

# **Pacemaker 1.1**

## **Configuration Explained**

**An A-Z guide to Pacemaker's Configuration Options**



**Andrew Beekhof**

# Pacemaker 1.1 Configuration Explained

## An A-Z guide to Pacemaker's Configuration Options

### Edition 10

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The purpose of this document is to definitively explain the concepts used to configure Pacemaker. To achieve this, it will focus exclusively on the XML syntax used to configure Pacemaker's Cluster Information Base (CIB).

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## 1. Document Conventions

This manual uses several conventions to highlight certain words and phrases and draw attention to specific pieces of information.

In PDF and paper editions, this manual uses typefaces drawn from the *Liberation Fonts*<sup>1</sup> set. The Liberation Fonts set is also used in HTML editions if the set is installed on your system. If not, alternative but equivalent typefaces are displayed. Note: Red Hat Enterprise Linux 5 and later include the Liberation Fonts set by default.

### 1.1. Typographic Conventions

Four typographic conventions are used to call attention to specific words and phrases. These conventions, and the circumstances they apply to, are as follows.

#### **Mono-spaced Bold**

Used to highlight system input, including shell commands, file names and paths. Also used to highlight keys and key combinations. For example:

To see the contents of the file **my\_next\_bestselling\_novel** in your current working directory, enter the **cat my\_next\_bestselling\_novel** command at the shell prompt and press **Enter** to execute the command.

The above includes a file name, a shell command and a key, all presented in mono-spaced bold and all distinguishable thanks to context.

Key combinations can be distinguished from an individual key by the plus sign that connects each part of a key combination. For example:

Press **Enter** to execute the command.

Press **Ctrl+Alt+F2** to switch to a virtual terminal.

The first example highlights a particular key to press. The second example highlights a key combination: a set of three keys pressed simultaneously.

If source code is discussed, class names, methods, functions, variable names and returned values mentioned within a paragraph will be presented as above, in **mono-spaced bold**. For example:

---

<sup>1</sup> <https://fedorahosted.org/liberation-fonts/>

File-related classes include **filesystem** for file systems, **file** for files, and **dir** for directories. Each class has its own associated set of permissions.

### Proportional Bold

This denotes words or phrases encountered on a system, including application names; dialog box text; labeled buttons; check-box and radio button labels; menu titles and sub-menu titles. For example:

Choose **System** → **Preferences** → **Mouse** from the main menu bar to launch **Mouse Preferences**. In the **Buttons** tab, select the **Left-handed mouse** check box and click **Close** to switch the primary mouse button from the left to the right (making the mouse suitable for use in the left hand).

To insert a special character into a **gedit** file, choose **Applications** → **Accessories** → **Character Map** from the main menu bar. Next, choose **Search** → **Find...** from the **Character Map** menu bar, type the name of the character in the **Search** field and click **Next**. The character you sought will be highlighted in the **Character Table**. Double-click this highlighted character to place it in the **Text to copy** field and then click the **Copy** button. Now switch back to your document and choose **Edit** → **Paste** from the **gedit** menu bar.

The above text includes application names; system-wide menu names and items; application-specific menu names; and buttons and text found within a GUI interface, all presented in proportional bold and all distinguishable by context.

### *Mono-spaced Bold Italic* or *Proportional Bold Italic*

Whether mono-spaced bold or proportional bold, the addition of italics indicates replaceable or variable text. Italics denotes text you do not input literally or displayed text that changes depending on circumstance. For example:

To connect to a remote machine using ssh, type **ssh *username@domain.name*** at a shell prompt. If the remote machine is **example.com** and your username on that machine is john, type **ssh *john@example.com***.

The **mount -o remount *file-system*** command remounts the named file system. For example, to remount the **/home** file system, the command is **mount -o remount */home***.

To see the version of a currently installed package, use the **rpm -q *package*** command. It will return a result as follows: ***package-version-release***.

Note the words in bold italics above — *username*, *domain.name*, *file-system*, *package*, *version* and *release*. Each word is a placeholder, either for text you enter when issuing a command or for text displayed by the system.

Aside from standard usage for presenting the title of a work, italics denotes the first use of a new and important term. For example:

Publican is a *DocBook* publishing system.

## 1.2. Pull-quote Conventions

Terminal output and source code listings are set off visually from the surrounding text.

Output sent to a terminal is set in **mono-spaced roman** and presented thus:

books	Desktop	documentation	drafts	mss	photos	stuff	svn
books_tests	Desktop1	downloads	images	notes	scripts	svgs	

Source-code listings are also set in **mono-spaced roman** but add syntax highlighting as follows:

```
package org.jboss.book.jca.ex1;

import javax.naming.InitialContext;

public class ExClient
{
    public static void main(String args[])
        throws Exception
    {
        InitialContext iniCtx = new InitialContext();
        Object          ref    = iniCtx.lookup("EchoBean");
        EchoHome        home   = (EchoHome) ref;
        Echo             echo   = home.create();

        System.out.println("Created Echo");

        System.out.println("Echo.echo('Hello') = " + echo.echo("Hello"));
    }
}
```

### 1.3. Notes and Warnings

Finally, we use three visual styles to draw attention to information that might otherwise be overlooked.



#### Note

Notes are tips, shortcuts or alternative approaches to the task at hand. Ignoring a note should have no negative consequences, but you might miss out on a trick that makes your life easier.



#### Important

Important boxes detail things that are easily missed: configuration changes that only apply to the current session, or services that need restarting before an update will apply. Ignoring a box labeled 'Important' will not cause data loss but may cause irritation and frustration.



#### Warning

Warnings should not be ignored. Ignoring warnings will most likely cause data loss.

## 2. We Need Feedback!

## Preface

---

If you find a typographical error in this manual, or if you have thought of a way to make this manual better, we would love to hear from you! Please submit a report in Bugzilla<sup>2</sup> against the product **Pacemaker**.

When submitting a bug report, be sure to mention the manual's identifier: *Pacemaker\_Explained*

If you have a suggestion for improving the documentation, try to be as specific as possible when describing it. If you have found an error, please include the section number and some of the surrounding text so we can find it easily.

---

<sup>2</sup> <http://bugs.clusterlabs.org>

# Read-Me-First

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## 1.1. The Scope of this Document

The purpose of this document is to definitively explain the concepts used to configure Pacemaker. To achieve this, it will focus exclusively on the XML syntax used to configure the CIB.

For those that are allergic to XML, there exist several unified shells and GUIs for Pacemaker. However these tools will not be covered at all in this document <sup>1</sup>, precisely because they hide the XML.

Additionally, this document is NOT a step-by-step how-to guide for configuring a specific clustering scenario.

Although such guides exist, <sup>2</sup> the purpose of this document is to provide an understanding of the building blocks that can be used to construct any type of Pacemaker cluster.

## 1.2. What Is *Pacemaker*?

Pacemaker is a *cluster resource manager*, that is, a logic responsible for a life-cycle of deployed software — indirectly perhaps even whole systems or their interconnections — under its control within a set of computers (a.k.a. *nodes*) and driven by prescribed rules.

It achieves maximum availability for your cluster services (a.k.a. *resources*) by detecting and recovering from node- and resource-level failures by making use of the messaging and membership capabilities provided by your preferred cluster infrastructure (either *Corosync*<sup>3</sup> or *Heartbeat*<sup>4</sup>), and possibly by utilizing other parts of the overall cluster stack.



### Note

For **the goal of minimal downtime** a term *high availability* was coined and together with its acronym, *HA*, is well-established in the sector. To differentiate this sort of clusters from high performance computing (*HPC*) ones, should a context require it (apparently, not the case in this document), using *HA cluster* is an option.

Pacemaker's key features include:

<sup>1</sup> I hope, however, that the concepts explained here make the functionality of these tools more easily understood.

<sup>2</sup> For example, see the *Clusters from Scratch* [<http://www.clusterlabs.org/doc/>] guide.

<sup>3</sup> <http://www.corosync.org/>

<sup>4</sup> <http://linux-ha.org/wiki/Heartbeat>

- Detection and recovery of node and service-level failures
- Storage agnostic, no requirement for shared storage
- Resource agnostic, anything that can be scripted can be clustered
- Supports *fencing* (also referred to as the *STONITH* acronym, *deciphered* later on) for ensuring data integrity
- Supports large and small clusters
- Supports both quorate and resource-driven clusters
- Supports practically any redundancy configuration
- Automatically replicated configuration that can be updated from any node
- Ability to specify cluster-wide service ordering, colocation and anti-colocation
- Support for advanced service types
  - Clones: for services which need to be active on multiple nodes
  - Multi-state: for services with multiple modes (e.g. master/slave, primary/secondary)
- Unified, scriptable cluster management tools

### 1.3. Pacemaker Architecture

At the highest level, the cluster is made up of three pieces:

- **Non-cluster-aware components.** These pieces include the resources themselves; scripts that start, stop and monitor them; and a local daemon that masks the differences between the different standards these scripts implement. Even though interactions of these resources when run as multiple instances can resemble a distributed system, they still lack the proper HA mechanisms and/or autonomous cluster-wide governance as subsumed in the following item.
- **Resource management.** Pacemaker provides the brain that processes and reacts to events regarding the cluster. These events include nodes joining or leaving the cluster; resource events caused by failures, maintenance and scheduled activities; and other administrative actions. Pacemaker will compute the ideal state of the cluster and plot a path to achieve it after any of these events. This may include moving resources, stopping nodes and even forcing them offline with remote power switches.
- **Low-level infrastructure.** Projects like *Corosync*, *CMAN* and *Heartbeat* provide reliable messaging, membership and quorum information about the cluster.

When combined with Corosync, Pacemaker also supports popular open source cluster filesystems.<sup>5</sup>

Due to past standardization within the cluster filesystem community, cluster filesystems make use of a common *distributed lock manager*, which makes use of Corosync for its messaging and membership capabilities (which nodes are up/down) and Pacemaker for fencing services.

---

<sup>5</sup> Even though Pacemaker also supports Heartbeat, the filesystems need to use the stack for messaging and membership, and Corosync seems to be what they're standardizing on. Technically, it would be possible for them to support Heartbeat as well, but there seems little interest in this.

