configuration

Use the following command to display the full current cluster configuration.

```
pcs config
```

2.7. Displaying The Current pcs Version

The following command displays the current version of **pcs** that is running.

```
pcs --version
```

2.8. Backing Up and Restoring a Cluster Configuration

As of the Red Hat Enterprise Linux 7.1 release, you can back up the cluster configuration in a tarball with the following command. If you do not specify a file name, the standard ouptut will be used.

```
pcs config backup filename
```

Use the following command to restore the cluster configuration files on all nodes from the backup. If you do not specify a file name, the standard input will be used. Specifying the **--local** option restores only the files on the current node.

```
pcs config restore [--local] [filename]
```

Chapter 3. Cluster Creation and Administration

This chapter describes how to perform basic cluster administration with Pacemaker, including creating the cluster, managing the cluster components, and displaying cluster status.

3.1. Cluster Creation

To create a running cluster, perform the following steps:

1. Start the **pcsd** on each node in the cluster.
2. Authenticate the nodes that will constitute the cluster.
3. Configure and sync the cluster nodes.
4. Start cluster services on the cluster nodes.

The following sections described the commands that you use to perform these steps.

3.1.1. Starting the pcsd daemon

The following commands start the **pcsd** service and enable **pcsd** at system start. These commands should be run on each node in the cluster.

```
# systemctl start pcsd.service
# systemctl enable pcsd.service
```

3.1.2. Authenticating the Cluster Nodes

The following command authenticates **pcs** to the **pcs** daemon on the nodes in the cluster.

- The username for the **pcs** administrator must be **hacluster** on every node. It is recommended that the password for user **hacluster** be the same on each node.
- If you do not specify username or password, the system will prompt you for those parameters for each node when you execute the command.
- If you do not specify any nodes, this command will authenticate **pcs** on the nodes that are specified with a **pcs cluster setup** command, if you have previously executed that command.

```
pcs cluster auth [node] [...] [-u username] [-p password]
```

For example, the following command authenticates user **hacluster** on **z1.example.com** for both of the nodes in the cluster that consist of **z1.example.com** and **z2.example.com**. This command prompts for the password for user **hacluster** on the cluster nodes.

```
root@z1 ~]# pcs cluster auth z1.example.com z2.example.com
Username: hacluster
Password:
z1.example.com: Authorized
z2.example.com: Authorized
```

Authorization tokens are stored in the file **~/.pcs/tokens** (or **/var/lib/pcsd/tokens**).

3.1.3. Configuring and Starting the Cluster Nodes

The following command configures the cluster configuration file and syncs the configuration to the specified nodes.

- If you specify the **--start** option, the command will also start the cluster services on the specified nodes. If necessary, you can also start the cluster services with a separate **pcs cluster start** command.

  When you create a cluster with the **pcs cluster setup --start** command or when you start cluster services with the **pcs cluster start** command, there may be a slight delay before the cluster is up and running. Before performing any subsequent actions on the cluster and its configuration, it is recommended that you use the **pcs cluster status** command to be sure that the cluster is up and running.

- If you specify the **--local** option, the command will perform changes on the local node only.

pcs cluster setup [--start] [--local] --name *cluster_ name node1* [*node2*] [...]

The following command starts cluster services on the specified node or nodes.

- If you specify the **--all** option, the command starts cluster services on all nodes.
- If you do not specify any nodes, cluster services are started on the local node only.

pcs cluster start [--all] [*node*] [...]

3.1.4. Configuring Timeout Values for a Cluster

When you create a cluster with the **pcs cluster setup** command, timeout values for the cluster are set to default values that should be suitable for most cluster configurations. If you system requires different timeout values, however, you can modify these values with the **pcs cluster setup** options summarized in Table 3.1, “Timeout Options”

Table 3.1. Timeout Options

Option	Description
--token *timeout*	Sets time in milliseconds until a token loss is declared after not receiving a token (default 1000 ms)
--join *timeout*	sets time in milliseconds to wait for join mesages (default 50 ms)
--consensus *timeout*	sets time in milliseconds to wait for consensus to be achieved before starting a new round of member- ship configuration (default 1200 ms)
--miss_count_const *count*	sets the maximum number of times on receipt of a token a message is checked for retransmission before a retransmission occurs (default 5 messages)
--fail_recv_const *failures*	specifies how many rotations of the token without receiving any messages when messages should be received may occur before a new configuration is formed (default 2500 failures)

For example, the following command creates the cluster **new_cluster** and sets the token timeout value to 10000ms (10 seconds) and the join timeout value to 100ms.

pcs cluster setup --name new_cluster nodeA nodeB --token 10000 --join 100

3.1.5. Configuring Redundant Ring Protocol (RRP)

When you create a cluster with the **pcs cluster setup** command, you can configure a cluster with Redundant Ring Protocol by specifying both interfaces for each node. When using the default udpu transport, when you specify the cluster nodes you specify the ring 0 address followed by a ',', then the ring 1 address.

For example, the following command configures a cluster named **my_rrp_clusterM** with two nodes, node A and node B. Node A has two interfaces, **nodeA-0** and **nodeA-1**. Node B has two interfaces, **nodeB-0** and **nodeB-1**. To configure these nodes as a cluster using RRP, execute the following command.

```
# pcs cluster setup --name my_rrp_cluster nodeA-0,nodeA-1 nodeB-0,nodeB-1
```

For information on configuring RRP in a cluster that uses **udp** transport, see the help screen for the **pcs cluster setup** command.

3.1.6. Configuring Quorum Options

A Red Hat Enterprise Linux High Availability Add-On cluster uses the **votequorum** service to avoid split-brain situations. A number of votes is assigned to each system in the cluster, and cluster operations are allowed to proceed only when a majority of votes is present. The service must be loaded into all nodes or none; if it is loaded into a subset of cluster nodes, the results will be unpredictable. For information on the configuration and operation of the **votequorum** service, see the **votequorum**(5) man page.

In a situation in which you know that the cluster in inquorate but you want the cluster to proceed with resource management, you can use the following command to prevent the cluster from waiting for all nodes when establishing quorum.

Note

This command should be used with extreme caution. Before issuing this command, it is imperative that you ensure that nodes that are not currently in the cluster are switched off.

```
# pcs cluster quorum unblock
```

There are some special features of quorum configuration that you can set when you create a cluster with the **pcs cluster setup** command. Table 3.2, “Quorum Options” summarizes these options.

Table 3.2. Quorum Options

Option	Description
--wait_for_all	When enabled, the cluster will be quorate for the first time only after all nodes have been visible at least once at the same time.
--auto_tie_breaker	When enabled, the cluster can suffer up to 50% of the nodes failing at the same time, in a deterministic fashion. The cluster partition, or the set of nodes that are still in contact with the **nodeid** configured in **auto_tie_breaker_node** (or lowest **nodeid** if not set), will remain quorate. The other nodes will be inquorate.

Option	Description
--last_man_standing	When enabled, the cluster can dynamically recalculate **expected_votes** and quorum under specific circumstances. You must enable **wait_for_all** and you must specify **last_man_standing_window** when you enable this option.
--last_man_standing_window	The time, in milliseconds, to wait before recalculating **expected_votes** and quorum after a cluster loses nodes.

For further information about configuring and using these options, see the **votequorum**(5) man page.

3.2. Managing Cluster Nodes

The following sections describe the commands you use to manage cluster nodes, including commands to start and stop cluster services and to add and remove cluster nodes.

3.2.1. Stopping Cluster Services

The following command stops cluster services on the specified node or nodes. As with the **pcs cluster start**, the **--all** option stops cluster services on all nodes and if you do not specify any nodes, cluster services are stopped on the local node only.

```
pcs cluster stop [--all] [node] [...]
```

You can force a stop of cluster services on the local node with the following command, which performs a **kill -9** command.

```
pcs cluster kill
```

3.2.2. Enabling and Disabling Cluster Services

Use the following command to configure the cluster services to run on startup on the specified node or nodes.

- If you specify the **--all** option, the command enables cluster services on all nodes.
- If you do not specify any nodes, cluster services are enabled on the local node only.

```
pcs cluster enable [--all] [node] [...]
```

Use the following command to configure the cluster services not to run on startup on the specified node or nodes.

- If you specify the **--all** option, the command disables cluster services on all nodes.
- If you do not specify any nodes, cluster services are disables on the local node only.

```
pcs cluster disable [--all] [node] [...]
```

3.2.3. Adding Cluster Nodes

Use the following procedure to add a new node to an existing cluster. In this example, the existing cluster nodes are **clusternode-01.example.com**, **clusternode-02.example.com**, and **clusternode-03.example.com**. The new node is **newnode.example.com**.

On the new node to add to the cluster, perform the following tasks.

1. Install the cluster packages;

```
[root@newnode ~]# yum install -y pcs fence-agents-all
```

2. If you are running the **firewalld** daemon, execute the following commands to enable the ports that are required by the Red Hat High Availability Add-On.

```
# firewall-cmd --permanent --add-service=high-availability
# firewall-cmd --add-service=high-availability
```

3. Set a password for the user ID **hacluster**. It is recommended that you use the same password for each node in the cluster.

```
[root@newnode ~]# passwd hacluster
Changing password for user hacluster.
New password:
Retype new password:
passwd: all authentication tokens updated successfully.
```

4. Execute the following commands to start the **pcsd** service and to enable **pcsd** at system start.

```
# systemctl start pcsd.service
# systemctl enable pcsd.service
```

On a node in the existing cluster, perform the following tasks.

1. Authenticate user **hacluster** on the new cluster node.

```
[root@clusternode-01 ~]# pcs cluster auth newnode.example.com
Username: hacluster
Password:
newnode.example.com: Authorized
```

2. Add the new node to the existing cluster. This command also syncs the cluster configuration file **corosync.conf** to all nodes in the cluster, including the new node you are adding.

```
[root@clusternode-01 ~]# pcs cluster node add newnode.example.com
```

On the new node to add to the cluster, perform the following tasks.

1. Authenticate user **hacluster** on the new node for all nodes in the cluster.

```
[root@newnode ~]# pcs cluster auth
Username: hacluster
Password:
clusternode-01.example.com: Authorized
```

```
clusternode-02.example.com: Authorized
clusternode-03.example.com: Authorized
newnode.example.com: Already authorized
```

2. Start and enable cluster services on the new node.

```
[root@newnode ~]# pcs cluster start
Starting Cluster...
[root@newnode ~]# pcs cluster enable
```

3. Ensure that you configure a fencing device for the new cluster node. For information on configuring fencing devices, see Chapter 4, *Fencing: Configuring STONITH*.

3.2.4. Removing Cluster Nodes

The following command shuts down the specified node and removes it from the cluster configuration file, **corosync.conf**, on all of the other nodes in the cluster. For information on removing all information about the cluster from the cluster nodes entirely, thereby destroying the cluster permanently, refer to Section 3.4, “Removing the Cluster Configuration”.

```
pcs cluster node remove node
```

3.2.5. Standby Mode

The following command puts the specified node into standby mode. The specified node is no longer able to host resources. Any resources currently active on the node will be moved to another node. If you specify the **--all**, this command puts all nodes into standby mode.

You can use this command when updating a resource's packages. You can also use this command when testing a configuration, to simulate recovery without actually shutting down a node.

```
pcs cluster standby node | --all
```

The following command removes the specified node from standby mode. After running this command, the specified node is then able to host resources. If you specify the **--all**, this command removes all nodes from standby mode.

```
pcs cluster unstandby node | --all
```

Note that when you execute the **pcs cluster standby** command, this adds constraints to the resources to prevent them from running on the indicated node. When you execute the **pcs cluster unstandby** command, this removes the constraints. This does not necessarily move the resources back to the indicated node; where the resources can run at that point depends on how you have configured your resources initially. For information on resource constraints, refer to Chapter 6, *Resource Constraints*.

3.3. Setting User Permissions

By default, the root user and any user who is a member of the group **haclient** has full read/write access to the cluster configuration. As of Red Hat Enteprise Linux 7.1, you can use the **pcs acl** command to set permissions for local users to allow read-only or read-write access to the cluster configuration by using access control lists (ACLs).

Setting permissions for local users is a two-step process:

1. Execute the **pcs acl role create...** command to create a *role* which defines the permissions for that role.
2. Assign the role you created to a user with the **pcs acl user create** command.

The following example procedure provides read-only access for a cluster configuration to a local user named **rouser**.

1. This procedure requires that the user **rouser** exists on the local system and that the user **rouser** is a member of the group **haclient**.

```
# adduser rouser
# usermod -a -G haclient rouser
```

2. Enable Pacemaker ACLs with the **enable-acl** cluster property.

```
# pcs property set enable-acl=true --force
```

3. Create a role named **read-only** with read-only permissions for the cib.

```
# pcs acl role create read-only description="Read access to cluster" read xpath /cib
```

4. Create the user **rouser** in the pcs ACL system and assign that user the **read-only** role.

```
# pcs acl user create rouser read-only
```

5. View the current ACLs.

```
# pcs acl
User: rouser
  Roles: read-only
Role: read-only
  Description: Read access to cluster
  Permission: read xpath /cib (read-only-read)
```

The following example procedure provides write access for a cluster configuration to a local user named **wuser**.

1. This procedure requires that the user **wuser** exists on the local system and that the user **wuser** is a member of the group **haclient**.

```
# adduser wuser
# usermod -a -G haclient wuser
```

2. Enable Pacemaker ACLs with the **enable-acl** cluster property.

```
# pcs property set enable-acl=true --force
```

3. Create a role named **write-access** with write permissions for the cib.

```
# pcs acl role create write-access description="Full access" write xpath /cib
```

4. Create the user **wuser** in the pcs ACL system and assign that user the **write-access** role.

```
# pcs acl user create wuser write-access
```

5. View the current ACLs.

```
# pcs acl
User: rouser
  Roles: read-only
User: wuser
  Roles: write-access
Role: read-only
  Description: Read access to cluster
  Permission: read xpath /cib (read-only-read)
Role: write-access
  Description: Full Access
  Permission: write xpath /cib (write-access-write)
```

For further information about cluster ACLs, see the help screen for the **pcs acl** command.

3.4. Removing the Cluster Configuration

To remove all cluster configuration files and stop all cluster services, thus permanently destroying a cluster, use the following command.

Warning

This command permanently removes any cluster configuration that has been created. It is recommended that you run **pcs cluster stop** before destroying the cluster.

```
pcs cluster destroy
```

3.5. Displaying Cluster Status

The following command displays the current status of the cluster and the cluster resources.

```
pcs status
```

You can display a subset of information about the current status of the cluster with the following commands.

The following command displays the status of the cluster, but not the cluster resources.

```
pcs cluster status
```

The following command displays the status of the cluster resources.

```
pcs status resources
```

Chapter 4. Fencing: Configuring STONITH

STONITH is an acronym for Shoot-The-Other-Node-In-The-Head and it protects your data from being corrupted by rogue nodes or concurrent access.

Just because a node is unresponsive, this does not mean it is not accessing your data. The only way to be 100% sure that your data is safe, is to fence the node using STONITH so we can be certain that the node is truly offline, before allowing the data to be accessed from another node.

STONITH also has a role to play in the event that a clustered service cannot be stopped. In this case, the cluster uses STONITH to force the whole node offline, thereby making it safe to start the service elsewhere.