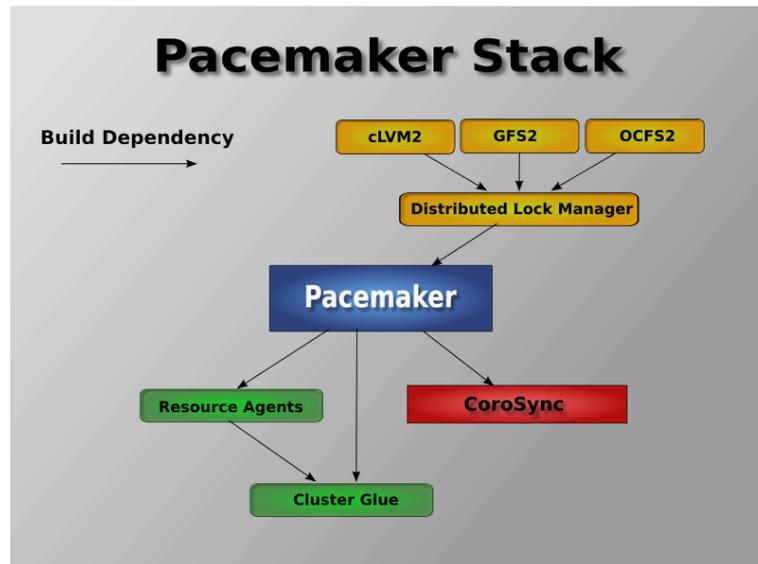


Figure 1.1. The Pacemaker Stack

### 1.3.1. Internal Components

Pacemaker itself is composed of five key components:

- *Cluster Information Base (CIB)*
- *Cluster Resource Management daemon (CRMd)*
- *Local Resource Management daemon (LRMd)*
- *Policy Engine (PEngine or PE)*
- *Fencing daemon (STONITHd)*

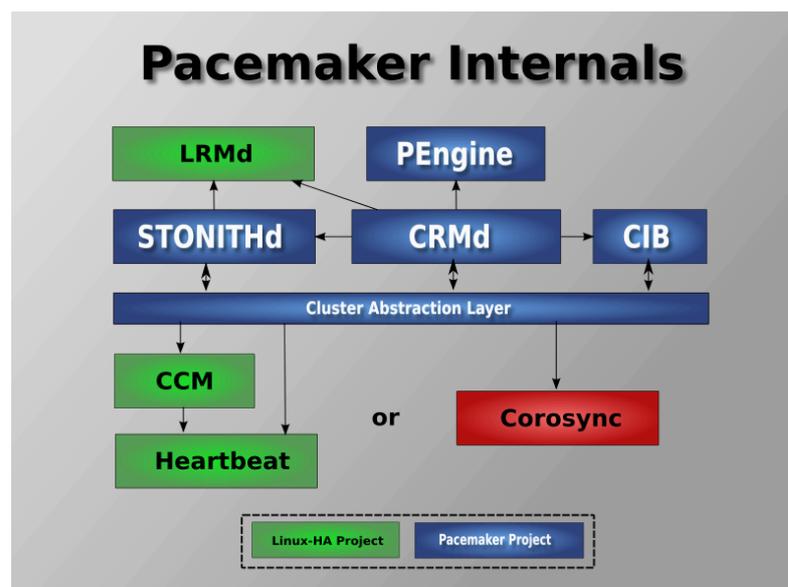


Figure 1.2. Internal Components

The CIB uses XML to represent both the cluster's configuration and current state of all resources in the cluster. The contents of the CIB are automatically kept in sync across the entire cluster and are used by the PEngine to compute the ideal state of the cluster and how it should be achieved.

This list of instructions is then fed to the *Designated Controller (DC)*. Pacemaker centralizes all cluster decision making by electing one of the CRMD instances to act as a master. Should the elected CRMD process (or the node it is on) fail, a new one is quickly established.

The DC carries out the PEngine's instructions in the required order by passing them to either the Local Resource Management daemon (LRMD) or CRMD peers on other nodes via the cluster messaging infrastructure (which in turn passes them on to their LRMD process).

The peer nodes all report the results of their operations back to the DC and, based on the expected and actual results, will either execute any actions that needed to wait for the previous one to complete, or abort processing and ask the PEngine to recalculate the ideal cluster state based on the unexpected results.

In some cases, it may be necessary to power off nodes in order to protect shared data or complete resource recovery. For this, Pacemaker comes with STONITHd.



### Note

**STONITH** is an acronym for *Shoot-The-Other-Node-In-The-Head*, a recommended practice that misbehaving node is best to be promptly *fenced* (shut off, cut from shared resources or otherwise immobilized), and is usually implemented with a remote power switch.

In Pacemaker, STONITH devices are modeled as resources (and configured in the CIB) to enable them to be easily monitored for failure, however STONITHd takes care of understanding the STONITH topology such that its clients simply request a node be fenced, and it does the rest.

## 1.4. Types of Pacemaker Clusters

Pacemaker makes no assumptions about your environment. This allows it to support practically any *redundancy configuration*<sup>6</sup> including *Active/Active*, *Active/Passive*, *N+1*, *N+M*, *N-to-1* and *N-to-N*.

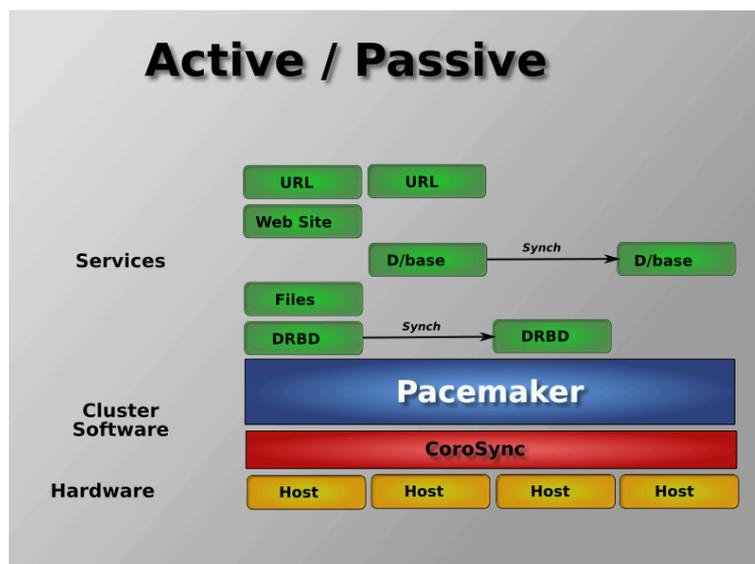


Figure 1.3. Active/Passive Redundancy

<sup>6</sup> [http://en.wikipedia.org/wiki/High-availability\\_cluster#Node\\_configurations](http://en.wikipedia.org/wiki/High-availability_cluster#Node_configurations)

Two-node Active/Passive clusters using Pacemaker and *DRBD* are a cost-effective solution for many High Availability situations.

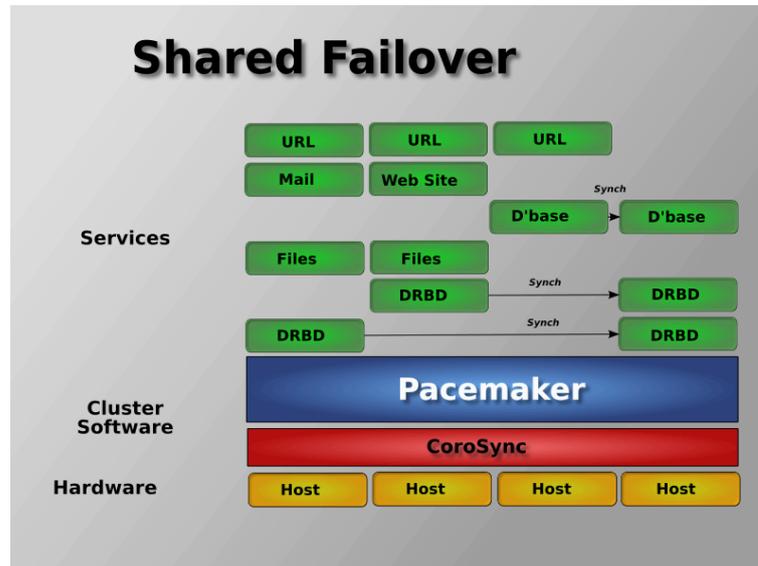


Figure 1.4. Shared Failover

By supporting many nodes, Pacemaker can dramatically reduce hardware costs by allowing several active/passive clusters to be combined and share a common backup node.

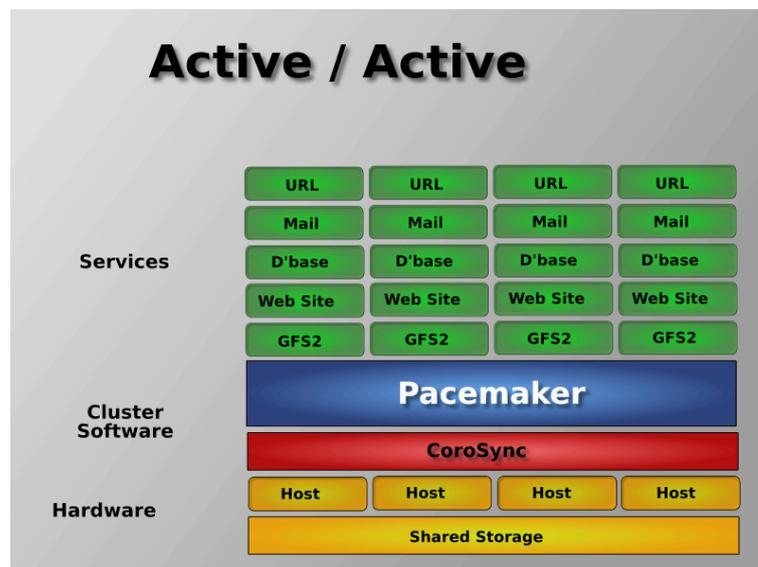


Figure 1.5. N to N Redundancy

When shared storage is available, every node can potentially be used for failover. Pacemaker can even run multiple copies of services to spread out the workload.

---

# Configuration Basics

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## 2.1. Configuration Layout

The cluster is defined by the Cluster Information Base (CIB), which uses XML notation. The simplest CIB, an empty one, looks like this:

Example 2.1. An empty configuration

```
<cib crm_feature_set="3.0.7" validate-with="pacemaker-1.2" admin_epoch="1" epoch="0"
num_updates="0">
  <configuration>
    <crm_config/>
    <nodes/>
    <resources/>
    <constraints/>
  </configuration>
  <status/>
</cib>
```

The empty configuration above contains the major sections that make up a CIB:

- **cib**: The entire CIB is enclosed with a **cib** tag. Certain fundamental settings are defined as attributes of this tag.
  - **configuration**: This section — the primary focus of this document — contains traditional configuration information such as what resources the cluster serves and the relationships among them.
    - **crm\_config**: cluster-wide configuration options
    - **nodes**: the machines that host the cluster
    - **resources**: the services run by the cluster
    - **constraints**: indications of how resources should be placed
  - **status**: This section contains the history of each resource on each node. Based on this data, the cluster can construct the complete current state of the cluster. The authoritative source for this section is the local resource manager (lrmd process) on each cluster node, and the cluster

will occasionally repopulate the entire section. For this reason, it is never written to disk, and administrators are advised against modifying it in any way.