4.1. Available STONITH (Fencing) Agents

Use the following command to view of list of all available STONITH agents. You specify a filter, then this command displays only the STONITH agents that match the filter.

```
pcs stonith list [filter]
```

4.2. General Properties of Fencing Devices

Note

To disable a fencing device/resource, you can set the **target-role** as you would for a normal resource.

Note

To prevent a specific node from using a fencing device, you can configure location constraints for the fencing resource.

Table 4.1, “General Properties of Fencing Devices” describes the general properties you can set for fencing devices. Refer to Section 4.3, “Displaying Device-Specific Fencing Options” for information on fencing properties you can set for specific fencing devices.

Note

For information on more advanced fencing configuration properties, refer to Section 4.9, “Additional Fencing Configuration Options”

Table 4.1. General Properties of Fencing Devices

Field	Type	Default	Description

Field	Type	Default	Description
priority	integer	0	The priority of the stonith resource. Devices are tried in order of highest priority to lowest.
pcmk_host_map	string		A mapping of host names to ports numbers for devices that do not support host names. For example: **node1:1;node2:2,3** tells the cluster to use port 1 for node1 and ports 2 and 3 for node2
pcmk_host_list	string		A list of machines controlled by this device (Optional unless **pcmk_host_check=static-list**).
pcmk_host_check	string	dynamic-list	How to determine which machines are controlled by the device. Allowed values: **dynamic-list** (query the device), **static-list** (check the **pcmk_host_list** attribute), none (assume every device can fence every machine)

4.3. Displaying Device-Specific Fencing Options

Use the following command to view the options for the specified STONITH agent.

```
pcs stonith describe stonith_agent
```

For example, the following command displays the options for the fence agent for APC over telnet/SSH.

```
# pcs stonith describe fence_apc
Stonith options for: fence_apc
  ipaddr (required): IP Address or Hostname
  login (required): Login Name
  passwd: Login password or passphrase
  passwd_script: Script to retrieve password
  cmd_prompt: Force command prompt
  secure: SSH connection
  port (required): Physical plug number or name of virtual machine
  identity_file: Identity file for ssh
  switch: Physical switch number on device
  inet4_only: Forces agent to use IPv4 addresses only
  inet6_only: Forces agent to use IPv6 addresses only
  ipport: TCP port to use for connection with device
  action (required): Fencing Action
  verbose: Verbose mode
  debug: Write debug information to given file
  version: Display version information and exit
  help: Display help and exit
  separator: Separator for CSV created by operation list
  power_timeout: Test X seconds for status change after ON/OFF
  shell_timeout: Wait X seconds for cmd prompt after issuing command
  login_timeout: Wait X seconds for cmd prompt after login
  power_wait: Wait X seconds after issuing ON/OFF
  delay: Wait X seconds before fencing is started
```

retry_on: Count of attempts to retry power on

4.4. Creating a Fencing Device

The following command creates a stonith device.

```
pcs stonith create stonith_id stonith_device_type [stonith_device_options]
```

```
# pcs stonith create MyStonith fence_virt pcmk_host_list=f1 op monitor interval=30s
```

If you use a single fence device for several nodes, using a different port of each node, you do not need to create a device separately for each node. Instead you can use the **pcmk_host_map** option to define which port goes to which node. For example, the following command creates a single fencing device called **myapc-west-13** that uses an APC powerswitch called **west-apc** and uses port 15 for node **west-13**.

```
# pcs stonith create myapc-west-13 fence_apc pcmk_host_list="west-13" ipaddr="west-apc" login="apc" passwd="apc" port="15"
```

The following example, however, uses the APC powerswitch named **west-apc** to fence nodes **west-13** using port 15, **west-14** using port 17, **west-15** using port 18, and **west-16** using port 19.

```
# pcs stonith create myapc fence_apc pcmk_host_list="west-13,west-14,west-15,west-16" pcmk_host_map="west-13:15;west-14:17;west-15:18;west-16:19" ipaddr="west-apc" login="apc" passwd="apc"
```

4.5. Configuring Storage-Based Fence Devices with unfencing

When creating a SAN/storage fence device (that is, one that uses a non-power based fencing agent), you must set the meta option **provides=unfencing** when creating the **stonith** device. This ensures that a fenced node is unfenced before the node is rebooted and the cluster services are started on the node.

Setting the **provides=unfencing** meta option is not necessary when configuring a power-based fence device, since the device itself is providing power to the node in order for it to boot (and attempt to rejoin the cluster). The act of booting in this case implies that unfencing occurred.

The following command configures a stonith device named **my-scsi-shooter** that uses the **fence_scsi** fence agent, enabling unfencing for the device.

```
pcs stonith create my-scsi-shooter fence_scsi devices=/dev/sda meta provides=unfencing
```

4.6. Displaying Fencing Devices

The following command shows all currenly configured fencing devices. If a *stonith_id* is specified, the command shows the options for that configured stonith device only. If the **--full** option is specified, all configured stonith options are displayed.

```
pcs stonith show [stonith_id] [--full]
```

4.7. Modifying and Deleting Fencing Devices

Use the following command to modify or add options to a currently configured fencing device.

```
pcs stonith update stonith_id [stonith_device_options]
```

Use the following command to remove a fencing device from the current configuration.

```
pcs stonith delete stonith_id
```

4.8. Managing Nodes with Fence Devices

You can fence a node manually with the following command. If you specify **--off** this will use the **off** API call to stonith which will turn the node off instead of rebooting it.

```
pcs stonith fence node [--off]
```

You can confirm whether a specified node is currently powered off with the following command.

Note

If the node you specify is still running the cluster software or services normally controlled by the cluster, data corruption/cluster failure will occur.

```
pcs stonith confirm node
```

4.9. Additional Fencing Configuration Options

Table 4.2, “Advanced Properties of Fencing Devices”. summarizes additional properties you can set for fencing devices. Note that these properties are for advanced use only.

Table 4.2. Advanced Properties of Fencing Devices

Field	Type	Default	Description
pcmk_host_argument	string	port	An alternate parameter to supply instead of port. Some devices do not support the standard port parameter or may provide additional ones. Use this to specify an alternate, device-specific, parameter that should indicate the machine to be fenced. A value of **none** can be used to tell the cluster not to supply any additional parameters.
pcmk_reboot_action	string	reboot	An alternate command to run instead of **reboot**. Some devices do not support the standard commands or may provide additional ones. Use this to specify an alternate, device-specific, command that implements the reboot action.

Field	Type	Default	Description
pcmk_reboot_timeout	time	60s	Specify an alternate timeout to use for reboot actions instead of **stonith-timeout**. Some devices need much more/less time to complete than normal. Use this to specify an alternate, device-specific, timeout for reboot actions.
pcmk_reboot_retries	integer	2	The maximum number of times to retry the **reboot** command within the timeout period. Some devices do not support multiple connections. Operations may fail if the device is busy with another task so Pacemaker will automatically retry the operation, if there is time remaining. Use this option to alter the number of times Pacemaker retries reboot actions before giving up.
pcmk_off_action	string	off	An alternate command to run instead of **off**. Some devices do not support the standard commands or may provide additional ones. Use this to specify an alternate, device-specific, command that implements the off action.
pcmk_off_timeout	time	60s	Specify an alternate timeout to use for off actions instead of **stonith-timeout**. Some devices need much more or much less time to complete than normal. Use this to specify an alternate, device-specific, timeout for off actions.
pcmk_off_retries	integer	2	The maximum number of times to retry the off command within the timeout period. Some devices do not support multiple connections. Operations may fail if the device is busy with another task so Pacemaker will automatically retry the operation, if there is time remaining. Use this option to alter the number of times Pacemaker retries off actions before giving up.
pcmk_list_action	string	list	An alternate command to run instead of **list**. Some devices do not support the standard commands or may provide additional ones. Use this to specify an alternate, device-specific, command that implements the list action.
pcmk_list_timeout	time	60s	Specify an alternate timeout to use for list actions instead of **stonith-timeout**. Some devices need much more or much less time to complete than normal. Use this to specify an alternate, device-specific, timeout for list actions.

Field	Type	Default	Description
pcmk_list_retries	integer	2	The maximum number of times to retry the **list** command within the timeout period. Some devices do not support multiple connections. Operations may fail if the device is busy with another task so Pacemaker will automatically retry the operation, if there is time remaining. Use this option to alter the number of times Pacemaker retries list actions before giving up.
pcmk_monitor_action	string	monitor	An alternate command to run instead of **monitor**. Some devices do not support the standard commands or may provide additional ones. Use this to specify an alternate, device-specific, command that implements the monitor action.
pcmk_monitor_timeout	time	60s	Specify an alternate timeout to use for monitor actions instead of **stonith-timeout**. Some devices need much more or much less time to complete than normal. Use this to specify an alternate, device-specific, timeout for monitor actions.
pcmk_monitor_retries	integer	2	The maximum number of times to retry the **monitor** command within the timeout period. Some devices do not support multiple connections. Operations may fail if the device is busy with another task so Pacemaker will automatically retry the operation, if there is time remaining. Use this option to alter the number of times Pacemaker retries monitor actions before giving up.
pcmk_status_action	string	status	An alternate command to run instead of **status**. Some devices do not support the standard commands or may provide additional ones. Use this to specify an alternate, device-specific, command that implements the status action.
pcmk_status_timeout	time	60s	Specify an alternate timeout to use for status actions instead of **stonith-timeout**. Some devices need much more or much less time to complete than normal. Use this to specify an alternate, device-specific, timeout for status actions.

Field	Type	Default	Description
pcmk_status_retries	integer	2	The maximum number of times to retry the status command within the timeout period. Some devices do not support multiple connections. Operations may fail if the device is busy with another task so Pacemaker will automatically retry the operation, if there is time remaining. Use this option to alter the number of times Pacemaker retries status actions before giving up.

4.10. Configuring Fencing Levels

Pacemaker supports fencing nodes with multiple devices through a feature called fencing topologies. To implement topologies, create the individual devices as you normally would and then define one or more fencing levels in the fencing-topology section in the configuration.

- Each level is attempted in ascending numeric order, starting at 1.
- If a device fails, processing terminates for the current level. No further devices in that level are exercised and the next level is attempted instead.
- If all devices are successfully fenced, then that level has succeeded and no other levels are tried.
- The operation is finished when a level has passed (success), or all levels have been attempted (failed).

Use the following command to add a fencing level to a node. The devices are given as a comma-separated list of stonith ids, which are attempted for the node at that level.

```
pcs stonith level add level node devices
```

The following command lists all of the fencing levels that are currently configured.

```
pcs stonith level
```

In the following example, there are two fence devices configured for node **rh7-2**: an ilo fence device called **my_ilo** and an apc fence device called **my_apc**. These commands sets up fence levels so that if the device **my_ilo** fails and is unable to fence the node, then Pacemaker will attempt to use the device **my_apc**. This example also shows the output of the **pcs stonith level** command after the levels are configured.

```
# pcs stonith level add 1 rh7-2 my_ilo
# pcs stonith level add 2 rh7-2 my_apc
# pcs stonith level
 Node: rh7-2
  Level 1 - my_ilo
  Level 2 - my_apc
```

The following command removes the fence level for the specified node and devices. If no nodes or devices are specified then the fence level you specify is removed from all nodes.

```
pcs stonith level remove level [node_id] [stonith_id] ... [stonith_id]
```

The following command clears the fence levels on the specified node or stonith id. If you do not specify a node or stonith id, all fence levels are cleared.

```
pcs stonith level clear [node|stonith_id(s)]
```

If you specify more than one stonith id, they must be separated by a comma and no spaces, as in the following example.

```
# pcs stonith level clear dev_a,dev_b
```

The following command verifies that all fence devices and nodes specified in fence levels exist.

```
pcs stonith level verify
```

4.11. Configuring Fencing for Redundant Power Supplies

When configuring fencing for redundant power supplies, the cluster must ensure that when attempting to reboot a host, both power supplies are turned off before either power supply is turned back on.

If the node never completely loses power, the node may not release its resources. This opens up the possibility of nodes accessing these resources simultaneously and corrupting them.

Prior to Red Hat Enterprise Linux 7.2, you needed to explicitly configure different versions of the devices which used either the 'on' or 'off' actions. Since Red Hat Enterprise Linux 7.2, it is now only required to define each device once and to specify that both are required to fence the node, as in the following example.

```
# pcs stonith create apc1 fence_apc_snmp ipaddr=apc1.example.com login=user
passwd='7a4D#1j!pz864'
pcmk_host_map="node1.example.com:1;node2.example.com:2"

# pcs stonith create apc2 fence_apc_snmp ipaddr=apc2.example.com login=user
passwd='7a4D#1j!pz864'
pcmk_host_map="node1.example.com:1;node2.example.com:2"

# pcs stonith level add 1 node1.example.com apc1,apc2
# pcs stonith level add 1 node2.example.com apc1,apc2
```

Chapter 5. Configuring Cluster Resources

This chapter provides information on configuring resources in a cluster.

5.1. Resource Creation

Use the following command to create a cluster resource.

```
pcs resource create resource_id standard:provider:type|type [resource options]
[op operation_action operation_options [operation_action  operation_options]...]
[meta meta_options...] [--clone clone_options |
--master master_options | --group group_name
[--before  resource_id | --after resource_id]] [--disabled]
```

When you specify the **--group** option, the resource is added to the resource group named. If the group does not exist, this creates the group and adds this resource to the group. For information on resource groups, refer to Section 5.5, “Resource Groups”.

The **--before** and **--after** options specify the position of the added resource relative to a resource that already exists in a resource group.

Specifying the **--disabled** option indicates that the resource is not started automatically.

The following command creates a resource with the name VirtualIP of standard **ocf**, provider **heartbeat**, and type **IPaddr2**. The floating address of this resource is 192.168.0.120, the system will check whether the resource is running every 30 seconds.

```
# pcs resource create VirtualIP ocf:heartbeat:IPaddr2 ip=192.168.0.120
cidr_netmask=24 op monitor interval=30s
```

Alternately, you can omit the *standard* and *provider* fields and use the following command. This will default to a standard of **ocf** and a provider of **heartbeat**.

```
# pcs resource create VirtualIP IPaddr2 ip=192.168.0.120 cidr_netmask=24 op
monitor interval=30s
```

Use the following command to delete a configured resource.

```
pcs resource delete resource_id
```

For example, the following command deletes an existing resource with a resource ID of **VirtualIP**

```
# pcs resource delete VirtualIP
```

- For information on the *resource_id*, *standard*, *provider*, and *type* fields of the **pcs resource create** command, refer to Section 5.2, “Resource Properties”.
- For information on defining resource parameters for individual resources, refer to Section 5.3, “Resource-Specific Parameters”.
- For information on defining resource meta options, which are used by the cluster to decide how a resource should behave, refer to Section 5.4, “Resource Meta Options”.

- For information on defining the operations to perform on a resource, refer to Section 5.6, "Resource Operations".
- Specifying the **--clone** creates a clone resource. Specifying the **--master** creates a master/slave resource. For information on resource clones and resources with multiple modes, refer to Chapter 8, *Advanced Resource types*.

5.2. Resource Properties

The properties that you define for a resource tell the cluster which script to use for the resource, where to find that script and what standards it conforms to. Table 5.1, "Resource Properties" describes these properties.