In this document, configuration settings will be described as *properties* or *options* based on how they are defined in the CIB:

- Properties are XML attributes of an XML element.
- Options are name-value pairs expressed as **nvpair** child elements of an XML element.

Normally you will use command-line tools that abstract the XML, so the distinction will be unimportant; both properties and options are cluster settings you can tweak.

## 2.2. The Current State of the Cluster

Before one starts to configure a cluster, it is worth explaining how to view the finished product. For this purpose we have created the **crm\_mon** utility, which will display the current state of an active cluster. It can show the cluster status by node or by resource and can be used in either single-shot or dynamically-updating mode. There are also modes for displaying a list of the operations performed (grouped by node and resource) as well as information about failures.

Using this tool, you can examine the state of the cluster for irregularities and see how it responds when you cause or simulate failures.

Details on all the available options can be obtained using the **crm\_mon --help** command.

### Example 2.2. Sample output from `crm_mon`

```
=====
Last updated: Fri Nov 23 15:26:13 2007
Current DC: sles-3 (2298606a-6a8c-499a-9d25-76242f7006ec)
3 Nodes configured.
5 Resources configured.
=====

Node: sles-1 (1186dc9a-324d-425a-966e-d757e693dc86): online
  192.168.100.181 (heartbeat::ocf:IPaddr): Started sles-1
  192.168.100.182 (heartbeat:IPaddr): Started sles-1
  192.168.100.183 (heartbeat::ocf:IPaddr): Started sles-1
  rsc_sles-1 (heartbeat::ocf:IPaddr): Started sles-1
  child_DoFencing:2 (stonith:external/vmware): Started sles-1
Node: sles-2 (02fb99a8-e30e-482f-b3ad-0fb3ce27d088): standby
Node: sles-3 (2298606a-6a8c-499a-9d25-76242f7006ec): online
  rsc_sles-2 (heartbeat::ocf:IPaddr): Started sles-3
  rsc_sles-3 (heartbeat::ocf:IPaddr): Started sles-3
  child_DoFencing:0 (stonith:external/vmware): Started sles-3
```

### Example 2.3. Sample output from `crm_mon -n`

```
=====
Last updated: Fri Nov 23 15:26:13 2007
Current DC: sles-3 (2298606a-6a8c-499a-9d25-76242f7006ec)
3 Nodes configured.
5 Resources configured.
=====

Node: sles-1 (1186dc9a-324d-425a-966e-d757e693dc86): online
Node: sles-2 (02fb99a8-e30e-482f-b3ad-0fb3ce27d088): standby
Node: sles-3 (2298606a-6a8c-499a-9d25-76242f7006ec): online
```

```

Resource Group: group-1
  192.168.100.181 (heartbeat::ocf:IPAddr): Started sles-1
  192.168.100.182 (heartbeat:IPAddr): Started sles-1
  192.168.100.183 (heartbeat::ocf:IPAddr): Started sles-1
rsc_sles-1 (heartbeat::ocf:IPAddr): Started sles-1
rsc_sles-2 (heartbeat::ocf:IPAddr): Started sles-3
rsc_sles-3 (heartbeat::ocf:IPAddr): Started sles-3
Clone Set: DoFencing
  child_DoFencing:0 (stonith:external/vmware): Started sles-3
  child_DoFencing:1 (stonith:external/vmware): Stopped
  child_DoFencing:2 (stonith:external/vmware): Started sles-1

```

The DC (Designated Controller) node is where all the decisions are made, and if the current DC fails a new one is elected from the remaining cluster nodes. The choice of DC is of no significance to an administrator beyond the fact that its logs will generally be more interesting.

## 2.3. How Should the Configuration be Updated?

There are three basic rules for updating the cluster configuration:

- Rule 1 - Never edit the `cib.xml` file manually. Ever. I'm not making this up.
- Rule 2 - Read Rule 1 again.
- Rule 3 - The cluster will notice if you ignored rules 1 & 2 and refuse to use the configuration.

Now that it is clear how *not* to update the configuration, we can begin to explain how you *should*.

### 2.3.1. Editing the CIB Using XML

The most powerful tool for modifying the configuration is the `cibadmin` command. With `cibadmin`, you can query, add, remove, update or replace any part of the configuration. All changes take effect immediately, so there is no need to perform a reload-like operation.

The simplest way of using `cibadmin` is to use it to save the current configuration to a temporary file, edit that file with your favorite text or XML editor, and then upload the revised configuration.<sup>1</sup>

#### Example 2.4. Safely using an editor to modify the cluster configuration

```

# cibadmin --query > tmp.xml
# vi tmp.xml
# cibadmin --replace --xml-file tmp.xml

```

Some of the better XML editors can make use of a Relax NG schema to help make sure any changes you make are valid. The schema describing the configuration can be found in `pacemaker.rng`, which may be deployed in a location such as `/usr/share/pacemaker` or `/usr/lib/heartbeat` depending on your operating system and how you installed the software.

If you want to modify just one section of the configuration, you can query and replace just that section to avoid modifying any others.

<sup>1</sup> This process might appear to risk overwriting changes that happen after the initial `cibadmin` call, but `pacemaker` will reject any update that is "too old". If the CIB is updated in some other fashion after the initial `cibadmin`, the second `cibadmin` will be rejected because the version number will be too low.

### Example 2.5. Safely using an editor to modify only the resources section

```
# cibadmin --query --scope resources > tmp.xml
# vi tmp.xml
# cibadmin --replace --scope resources --xml-file tmp.xml
```

### 2.3.2. Quickly Deleting Part of the Configuration

Identify the object you wish to delete by XML tag and id. For example, you might search the CIB for all STONITH-related configuration:

### Example 2.6. Searching for STONITH-related configuration items

```
# cibadmin -Q | grep stonith
<nvpair id="cib-bootstrap-options-stonith-action" name="stonith-action" value="reboot"/>
<nvpair id="cib-bootstrap-options-stonith-enabled" name="stonith-enabled" value="1"/>
<primitive id="child_DoFencing" class="stonith" type="external/vmware">
<lrms_resource id="child_DoFencing:0" type="external/vmware" class="stonith">
<lrms_resource id="child_DoFencing:0" type="external/vmware" class="stonith">
<lrms_resource id="child_DoFencing:1" type="external/vmware" class="stonith">
<lrms_resource id="child_DoFencing:0" type="external/vmware" class="stonith">
<lrms_resource id="child_DoFencing:2" type="external/vmware" class="stonith">
<lrms_resource id="child_DoFencing:0" type="external/vmware" class="stonith">
<lrms_resource id="child_DoFencing:3" type="external/vmware" class="stonith">
```

If you wanted to delete the **primitive** tag with id **child\_DoFencing**, you would run:

```
# cibadmin --delete --xml-text '<primitive id="child_DoFencing"/>'
```

### 2.3.3. Updating the Configuration Without Using XML

Most tasks can be performed with one of the other command-line tools provided with pacemaker, avoiding the need to read or edit XML.

To enable STONITH for example, one could run:

```
# crm_attribute --name stonith-enabled --update 1
```

Or, to check whether **somenode** is allowed to run resources, there is:

```
# crm_standby --get-value --node somenode
```

Or, to find the current location of **my-test-rsc**, one can use:

```
# crm_resource --locate --resource my-test-rsc
```

Examples of using these tools for specific cases will be given throughout this document where appropriate.

**Note**

Old versions of pacemaker (1.0.3 and earlier) had different command-line tool syntax. If you are using an older version, check your installed manual pages for the proper syntax to use.

## 2.4. Making Configuration Changes in a Sandbox

Often it is desirable to preview the effects of a series of changes before updating the configuration all at once. For this purpose, we have created **crm\_shadow** which creates a "shadow" copy of the configuration and arranges for all the command line tools to use it.

To begin, simply invoke **crm\_shadow --create** with the name of a configuration to create<sup>2</sup>, and follow the simple on-screen instructions.

**Warning**

Read this section and the on-screen instructions carefully; failure to do so could result in destroying the cluster's active configuration!

### Example 2.7. Creating and displaying the active sandbox

```
# crm_shadow --create test
Setting up shadow instance
Type Ctrl-D to exit the crm_shadow shell
shadow[test]:
shadow[test] # crm_shadow --which
test
```

From this point on, all cluster commands will automatically use the shadow copy instead of talking to the cluster's active configuration. Once you have finished experimenting, you can either make the changes active via the **--commit** option, or discard them using the **--delete** option. Again, be sure to follow the on-screen instructions carefully!

For a full list of **crm\_shadow** options and commands, invoke it with the **--help** option.

### Example 2.8. Use sandbox to make multiple changes all at once, discard them, and verify real configuration is untouched

```
shadow[test] # crm_failcount -r rsc_c001n01 -G
scope=status name=fail-count-rsc_c001n01 value=0
shadow[test] # crm_standby --node c001n02 -v on
shadow[test] # crm_standby --node c001n02 -G
scope=nodes name=standby value=on

shadow[test] # cibadmin --erase --force
```

<sup>2</sup> Shadow copies are identified with a name, making it possible to have more than one.

```
shadow[test] # cibadmin --query
<cib cib_feature_revision="1" validate-with="pacemaker-1.0" admin_epoch="0"
crm_feature_set="3.0" have-quorum="1" epoch="112"
  dc-uuid="c001n01" num_updates="1" cib-last-written="Fri Jun 27 12:17:10 2008">
  <configuration>
    <crm_config/>
    <nodes/>
    <resources/>
    <constraints/>
  </configuration>
  <status/>
</cib>
shadow[test] # crm_shadow --delete test --force
Now type Ctrl-D to exit the crm_shadow shell
shadow[test] # exit
# crm_shadow --which
No active shadow configuration defined
# cibadmin -Q
<cib cib_feature_revision="1" validate-with="pacemaker-1.0" admin_epoch="0"
crm_feature_set="3.0" have-quorum="1" epoch="110"
  dc-uuid="c001n01" num_updates="551">
  <configuration>
    <crm_config>
      <cluster_property_set id="cib-bootstrap-options">
        <nvpair id="cib-bootstrap-1" name="stonith-enabled" value="1"/>
        <nvpair id="cib-bootstrap-2" name="pe-input-series-max" value="30000"/>
      </cluster_property_set>
    </crm_config>
  </configuration>
</cib>
```

## 2.5. Testing Your Configuration Changes

We saw previously how to make a series of changes to a "shadow" copy of the configuration. Before loading the changes back into the cluster (e.g. `crm_shadow --commit mytest --force`), it is often advisable to simulate the effect of the changes with `crm_simulate`. For example:

```
# crm_simulate --live-check -VVVV --save-graph tmp.graph --save-dotfile tmp.dot
```

This tool uses the same library as the live cluster to show what it would have done given the supplied input. Its output, in addition to a significant amount of logging, is stored in two files `tmp.graph` and `tmp.dot`. Both files are representations of the same thing: the cluster's response to your changes.