Table 5.1. Resource Properties

Field	Description
resource_id	Your name for the resource
standard	The standard the script conforms to. Allowed values: **ocf**, **service**, **upstart**, **systemd**, **lsb**, **stonith**
type	The name of the Resource Agent you wish to use, for example **IPaddr** or **Filesystem**
provider	The OCF spec allows multiple vendors to supply the same ResourceAgent. Most of the agents shipped by Red Hat use **heartbeat** as the provider.

Table 5.2, "Commands to Display Resource Properties". summarizes the commands that display the available resource properties.

Table 5.2. Commands to Display Resource Properties

pcs Display Command	Output
pcs resource list	Displays a list of all available resources.
pcs resource standard	Displays a list of available resources agent standards.
pcs resource providers	Displays a list of available resources agent providers.
pcs resource list *string*	Displays a list of available resources filtered by the specified string. You can use this command to display resources filtered by the name of a standard, a provider, or a type.

5.3. Resource-Specific Parameters

For any individual resource, you can use the following command to display the parameters you can set for that resource.

```
# pcs resource describe standard:provider:type|type
```

For example, the following command displays the parameters you can set for a resource of type **LVM**.

```
# pcs resource describe LVM
Resource options for: LVM
  volgrpname (required): The name of volume group.
  exclusive: If set, the volume group will be activated exclusively.
```

partial_activation: If set, the volume group will be activated even only partial of the physical volumes available. It helps to set to true, when you are using mirroring logical volumes.

5.4. Resource Meta Options

In addition to the resource-specific parameters, you can configure additional resource options for any resource. These options are used by the cluster to decide how your resource should behave. Table 5.3, “Resource Meta Options” describes this options.

Table 5.3. Resource Meta Options

Field	Default	Description
priority	**0**	If not all resources can be active, the cluster will stop lower priority resources in order to keep higher priority ones active.
target-role	**Started**	What state should the cluster attempt to keep this resource in? Allowed values: * *Stopped* - Force the resource to be stopped * *Started* - Allow the resource to be started (In the case of multistate resources, they will not promoted to master) * *Master* - Allow the resource to be started and, if appropriate, promoted
is-managed	**true**	Is the cluster allowed to start and stop the resource? Allowed values: **true**, **false**
resource-stickiness	0	Value to indicate how much the resource prefers to stay where it is.

Field	Default	Description
requires	Calculated	Indicates under what conditions the resource can be started. Defaults to **fencing** except under the conditions noted below. Possible values: * **nothing** - The cluster can always start the resource. * **quorum** - The cluster can only start this resource if a majority of the configured nodes are active. This is the default value if **stonith-enabled** is **false** or the the resource's **standard** is **stonith**. * **fencing** - The cluster can only start this resource if a majority of the configured nodes are active *and* any failed or unknown nodes have been powered off. * **unfencing** - The cluster can only start this resource if a majority of the configured nodes are active *and* any failed or unknown nodes have been powered off *and* only on nodes that have been *unfenced*. This is the default value if the **provides=unfencing stonith** meta option has been set for a fencing device. For information on the **provides=unfencing stonith** meta option, see Section 4.5, “Configuring Storage-Based Fence Devices with unfencing”.
migration-threshold	**INFINITY** (disabled)	How many failures may occur for this resource on a node, before this node is marked ineligible to host this resource. For information on configuring the **migration-threshold** option, refer to Section 7.2, “Moving Resources Due to Failure”.
failure-timeout	**0** (disabled)	Used in conjunction with the **migration-threshold** option, indicates how many seconds to wait before acting as if the failure had not occurred, and potentially allowing the resource back to the node on which it failed. For information on configuring the **failure-timeout** option, refer to Section 7.2, “Moving Resources Due to Failure”.
multiple-active	**stop_start**	What should the cluster do if it ever finds the resource active on more than one node. Allowed values: * **block** - mark the resource as unmanaged * **stop_only** - stop all active instances and leave them that way * **stop_start** - stop all active instances and start the resource in one location only

To change the default value of a resource option, use the following command.

```
pcs resource defaults options
```

For example, the following command resets the default value of **resource-stickiness** to 100.

```
# pcs resource defaults resource-stickiness=100
```

Omitting the *options* parameter from the **pcs resource defaults** displays a list of currently configured default values for resource options. The following example shows the output of this command after you have reset the default value of **resource-stickiness** to 100.

```
# pcs resource defaults
resource-stickiness:100
```

Whether you have reset the default value of a resource meta option or not, you can set a resource option for a particular resource to a value other than the default when you create the resource. The following shows the format of the **pcs resource create** command you use when specifying a value for a resource meta option.

```
pcs resource create resource_id standard:provider:type|type [resource options] [meta meta_options...]
```

For example, the following command creates a resource with a **resource-stickiness** value of 50.

```
# pcs resource create VirtualIP ocf:heartbeat:IPaddr2 ip=192.168.0.120
cidr_netmask=24 meta resource-stickiness=50
```

You can also set the value of a resource meta option for an existing resource, group, cloned resource, or master resource with the following command.

```
pcs resource meta resource_id | group_id | clone_id | master_id  meta_options
```

In the following example, there is an existing resource named **dummy_resource**. This command sets the **failure-timeout** meta option to 20 seconds, so that the resource can attempt to restart on the same node in 20 seconds.

```
# pcs resource meta dummy_resource failure-timeout=20s
```

After executing this command, you can display the values for the resource to verity that **failure-timeout=20s** is set.

```
# pcs resource show dummy_resource
 Resource: dummy_resource (class=ocf provider=heartbeat type=Dummy)
  Meta Attrs: failure-timeout=20s
  Operations: start interval=0s timeout=20 (dummy_resource-start-timeout-20)
              stop interval=0s timeout=20 (dummy_resource-stop-timeout-20)
              monitor interval=10 timeout=20 (dummy_resource-monitor-interval-10)
```

For information on resource clone meta options, see Section 8.1, “Resource Clones”. For information on resource master meta options, see Section 8.2, “Multi-State Resources: Resources That Have Multiple Modes”.

5.5. Resource Groups

One of the most common elements of a cluster is a set of resources that need to be located together, start sequentially, and stop in the reverse order. To simplify this configuration, Pacemaker supports the concept of groups.

You create a resource group with the following command, specifying the resources to include in the group. If the group does not exist, this command creates the group. If the group exists, this command adds additional resources to the group. The resources will start in the order you specify them with this command, and will stop in the reverse order of their starting order.

```
pcs resource group add group_name resource_id [resource_id] ... [resource_id]
[--before resource_id | --after resource_id
```

You can use the **--before** and **--after** options of this command to specify the position of the added resources relative to a resource that already exists in the group.

You can also add a new resource to an existing group when you create the resource, using the following command. The resource you create is added to the group named *group_name*.

```
pcs resource create resource_id standard:provider:type|type [resource_options] [op operation_action operation_options] --group group_name
```

You remove a resource from a group with the following command. If there are no resources in the group, this command removes the group itself.

```
pcs resource group remove group_name resource_id...
```

The following command lists all currently configured resource groups.

```
pcs resource group list
```

The following example creates a resource group named **shortcut** that contains the existing resources **IPaddr** and **Email**.

```
# pcs resource group add shortcut IPaddr Email
```

There is no limit to the number of resources a group can contain. The fundamental properties of a group are as follows.

- Resources are started in the order in which you specify them (in this example, **IPaddr** first, then **Email**).
- Resources are stopped in the reverse order in which you specify them. (**Email** first, then **IPaddr**).

If a resource in the group cannot run anywhere, then no resource specified after that resource is allowed to run.

- If **IPaddr** cannot run anywhere, neither can **Email**.
- If **Email** cannot run anywhere, however, this does not affect **IPaddr** in any way.

Obviously as the group grows bigger, the reduced configuration effort of creating resource groups can become significant.

5.5.1. Group Options

A resource group inherits the following options from the resources that it contains: **priority**, **target-role**, **is-managed** For information on resource options, refer to Table 5.3, “Resource Meta Options”.

5.5.2. Group Stickiness

Stickiness, the measure of how much a resource wants to stay where it is, is additive in groups. Every active resource of the group will contribute its stickiness value to the group’s total. So if the default **resource-stickiness** is 100, and a group has seven members, five of which are active, then the group as a whole will prefer its current location with a score of 500.

5.6. Resource Operations

To ensure that resources remain healthy, you can add a monitoring operation to a resource's definition. If you do not specify a monitoring operation for a resource, by default the **pcs** command will create a monitoring operation, with an interval that is determined by the resource agent. If the resource agent does not provide a default monitoring interval, the pcs command will create a monitoring operation with an interval of 60 seconds.

Table 5.4, “Properties of an Operation” summarizes the properties of a resource monitoring operation.

Table 5.4. Properties of an Operation

Field	Description
id	Unique name for the action. The system assigns this when you configure an operation.
name	The action to perform. Common values: **monitor**, **start**, **stop**
interval	How frequently (in seconds) to perform the operation. Default value: **0**, meaning never.
timeout	How long to wait before declaring the action has failed. If you find that your system includes a resource that takes a long time to start or stop or perform a non-recurring monitor action at startup, and requires more time than the system allows before declaring that the start action has failed, you can increase this value from the default of 20 or the value of **timeout** in "op defaults".
on-fail	The action to take if this action ever fails. Allowed values: * **ignore** - Pretend the resource did not fail * **block** - Do not perform any further operations on the resource * **stop** - Stop the resource and do not start it elsewhere * **restart** - Stop the resource and start it again (possibly on a different node) * **fence** - STONITH the node on which the resource failed * **standby** - Move *all* resources away from the node on which the resource failed The default for the **stop** operation is **fence** when STONITH is enabled and **block** otherwise. All other operations default to **restart**.
enabled	If **false**, the operation is treated as if it does not exist. Allowed values: **true**, **false**

You can configure monitoring operations when you create a resource, using the following command.

```
pcs resource create resource_id standard:provider:type|type [resource_options] [op operation_action operation_options [operation_type operation_options]...]
```

For example, the following command creates an **IPaddr2** resource with a monitoring operation. The new resource is called **VirtualIP** with an IP address of 192.168.0.99 and a netmask of 24 on **eth2**. A monitoring operation will be performed every 30 seconds.

```
# pcs resource create VirtualIP ocf:heartbeat:IPaddr2 ip=192.168.0.99 cidr_netmask=24 nic=eth2 op monitor interval=30s
```

Alternately, you can add a monitoring operation to an existing resource with the following command.

```
pcs resource op add resource_id operation_action [operation_properties]
```

Use the following command to delete a configured resource operation.

```
pcs resource op remove resource_id operation_name operation_properties
```

Note

You must specify the exact operation properties to properly remove an existing operation.

To change the values of a monitoring option, you remove the existing operation, then add the new operation. For example, you can create a **VirtualIP** with the following command.

```
# pcs resource create VirtualIP ocf:heartbeat:IPaddr2 ip=192.168.0.99 cidr_netmask=24 nic=eth2
```

By default, this command creates these operations.

```
Operations: start interval=0s timeout=20s (VirtualIP-start-timeout-20s)
            stop interval=0s timeout=20s (VirtualIP-stop-timeout-20s)
            monitor interval=10s timeout=20s (VirtualIP-monitor-interval-10s)
```

The change the stop timeout operation, execute the following commands.

```
# pcs resource op remove VirtualIP stop interval=0s timeout=20s
# pcs resource op add VirtualIP stop interval=0s timeout=40s

# pcs resource show VirtualIP
 Resource: VirtualIP (class=ocf provider=heartbeat type=IPaddr2)
  Attributes: ip=192.168.0.99 cidr_netmask=24 nic=eth2
  Operations: start interval=0s timeout=20s (VirtualIP-start-timeout-20s)
              monitor interval=10s timeout=20s (VirtualIP-monitor-interval-10s)
              stop interval=0s timeout=40s (VirtualIP-name-stop-interval-0s-timeout-40s)
```

To set global default values for monitoring operations, use the following command.

```
pcs resource op defaults [options]
```

For example, the following command sets a global default of a **timeout** value of 240s for all monitoring operations.

```
# pcs resource op defaults timeout=240s
```

To display the currently configured default values for monitoring operations, do not specify any options when you execute the **pcs resource op defaults** commmand.

For example, following command displays the default monitoring operation values for a cluster which has been configured with a **timeout** value of 240s.

```
# pcs resource op defaults
timeout: 240s
```

5.7. Displaying Configured Resources

To display a list of all configured resources, use the following command.

```
pcs resource show
```

For example, if your system is configured with a resource named **VirtualIP** and a resource named **WebSite**, the **pcs resource show** command yields the following output.

```
# pcs resource show
 VirtualIP (ocf::heartbeat:IPaddr2): Started
 WebSite (ocf::heartbeat:apache): Started
```

To display a list of all configured resources and the parameters configured for those resources, use the **--full** option of the the **pcs resource show** command, as in the following example.

```
# pcs resource show --full
 Resource: VirtualIP (type=IPaddr2 class=ocf provider=heartbeat)
  Attributes: ip=192.168.0.120 cidr_netmask=24
  Operations: monitor interval=30s
 Resource: WebSite (type=apache class=ocf provider=heartbeat)
  Attributes: statusurl=http://localhost/server-status configfile=/etc/httpd/conf/httpd.conf
  Operations: monitor interval=1min
```

To display the configured parameters for a resource, use the following command.

```
pcs resource show resource_id
```

For example, the following command displays the currently configured parameters for resource **VirtualIP**.

```
# pcs resource show VirtualIP
 Resource: VirtualIP (type=IPaddr2 class=ocf provider=heartbeat)
  Attributes: ip=192.168.0.120 cidr_netmask=24
  Operations: monitor interval=30s
```

5.8. Modifying Resource Parameters

5.8. Modifying Resource Parameters

To modify the parameters of a configured resource, use the following command.

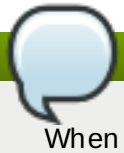
```
pcs resource update resource_id [resource_options]
```

The following sequence of commands show the initial values of the configured parameters for resource **VirtualIP**, the command to change the value of the **ip** parameter, and the values following the update command.

```
# pcs resource show VirtualIP
 Resource: VirtualIP (type=IPaddr2 class=ocf provider=heartbeat)
  Attributes: ip=192.168.0.120 cidr_netmask=24
  Operations: monitor interval=30s
# pcs resource update VirtualIP ip=192.169.0.120
# pcs resource show VirtualIP
 Resource: VirtualIP (type=IPaddr2 class=ocf provider=heartbeat)
  Attributes: ip=192.169.0.120 cidr_netmask=24
  Operations: monitor interval=30s
```

5.9. Multiple Monitoring Operations

You can configure a single resource with as many monitor operations as a resource agent supports. In this way you can do a superficial health check every minute and progressively more intense ones at higher intervals.



Note

When configuring multiple monitor operations, you must ensure that no two operations are performed at the same interval.

To configure additional monitoring operations for a resource that supports more in-depth checks at different levels, you add an **OCF_CHECK_LEVEL=*n*** option.

For example, if you configure the following **IPaddr2** resource, by default this creates a monitoring operation with an interval of 10 seconds and a timeout value of 20 seconds.

```
# pcs resource create VirtualIP ocf:heartbeat:IPaddr2 ip=192.168.0.99
cidr_netmask=24 nic=eth2
```

If the Virtual IP supports a different check with a depth of 10, the following command causes Packemaker to perform the more advanced monitoring check every 60 seconds in addition to the normal Virtual IP check every 10 seconds. (As noted, you should not configure the additional monitoring operation with a 10-second interval as well.)

```
# pcs resource op add VirtualIP monitor interval=60s OCF_CHECK_LEVEL=10
```

5.10. Enabling and Disabling Cluster Resources

The following command enables the resource specified by **resource_id**.

```
pcs resource enable resource_id
```

The following command disables the resource specified by **resource_id**.

```
pcs resource disable resource_id
```

5.11. Cluster Resources Cleanup

If a resource has failed, a failure message appears when you display the cluster status. If you resolve that resource, you can clear that failure status with the **pcs resource cleanup** command. This command resets the resource status and failcount, telling the cluster to forget the operation history of a resource and re-detect its current state.

The following command cleans up the resource specified by *resource_id*.

```
pcs resource cleanup resource_id
```

If you do not specify a *resource_id*, this command resets the resource status and failcount for all resources.

Chapter 6. Resource Constraints

You can determine the behavior of a resource in a cluster by configuring constraints for that resource. You can configure the following categories of constraints:

- **location** constraints — A location constraint determines which nodes a resource can run on. Location constraints are described in Section 6.1, “Location Constraints”.
- **order** constraints — An order constraint determines the order in which the resources run. Order constraints are described in Section 6.2, “Order Constraints”.
- **colocation** constraints — A colocation constraint determines where resources will be placed relative to other resources. Colocation constraints are described in Section 6.3, “Colocation of Resources”.

As a shorthand for configuring a set of constraints that will locate a set of resources together and ensure that the resources start sequentially and stop in reverse order, Pacemaker supports the concept of resource groups. For information on resource groups, see Section 5.5, “Resource Groups”.

6.1. Location Constraints

Location constraints determine which nodes a resource can run on. You can configure location constraints to determine whether a resource will prefer or avoid a specified node.

Table 6.1, “Location Constraint Options”. summarizes the options for configuring location constraints.

Table 6.1. Location Constraint Options

Field	Description
rsc	A resource name
node	A node’s name
score	Value to indicate the preference for whether a resource should run on or avoid a node. A Value of **INFINITY** changes "should" to "must"; **INFINITY** is the default **score** value for a resource location constraint.

Field	Description
resource-discovery	Value to indicate the preference for whether Pacemaker should perform resource discovery on this node for the specified resource. Limiting resource discovery to a subset of nodes the resource is physically capable of running on can significantly boost performance when a large set of nodes is present. When pacemaker_remote is in use to expand the node count into the hundreds of nodes range, this option should be considered. Possible values include: **always**: Always perform resource discovery for the specified resource on this node. **never**: Never perform resource discovery for the specified resource on this node. **exclusive**: Perform resource discovery for the specified resource only on this node (and other nodes similarly marked as **exclusive**). Multiple location constraints using **exclusive** discovery for the same resource across different nodes creates a subset of nodes **resource-discovery** is exclusive to. If a resource is marked for **exclusive** discovery on one or more nodes, that resource is only allowed to be placed within that subset of nodes. Note that setting this option to **never** or **exclusive** allows the possibility for the resource to be active in those locations without the cluster's knowledge. This can lead to the resource being active in more than one location if the service is started outside the cluster's control (for example, by **systemd** or by an administrator). This can also occur if the **resource-discovery** property is changed while part of the cluster is down or suffering split-brain, or if the **resource-discovery** property is changed for a resource and node while the resource is active on that node. For this reason, using this option is appropriate only when you have more than eight nodes and there is a way to guarantee that the resource can run only in a particular location (for example, when the required software is not installed anywhere else). **always** is the default **resource-discovery** value for a resource location constraint.

The following command creates a location constraint for a resource to prefer the specified node or nodes.

```
pcs constraint location rsc prefers node[=score] ...
```

The following command creates a location constraint for a resource to avoid the specified node or nodes.

```
pcs constraint location rsc avoids node[=score] ...
```

There are two alternative strategies for specifying which nodes a resources can run on:

- Opt-In Clusters — Configure a cluster in which, by default, no resource can run anywhere and then selectively enable allowed nodes for specific resources. The procedure for configuring an opt-in cluster is described in Section 6.1.1, “Configuring an "Opt-In" Cluster”.
- Opt-Out Clusters — Configure a cluster in which, by default, all resources an run anywhere and then create location constraints for resources that are not allowed to run on specific nodes. The procedure for configuring an opt-out cluster is described in Section 6.1.2, “Configuring an "Opt-Out" Cluster”.

Whether you should choose to configure an opt-in or opt-out cluster depends both on your personal preference and the make-up of your cluster. If most of your resources can run on most of the nodes, then an opt-out arrangement is likely to result in a simpler configuration. On the other-hand, if most resources can only run on a small subset of nodes an opt-in configuration might be simpler.

6.1.1. Configuring an "Opt-In" Cluster

To create an opt-in cluster, set the **symmetric-cluster** cluster property to **false** to prevent resources from running anywhere by default.

```
# pcs property set symmetric-cluster=false
```

Enable nodes for individual resources. The following commands configure location constraints so that the resource **Webserver** prefers node **example-1**, the resource **Database** prefers node **example-2**, and both resources can fail over to node **example-3** if their preferred node fails.

```
# pcs constraint location Webserver prefers example-1=200
# pcs constraint location Webserver prefers example-3=0
# pcs constraint location Database prefers example-2=200
# pcs constraint location Database prefers example-3=0
```

6.1.2. Configuring an "Opt-Out" Cluster

To create an opt-out cluster, set the **symmetric-cluster** cluster property to **true** to allow resources to run everywhere by default.

```
# pcs property set symmetric-cluster=true
```

The following commands will then yield a configuration that is equivalent to the example in Section 6.1.1, “Configuring an "Opt-In" Cluster”. Both resources can fail over to node **example-3** if their preferred node fails, since every node has an implicit score of 0.

```
# pcs constraint location Webserver prefers example-1=200
# pcs constraint location Webserver avoids example-2=INFINITY
# pcs constraint location Database avoids example-1=INFINITY
# pcs constraint location Database prefers example-2=200
```

Note that it is not necessary to specify a score of INFINITY in these commands, since that is the default value for the score.

6.2. Order Constraints

Order constraints determine the order in which the resources run. You can configure an order constraint to determine the order in which resources start and stop.

Use the following command to configure an order constraint.

```
pcs constraint order [action] resource_id then [action] resource_id [options]
```

Table 6.2, “Properties of an Order Constraint”. summarizes the properties and options for configuring order constraints.

Table 6.2. Properties of an Order Constraint

Field	Description
resource_id	The name of a resource on which an action is performed.
action	The action to perform on a resource. Possible values of the *action* property are as follows: * **start** - Start the resource. * **stop** - Stop the resource. * **promote** - Promote the resource from a slave resource to a master resource. * **demote** - Demote the resource from a master resource to a slave resource. If no action is specified, the default action is **start**. For information on master and slave resources, refer to Section 8.2, “Multi-State Resources: Resources That Have Multiple Modes”.
kind option	How to enforce the constraint. The possible values of the **kind** option are as follows: * **Optional** - Only applies if both resources are starting and/or stopping. For information on optional ordering, refer to Section 6.2.2, “Advisory Ordering”. * **Mandatory** - Always (default value). If the first resource you specified is stopping or cannot be started, the second resource you specified must be stopped. For information on mandatory ordering, refer to Section 6.2.1, “Mandatory Ordering”. * **Serialize** - Ensure that no two stop/start actions occur concurrently for a set of resources.
symmetrical option	If true, which is the default, stop the resources in the reverse order. Default value: **true**

6.2.1. Mandatory Ordering

A mandatory constraints indicates that the second resource you specify cannot run without the first resource you specify being active. This is the default value of the **kind** option. Leaving the default value ensures that the second resource you specify will react when the first resource you specify changes state.

- If the first resource you specified resource was running and is stopped, the second resource you specified will also be stopped (if it is running).

- If the first resource you specified resource was not running and cannot be started, the second resource you specified will be stopped (if it is running).
- If the first resource you specified is (re)started while the second resource you specified is running, the second resource you specified will be stopped and restarted.

6.2.2. Advisory Ordering

When the **kind=Optional** option is specified for an order constraint, the constraint is considered optional and only has an effect when both resources are stopping and/or starting. Any change in state of the first resource you specified has no effect on the second resource you specified.

The following command configures an advisory ordering constraint for the resources named **VirtualIP** and **dummy_resource**,

```
# pcs constraint order VirtualIP then dummy_resource kind=Optional
```

6.2.3. Ordered Resource Sets

A common situation is for an administrator to create a chain of ordered resources, where, for example, resource A starts before resource B which starts before resource C. You can configure a chain of ordered resources with the following command. The resources will start in the specified order.

You can create an order constraint on a set or sets of resources with the **pcs constraint order set** command.

You can set the following options for a set of resources following the **options** parameter of the **pcs constraint order set** command.

- **sequential**, which can be set to **true** or **false** to indicate whether the set of colocated resources is an ordered set.
- **require-all**, which can be set to **true** or **false** to indicate whether all of the resources in the set must be up.
- **action**, which can be set to **start**, **promote**, **demote** or **stop**, as described in Table 6.2, “Properties of an Order Constraint”.
- **role**, which can be set to **Stopped**, **Started**, **Master**, or **Slave**. For information on multi-state resources, see Section 8.2, “Multi-State Resources: Resources That Have Multiple Modes”.

You can set the following constraint options for a set of resources following the **setoptions** parameter of the **pcs constraint order set** command.

- **id**, to provide a name for the constraint you are defining.
- **score**, to indicate the degree of preference for this constraint. For information on this option, see Table 6.3, “Properties of a Colocation Constraint”.

```
pcs constraint order set resource1 resource2 [resourceN]... [options] [set resourceX resourceY ... [options]] [setoptions [constraint_options]]
```

If you have three resources named **D1**, **D2**, and **D3**, the following command configures them as an ordered resource set.

```
# pcs constraint order set D1 D2 D3
```

6.2.4. Removing Resources From Ordering Constraints

Use the following command to remove resources from any ordering constraint.

```
pcs constraint order remove resource1 [resourceN]...
```

6.3. Colocation of Resources

A colocation constraint determines that the location of one resource depends on the location of another resource.

There is an important side effect of creating a colocation constraint between two resources: it affects the order in which resources are assigned to a node. This is because you cannot place resource A relative to resource B unless you know where resource B is. So when you are creating colocation constraints, it is important to consider whether you should colocate resource A with resource B or resource B with resource A.

Another thing to keep in mind when creating colocation constraints is that, assuming resource A is collocated with resource B, the cluster will also take into account resource A's preferences when deciding which node to choose for resource B.

The following command creates a colocation constraint.

```
pcs constraint colocation add [master|slave] source_resource with [master|slave] target_resource [score] [options]
```

For information on master and slave resources, see Section 8.2, “Multi-State Resources: Resources That Have Multiple Modes”.

Table 6.3, “Properties of a Colocation Constraint”. summarizes the properties and options for configuring colocation constraints.

Table 6.3. Properties of a Colocation Constraint

Field	Description
source_resource	The colocation source. If the constraint cannot be satisfied, the cluster may decide not to allow the resource to run at all.
target_resource	The colocation target. The cluster will decide where to put this resource first and then decide where to put the source resource.
score	Positive values indicate the resource should run on the same node. Negative values indicate the resources should not run on the same node. A value of + **INFINITY**, the default value, indicates that the *source_resource* must run on the same node as the *target_resource*. A value of - **INFINITY** indicates that the *source_resource* must not run on the same node as the *target_resource*.

6.3.1. Mandatory Placement

Mandatory placement occurs any time the constraint's score is **+INFINITY** or **-INFINITY**. In such cases, if the constraint cannot be satisfied, then the *source_resource* is not permitted to run. For **score=INFINITY**, this includes cases where the *target_resource* is not active.

If you need **myresource1** to always run on the same machine as **myresource2**, you would add the following constraint:

```
# pcs constraint colocation add myresource1 with myresource2 score=INFINITY
```

Because **INFINITY** was used, if **myresource2** cannot run on any of the cluster nodes (for whatever reason) then **myresource1** will not be allowed to run.

Alternatively, you may want to configure the opposite, a cluster in which **myresource1** cannot run on the same machine as **myresource2**. In this case use **score=-INFINITY**

```
# pcs constraint colocation add myresource1 with myresource2 score=-INFINITY
```

Again, by specifying **-INFINITY**, the constraint is binding. So if the only place left to run is where **myresource2** already is, then **myresource1** may not run anywhere.

6.3.2. Advisory Placement

If mandatory placement is about "must" and "must not", then advisory placement is the "I'd prefer if" alternative. For constraints with scores greater than **-INFINITY** and less than **INFINITY**, the cluster will try to accommodate your wishes but may ignore them if the alternative is to stop some of the cluster resources. Advisory colocation constraints can combine with other elements of the configuration to behave as if they were mandatory.

6.3.3. Colocating Sets of Resources

You can create a colocation constraint on a set or sets of resources with the **pcs constraint colocation set** command.

You can set the following options for a set of resources following the **options** parameter of the **pcs constraint colocation set** command.

- **sequential**, which can be set to **true** or **false** to indicate whether the set of colocated resources is an ordered set.
- **require-all**, which can be set to **true** or **false** to indicate whether all of the resources in the set must be up.
- **action**, which can be set to **start**, **promote**, **demote** or **stop**, as described in Table 6.2, “Properties of an Order Constraint”.
- **role**, which can be set to **Stopped**, **Started**, **Master**, or **Slave**. For information on multi-state resources, see Section 8.2, “Multi-State Resources: Resources That Have Multiple Modes”.

You can set the following constraint options for a set of resources following the **setoptions** parameter of the **pcs constraint colocation set** command.

- **kind**, to indicate how to enforce the constraint. For information on this option, see Table 6.2, “Properties of an Order Constraint”.
- **symmetrical**, to indicate the order in which to stop the resourses. If true, which is the default, stop the resources in the reverse order. Default value: **true**
- **id**, to provide a name for the constraint you are defining.

The following command creates a colocation constraint on a set or sets of resources.

```
pcs constraint colocation set resource1 resource2 [resourceN]... [options] [set resourceX resourceY ... [options]] [setoptions [constraint_options]]
```

6.3.4. Removing Colocation Constraints

Use the following command to remove colocation constraints with *source_resource*.

```
pcs constraint colocation remove source_resource target_resource
```

6.4. Displaying Constraints

There are a several commands you can use to display constraints that have been configured.

The following command lists all current location, order, and colocation constraints.

```
pcs constraint list|show
```

The following command lists all current location constraints.

- If **resources** is specified, location constraints are displayed per resource. This is the default behavior.
- If **nodes** is specified, location constraints are displayed per node.
- If specific resources or nodes are specified, then only information about those resources or nodes is displayed.

```
pcs constraint location [show resources|nodes [specific nodes|resources]] [--full]
```

The following command lists all current ordering constraints. If the **--full** option is specified, show the internal constraint IDs.

```
pcs constraint order show [--full]
```

The following command lists all current colocation constraints. If the **--full** option is specified, show the internal constraint IDs.

```
pcs constraint colocation show [--full]
```

The following command lists the constraints that reference specific resources.

```
pcs constraint ref resource ...
```

Chapter 7. Managing Cluster Resources

This chapter describes various commands you can use to manage cluster resources. It provides information on the following procedures.