The graph file stores the complete transition from the existing cluster state to your desired new state, containing a list of all the actions, their parameters and their pre-requisites. Because the transition graph is not terribly easy to read, the tool also generates a Graphviz<sup>3</sup> dot-file representing the same information.

For information on the options supported by `crm_simulate`, use its `--help` option.

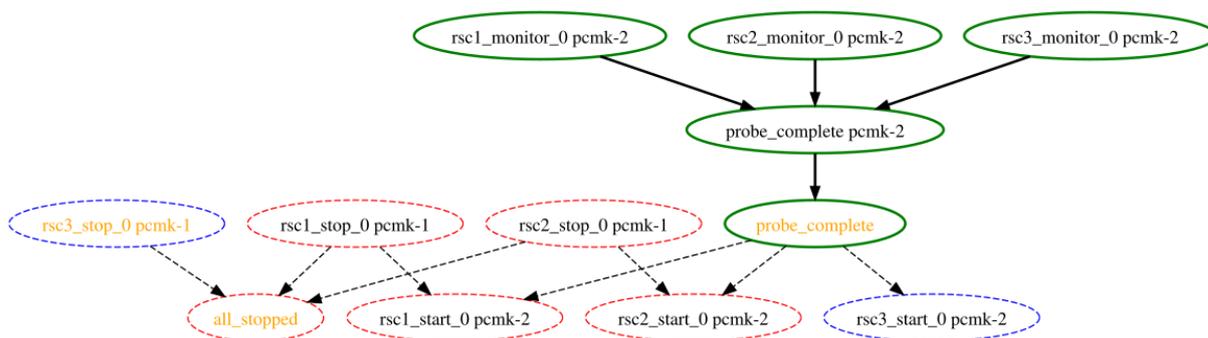
### Interpreting the Graphviz output

- Arrows indicate ordering dependencies
- Dashed arrows indicate dependencies that are not present in the transition graph
- Actions with a dashed border of any color do not form part of the transition graph
- Actions with a green border form part of the transition graph
- Actions with a red border are ones the cluster would like to execute but cannot run

<sup>3</sup> Graph visualization software. See <http://www.graphviz.org/> for details.

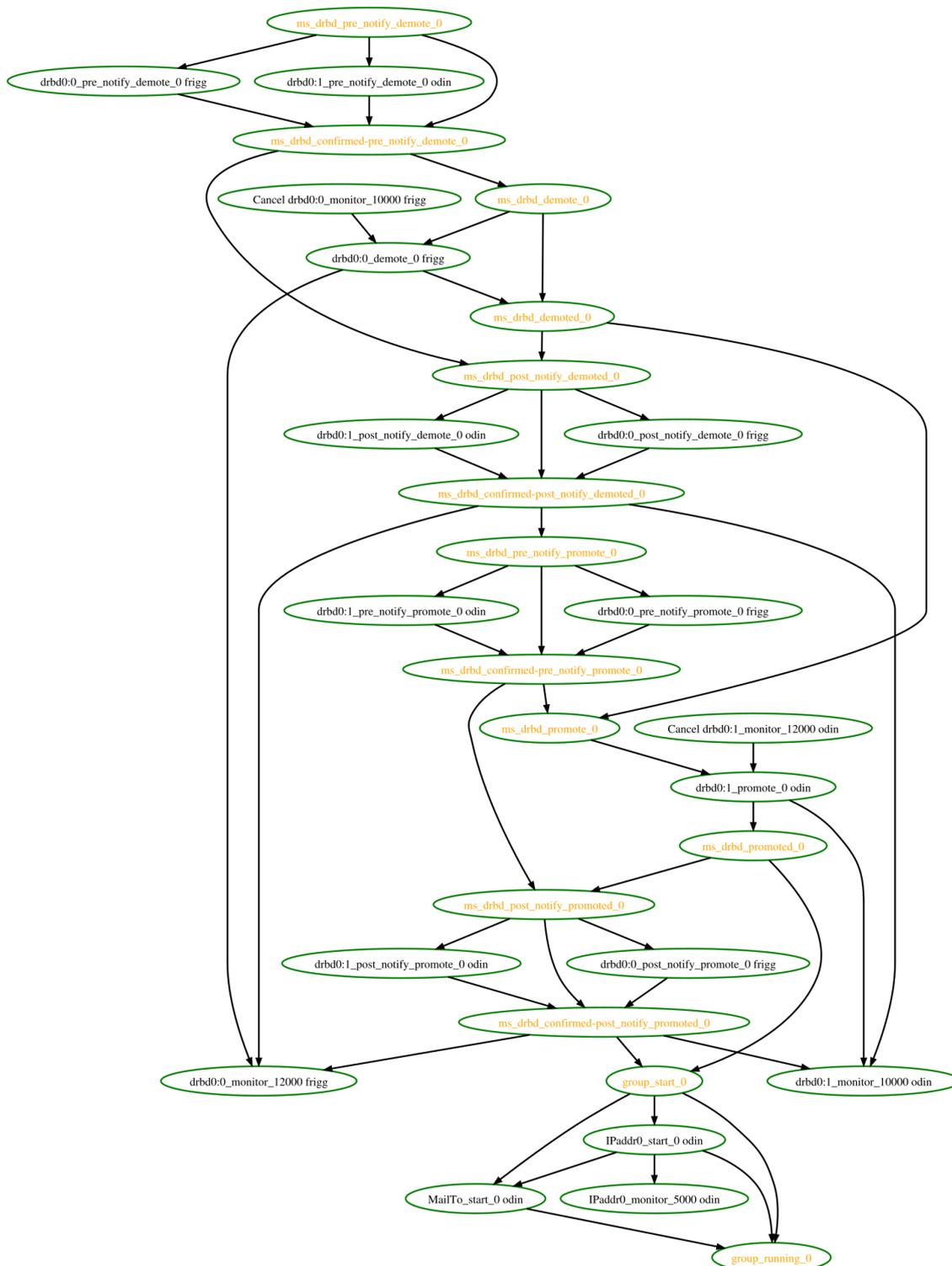
- Actions with a blue border are ones the cluster does not feel need to be executed
- Actions with orange text are pseudo/pretend actions that the cluster uses to simplify the graph
- Actions with black text are sent to the LRM
- Resource actions have text of the form *rsc\_action\_interval node*
- Any action depending on an action with a red border will not be able to execute.
- Loops are *really* bad. Please report them to the development team.

### 2.5.1. Small Cluster Transition



In the above example, it appears that a new node, **pcmk-2**, has come online and that the cluster is checking to make sure **rsc1**, **rsc2** and **rsc3** are not already running there (Indicated by the **rscN\_monitor\_0** entries). Once it did that, and assuming the resources were not active there, it would have liked to stop **rsc1** and **rsc2** on **pcmk-1** and move them to **pcmk-2**. However, there appears to be some problem and the cluster cannot or is not permitted to perform the stop actions which implies it also cannot perform the start actions. For some reason the cluster does not want to start **rsc3** anywhere.

## 2.5.2. Complex Cluster Transition



## 2.6. Do I Need to Update the Configuration on All Cluster Nodes?

No. Any changes are immediately synchronized to the other active members of the cluster.

To reduce bandwidth, the cluster only broadcasts the incremental updates that result from your changes and uses MD5 checksums to ensure that each copy is completely consistent.



# Cluster-Wide Configuration

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## 3.1. CIB Properties

Certain settings are defined by CIB properties (that is, attributes of the **cib** tag) rather than with the rest of the cluster configuration in the **configuration** section.

The reason is simply a matter of parsing. These options are used by the configuration database which is, by design, mostly ignorant of the content it holds. So the decision was made to place them in an easy-to-find location.

Table 3.1. CIB Properties

Field	Description
<b>admin_epoch</b>	When a node joins the cluster, the cluster performs a check to see which node has the best configuration. It asks the node with the highest ( <b>admin_epoch</b> , <b>epoch</b> , <b>num_updates</b> ) tuple to replace the configuration on all the nodes — which makes setting them, and setting them correctly, very important. <b>admin_epoch</b> is never modified by the cluster; you can use this to make the configurations on any inactive nodes obsolete. <i>Never set this value to zero.</i> In such cases, the cluster cannot tell the difference between your configuration and the "empty" one used when nothing is found on disk.
<b>epoch</b>	The cluster increments this every time the configuration is updated (usually by the administrator).
<b>num_updates</b>	The cluster increments this every time the configuration or status is updated (usually by the cluster) and resets it to 0 when epoch changes.
<b>validate-with</b>	Determines the type of XML validation that will be done on the configuration. If set to <b>none</b> , the cluster will not verify that updates conform to the DTD (nor reject ones that don't). This option can be useful when operating a mixed-version cluster during an upgrade.
<b>cib-last-written</b>	Indicates when the configuration was last written to disk. Maintained by the cluster; for informational purposes only.
<b>have-quorum</b>	Indicates if the cluster has quorum. If false, this may mean that the cluster cannot start resources or fence other nodes (see <b>no-quorum-policy</b> below). Maintained by the cluster.
<b>dc-uuid</b>	Indicates which cluster node is the current leader. Used by the cluster when placing resources and determining the order of some events. Maintained by the cluster.

### 3.1.1. Working with CIB Properties

Although these fields can be written to by the user, in most cases the cluster will overwrite any values specified by the user with the "correct" ones.