- Section 7.1, “Manually Moving Resources Around the Cluster”
- Section 7.2, “Moving Resources Due to Failure”
- Section 7.4, “Enabling, Disabling, and Banning Cluster Resources”
- Section 7.5, “Disabling a Monitor Operations”

7.1. Manually Moving Resources Around the Cluster

You can override the cluster and force resources to move from their current location. There are two occasions when you would want to do this:

- When a node is under maintenance, and you need to move all resources running on that node to a different node
- When individually specified resources needs to be moved

To move all resources running on a node to a different node, you put the node in standby mode. For information on putting a cluster node in standby node, refer to Section 3.2.5, “Standby Mode”.

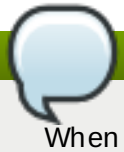
You can move individually specified resources in either of the following ways.

- You can use the **pcs resource move** command to move a resource off a node on which it is currently running, as described in Section 7.1.1, “Moving a Resource from its Current Node”.
- You can use the **pcs resource relocate run** command to move a resource to its preferred node, as determined by current cluster status, constraints, location of resources and other settings. For information on this command, see Section 7.1.2, “Moving a Resource to its Preferred Node”.

7.1.1. Moving a Resource from its Current Node

To move a resource off the node on which it is currently running, use the following command, specifying the *resource_id* of the node as defined. Specify the **destination_node**. if you want to indicate on which node to run the resource that you are moving.

```
pcs resource move resource_id [destination_node] [--master] [lifetime=lifetime]
```



Note

When you execute the **pcs resource move** command, this adds a constraint to the resource to prevent it from running on the node on which it is currently running. You can execute the **pcs resource clear** or the **pcs constraint delete** command to remove the constraint. This does not necessarily move the resources back to the original node; where the resources can run at that point depends on how you have configured your resources initially.

If you specify the **--master** parameter of the **pcs resource ban** command, the scope of the constraint is limited to the master role and you must specify *master_id* rather than *resource_id*.

You can optionally configure a **lifetime** parameter for the **pcs resource move** command to indicate a period of time the constraint should remain. You specify the units of a **lifetime** parameter according to the format defined in ISO 8601, which requires that you specify the unit as a capital letter such as Y (for years), M (for months), W (for weeks), D (for days), H (for hours), M (for minutes), and S (for seconds).

To distinguish a unit of minutes(M) from a unit of months(M), you must specify PT before indicating the value in minutes. For example, a **lifetime** parameter of 5M indicates an interval of five months, while a **lifetime** parameter of PT5M indicates an interval of five minutes.

The **lifetime** parameter is checked at intervals defined by the **cluster-recheck-interval** cluster property. By default this value is 15 minutes. If your configuration requires that you check this parameter more frequently, you can reset this value with the following command.

```
pcs property set cluster-recheck-interval=value
```

You can optionally configure a **--wait[=*n*]** parameter for the **pcs resource ban** command to indicate the number of seconds to wait for the resource to start on the destination node before returning 0 if the resource is starated or 1 if the resource has not yet started. If you do not specify n, the default resource timeout willb e used.

The following command moves the resource **resource1** to node **example-node2** and prevents it from moving back to the node on which it was originally running for one hour and thirty minutes.

```
pcs resource move resource1 example-node2 lifetime=PT1H30M
```

The following command moves the resource **resource1** to node **example-node2** and prevents it from moving back to the node on which it was originally running for thirty minutes.

```
pcs resource move resource1 example-node2 lifetime=PT30M
```

For information on resource constraints, refer to Chapter 6, *Resource Constraints*.

7.1.2. Moving a Resource to its Preferred Node

After a resource has moved, either due to a failover or to an administrator manually moving the node, it will not necessarily move back to its original node even after the circumstances that caused the failover have been corrected. To relocate resources to their preferred node, use the following command. A preferred node is determined by the current cluster status, constraints, resource location, and other settings and may change over time.

```
pcs resource relocate run [resource1] [resource2] ...
```

If you do not specify any resources, all resource are relocated to their preferred nodes.

This command calculates the preferred node for each resource while ignoring resource stickiness. After calculating the preferred node, it creates location constraints which will cause the resources to move to their preferred nodes. Once the resources have been moved, the constraints are deleted auto matically. To remove all constraints created by the **pcs resource relocate run** command, you can run the **pcs resource relocate clear** command. To display the current status of resources and their optimal node ignoring resource stickiness, run the **pcs resource relocate show** command.

7.2. Moving Resources Due to Failure

When you create a resource, you can configure the resource so that it will move to a new node after a defined number of failures by setting the **migration-threshold** option for that resource. Once the threshold has been reached, this node will no longer be allowed to run the failed resource until:

- The administrator manually resets the resource's failcount using the **pcs resource failcount** command.
- The resource's **failure-timeout** value is reached.

There is no threshold defined by default.

Note

Setting a **migration-threshold** for a resource is not the same as configuring a resource for migration, in which the resource moves to another location without loss of state.

The following example adds a migration threshold of 10 to the resource named **dummy_resource**, which indicates that the resource will move to a new node after 10 failures.

```
# pcs resource meta dummy_resource migration-threshold=10
```

You can add a migration threshold to the defaults for the whole cluster with the following command.

```
# pcs resource defaults migration-threshold=10
```

To determine the resource's current failure status and limits, use the **pcs resource failcount** command.

There are two exceptions to the migration threshold concept; they occur when a resource either fails to start or fails to stop. Start failures cause the failcount to be set to **INFINITY** and thus always cause the resource to move immediately.

Stop failures are slightly different and crucial. If a resource fails to stop and STONITH is enabled, then the cluster will fence the node in order to be able to start the resource elsewhere. If STONITH is not enabled, then the cluster has no way to continue and will not try to start the resource elsewhere, but will try to stop it again after the failure timeout.

7.3. Moving Resources Due to Connectivity Changes

Setting up the cluster to move resources when external connectivity is lost is a two-step process.

1. Add a **ping** resource to the cluster. The **ping** resource uses the system utility of the same name to test if a list of machines (specified by DNS hostname or IPv4/IPv6 address) are reachable and uses the results to maintain a node attribute called **pingd**.
2. Configure a location constraint for the resource that will move the resource to a different node when connectivity is lost.

Table 5.1, “Resource Properties” describes the properties you can set for a **ping** resource.

Table 7.1. Properties of a ping resources

Field	Description
dampen	The time to wait (dampening) for further changes to occur. This prevents a resource from bouncing around the cluster when cluster nodes notice the loss of connectivity at slightly different times.
multiplier	The number of connected ping nodes gets multiplied by this value to get a score. Useful when there are multiple ping nodes configured.
host_list	The machines to contact in order to determine the current connectivity status. Allowed values include resolvable DNS host names, IPv4 and IPv6 addresses.

The following example command creates a **ping** resource that verifies connectivity to **www.example.com**. In practice, you would verify connectivity to your network gateway/router. You configure the **ping** resource as a clone so that the resource will run on all cluster nodes.

```
# pcs resource create ping ocf:pacemaker:ping dampen=5s multiplier=1000
host_list=www.example.com --clone
```

The following example configures a location constraint rule for the existing resource named **Webserver**. This will cause the **Webserver** resource to move to a host that is able to ping **www.example.com** if the host that it is currently running on can not ping **www.example.com**

```
# pcs constraint location Webserver rule score=-INFINITY pingd lt 1 or not_defined
pingd
```

7.4. Enabling, Disabling, and Banning Cluster Resources

In addition to the **pcs resource move** and **pcs resource relocate** commands described in Section 7.1, “Manually Moving Resources Around the Cluster”, there are a variety of other commands you can use to control the behavior of cluster resources.

You can manually stop a running resource and prevent the cluster from starting it again with the following command. Depending on the rest of the configuration (constraints, options, failures, etc), the resource may remain started. If you specify the **--wait** option, **pcs** will wait up to 30 seconds (or 'n' seconds, as specified) for the resource to stop and then return 0 if the resource is stopped or 1 if the resource has not stopped.

```
pcs resource disable resource_id [--wait[=n]]
```

You can use the following command to allow the cluster to start a resource. Depending on the rest of the configuration, the resource may remain stopped. If you specify the **--wait** option, **pcs** will wait up to 30 seconds (or 'n' seconds, as specified) for the resource to start and then return 0 if the resource is started or 1 if the resource has not started.

```
pcs resource enable resource_id [--wait[=n]]
```

Use the following command to prevent a resource from running on a specified node, or on the current node if no node is specified.

```
pcs resource ban resource_id [node] [--master] [lifetime=lifetime]
```

Note that when you execute the **pcs resource ban** command, this adds a -INFINITY location constraint to the resource to prevent it from running on the indicated node. You can execute the **pcs**

resource clear or the **pcs constraint delete** command to remove the constraint. This does not necessarily move the resources back to the indicated node; where the resources can run at that point depends on how you have configured your resources initially. For information on resource constraints, refer to Chapter 6, *Resource Constraints*.

If you specify the **--master** parameter of the **pcs resource ban** command, the scope of the constraint is limited to the master role and you must specify *master_id* rather than *resource_id*.

You can optionally configure a **lifetime** parameter for the **pcs resource ban** command to indicate a period of time the constraint should remain. For information on specifying units for the **lifetime** parameter and on specifying the intervals at which the **lifetime** parameter should be checked, see Section 7.1, “Manually Moving Resources Around the Cluster”.

You can optionally configure a **--wait[=*n*]** parameter for the **pcs resource ban** command to indicate the number of seconds to wait for the resource to start on the destination node before returning 0 if the resource is starated or 1 if the resource has not yet started. If you do not specify n, the default resource timeout willb e used.

You can use the **debug-start** parameter of the **pcs resource** command to force a specified resource to start on the current node, ignoring the cluster recommendations and printing the output from starting the resource. This is mainly used for debugging resources; starting resources on a cluster is (almost) always done by Pacemaker and not directly with a **pcs** command. If your resource is not starting, it is usually due to either a misconfiguration of the resource (which you debug in the system log), constraints that the resource from starting, or the resource being disabled. You can use this command to test resource configuration, but it should not normally be used to start resources in a cluster.

The format of the **debug-start** command is as follows.

```
pcs resource debug-start resource_id
```

7.5. Disabling a Monitor Operations

The easiest way to stop a recurring monitor is to delete it. However, there can be times when you only want to disable it temporarily. In such cases, add **enabled="false"** to the operation’s definition. When you want to reinstate the monitoring operation, set **enabled="true"** to the operation's definition.

7.6. Managed Resources

You can set a resource to unmanaged mode, which indicates that the resource is still in the configuration but Pacemaker does not manage the resource.

The following command sets the indicated resources to unmanaged mode.

```
pcs resource unmanage resource1  [resource2] ...
```

The following command sets resources to managed mode, which is the default state.

```
pcs resource manage resource1  [resource2] ...
```

You can specify the name of a resource group with the **pcs resource manage** or **pcs resource unmanage** command. The command will act on all of the resources in the group, so that you can manage or unmanage all of the resource in a group with a single command and then manage the contained resources individually.

Chapter 8. Advanced Resource types

This chapter describes advanced resource types that Pacemaker supports.

8.1. Resource Clones

You can clone a resource so that the resouce can be active on multiple nodes. For example, you can use cloned resources to configure multiple instances of an IP resource to distribute throughout a cluster for node balancing. You can clone any resource provided the resource agent supports it. A clone consists of one resource or one resource group.

Note

Only resources that can be active on multiple nodes at the same time are suitable for cloning. For example, a **Filesystem** resource mounting a non-clustered file system such as **ext4** from a shared memory device should not be cloned. Since the **ext4** partition is not cluster aware, this file system is not suitable for read/write operations occurring from multiple nodes at the same time.

8.1.1. Creating and Removing a Cloned Resource

You can create a resource and a clone of that resource at the same time with the following command.

```
pcs resource create resource_id standard:provider:type|type [resource options] \
clone [meta clone_options]
```

The name of the clone will be ***resource_id*-clone**.

You cannot create a resource group and a clone of that resource group in a single command.

Alternately, you can create a clone of a previously-created resource or resource group with the following command.

```
pcs resource clone resource_id | group_name [clone_options]...
```

The name of the clone will be ***resource_id*-clone** or ***group_name*-clone**.

Note

You need to configure resource configuration changes on one node only.

Note

When configuring constraints, always use the name of the group or clone.

When you create a clone of a resource, the clone takes on the name of the resource with **-clone** appended to the name. The following commands creates a resource of type **apache** named **webfarm** and a clone of that resource named **webfarm-clone**.

```
# pcs resource create webfarm apache clone
```

Use the following command to remove a clone of a resource or a resource group. This does not remove the resource or resource group itself.

```
pcs resource unclone resource_id | group_name
```

For information on resource options, refer to Section 5.1, “Resource Creation”.

Table 8.1, “Resource Clone Options” describes the options you can specify for a cloned resource.

Table 8.1. Resource Clone Options

Field	Description
priority, target-role, is-managed	Options inherited from resource that is being cloned, as described in. Table 5.3, “Resource Meta Options”.
clone-max	How many copies of the resource to start. Defaults to the number of nodes in the cluster.
clone-node-max	How many copies of the resource can be started on a single node; the default value is **1**.
notify	When stopping or starting a copy of the clone, tell all the other copies beforehand and when the action was successful. Allowed values: **false**, **true**. The default value is **false**.
globally-unique	Does each copy of the clone perform a different function? Allowed values: **false**, **true** If the value of this option is **false**, these resources behave identically everywhere they are running and thus there can be only one copy of the clone active per machine. If the value of this option is **true**, a copy of the clone running on one machine is not equivalent to another instance, whether that instance is running on another node or on the same node. The default value is **true** if the value of **clone-node-max** is greater than one; otherwise the default value is **false**.
ordered	Should the copies be started in series (instead of in parallel). Allowed values: **false**, **true**. The default value is **false**.
interleave	Changes the behavior of ordering constraints (between clones/masters) so that copies of the first clone can start or stop as soon as the copy on the same node of the second clone has started or stopped (rather than waiting until every instance of the second clone has started or stopped). Allowed values: **false**, **true**. The default value is **false**.

8.1.2. Clone Constraints

In most cases, a clone will have a single copy on each active cluster node. You can, however, set **clone-max** for the resource clone to a value that is less than the total number of nodes in the cluster. If this is the case, you can indicate which nodes the cluster should preferentially assign copies to with resource location constraints. These constraints are written no differently to those for regular

resources except that the clone's id must be used.

The following command creates a location constraint for the cluster to preferentially assign resource clone **webfarm-clone** to **node1**.

```
# pcs constraint location webfarm-clone prefers node1
```

Ordering constraints behave slightly differently for clones. In the example below, **webfarm-stats** will wait until all copies of **webfarm-clone** that need to be started have done so before being started itself. Only if no copies of **webfarm-clone** can be started then **webfarm-stats** will be prevented from being active. Additionally, **webfarm-clone** will wait for **webfarm-stats** to be stopped before stopping itself.

```
# pcs constraint order start webfarm-clone then webfarm-stats
```

Colocation of a regular (or group) resource with a clone means that the resource can run on any machine with an active copy of the clone. The cluster will choose a copy based on where the clone is running and the resource's own location preferences.

Colocation between clones is also possible. In such cases, the set of allowed locations for the clone is limited to nodes on which the clone is (or will be) active. Allocation is then performed as normally.

The following command creates a colocation constraint to ensure that the resource **webfarm-stats** runs on the same node as an active copy of **webfarm-clone**.

```
# pcs constraint colocation add webfarm-stats with webfarm-clone
```

8.1.3. Clone Stickiness

To achieve a stable allocation pattern, clones are slightly sticky by default. If no value for **resource-stickiness** is provided, the clone will use a value of 1. Being a small value, it causes minimal disturbance to the score calculations of other resources but is enough to prevent Pacemaker from needlessly moving copies around the cluster.

8.2. Multi-State Resources: Resources That Have Multiple Modes

Multi-state resources are a specialization of Clone resources. They allow the instances to be in one of two operating modes; these are called **Master** and **Slave**. The names of the modes do not have specific meanings, except for the limitation that when an instance is started, it must come up in the **Slave** state.

You can create a resource as a master/slave clone with the following single command.

```
pcs resource create resource_id standard:provider:type|type [resource options] \
--master [meta master_options]
```

The name of the master/slave clone will be ***resource_id*-master**.

Alternately, you can create a master/slave resource from a previously-created resource or resource group with the following command: When you use this command, you can specify a name for the master/slave clone. If you do not specify a name, the name of the master/slave clone will be ***resource_id*-master** or ***group_name*-master**.

```
pcs resource master master/slave_name resource_id|group_name [master_options]
```

For information on resource options, refer to Section 5.1, “Resource Creation”.

Table 8.2, “Properties of a Multi-State Resource” describes the options you can specify for a multi-state resource.

Table 8.2. Properties of a Multi-State Resource

Field	Description
id	Your name for the multi-state resource
priority, **target-role**, **is-managed**	See Table 5.3, “Resource Meta Options”.
clone-max, **clone-node-max**, **notify**, **globally-unique**, **ordered**, **interleave**	See Table 8.1, “Resource Clone Options”.
master-max	How many copies of the resource can be promoted to **master** status; default 1.
master-node-max	How many copies of the resource can be promoted to **master** status on a single node; default 1.

8.2.1. Monitoring Multi-State Resources

To add a monitoring operation for the master resource only, you can add an additional monitor operation to the resource. Note, however, that every monitor operation on a resource must have a different interval.

The following example configures a monitor operation with an interval of 11 seconds on the master resource for **ms_resource**. This monitor operation is in addition to the default monitor operation with the default monitor interval of 10 seconds.

```
# pcs resource op add ms_resource interval=11s role=Master
```

8.2.2. Multi-state Constraints

In most cases, a multi-state resources will have a single copy on each active cluster node. If this is not the case, you can indicate which nodes the cluster should preferentially assign copies to with resource location constraints. These constraints are written no differently than those for regular resources.

For information on resource location constraints, see Section 6.1, “Location Constraints”.

You can create a colocation constraint which specifies whether the resources are master or slave resources. The following command creates a resource colocation constraint.

```
pcs constraint colocation add [master|slave] source_resource with [master|slave] target_resource [score] [options]
```

For information on colocation constraints, see Section 6.3, “Colocation of Resources”.

When configuring an ordering constraint that includes multi-state resources, one of the actions that you can specify for the resources is **promote**, indicating that the resource be promoted from slave to master. Additionally, you can specify an action of **demote**, indicated that the resource be demoted from master to slave.

The command for configuring an order constraint is as follows.

```
pcs constraint order [action] resource_id then [action] resource_id [options]
```

For information on resource order constraints, see Section 6.2, “Order Constraints”.

8.2.3. Multi-state Stickiness

To achieve a stable allocation pattern, multi-state resources are slightly sticky by default. If no value for **resource-stickiness** is provided, the multi-state resource will use a value of 1. Being a small value, it causes minimal disturbance to the score calculations of other resources but is enough to prevent Pacemaker from needlessly moving copies around the cluster.

8.3. Event Notification with Monitoring Resources

A Pacemaker cluster is an event-driven system, where an event might be a resource failure or configuration change. The **ocf:pacemaker:ClusterMon** resource can monitor the cluster status and trigger alerts on each cluster event. This resource runs the **crm_mon** command in the background at regular intervals.

By default, the **crm_mon** command listens for resource events only; to enable listing for fencing events you can provide the **--watch-fencing** option to the command when you configure the **ClusterMon** resource. The **crm_mon** command does not monitor for membership issues but will print a message when fencing is started and when monitoring is started for that node, which would imply that a member just joined the cluster.

The **ClusterMon** resource can execute an external program to determine what to do with cluster notifications by means of the **extra_options** parameter. Table 8.3, “Environment Variables Passed to the External Monitor Program” lists the environment variables that are passed to that program, which describe the type of cluster event that occurred.

Table 8.3. Environment Variables Passed to the External Monitor Program

Environment Variable	Description
CRM_notify_recipient	The static external-recipient from the resource definition
CRM_notify_node	The node on which the status change happened
CRM_notify_rsc	The name of the resource that changed the status
CRM_notify_task	The operation that caused the status change
CRM_notify_desc	The textual output relevant error code of the operation (if any) that caused the status change
CRM_notify_rc	The return code of the operation
CRM_target_rc	The expected return code of the operation
CRM_notify_status	The numerical representation of the status of the operation

The following example configures a **ClusterMon** resource that executes the external program **crm_logger.sh** which will log the event notifications specified in the program.

The following procedure creates the **crm_logger.sh** program that this resource will use.

1. On one node of the cluster, create the program that will log the event notifications.

```
# cat <<-END >/usr/local/bin/crm_logger.sh
```

```
#!/bin/sh
logger -t "ClusterMon-External" "${CRM_notify_node} ${CRM_notify_rsc} \
${CRM_notify_task} ${CRM_notify_desc} ${CRM_notify_rc} \
${CRM_notify_target_rc} ${CRM_notify_status} ${CRM_notify_recipient}";
exit;
END
```

2. Set the ownership and permissions for the program.

```
# chmod 700 /usr/local/bin/crm_logger.sh
# chown root.root /usr/local/bin/crm_logger.sh
```

3. Use the **scp** command to copy the **crm_logger.sh** program to the other nodes of the cluster, putting the program in the same location on those nodes and setting the same ownership and permissions for the program.

The following example configures the **ClusterMon** resource, named **ClusterMon-External**, that runs the program **/usr/local/bin/crm_logger.sh**. The **ClusterMon** resource outputs the cluster status to an **html** file, which is **/var/www/html/cluster_mon.html** in this example. The **pidfile** detects whether **ClusterMon** is already running; in this example that file is **/var/run/crm_mon-external.pid**. This resource is created as a clone so that it will run on every node in the cluster. The **watch-fencing** is specified to enable monitoring of fencing events in addition to resource events, unclding the start/stop/monitor, start/monitor. and stop of the fencing resource.

```
# pcs resource create ClusterMon-External ClusterMon user=root \
update=10 extra_options="-E /usr/local/bin/crm_logger.sh --watch-fencing" \
htmlfile=/var/www/html/cluster_mon.html \
pidfile=/var/run/crm_mon-external.pid clone
```

Note

The **crm_mon** command that this resource executes and which could be run manually is as follows:

```
# /usr/sbin/crm_mon -p /var/run/crm_mon-manual.pid -d -i 5 \
-h /var/www/html/crm_mon-manual.html -E "/usr/local/bin/crm_logger.sh" \
--watch-fencing
```

The following example shows the format of the output of the monitoring notifications that this example yields.

```
Aug  7 11:31:32 rh6node1pcmk ClusterMon-External: rh6node2pcmk.examplerh.com ClusterIP
st_notify_fence Operation st_notify_fence requested by rh6node1pcmk.examplerh.com for peer
rh6node2pcmk.examplerh.com: OK (ref=b206b618-e532-42a5-92eb-44d363ac848e) 0 0 0 #177
Aug  7 11:31:32 rh6node1pcmk ClusterMon-External: rh6node1pcmk.examplerh.com ClusterIP
start OK 0 0 0
Aug  7 11:31:32 rh6node1pcmk ClusterMon-External: rh6node1pcmk.examplerh.com ClusterIP
monitor OK 0 0 0
Aug  7 11:33:59 rh6node1pcmk ClusterMon-External: rh6node1pcmk.examplerh.com fence_xvms
monitor OK 0 0 0
Aug  7 11:33:59 rh6node1pcmk ClusterMon-External: rh6node1pcmk.examplerh.com ClusterIP
```

```
monitor OK 0 0 0
Aug  7 11:33:59 rh6node1pcmk ClusterMon-External: rh6node1pcmk.examplerh.com
ClusterMon-External start OK 0 0 0
Aug  7 11:33:59 rh6node1pcmk ClusterMon-External: rh6node1pcmk.examplerh.com fence_xvms
start OK 0 0 0
Aug  7 11:33:59 rh6node1pcmk ClusterMon-External: rh6node1pcmk.examplerh.com ClusterIP
start OK 0 0 0
Aug  7 11:33:59 rh6node1pcmk ClusterMon-External: rh6node1pcmk.examplerh.com
ClusterMon-External monitor OK 0 0 0
Aug  7 11:34:00 rh6node1pcmk crmd[2887]:   notice: te_rsc_command: Initiating action 8:
monitor ClusterMon-External:1_monitor_0 on rh6node2pcmk.examplerh.com
Aug  7 11:34:00 rh6node1pcmk crmd[2887]:   notice: te_rsc_command: Initiating action 16: start
ClusterMon-External:1_start_0 on rh6node2pcmk.examplerh.com
Aug  7 11:34:00 rh6node1pcmk ClusterMon-External: rh6node1pcmk.examplerh.com ClusterIP
stop OK 0 0 0
Aug  7 11:34:00 rh6node1pcmk crmd[2887]:   notice: te_rsc_command: Initiating action 15:
monitor ClusterMon-External_monitor_10000 on rh6node2pcmk.examplerh.com
Aug  7 11:34:00 rh6node1pcmk ClusterMon-External: rh6node2pcmk.examplerh.com
ClusterMon-External start OK 0 0 0
Aug  7 11:34:00 rh6node1pcmk ClusterMon-External: rh6node2pcmk.examplerh.com
ClusterMon-External monitor OK 0 0 0
Aug  7 11:34:00 rh6node1pcmk ClusterMon-External: rh6node2pcmk.examplerh.com ClusterIP
start OK 0 0 0
Aug  7 11:34:00 rh6node1pcmk ClusterMon-External: rh6node2pcmk.examplerh.com ClusterIP
monitor OK 0 0 0
```

8.4. The pacemaker_remote Service

The **pacemaker_remote** service allows nodes not running **corosync** to integrate into the cluster and have the cluster manage their resources just as if they were real cluster nodes. This means that Pacemaker clusters are now capable of managing virtual environments (KVM/LXC) as well as the resources that live within those virtual environments without requiring the virtual environments to run **pacemaker** or **corosync**.

The following terms are used to describe the **pacemaker_remote** service.

- *cluster node* - A node running the High Availability services (**pacemaker** and **corosync**).
- *remote node* — A node running **pacemaker_remote** to remotely integrate into the cluster without requiring **corosync** cluster membership.
- *container* — A Pacemaker resource that contains additional resources. For example, a KVM virtual machine resource that contains a webserver resource.
- *container remote node* — A virtual guest remote node running the **pacemaker_remote** service. This describes a specific remote node use case where a virtual guest resource managed by the cluster is both started by the cluster and integrated into the cluster as a remote node.
- *pacemaker_remote* — A service daemon capable of performing remote application management within guest nodes (KVM and LXC) in both Pacemaker cluster environments and standalone (non-cluster) environments. This service is an enhanced version of Pacemaker's local resource manage daemon (LRMD) that is capable of managing and monitoring LSB, OCF, upstart, and systemd resources on a guest remotely. It also allows **pcs** to work on remote nodes.
- *LXC* — A Linux Container defined by the **libvirt-lxc** Linux container driver.

A Pacemaker cluster running the **pacemaker_remote** service has the following characteristics.

- The virtual remote nodes run the **pacemaker_remote** service (with very little configuration required on the virtual machine side).
- The cluster stack (**pacemaker** and **corosync**), running on the cluster nodes, launches the virtual machines and immediately connects to the **pacemaker_remote** service, allowing the virtual machines to integrate into the cluster.

The key difference between the virtual machine remote nodes and the cluster nodes is that the remote nodes are not running the cluster stack. This means the remote nodes do not take place in quorum. On the other hand, this also means that remote nodes are not bound to the scalability limits associated with the cluster stack. Other than the quorum limitation, the remote nodes behave just like cluster nodes in respect to resource management. The cluster is fully capable of managing and monitoring resources on each remote node. You can build constraints against remote nodes, put them in standby, or perform any other action you perform on cluster nodes. Remote nodes appear in cluster status output just as cluster nodes do.

8.4.1. Container Remote Node Resource Options

When configuring a virtual machine or LXC resource to act as a remote node, you create a **VirtualDomain** resource, which manages the virtual machine. For descriptions of the options you can set for a **VirtualDomain** resource, use the following command.

```
# pcs resource describe VirtualDomain
```

In addition to the **VirtualDomain** resource options, you can configure metadata options to both enable the resource as a remote node and define the connection parameters. Table 8.4, “Metadata Options for Configuring KVM/LXC Resources as Remote Nodes” describes these metadata options.

Table 8.4. Metadata Options for Configuring KVM/LXC Resources as Remote Nodes

Field	Default	Description
remote-node	<none>	The name of the remote node this resource defines. This both enables the resource as a remote node and defines the unique name used to identify the remote node. If no other parameters are set, this value will also be assumed as the hostname to connect to at port 3121. *WARNING*: This value cannot overlap with any resource or node IDs.
remote-port	3121	Configures a custom port to use for the guest connection to **pacemaker_remote**.
remote-addr	**remote-node** value used as hostname	The IP address or hostname to connect to if remote node’s name is not the hostname of the guest
remote-connect-timeout	60s	Amount of time before a pending guest connection will time out

8.4.2. Host and Guest Authentication

Authentication and encryption of the connection between cluster-nodes and remote nodes is achieved using TLS with PSK encryption/authentication on TCP port 3121. This means both the cluster node and the remote node must share the same private key. By default this key must be placed at **/etc/pacemaker/authkey** on both cluster nodes and remote nodes.

8.4.3. Changing Default pacemaker_remote Options

If you need to change the default port or **authkey** location for either Pacemaker or **pacemaker_remote**, there are environment variables you can set that affect both of those daemons. These environment variables can be enabled by placing them in the **/etc/sysconfig/pacemaker** file as follows.

```
#==#==# Pacemaker Remote
# Use a custom directory for finding the authkey.
PCMK_authkey_location=/etc/pacemaker/authkey
#
# Specify a custom port for Pacemaker Remote connections
PCMK_remote_port=3121
```

8.4.4. Configuration Overview: KVM Remote Node

This section provides a high-level summary overview of the steps to perform to have Pacemaker launch a virtual machine and to integrate that machine as a remote node, using **libvirt** and KVM virtual guests.

1. After installing the virtualization software and enabling the **libvirtd** service on the cluster nodes, put an **authkey** with the path **/etc/pacemaker/authkey** on every cluster node and virtual machine. This secures remote communication and authentication.

   The following command creates an **authkey**.

   ```
   # dd if=/dev/urandom of=/etc/pacemaker/authkey bs=4096 count=1
   ```

2. On every virtual machine, install **pacemaker_remote** packages, start the **pacemaker_remote** service and enable it to run on startup, and allow TCP port 3121 through the firewall.