To change the ones that can be specified by the user, for example **admin\_epoch**, one should use:

```
# cibadmin --modify --xml-text '<cib admin_epoch="42"/>'
```

A complete set of CIB properties will look something like this:

#### Example 3.1. Attributes set for a cib object

```
<cib crm_feature_set="3.0.7" validate-with="pacemaker-1.2"
  admin_epoch="42" epoch="116" num_updates="1"
  cib-last-written="Mon Jan 12 15:46:39 2015" update-origin="rhel7-1"
  update-client="crm_attribute" have-quorum="1" dc-uuid="1">
```

## 3.2. Cluster Options

Cluster options, as you might expect, control how the cluster behaves when confronted with certain situations.

They are grouped into sets within the **crm\_config** section, and, in advanced configurations, there may be more than one set. (This will be described later in the section on [Chapter 8, Rules](#) where we will show how to have the cluster use different sets of options during working hours than during weekends.) For now, we will describe the simple case where each option is present at most once.

You can obtain an up-to-date list of cluster options, including their default values, by running the **man pengine** and **man crmd** commands.

Table 3.2. Cluster Options

Option	Default	Description
<b>dc-version</b>		Version of Pacemaker on the cluster's DC. Determined automatically by the cluster. Often includes the hash which identifies the exact Git changeset it was built from. Used for diagnostic purposes.
<b>cluster-infrastructure</b>		The messaging stack on which Pacemaker is currently running. Determined automatically by the cluster. Used for informational and diagnostic purposes.
<b>expected-quorum-votes</b>		The number of nodes expected to be in the cluster. Determined automatically by the cluster. Used to calculate quorum in clusters that use Corosync 1.x without CMAN as the messaging layer.
<b>no-quorum-policy</b>	stop	What to do when the cluster does not have quorum. Allowed values: <ul style="list-style-type: none"> <li><b>ignore</b>: continue all resource management</li> <li><b>freeze</b>: continue resource management, but don't recover resources from nodes not in the affected partition</li> <li><b>stop</b>: stop all resources in the affected cluster partition</li> </ul>

Option	Default	Description
		<ul style="list-style-type: none"> <li>• <b>suicide</b>: fence all nodes in the affected cluster partition</li> </ul>
<b>batch-limit</b>	0 (30 before version 1.1.11)	The maximum number of actions that the cluster may execute in parallel across all nodes. The "correct" value will depend on the speed and load of your network and cluster nodes. If zero, the cluster will impose a dynamically calculated limit only when any node has high load.
<b>migration-limit</b>	-1	The number of migration jobs that the TE is allowed to execute in parallel on a node. A value of -1 means unlimited.
<b>symmetric-cluster</b>	TRUE	Can all resources run on any node by default?
<b>stop-all-resources</b>	FALSE	Should the cluster stop all resources?
<b>stop-orphan-resources</b>	TRUE	Should deleted resources be stopped? This value takes precedence over <b>is-managed</b> (i.e. even unmanaged resources will be stopped if deleted from the configuration when this value is TRUE).
<b>stop-orphan-actions</b>	TRUE	Should deleted actions be cancelled?
<b>start-failure-is-fatal</b>	TRUE	Should a failure to start a resource on a particular node prevent further start attempts on that node? If FALSE, the cluster will decide whether the same node is still eligible based on the resource's current failure count and <b>migration-threshold</b> (see <a href="#">Section 9.3, "Handling Resource Failure"</a> ).
<b>enable-startup-probes</b>	TRUE	Should the cluster check for active resources during startup?
<b>maintenance-mode</b>	FALSE	Should the cluster refrain from monitoring, starting and stopping resources?
<b>stonith-enabled</b>	TRUE	<p>Should failed nodes and nodes with resources that can't be stopped be shot? If you value your data, set up a STONITH device and enable this.</p> <p>If true, or unset, the cluster will refuse to start resources unless one or more STONITH resources have been configured. If false, unresponsive nodes are immediately assumed to be running no resources, and resource takeover to online nodes starts without any further protection (which means <i>data loss</i> if the unresponsive node still accesses shared storage, for example). See also the <b>requires</b> meta-attribute in <a href="#">Section 5.4, "Resource Options"</a>.</p>
<b>stonith-action</b>	reboot	Action to send to STONITH device. Allowed values are <b>reboot</b> and <b>off</b> . The value <b>poweroff</b> is also allowed, but is only used for legacy devices.
<b>stonith-timeout</b>	60s	How long to wait for STONITH actions (reboot, on, off) to complete

Option	Default	Description
<b>stonith-max-attempts</b>	10	How many times fencing can fail for a target before the cluster will no longer immediately re-attempt it. ( <i>since 1.1.17</i> )
<b>concurrent-fencing</b>	FALSE	Is the cluster allowed to initiate multiple fence actions concurrently? ( <i>since 1.1.15</i> )
<b>cluster-delay</b>	60s	Estimated maximum round-trip delay over the network (excluding action execution). If the TE requires an action to be executed on another node, it will consider the action failed if it does not get a response from the other node in this time (after considering the action's own timeout). The "correct" value will depend on the speed and load of your network and cluster nodes.
<b>dc-deadtime</b>	20s	How long to wait for a response from other nodes during startup.  The "correct" value will depend on the speed/load of your network and the type of switches used.
<b>cluster-recheck-interval</b>	15min	Polling interval for time-based changes to options, resource parameters and constraints.  The Cluster is primarily event-driven, but your configuration can have elements that take effect based on the time of day. To ensure these changes take effect, we can optionally poll the cluster's status for changes. A value of 0 disables polling. Positive values are an interval (in seconds unless other SI units are specified, e.g. 5min).
<b>cluster-ipc-limit</b>	500	The maximum IPC message backlog before one cluster daemon will disconnect another. This is of use in large clusters, for which a good value is the number of resources in the cluster multiplied by the number of nodes. The default of 500 is also the minimum. Raise this if you see "Evicting client" messages for cluster daemon PIDs in the logs.
<b>pe-error-series-max</b>	-1	The number of PE inputs resulting in ERRORS to save. Used when reporting problems. A value of -1 means unlimited (report all).
<b>pe-warn-series-max</b>	-1	The number of PE inputs resulting in WARNINGS to save. Used when reporting problems. A value of -1 means unlimited (report all).
<b>pe-input-series-max</b>	-1	The number of "normal" PE inputs to save. Used when reporting problems. A value of -1 means unlimited (report all).
<b>placement-strategy</b>	default	How the cluster should allocate resources to nodes (see <a href="#">Chapter 12, Utilization and Placement Strategy [111]</a> ). Allowed values are <b>default</b> , <b>utilization</b> , <b>balanced</b> , and <b>minimal</b> . ( <i>since 1.1.0</i> )
<b>node-health-strategy</b>	none	How the cluster should react to node health attributes (see <a href="#">Section 9.5, "Tracking Node Health"</a> ). Allowed

Option	Default	Description
		values are <b>none</b> , <b>migrate-on-red</b> , <b>only-green</b> , <b>progressive</b> , and <b>custom</b> .
<b>node-health-base</b>	0	The base health score assigned to a node. Only used when <b>node-health-strategy</b> is <b>progressive</b> . (since 1.1.16)
<b>node-health-green</b>	0	The score to use for a node health attribute whose value is <b>green</b> . Only used when <b>node-health-strategy</b> is <b>progressive</b> or <b>custom</b> .
<b>node-health-yellow</b>	0	The score to use for a node health attribute whose value is <b>yellow</b> . Only used when <b>node-health-strategy</b> is <b>progressive</b> or <b>custom</b> .
<b>node-health-red</b>	0	The score to use for a node health attribute whose value is <b>red</b> . Only used when <b>node-health-strategy</b> is <b>progressive</b> or <b>custom</b> .
<b>remove-after-stop</b>	FALSE	<i>Advanced Use Only:</i> Should the cluster remove resources from the LRM after they are stopped? Values other than the default are, at best, poorly tested and potentially dangerous.
<b>startup-fencing</b>	TRUE	<i>Advanced Use Only:</i> Should the cluster shoot unseen nodes? Not using the default is very unsafe!
<b>election-timeout</b>	2min	<i>Advanced Use Only:</i> If you need to adjust this value, it probably indicates the presence of a bug.
<b>shutdown-escalation</b>	20min	<i>Advanced Use Only:</i> If you need to adjust this value, it probably indicates the presence of a bug.
<b>crmd-integration-timeout</b>	3min	<i>Advanced Use Only:</i> If you need to adjust this value, it probably indicates the presence of a bug.
<b>crmd-finalization-timeout</b>	30min	<i>Advanced Use Only:</i> If you need to adjust this value, it probably indicates the presence of a bug.
<b>crmd-transition-delay</b>	0s	<i>Advanced Use Only:</i> Delay cluster recovery for the configured interval to allow for additional/related events to occur. Useful if your configuration is sensitive to the order in which ping updates arrive. Enabling this option will slow down cluster recovery under all conditions.
<b>default-resource-stickiness</b>	0	<i>Deprecated:</i> See <a href="#">Section 5.4.2, "Setting Global Defaults for Resource Meta-Attributes"</a> instead
<b>is-managed-default</b>	TRUE	<i>Deprecated:</i> See <a href="#">Section 5.4.2, "Setting Global Defaults for Resource Meta-Attributes"</a> instead
<b>default-action-timeout</b>	20s	<i>Deprecated:</i> See <a href="#">Section 5.5.3, "Setting Global Defaults for Operations"</a> instead

### 3.2.1. Querying and Setting Cluster Options

Cluster options can be queried and modified using the `crm_attribute` tool. To get the current value of `cluster-delay`, you can run:

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---

```
# crm_attribute --query --name cluster-delay
```

which is more simply written as

```
# crm_attribute -G -n cluster-delay
```

If a value is found, you'll see a result like this:

```
# crm_attribute -G -n cluster-delay
scope=crm_config name=cluster-delay value=60s
```

If no value is found, the tool will display an error:

```
# crm_attribute -G -n clusta-deway
scope=crm_config name=clusta-deway value=(null)
Error performing operation: No such device or address
```

To use a different value (for example, 30 seconds), simply run:

```
# crm_attribute --name cluster-delay --update 30s
```

To go back to the cluster's default value, you can delete the value, for example:

```
# crm_attribute --name cluster-delay --delete
Deleted crm_config option: id=cib-bootstrap-options-cluster-delay name=cluster-delay
```

### 3.2.2. When Options are Listed More Than Once

If you ever see something like the following, it means that the option you're modifying is present more than once.