   ```
   # yum install pacemaker-remote resource-agents
   # systemctl start pacemaker_remote.service
   # systemctl enable pacemaker_remote.service
   # firewall-cmd --add-port 3121/tcp --permanent
   ```

3. Give each virtual machine a static network address and unique hostname.

4. To create the **VirtualDomain** resource agent for the management of the virtual machine, Pacemaker requires the virtual machine's xml config file to be dumped to a file on disk. For example, if you created a virtual machine named **guest1**, dump the xml to a file somewhere on the host using the following command.

   ```
   # virsh dumpxml guest1 > /virtual_machines/guest1.xml
   ```

5. Create the **VirtualDomain** resource, configuring the **remote-note** resource meta option to indicate that the virtual machine is a remote node capable of running resources.

   In the example below, the meta-attribute **remote-node=guest1** tells pacemaker that this resource is a remote node with the hostname **guest1** that is capable of being integrated into the cluster. The cluster will attempt to contact the virtual machine's **pacemaker_remote** service at the hostname **guest1** after it launches.

   ```
   # pcs resource create vm-guest1 VirtualDomain hypervisor="qemu:///system"
   config="/virtual_machines/vm-guest1.xml" meta remote-node=guest1
   ```

6. After creating the **VirtualDomain** resource, you can treat the remote node just as you would treat any other node in the cluster. For example, you can create a resource and place a resource constraint on the resource to run on the remote node.

```
# pcs resource create webserver apache params
configfile=/etc/httpd/conf/httpd.conf op monitor interval=30s
# pcs constraint location webserver prefers guest1
```

   Once a remote node is integrated into the cluster, you can execute **pcs** commands from the remote node itself, just as if the remote node was running Pacemaker.

Chapter 9. Pacemaker Rules

Rules can be used to make your configuration more dynamic. One common example is to set one value for **resource-stickiness** during working hours, to prevent resources from being moved back to their most preferred location, and another on weekends when no-one is around to notice an outage.

Another use of rules might be to assign machines to different processing groups (using a node attribute) based on time and to then use that attribute when creating location constraints.

Each rule can contain a number of expressions, date-expressions and even other rules. The results of the expressions are combined based on the rule's **boolean-op** field to determine if the rule ultimately evaluates to **true** or **false**. What happens next depends on the context in which the rule is being used.

Table 9.1. Properties of a Rule

Field	Description
role	Limits the rule to apply only when the resource is in that role. Allowed values: **Started**, **Slave,** and **Master**. NOTE: A rule with **role="Master"** can not determine the initial location of a clone instance. It will only affect which of the active instances will be promoted.
score	The score to apply if the rule evaluates to **true**. Limited to use in rules that are part of location constraints.
score-attribute	The node attribute to look up and use as a score if the rule evaluates to **true**. Limited to use in rules that are part of location constraints.
boolean-op	How to combine the result of multiple expression objects. Allowed values: **and** and **or**. The default value is **and**.

9.1. Node Attribute Expressions

Node attribute expressions are used to control a resource based on the attributes defined by a node or nodes.

Table 9.2. Properties of an Expression

Field	Description
value	User supplied value for comparison
attribute	The node attribute to test
type	Determines how the value(s) should be tested. Allowed values: **string**, **integer**, **version**

Field	Description
operation	The comparison to perform. Allowed values: * **lt** - True if the node attribute's value is less than **value** * **gt** - True if the node attribute's value is greater than **value** * **lte** - True if the node attribute's value is less than or equal to **value** * **gte** - True if the node attribute's value is greater than or equal to **value** * **eq** - True if the node attribute's value is equal to **value** * **ne** - True if the node attribute's value is not equal to **value** * **defined** - True if the node has the named attribute * **not_defined** - True if the node does not have the named attribute

9.2. Time/Date Based Expressions

Date expressions are used to control a resource or cluster option based on the current date/time. They can contain an optional date specification.

Table 9.3. Properties of a Date Expression

Field	Description
start	A date/time conforming to the ISO8601 specification.
end	A date/time conforming to the ISO8601 specification.
operation	Compares the current date/time with the start and/or end date, depending on the context. Allowed values: * **gt** - True if the current date/time is after **start** * **lt** - True if the current date/time is before **end** * **in-range** - True if the current date/time is after **start** and before **end** * **date-spec** - performs a cron-like comparison to the current date/time

9.3. Date Specifications

Date specificiations are used to create cron-like expressions relating to time. Each field can contain a single number or a single range. Instead of defaulting to zero, any field not supplied is ignored.

For example, **monthdays="1"** matches the first day of every month and **hours="09-17"** matches the hours between 9am and 5pm (inclusive). However, you cannot specify **weekdays="1,2"** or **weekdays="1-2,5-6"** since they contain multiple ranges.

Table 9.4. Properties of a Date Specification

Field	Description
id	A unique name for the date

Field	Description
hours	Allowed values: 0-23
monthdays	Allowed values: 0-31 (depending on month and year)
weekdays	Allowed values: 1-7 (1=Monday, 7=Sunday)
yeardays	Allowed values: 1-366 (depending on the year)
months	Allowed values: 1-12
weeks	Allowed values: 1-53 (depending on weekyear)
years	Year according the Gregorian calendar
weekyears	May differ from Gregorian years; for example, **2005-001 Ordinal** is also **2005-01-01 Gregorian** is also **2004-W53-6 Weekly**
moon	Allowed values: 0-7 (0 is new, 4 is full moon).

9.4. Durations

Durations are used to calculate a value for **end** when one is not supplied to in_range operations. They contain the same fields as **date_spec** objects but without the limitations (ie. you can have a duration of 19 months). Like **date_specs**, any field not supplied is ignored.

9.5. Configuring Rules with pcs

To configure a rule, use the following command. If **score** is omitted, it defaults to INFINITY. If **id** is omitted, one is generated from the *constraint_id*. The *rule_type* should be **expression** or **date_expression**.

```
pcs constraint rule add constraint_id [rule_type] [score=score [id=rule_id]
expression|date_expression|date_spec options
```

To remove a rule, use the following. If the rule that you are removing is the last rule in its constraint, the constraint will be removed.

```
pcs constraint rule remove rule_id
```

9.6. Sample Time Based Expressions

The following command configures an expression that is true if now is any time in the year 2005.

```
# pcs constraint location Webserver rule score=INFINITY date-spec years=2005
```

The following command configures an expression that is true from 9am to 5pm, Monday through Friday. Note that the hours value of 16 matches up to 16:59:59, as the numeric value (hour) still matches.

```
# pcs constraint location Webserver rule score=INFINITY date-spec hours="9-16"
weekdays="1-5"
```

The following command configures an expression that is true when there is a full moon on Friday the 13th.

```
# pcs constraint location Webserver rule date-spec weekdays=5 monthdays=13
moon=4
```

9.7. Using Rules to Determine Resource Location

You can use a rule to determine a resource's location with the following command.

```
pcs constraint location resource_id rule [rule_id] [role=master|slave] [score=score expression]
```

The *expression* can be one of the following:

- **defined|not_defined *attribute***
- ***attribute* lt|gt|lte|gte|eq|ne *value***
- **date [start=*start*] [end=*end*] operation=gt|lt|in-range**
- **date-spec *date_spec_options***

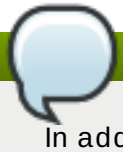
Chapter 10. Pacemaker Cluster Properties

Cluster properties control how the cluster behaves when confronted with situations that may occur during cluster operation.

- Table 10.1, “Cluster Properties” describes the cluster properties options.
- Section 10.2, “Setting and Removing Cluster Properties” describes how to set cluster properties.
- Section 10.3, “Querying Cluster Property Settings” describes how to list the currently set cluster properties.

10.1. Summary of Cluster Properties and Options

Table 10.1, “Cluster Properties” summaries the Pacemaker cluster properties, showing the default values of the properties and the possible values you can set for those properties.



Note

In addition to the properties described in this table, there are additional cluster properties that are exposed by the cluster software. For these properties, it is recommended that you not change their values from their defaults.

Table 10.1. Cluster Properties

Option	Default	Description
batch-limit	30	The number of jobs that the transition engine (TE) is allowed to execute in parallel. The "correct" value will depend on the speed and load of your network and cluster nodes.
migration-limit	-1 (unlimited)	The number of migration jobs that the TE is allowed to execute in parallel on a node.
no-quorum-policy	stop	What to do when the cluster does not have quorum. Allowed values: * ignore - continue all resource management * freeze - continue resource management, but do not recover resources from nodes not in the affected partition * stop - stop all resources in the affected cluster partition * suicide - fence all nodes in the affected cluster partition
symmetric-cluster	true	Indicates whether resources can run on any node by default.

Option	Default	Description
stonith-enabled	true	Indicates that failed nodes and nodes with resources that can not be stopped should be fenced. Protecting your data requires that you set this **true**. If **true**, or unset, the cluster will refuse to start resources unless one or more STONITH resources have been configured also.
stonith-action	reboot	Action to send to STONITH device. Allowed values: **reboot**, **off**. The value **poweroff** is also allowed, but is only used for legacy devices.
cluster-delay	60s	Round trip delay over the network (excluding action execution). The "correct" value will depend on the speed and load of your network and cluster nodes.
stop-orphan-resources	true	Indicates whether deleted resources should be stopped.
stop-orphan-actions	true	Indicates whether deleted actions should be cancelled.
start-failure-is-fatal	true	Indicates whether a failure to start is treated as fatal for a resource. When set to **false**, the cluster will instead use the resource's **failcount** and value for **migration-threshold**. For information on setting the **migration-threshold** option for a resource, see Section 7.2, “Moving Resources Due to Failure”.
pe-error-series-max	-1 (all)	The number of PE inputs resulting in ERRORs to save. Used when reporting problems.
pe-warn-series-max	-1 (all)	The number of PE inputs resulting in WARNINGs to save. Used when reporting problems.
pe-input-series-max	-1 (all)	The number of "normal" PE inputs to save. Used when reporting problems.
cluster-infrastructure		The messaging stack on which Pacemaker is currently running. Used for informational and diagnostic purposes; not user-configurable.
dc-version		Version of Pacemaker on the cluster's Designated Controller (DC). Used for diagnostic purposes; not user-configurable.
last-lrm-refresh		Last refresh of the Local Resource Manager, given in units of seconds since epoca. Used for diagnostic purposes; not user-configurable.
cluster-recheck-interval	15min	Polling interval for time-based changes to options, resource parameters and constraints. Allowed values: Zero disables polling, positive values are an interval in seconds (unless other SI units are specified, such as 5min).
default-action-timeout	20s	Timeout value for a Pacemaker action. The setting for an operation in a resource itself always takes precedence over the default value set as a cluster option.

Option	Default	Description
maintenance-mode	false	Maintenance Mode tells the cluster to go to a "hands off" mode, and not start or stop any services until told otherwise. When maintanence mode is completed, the cluster does a sanity check of the current state of any services, and then stops or starts any that need it.
shutdown-escalation	20min	The time after which to give up trying to shut down gracefully and just exit. Advanced use only.
stonith-timeout	60s	How long to wait for a STONITH action to complete.
stop-all-resources	false	Should the cluster stop all resources.
default-resource-stickiness	5000	Indicates how much a resource prefers to stay where it is. It is recommended that you set this value as a resource/operation default rather than as a cluster option.
is-managed-default	true	Indicates whether the cluster is allowed to start and stop a resource. It is recommended that you set this value as a resource/operation default rather than as a cluster option.
enable-acl	false	(Red Hat Enterprise Linux 7.1 and later) Indicates whether the cluster can use access control lists, as set with the **pcs acl** command.

10.2. Setting and Removing Cluster Properties

To set the value of a cluster property, use the following **pcs** command.

```
pcs property set property=value
```

For example, to set the value of **symmetric-cluster** to **false**, use the following command.

```
# pcs property set symmetric-cluster=false
```

You can remove a cluster property from the configuration with the following command.

```
pcs property unset property
```

Alternately, you can remove a cluster property from a configuration by leaving the value field of the **pcs property set** command blank. This restores that property to its default value. For example, if you have previously set the **symmetric-cluster** property to **false**, the following command removes the value you have set from the configuration and restores the value of **symmetric-cluster** to **true**, which is its default value.

```
# pcs property set symmetic-cluster=
```

10.3. Querying Cluster Property Settings

In most cases, when you use the **pcs** command to display values of the various cluster components, you can use **pcs list** or **pcs show** interchangeably. In the following examples, **pcs list** is the format used to display an entire list of all settings for more than one property, while **pcs show** is the format used to display the values of a specific property.

To display the values of the property settings that have been set for the cluster, use the following **pcs** command.

```
pcs property list
```

To display all of the values of the property settings for the cluster, including the default values of the property settings that have not been explicitly set, use the following command.

```
pcs property list --all
```

To display the current value of a specific cluster property, use the following command.

```
pcs property show property
```

For example, to display the current value of the **cluster-infrastructure** property, execute the following command:

```
# pcs property show cluster-infrastructure
Cluster Properties:
 cluster-infrastructure: cman
```

For informational purposes, you can display a list of all of the default values for the properties, whether they have been set to a value other than the default or not, by using the following command.

```
pcs property [list|show] --defaults
```

Chapter 11. The pcsd Web UI

This chapter provides an overview of configuring a Red Hat High Availability cluster with the **pcsd** Web UI.

11.1. pcsd Web UI Setup

To set up your system to use the **pcsd** Web UI to configure a cluster, use the following procedure.

1. Install the Pacemaker configuration tools, as described in Section 1.2, “Installing Pacemaker configuration tools”.
2. On each node that will be part of the cluster, use the **passwd** command to set the password for user **hacluster**, using the same password on each node.
3. Start and enable the **pcsd** daemon on each node:

```
# systemctl start pcsd.service
# systemctl enable pcsd.service
```

4. On each node, authenticate the nodes that will constitute the cluster with the following command. After executing this command, you will be prompted for a **Username** and a **Password**. Specify **hacluster** as the **Username**.

```
# pcs cluster auth node1 node2 ... nodeN
```

5. On any system, open a browser to the following URL, specifying one of the nodes you have authorized (note that this uses the **https** protocol). This brings up the **pcsd** Web UI login screen.

```
https://nodename:2224
```

6. Log in as user **hacluster**. This brings up the **Manage Clusters** page.

11.2. Managing Clusters with the pcsd Web UI

From the **Manage Clusters** page, you can create a new cluster or add an existing cluster to the Web UI. Once you have created a cluster, the cluster name is displayed on this page. Moving the cursor over the cluster's name displays information about the cluster.

To create a cluster, click on **Create New** and enter the name of the cluster to create and the nodes that constitute the cluster. After entering this information, click **Create Cluster**. This displays the cluster just created on the **Manage Clusters** screen, showing the cluster nodes.

To add an existing cluster to the Web UI, click on **Add Existing** and enter the hostname or IP address of a node in the cluster that you would like to manage with the Web UI.

To manage a cluster, click on the name of the cluster. This brings up a page that allows you to configure the nodes, resources, fence devices, and cluster properties for that cluster.

Note

When using the **pcsd** Web UI to configure a cluster, you can move your mouse over the text describing many of the options to see longer descriptions of those options as a tooltip display.