#### Example 3.2. Deleting an option that is listed twice

```
# crm_attribute --name batch-limit --delete

Multiple attributes match name=batch-limit in crm_config:
Value: 50          (set=cib-bootstrap-options, id=cib-bootstrap-options-batch-limit)
Value: 100         (set=custom, id=custom-batch-limit)
Please choose from one of the matches above and supply the 'id' with --id
```

In such cases, follow the on-screen instructions to perform the requested action. To determine which value is currently being used by the cluster, refer to [Chapter 8, Rules](#).

# Cluster Nodes

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## 4.1. Defining a Cluster Node

Each node in the cluster will have an entry in the nodes section containing its UUID, uname, and type.

Example 4.1. Example Heartbeat cluster node entry

```
<node id="1186dc9a-324d-425a-966e-d757e693dc86" uname="pcmk-1" type="normal"/>
```

Example 4.2. Example Corosync cluster node entry

```
<node id="101" uname="pcmk-1" type="normal"/>
```

In normal circumstances, the admin should let the cluster populate this information automatically from the communications and membership data. However for Heartbeat, one can use the **crm\_uuid** tool to read an existing UUID or define a value before the cluster starts.

## 4.2. Where Pacemaker Gets the Node Name

Traditionally, Pacemaker required nodes to be referred to by the value returned by **uname -n**. This can be problematic for services that require the **uname -n** to be a specific value (e.g. for a licence file).

This requirement has been relaxed for clusters using Corosync 2.0 or later. The name Pacemaker uses is:

1. The value stored in **corosync.conf** under **ring0\_addr** in the **nodelist**, if it does not contain an IP address; otherwise
2. The value stored in **corosync.conf** under **name** in the **nodelist**; otherwise
3. The value of **uname -n**

Pacemaker provides the **crm\_node -n** command which displays the name used by a running cluster.

If a Corosync **nodelist** is used, **crm\_node --name-for-id number** is also available to display the name used by the node with the corosync **nodeid** of *number*, for example: **crm\_node --name-for-id 2**.

### 4.3. Node Attributes

*Node attributes* are a special type of option (name-value pair) that applies to a node object.

Beyond the basic definition of a node, the administrator can describe the node's attributes, such as how much RAM, disk, what OS or kernel version it has, perhaps even its physical location. This information can then be used by the cluster when deciding where to place resources. For more information on the use of node attributes, see [Chapter 8, Rules](#).

Node attributes can be specified ahead of time or populated later, when the cluster is running, using **crm\_attribute**.

Below is what the node's definition would look like if the admin ran the command:

Example 4.3. Result of using **crm\_attribute** to specify which kernel **pcmk-1** is running

```
# crm_attribute --type nodes --node pcmk-1 --name kernel --update $(uname -r)

<node uname="pcmk-1" type="normal" id="101">
  <instance_attributes id="nodes-101">
    <nvpair id="nodes-101-kernel" name="kernel" value="3.10.0-123.13.2.el7.x86_64"/>
  </instance_attributes>
</node>
```

Rather than having to read the XML, a simpler way to determine the current value of an attribute is to use **crm\_attribute** again:

```
# crm_attribute --type nodes --node pcmk-1 --name kernel --query
scope=nodes name=kernel value=3.10.0-123.13.2.el7.x86_64
```

By specifying **--type nodes** the admin tells the cluster that this attribute is persistent. There are also transient attributes which are kept in the status section which are "forgotten" whenever the node rejoins the cluster. The cluster uses this area to store a record of how many times a resource has failed on that node, but administrators can also read and write to this section by specifying **--type status**.

## 4.4. Managing Nodes in a Corosync-Based Cluster

### 4.4.1. Adding a New Corosync Node

To add a new node:

1. Install Corosync and Pacemaker on the new host.
2. Copy **/etc/corosync/corosync.conf** and **/etc/corosync/authkey** (if it exists) from an existing node. You may need to modify the **mcastaddr** option to match the new node's IP address.

3. Start the cluster software on the new host. If a log message containing "Invalid digest" appears from Corosync, the keys are not consistent between the machines.

## 4.4.2. Removing a Corosync Node

Because the messaging and membership layers are the authoritative source for cluster nodes, deleting them from the CIB is not a complete solution. First, one must arrange for corosync to forget about the node (**pcmk-1** in the example below).

1. Stop the cluster on the host to be removed. How to do this will vary with your operating system and installed versions of cluster software, for example, **pcs cluster stop** if you are using pcs for cluster management, or **service corosync stop** on a host using corosync 1.x with the pacemaker plugin.
2. From one of the remaining active cluster nodes, tell Pacemaker to forget about the removed host, which will also delete the node from the CIB:

```
# crm_node -R pcmk-1
```



### Note

This procedure only works for pacemaker 1.1.8 and later.

## 4.4.3. Replacing a Corosync Node

To replace an existing cluster node:

1. Make sure the old node is completely stopped.
2. Give the new machine the same hostname and IP address as the old one.
3. Follow the procedure above for adding a node.

## 4.5. Managing Nodes in a Heartbeat-based Cluster

### 4.5.1. Adding a New Heartbeat Node

To add a new node:

1. Install heartbeat and pacemaker on the new host.
2. Copy **ha.cf** and **authkeys** from an existing node.
3. If you do not use **autojoin any** in **ha.cf**, run:

```
hb_addnode $(uname -n)
```

4. Start the cluster software on the new node.

### 4.5.2. Removing a Heartbeat Node

Because the messaging and membership layers are the authoritative source for cluster nodes, deleting them from the CIB is not a complete solution. First, one must arrange for Heartbeat to forget about the node (pcmk-1 in the example below).

1. On the host to be removed, stop the cluster:

```
service heartbeat stop
```

2. From one of the remaining active cluster nodes, tell Heartbeat the node should be removed:

```
hb_delnode pcmk-1
```

3. Tell Pacemaker to forget about the removed host:

```
crm_node -R pcmk-1
```



#### Note

This procedure only works for pacemaker versions after 1.1.8.

### 4.5.3. Replacing a Heartbeat Node

To replace an existing cluster node:

1. Make sure the old node is completely stopped.
2. Give the new machine the same hostname as the old one.
3. Go to an active cluster node and look up the UUID for the old node in **/var/lib/heartbeat/hostcache**.
4. Install the cluster software.
5. Copy **ha.cf** and **authkeys** to the new node.
6. On the new node, populate its UUID using **crm\_uuid -w** and the UUID obtained earlier.
7. Start the new cluster node.

# Cluster Resources

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## 5.1. What is a Cluster Resource?

A resource is a service made highly available by a cluster. The simplest type of resource, a *primitive* resource, is described in this section. More complex forms, such as groups and clones, are described in later sections.

Every primitive resource has a *resource agent*. A resource agent is an external program that abstracts the service it provides and present a consistent view to the cluster.

This allows the cluster to be agnostic about the resources it manages. The cluster doesn't need to understand how the resource works because it relies on the resource agent to do the right thing when given a **start**, **stop** or **monitor** command. For this reason, it is crucial that resource agents are well-tested.

Typically, resource agents come in the form of shell scripts. However, they can be written using any technology (such as C, Python or Perl) that the author is comfortable with.

## 5.2. Resource Classes

Pacemaker supports several classes of agents:

- OCF

- LSB
- Upstart
- Systemd
- Service
- Fencing
- Nagios Plugins

### 5.2.1. Open Cluster Framework

The OCF standard <sup>1</sup> is basically an extension of the Linux Standard Base conventions for init scripts to:

- support parameters,
- make them self-describing, and
- make them extensible

OCF specs have strict definitions of the exit codes that actions must return. <sup>2</sup>

The cluster follows these specifications exactly, and giving the wrong exit code will cause the cluster to behave in ways you will likely find puzzling and annoying. In particular, the cluster needs to distinguish a completely stopped resource from one which is in some erroneous and indeterminate state.

Parameters are passed to the resource agent as environment variables, with the special prefix **OCF\_RESKEY\_**. So, a parameter which the user thinks of as **ip** will be passed to the resource agent as **OCF\_RESKEY\_ip**. The number and purpose of the parameters is left to the resource agent; however, the resource agent should use the **meta-data** command to advertise any that it supports.

The OCF class is the most preferred as it is an industry standard, highly flexible (allowing parameters to be passed to agents in a non-positional manner) and self-describing.

For more information, see the [reference](#)<sup>3</sup> and [Appendix B, More About OCF Resource Agents](#).

### 5.2.2. Linux Standard Base

LSB resource agents are those found in **/etc/init.d**.

Generally, they are provided by the OS distribution and, in order to be used with the cluster, they must conform to the LSB Spec. <sup>4</sup>

---

<sup>1</sup> See <http://www.opencf.org/cgi-bin/viewcvs.cgi/specs/ra/resource-agent-api.txt?rev=HEAD> — at least as it relates to resource agents. The Pacemaker implementation has been somewhat extended from the OCF specs, but none of those changes are incompatible with the original OCF specification.

<sup>2</sup> The resource-agents source code includes the **ocf-tester** script, which can be useful in this regard.

<sup>3</sup> [http://www.linux-ha.org/wiki/OCF\\_Resource\\_Agents](http://www.linux-ha.org/wiki/OCF_Resource_Agents)

<sup>4</sup> See [http://refspecs.linux-foundation.org/LSB\\_3.0.0/LSB-Core-generic/LSB-Core-generic/inisrptact.html](http://refspecs.linux-foundation.org/LSB_3.0.0/LSB-Core-generic/LSB-Core-generic/inisrptact.html) for the LSB Spec as it relates to init scripts.



### Warning

Many distributions claim LSB compliance but ship with broken init scripts. For details on how to check whether your init script is LSB-compatible, see [Appendix E, Init Script LSB Compliance](#). Common problematic violations of the LSB standard include:

- Not implementing the status operation at all
- Not observing the correct exit status codes for **start/stop/status** actions
- Starting a started resource returns an error
- Stopping a stopped resource returns an error



### Important

Remember to make sure the computer is *not* configured to start any services at boot time — that should be controlled by the cluster.

## 5.2.3. Systemd

Some newer distributions have replaced the old "SysV"<sup>5</sup> style of initialization daemons and scripts with an alternative called *Systemd*<sup>6</sup>.

Pacemaker is able to manage these services *if they are present*.

Instead of init scripts, systemd has *unit files*. Generally, the services (unit files) are provided by the OS distribution, but there are online guides for converting from init scripts.<sup>7</sup>



### Important

Remember to make sure the computer is *not* configured to start any services at boot time — that should be controlled by the cluster.