11.3. Cluster Nodes

Selecting the **Nodes** option from the menu along the top of the cluster management page displays the currently configured nodes and the status of the currently-selected node. You can add or remove nodes from this page, and you can start, stop, restart, or put a node in standby mode. For information on standby mode, see Section 3.2.5, "Standby Mode".

You can also configure fence devices directly from this page, as described in Section 11.4, "Fence Devices". by selecting **Configure Fencing**.

11.4. Fence Devices

Selecting the **Fence Devices** option from the menu along the top of the cluster management page displays **Fence Devices** screen, showing the currently configured fence devices.

To add a new fence device to the cluster, click **Add**. The brings up the **Add Fence Device** screen. When you select a fence device type from the drop-down **Type** menu, the arguments you must specify for that fence device appear in the menu. You can click on **Optional Arguments** to display additional arguments you can specify for the fence device you are defining. After entering the parameters for the new fence device, click **Create Fence Instance**.

For information on configuring fence devices with Pacemaker, see Chapter 4, *Fencing: Configuring STONITH*.

11.5. Cluster Resources

Selecting the **Resources** option from the menu along the top of the cluster management page displays the currently configured resources for the cluster as well as the configuration parameters of the currently selected resource. If a resource is part of a resource group, the name of the resource group will be displayed in parenthesis along with the resource name.

You can add or remove resources and you can edit the configuration of existing resources.

To add a new resource to the cluster, click **Add**. The brings up the **Add Resource** screen. When you select a resource type from the drop-down **Type** menu, the arguments you must specify for that resource appear in the menu. You can click **Optional Arguments** to display additional arguments you can specify for the resource you are defining. After entering the parameters for the resource you are creating, click **Create Resource**.

When configuring the arguments for a resource, a brief description of the argument appears in the menu. If you move the cursor to the field, a longer help description of that argument is displayed.

You can define as resource as a cloned resource, or as a master/slave resource. For information on these resource types, see Chapter 8, *Advanced Resource types*.

Once you have created at least one resource, you can create resource a resource group. For information on resource groups, see Section 5.5, "Resource Groups".

To create a resource group, select a resource that will be part of the group from the **Resources** screen, then click **Create Group**. This displays the **Create Group** screen. Enter a group name and click **Create Group**. This returns you to the **Resources** screen, which now displays the group name for the resource. After you have created a resource group, you can indicate that group name as a resource parameter when you create or modify additional resources.

11.6. Cluster Properties

Selecting the **Cluster Properties** option from the menu along the top of the cluster management page displays the cluster properties and allows you to modify these properties from their default values. For information on the Pacemaker cluster properties, see Chapter 10, *Pacemaker Cluster Properties*.

Appendix A. Cluster Creation in Red Hat Enterprise Linux 6 and Red Hat Enterprise Linux 7

Configuring a Red Hat High Availability Cluster in Red Hat Enterprise Linux 7 with Pacemaker requires a different set of configuration tools with a different administrative interface than configuring a cluster in Red Hat Enterprise Linux 6 with **rgmanager**. Section A.1, "Cluster Creation with rgmanager and with Pacemaker" summarizes the configuration differences between the various cluster components.

The Red Hat Enterprise Linux 6.5 release supports cluster configuration with Pacemaker, using the **pcs** configuration tool. Section A.2, "Cluster Creation with Pacemaker in Red Hat Enterprise Linux 6.5 and Red Hat Enterprise Linux 7" summarizes some small configuration differences between **pcs** support in Red Hat Enterprise Linux 6.5 and **pcs** support in Red Hat Enterprise Linux 7.0.

A.1. Cluster Creation with rgmanager and with Pacemaker

Table A.1, "Comparison of Cluster Configuration with rgmanager and with Pacemaker" provides a comparative summary of how you configure the components of a cluster with **rgmanager** in Red Hat Enterprise Linux 6 and with Pacemaker in Red Hat Enterprise Linux 7.

Table A.1. Comparison of Cluster Configuration with rgmanager and with Pacemaker

Configuration Component	rgmanager	Pacemaker
Cluster configuration file	The cluster configuration file on each node is **cluster.conf** file, which can can be edited directly if desired. Otherwise, use the **luci** or **ccs** interface to define the cluster configuration.	The cluster and Pacemaker configuration files are **corosync.conf** and **cib.xml**. Do not edit these files directly; use the **pcs** or **pcsd** interface instead.
Network setup	Configure IP addresses and SSH before configuring the cluster.	Configure IP addresses and SSH before configuring the cluster.
Cluster Configuration Tools	**luci**, **ccs** command, manual editing of **cluster.conf** file.	**pcs** or **pcsd**.
Installation	Install **rgmanager** (which pulls in all dependencies, including **ricci**, **luci**, and the resource and fencing agents). If needed, install **lvm2-cluster** and **gfs2-utils**.	Install **pcs**, and the fencing agents you require. If needed, install **lvm2-cluster** and **gfs2-utils**.

Configuration Component	rgmanager	Pacemaker
Starting cluster services	Start and enable cluster services with the following procedure: 1. Start **rgmanager**, **cman**, and, if needed, **clvmd** and **gfs2**. 2. Start **ricci**, and start **luci** if using the **luci** interface. 3. Run **chkconfig on** for the needed services so that they start at each runtime. Alternately, you can run **ccs --start** to start and enable the cluster services.	Start and enable cluster services with the following procedure: 1. On every node, execute **systemctl start pcsd.service**, then **systemctl enable pcsd.service** to enable **pcsd** to start at runtime. 2. On one node in the cluster, run **pcs cluster start --all** to start **corosync** and **pacemaker**.
Controlling access to configuration tools	For **luci**, the root user or a user with **luci** permissions can access **luci**. All access requires the **ricci** password for the node.	The **pcsd** gui requires that you authenticate as user **hacluster**, which is the common system user. The root user can set the password for **hacluster**.
Cluster creation	Name the cluster and define which nodes to include in the cluster with **luci** or **ccs**, or directly edit the **cluster.conf** file.	Name the cluster and include nodes with **pcs cluster setup** command or with the **pcsd** Web UI. You can add nodes to an existing cluster with the **pcs cluster node add** command or with the **pcsd** Web UI.
Propagating cluster configuration to all nodes	When configuration a cluster with **luci**, propagation is automatic. With **ccs**, use the **--sync** option. You can also use the **cman_tool version -r** command.	Propagation of the cluster and Pacemaker configuration files, **corosync.conf** and **cib.xml**, is automatic on cluster setup or when adding a node or resourcea
Global cluster properties	The following feature are supported with **rgmanager** in Red Hat Enterprise Linux 6: * You can configure the system so that the system chooses which multicast address to use for IP multicasting in the cluster network. * If IP multicasting is not available, you can use UDP Unicast transport mechanism. * You can configure a cluster to use RRP protocol.	Pacemaker in RHEL 7 supports the following features for a cluster: * You can set **no-quorum-policy** for the cluster to specify what the system should do when the cluster does not have quorum. * For additional cluster properties you can set, refer to Table 10.1, “Cluster Properties”.
Logging	You can set global and daemon-specific logging configuration.	See the file **/etc/sysconfig/pacemaker** for information on how to configure logging manually.

Configuration Component	rgmanager	Pacemaker
Validating the cluster	Cluster validation is automatic with **luci** and with **ccs**, using the cluster schema. The cluster is automatically validated on startup.	The cluster is automatically validated on startup, or you can validate the cluster with **pcs cluster verify**.
Quorum in 2-node clusters	With a two-node cluster, you can configure how the system determines quorum: * Configure a quorum disk * Use **ccs** or edit the **cluster.conf** file to set **two_node=1** and **expected_votes=1** to allow a single node to maintain quorum.	**pcs** automatically adds the necessary options for a two-node cluster to **corosync**.
Cluster status	On **luci**, the current status of the cluster is visible in the various components of the interface, which can be refreshed. You can use the **--getconf** option of the **ccs** command to see current the configuration file. You can use the **clustat** command to display cluster status.	You can display the current cluster status with the **pcs status** command.
Resources	You add resources of defined types and configure resource-specific properties with **luci** or the **ccs** command, or by editing the **cluster.conf** configuration file.	You add resources of defined types and configure resource-specific properties with the **pcs resource create** command or with the **pcsd** Web UI. For general information on configuring cluster resources with Pacemaker refer to Chapter 5, *Configuring Cluster Resources*.

Configuration Component	rgmanager	Pacemaker
Resource behavior, grouping, and start/stop order	Define cluster *services* to configure how resources interact.	With Pacemaker, you use resource groups as a shorthand method of defining a set of resources that need to be located together and started and stopped sequentially. In addition, you define how resources behave and interact in the following ways: * You set some aspects of resource behavior as resource options. * You use location constraints to determine which nodes a resource can run on. * You use order constraints to determine the order in which resources run. * You use colocation constraints to determine that the location of one resource depends on the location of another resource. For more complete information on these topics, refer to Chapter 5, *Configuring Cluster Resources* and Chapter 6, *Resource Constraints*.
Resource administration: Moving, starting, stopping resources	With **luci**, you can manage clusters, individual cluster nodes, and cluster services. With the **ccs** command, you can manage cluster. You can use the **clusvadm** to manage cluster services.	You can temporarily disable a node so that it can not host resources with the **pcs cluster standby** command, which causes the resources to migrate. You can stop a resource with the **pcs resource disable** command.
Removing a cluster configuration completely	With **luci**, you can select all nodes in a cluster for deletion to delete a cluster entirely. You can also remove the **cluster.conf** from each node in the cluster.	You can remove a cluster configuration with the **pcs cluster destroy** command.
Resources active on multiple nodes, resources active on multiple nodes in multiple modes	No equivalent.	With Pacemaker, you can clone resources so that they can run in multiple nodes, and you can define cloned resources as master and slave resources so that they can run in multiple modes. For information on cloned resources and master/slave resources, refer to Chapter 8, *Advanced Resource types*.

Configuration Component	rgmanager	Pacemaker
Fencing -- single fence device per node	Create fencing devices globally or locally and add them to nodes. You can define **post-fail delay** and **post-join delay** values for the cluster as a whole.	Create a fencing device for each node with the **pcs stonith create** command or with the **pcsd** Web UI. For devices that can fence multiple nodes, you need to define them only once rather than separately for each node. You can also define **pcmk_host_map** to configure fencing devices for all nodes with a single command; for information on **pcmk_host_map** refer to Table 4.1, "General Properties of Fencing Devices". You can define the **stonith-timeout** value for the cluster as a whole.
Multiple (backup) fencing devices per node	Define backup devices with **luci** or the **ccs** command, or by editing the **cluster.conf** file directly.	Configure fencing levels.

A.2. Cluster Creation with Pacemaker in Red Hat Enterprise Linux 6.5 and Red Hat Enterprise Linux 7

The Red Hat Enterprise Linux 6.5 release supports cluster configuration with Pacemaker, using the **pcs** configuration tool. There are, however, some differences in cluster installation and creation between Red Hat Enterprise Linux 6.5 and Red Hat Enterprise Linux 7 when using Pacemaker. This section provides a brief listing of the command differences between these two releases. For further information on installation and cluster creation in Red Hat Enterprise Linux 7, see Chapter 1, *Red Hat High Availability Add-On Configuration and Management Reference Overview* and Chapter 3, *Cluster Creation and Administration*.

A.2.1. Pacemaker Installation in Red Hat Enterprise Linux 6.5 and Red Hat Enterprise Linux 7

The following commands install the Red Hat High Availability Add-On software packages that Pacemaker requires in Red Hat Enterprise Linux 6.5 and prevent **corosync** from starting without **cman**. You must run these commands on each node in the cluster.

```
[root@rhel6]# yum install pacemaker cman
[root@rhel6]# yum install pcs
[root@rhel6]# chkconfig corosync off
```

In Red Hat Enterprise Linux 7, in addition to installing the Red Hat High Availability Add-On software packages that Pacemaker requires, you set up a password for the **pcs** administration account named **hacluster**, and you start and enable the **pcsd** service, You also authenticate the administration account for the nodes of the cluster.

In Red Hat Enterprise Linux 7, run the following commands on each node in the cluster.

```
[root@rhel7]# yum install pcs fence-agents-all
[root@rhel7]# passwd hacluster
[root@rhel7]# systemctl start pcsd.service
[root@rhel7]# systemctl enable pcsd.service
```

In Red Hat Enterprise Linux 7, run the following command on one node in the cluster.

```
[root@rhel7]# pcs cluster auth [node] [...] [-u username] [-p password]
```

A.2.2. Cluster Creation with Pacemaker in Red Hat Enterprise Linux 6.5 and Red Hat Enterprise Linux 7

To create a Pacemaker cluster in Red Hat Enterprise Linux 6.5, you must create the cluster and start the cluster services on each node in the cluster. For example, to create a cluster named **my_cluster** that consists of nodes **z1.example.com** and **z2.example.com** and start cluster services on those nodes, run the following commands from both **z1.example.com** and **z2.example.com**.

```
[root@rhel6]# pcs cluster setup --name my_cluster z1.example.com z2.example.com
[root@rhel6]# pcs cluster start
```

In Red Hat Enterprise Linux 7, you run the cluster creation command from one node of the cluster. The following command, run from one node only, creates the cluster named **my_cluster** that consists of nodes **z1.example.com** and **z2.example.com** and starts cluster services on those nodes.

```
[root@rhel7]# pcs cluster setup --start --name my_cluster z1.example.com
z2.example.com
```

Appendix B. Revision History

Revision 2.1-14 **Wed Apr 27 2016** **Steven Levine**

Republish of 7.2 document

Revision 2.1-8 **Mon Nov 9 2015** **Steven Levine**

Preparing document for 7.2 GA publication

Revision 2.1-7 **Fri Oct 16 2015** **Steven Levine**

Resolves #1129854
Documents updated pcs resource cleanup command

Resolves #1267443
Fixes small errors and typos

Resolves #1245806
Documents pcs resource relocate run command

Resolves #1245809
Clarifies behavior of pcs resource move command

Resolves #1244872
Updates and expands documentation on event monitoring

Resolves #1129713
Adds warning regarding using quorum unblock

Resolves #1229826
Adds note regarding time delay following pcs cluster create

Resolves #1202956
Adds procedure for adding new nodes to a running cluster

Resolves #1211674
Removes incorrect reference to stonith-timeout veing valid as a per-device attribute

Resolves #129451
Documents resouce-discovery location constraint option

Resolves #1129851
Documents use of tooltips when using the pcsd Web UI

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Version for 7.1 GA release

Revision 1.1-7 **Thu Dec 11 2014** **Steven Levine**

Version for 7.1 Beta release

Revision 1.1-2 **Tue Dec 2 2014** **Steven Levine**

Resolves #1129854
Documents updated pcs resource cleanup command.

Resolves #1129837
Documents lifetime parameter for pcs resource move command.

Resolves #1129862, #1129461
Documents support for access control lists.

Resolves #1069385
Adds port number to enable for DLM.

Resolves #1121128, #1129738
Updates and clarifies descriptions of set colocation and ordered sets.

Resolves #1129713
Documents cluster quorum unblock feature.

Resolves #1129722
Updates description of auto_tie_breaker quorum option.

Resolves #1129737
Documents disabled parameter for pcs resource create command.

Resolves #1129859
Documents pcs cluster configuration backup and restore.

Resolves #1098289
Small clarification to description of port requirements.

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Resolves: #794494
Documents quorum support

Resolves: #1088465
Documents unfencing

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Documents pcs updates

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First printing of initial draft		

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