## 5.2.4. Upstart

<sup>5</sup> <http://en.wikipedia.org/wiki/Init#SysV-style>

<sup>6</sup> <http://www.freedesktop.org/wiki/Software/systemd>

<sup>7</sup> For example, <http://0pointer.de/blog/projects/systemd-for-admins-3.html>

Some newer distributions have replaced the old "SysV"<sup>8</sup> style of initialization daemons (and scripts) with an alternative called *Upstart*<sup>9</sup>.

Pacemaker is able to manage these services *if they are present*.

Instead of init scripts, upstart has *jobs*. Generally, the services (jobs) are provided by the OS distribution.



### Important

Remember to make sure the computer is *not* configured to start any services at boot time — that should be controlled by the cluster.

## 5.2.5. System Services

Since there are various types of system services (**systemd**, **upstart**, and **lsb**), Pacemaker supports a special **service** alias which intelligently figures out which one applies to a given cluster node.

This is particularly useful when the cluster contains a mix of **systemd**, **upstart**, and **lsb**.

In order, Pacemaker will try to find the named service as:

1. an LSB init script
2. a Systemd unit file
3. an Upstart job

## 5.2.6. STONITH

The STONITH class is used exclusively for fencing-related resources. This is discussed later in [Chapter 13, STONITH](#).

## 5.2.7. Nagios Plugins

Nagios Plugins<sup>10</sup> allow us to monitor services on remote hosts.

Pacemaker is able to do remote monitoring with the plugins *if they are present*.

A common use case is to configure them as resources belonging to a resource container (usually a virtual machine), and the container will be restarted if any of them has failed. Another use is to configure them as ordinary resources to be used for monitoring hosts or services via the network.

---

<sup>8</sup> <http://en.wikipedia.org/wiki/Init#SysV-style>

<sup>9</sup> <http://upstart.ubuntu.com/>

<sup>10</sup> The project has two independent forks, hosted at <https://www.nagios-plugins.org/> and <https://www.monitoring-plugins.org/>. Output from both projects' plugins is similar, so plugins from either project can be used with pacemaker.

The supported parameters are same as the long options of the plugin.

## 5.3. Resource Properties

These values tell the cluster which resource agent to use for the resource, where to find that resource agent and what standards it conforms to.

Table 5.1. Properties of a Primitive Resource

Field	Description
<b>id</b>	Your name for the resource
<b>class</b>	The standard the resource agent conforms to. Allowed values: <b>lsb</b> , <b>nagios</b> , <b>ocf</b> , <b>service</b> , <b>stonith</b> , <b>systemd</b> , <b>upstart</b>
<b>type</b>	The name of the Resource Agent you wish to use. E.g. <b>IPaddr</b> or <b>Filesystem</b>
<b>provider</b>	The OCF spec allows multiple vendors to supply the same resource agent. To use the OCF resource agents supplied by the Heartbeat project, you would specify <b>heartbeat</b> here.

The XML definition of a resource can be queried with the **crm\_resource** tool. For example:

```
# crm_resource --resource Email --query-xml
```

might produce:

Example 5.1. A system resource definition

```
<primitive id="Email" class="service" type="exim"/>
```



### Note

One of the main drawbacks to system services (LSB, systemd or Upstart) resources is that they do not allow any parameters!

Example 5.2. An OCF resource definition

```
<primitive id="Public-IP" class="ocf" type="IPaddr" provider="heartbeat">
  <instance_attributes id="Public-IP-params">
    <nvpair id="Public-IP-ip" name="ip" value="192.0.2.2"/>
  </instance_attributes>
</primitive>
```

## 5.4. Resource Options

Resources have two types of options: *meta-attributes* and *instance attributes*. Meta-attributes apply to any type of resource, while instance attributes are specific to each resource agent.

### 5.4.1. Resource Meta-Attributes

Meta-attributes are used by the cluster to decide how a resource should behave and can be easily set using the **--meta** option of the **crm\_resource** command.

Table 5.2. Meta-attributes of a Primitive Resource

Field	Default	Description
<b>priority</b>	0	If not all resources can be active, the cluster will stop lower priority resources in order to keep higher priority ones active.
<b>target-role</b>	Started	What state should the cluster attempt to keep this resource in? Allowed values: <ul style="list-style-type: none"> <li>• <b>Stopped</b>: Force the resource to be stopped</li> <li>• <b>Started</b>: Allow the resource to be started (and in the case of <i>multi-state</i> resources, promoted to master if appropriate)</li> <li>• <b>Slave</b>: Allow the resource to be started, but only in Slave mode if the resource is <i>multi-state</i></li> <li>• <b>Master</b>: Equivalent to <b>Started</b></li> </ul>
<b>is-managed</b>	TRUE	Is the cluster allowed to start and stop the resource? Allowed values: <b>true</b> , <b>false</b>
<b>resource-stickiness</b>	value of <b>resource-stickiness</b> in the <b>rsc_defaults</b> section	How much does the resource prefer to stay where it is?
<b>requires</b>	<b>quorum</b> for resources with a <b>class</b> of <b>stonith</b> , otherwise <b>unfencing</b> if unfencing is active in the cluster, otherwise <b>fencing</b> if <b>stonith-enabled</b> is true, otherwise <b>quorum</b>	Conditions under which the resource can be started ( <i>since 1.1.8</i> ) Allowed values: <ul style="list-style-type: none"> <li>• <b>nothing</b>: can always be started</li> <li>• <b>quorum</b>: The cluster can only start this resource if a majority of the configured nodes are active</li> <li>• <b>fencing</b>: The cluster can only start this resource if a majority of the configured nodes are active <i>and</i> any failed or unknown nodes have been <i>fenced</i></li> <li>• <b>unfencing</b>: The cluster can only start this resource if a majority of the configured nodes are active <i>and</i> any failed or unknown nodes have been fenced <i>and</i> only on nodes that have been <i>unfenced</i> (<i>since 1.1.9</i>)</li> </ul>
<b>migration-threshold</b>	INFINITY	How many failures may occur for this resource on a node, before this node is marked ineligible to host this resource. A value of 0 indicates that this feature is disabled (the node will never be marked ineligible); by contrast, the cluster treats INFINITY (the default) as a very large but finite number. This option has an effect only if the failed operation has

Field	Default	Description
		on-fail=restart (the default), and additionally for failed start operations, if the cluster property start-failure-is-fatal is false.
<b>failure-timeout</b>	0	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. A value of 0 indicates that this feature is disabled. As with any time-based actions, this is not guaranteed to be checked more frequently than the value of <b>cluster-recheck-interval</b> (see <a href="#">Section 3.2, "Cluster Options"</a> ).
<b>multiple-active</b>	stop_start	What should the cluster do if it ever finds the resource active on more than one node? Allowed values: <ul style="list-style-type: none"> <li>• <b>block</b>: mark the resource as unmanaged</li> <li>• <b>stop_only</b>: stop all active instances and leave them that way</li> <li>• <b>stop_start</b>: stop all active instances and start the resource in one location only</li> </ul>
<b>allow-migrate</b>	TRUE for ocf:pacemaker:remote resources, FALSE otherwise	Whether the cluster should try to "live migrate" this resource when it needs to be moved (see <a href="#">Section 9.4.3, "Migrating Resources"</a> )
<b>container-attribute-target</b>		Specific to bundle resources; see <a href="#">Section 10.4.7, "Bundle Node Attributes"</a>
<b>remote-node</b>		The name of the Pacemaker Remote guest node this resource is associated with, if any. If specified, this both enables the resource as a guest node and defines the unique name used to identify the guest node. The guest must be configured to run the Pacemaker Remote daemon when it is started. <b>WARNING</b> : This value cannot overlap with any resource or node IDs. ( <i>since 1.1.9</i> )
<b>remote-port</b>	3121	If <b>remote-node</b> is specified, the port on the guest used for its Pacemaker Remote connection. The Pacemaker Remote daemon on the guest must be configured to listen on this port. ( <i>since 1.1.9</i> )
<b>remote-addr</b>	value of <b>remote-node</b>	If <b>remote-node</b> is specified, the IP address or hostname used to connect to the guest via Pacemaker Remote. The Pacemaker Remote daemon on the guest must be configured to accept connections on this address. ( <i>since 1.1.9</i> )

Field	Default	Description
<b>remote-connect-timeout</b>	60s	If <b>remote-node</b> is specified, how long before a pending guest connection will time out. ( <i>since 1.1.10</i> )

As an example of setting resource options, if you performed the following commands on an LSB Email resource:

```
# crm_resource --meta --resource Email --set-parameter priority --parameter-value 100
# crm_resource -m -r Email -p multiple-active -v block
```

the resulting resource definition might be:

#### Example 5.3. An LSB resource with cluster options

```
<primitive id="Email" class="lsb" type="exim">
  <meta_attributes id="Email-meta_attributes">
    <nvpair id="Email-meta_attributes-priority" name="priority" value="100"/>
    <nvpair id="Email-meta_attributes-multiple-active" name="multiple-active"
value="block"/>
  </meta_attributes>
</primitive>
```

### 5.4.2. Setting Global Defaults for Resource Meta-Attributes

To set a default value for a resource option, add it to the **rsc\_defaults** section with **crm\_attribute**. For example,

```
# crm_attribute --type rsc_defaults --name is-managed --update false
```

would prevent the cluster from starting or stopping any of the resources in the configuration (unless of course the individual resources were specifically enabled by having their **is-managed** set to **true**).

### 5.4.3. Resource Instance Attributes

The resource agents of some resource classes (lsb, systemd and upstart *not* among them) can be given parameters which determine how they behave and which instance of a service they control.

If your resource agent supports parameters, you can add them with the **crm\_resource** command. For example,

```
# crm_resource --resource Public-IP --set-parameter ip --parameter-value 192.0.2.2
```

would create an entry in the resource like this:

#### Example 5.4. An example OCF resource with instance attributes

```
<primitive id="Public-IP" class="ocf" type="IPAddr" provider="heartbeat">
  <instance_attributes id="params-public-ip">
    <nvpair id="public-ip-addr" name="ip" value="192.0.2.2"/>
  </instance_attributes>
</primitive>
```

For an OCF resource, the result would be an environment variable called **OCF\_RESKEY\_ip** with a value of **192.0.2.2**.

The list of instance attributes supported by an OCF resource agent can be found by calling the resource agent with the **meta-data** command. The output contains an XML description of all the supported attributes, their purpose and default values.

#### Example 5.5. Displaying the metadata for the Dummy resource agent template

```
# export OCF_ROOT=/usr/lib/ocf
# $OCF_ROOT/resource.d/pacemaker/Dummy meta-data
```

```
<?xml version="1.0"?>
<!DOCTYPE resource-agent SYSTEM "ra-api-1.dtd">
<resource-agent name="Dummy" version="1.0">
  <version>1.0</version>

  <longdesc>
    This is a Dummy Resource Agent. It does absolutely nothing except
    keep track of whether its running or not.
    Its purpose in life is for testing and to serve as a template for RA writers.

    NB: Please pay attention to the timeouts specified in the actions
    section below. They should be meaningful for the kind of resource
    the agent manages. They should be the minimum advised timeouts,
    but they shouldn't/cannot cover all possible resource
    instances. So, try to be neither overly generous nor too stingy,
    but moderate. The minimum timeouts should never be below 10 seconds.
  </longdesc>
  <shortdesc>Example stateless resource agent</shortdesc>

  <parameters>
    <parameter name="state" unique="1">
      <longdesc>
        Location to store the resource state in.
      </longdesc>
      <shortdesc>State file</shortdesc>
      <content type="string" default="/var/run/Dummy-default.state" />
    </parameter>

    <parameter name="fake" unique="0">
      <longdesc>
        Fake attribute that can be changed to cause a reload
      </longdesc>
      <shortdesc>Fake attribute that can be changed to cause a reload</shortdesc>
      <content type="string" default="dummy" />
    </parameter>

    <parameter name="op_sleep" unique="1">
      <longdesc>
        Number of seconds to sleep during operations. This can be used to test how
        the cluster reacts to operation timeouts.
      </longdesc>
      <shortdesc>Operation sleep duration in seconds.</shortdesc>
      <content type="string" default="0" />
    </parameter>
  </parameters>

  <actions>
    <action name="start" timeout="20" />
    <action name="stop" timeout="20" />
    <action name="monitor" timeout="20" interval="10" depth="0"/>
    <action name="reload" timeout="20" />
```

```
<action name="migrate_to" timeout="20" />
<action name="migrate_from" timeout="20" />
<action name="validate-all" timeout="20" />
<action name="meta-data" timeout="5" />
</actions>
</resource-agent>
```

## 5.5. Resource Operations

*Operations* are actions the cluster can perform on a resource by calling the resource agent. Resource agents must support certain common operations such as start, stop and monitor, and may implement any others.

Some operations are generated by the cluster itself, for example, stopping and starting resources as needed.

You can configure operations in the cluster configuration. As an example, by default the cluster will *not* ensure your resources stay healthy once they are started.<sup>11</sup> To instruct the cluster to do this, you need to add a **monitor** operation to the resource's definition.

Example 5.6. An OCF resource with a recurring health check

```
<primitive id="Public-IP" class="ocf" type="IPAddr" provider="heartbeat">
  <operations>
    <op id="public-ip-check" name="monitor" interval="60s"/>
  </operations>
  <instance_attributes id="params-public-ip">
    <nvpair id="public-ip-addr" name="ip" value="192.0.2.2"/>
  </instance_attributes>
</primitive>
```

Table 5.3. Properties of an Operation

Field	Default	Description
<b>id</b>		A unique name for the operation.
<b>name</b>		The action to perform. This can be any action supported by the agent; common values include <b>monitor</b> , <b>start</b> , and <b>stop</b> .
<b>interval</b>	0	How frequently (in seconds) to perform the operation. A value of 0 means never. A positive value defines a <i>recurring action</i> , which is typically used with <i>monitor</i> .
<b>timeout</b>		How long to wait before declaring the action has failed
<b>on-fail</b>	restart (except for stop operations, which default to fence when STONITH is enabled and block otherwise)	The action to take if this action ever fails. Allowed values: <ul style="list-style-type: none"> <li><b>ignore</b>: Pretend the resource did not fail.</li> </ul>

<sup>11</sup> Currently, anyway. Automatic monitoring operations may be added in a future version of Pacemaker.

Field	Default	Description
		<ul style="list-style-type: none"> <li>• <b>block</b>: Don't perform any further operations on the resource.</li> <li>• <b>stop</b>: Stop the resource and do not start it elsewhere.</li> <li>• <b>restart</b>: Stop the resource and start it again (possibly on a different node).</li> <li>• <b>fence</b>: STONITH the node on which the resource failed.</li> <li>• <b>standby</b>: Move <i>all</i> resources away from the node on which the resource failed.</li> </ul>
<b>enabled</b>	TRUE	If <b>false</b> , ignore this operation definition. This is typically used to pause a particular recurring monitor operation; for instance, it can complement the respective resource being unmanaged ( <b>is-managed=false</b> ), as this alone will <i>not block any configured monitoring</i> . Disabling the operation does not suppress all actions of the given type. Allowed values: <b>true</b> , <b>false</b> .
<b>record-pending</b>	FALSE	If <b>true</b> , the intention to perform the operation is recorded so that GUIs and CLI tools can indicate that an operation is in progress. This is best set as an <i>operation default</i> (see next section). Allowed values: <b>true</b> , <b>false</b> .
<b>role</b>		Run the operation only on node(s) that the cluster thinks should be in the specified role. This only makes sense for recurring monitor operations. Allowed (case-sensitive) values: <b>Stopped</b> , <b>Started</b> , and in the case of <i>multi-state</i> resources, <b>Slave</b> and <b>Master</b> .

### 5.5.1. Monitoring Resources for Failure

When Pacemaker first starts a resource, it runs one-time monitor operations (referred to as *probes*) to ensure the resource is running where it's supposed to be, and not running where it's not supposed to be. (This behavior can be affected by the **resource-discovery** location constraint property.)

Other than those initial probes, Pacemaker will not (by default) check that the resource continues to stay healthy. As in the example above, you must configure monitor operations explicitly to perform these checks.

By default, a monitor operation will ensure that the resource is running where it is supposed to. The **target-role** property can be used for further checking.

For example, if a resource has one monitor operation with **interval=10** **role=Started** and a second monitor operation with **interval=11** **role=Stopped**, the cluster will run the first monitor on any nodes it thinks *should* be running the resource, and the second monitor on any nodes that it thinks

*should not* be running the resource (for the truly paranoid, who want to know when an administrator manually starts a service by mistake).

### 5.5.2. Monitoring Resources When Administration is Disabled

Recurring monitor operations behave differently under various administrative settings:

- When a resource is unmanaged (by setting **is-managed=false**): No monitors will be stopped.

If the unmanaged resource is stopped on a node where the cluster thinks it should be running, the cluster will detect and report that it is not, but it will not consider the monitor failed, and will not try to start the resource until it is managed again.

Starting the unmanaged resource on a different node is strongly discouraged and will at least cause the cluster to consider the resource failed, and may require the resource's **target-role** to be set to **Stopped** then **Started** to be recovered.

- When a node is put into standby: All resources will be moved away from the node, and all monitor operations will be stopped on the node, except those with **role=Stopped**. Monitor operations with **role=Stopped** will be started on the node if appropriate.
- When the cluster is put into maintenance mode: All resources will be marked as unmanaged. All monitor operations will be stopped, except those with **role=Stopped**. As with single unmanaged resources, starting a resource on a node other than where the cluster expects it to be will cause problems.

### 5.5.3. Setting Global Defaults for Operations

You can change the global default values for operation properties in a given cluster. These are defined in an **op\_defaults** section of the CIB's **configuration** section, and can be set with **crm\_attribute**. For example,

```
# crm_attribute --type op_defaults --name timeout --update 20s
```

would default each operation's **timeout** to 20 seconds. If an operation's definition also includes a value for **timeout**, then that value would be used for that operation instead.

### 5.5.4. When Implicit Operations Take a Long Time

The cluster will always perform a number of implicit operations: **start**, **stop** and a non-recurring **monitor** operation used at startup to check whether the resource is already active. If one of these is taking too long, then you can create an entry for them and specify a longer timeout.

Example 5.7. An OCF resource with custom timeouts for its implicit actions

```
<primitive id="Public-IP" class="ocf" type="IPaddr" provider="heartbeat">
  <operations>
    <op id="public-ip-startup" name="monitor" interval="0" timeout="90s"/>
    <op id="public-ip-start" name="start" interval="0" timeout="180s"/>
    <op id="public-ip-stop" name="stop" interval="0" timeout="15min"/>
  </operations>
  <instance_attributes id="params-public-ip">
    <nvpair id="public-ip-addr" name="ip" value="192.0.2.2"/>
  </instance_attributes>
</primitive>
```

### 5.5.5. Multiple Monitor Operations

Provided no two operations (for a single resource) have the same name and interval, you can have as many monitor operations as you like. In this way, you can do a superficial health check every minute and progressively more intense ones at higher intervals.

To tell the resource agent what kind of check to perform, you need to provide each monitor with a different value for a common parameter. The OCF standard creates a special parameter called **OCF\_CHECK\_LEVEL** for this purpose and dictates that it is "made available to the resource agent without the normal **OCF\_RESKEY** prefix".

Whatever name you choose, you can specify it by adding an **instance\_attributes** block to the **op** tag. It is up to each resource agent to look for the parameter and decide how to use it.

Example 5.8. An OCF resource with two recurring health checks, performing different levels of checks specified via **OCF\_CHECK\_LEVEL**.

```
<primitive id="Public-IP" class="ocf" type="IPAddr" provider="heartbeat">
  <operations>
    <op id="public-ip-health-60" name="monitor" interval="60">
      <instance_attributes id="params-public-ip-depth-60">
        <nvpair id="public-ip-depth-60" name="OCF_CHECK_LEVEL" value="10"/>
      </instance_attributes>
    </op>
    <op id="public-ip-health-300" name="monitor" interval="300">
      <instance_attributes id="params-public-ip-depth-300">
        <nvpair id="public-ip-depth-300" name="OCF_CHECK_LEVEL" value="20"/>
      </instance_attributes>
    </op>
  </operations>
  <instance_attributes id="params-public-ip">
    <nvpair id="public-ip-level" name="ip" value="192.0.2.2"/>
  </instance_attributes>
</primitive>
```

### 5.5.6. Disabling a Monitor Operation

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

Example 5.9. Example of an OCF resource with a disabled health check

```
<primitive id="Public-IP" class="ocf" type="IPAddr" provider="heartbeat">
  <operations>
    <op id="public-ip-check" name="monitor" interval="60s" enabled="false"/>
  </operations>
  <instance_attributes id="params-public-ip">
    <nvpair id="public-ip-addr" name="ip" value="192.0.2.2"/>
  </instance_attributes>
</primitive>
```

This can be achieved from the command line by executing:

```
# cibadmin --modify --xml-text '<op id="public-ip-check" enabled="false"/>'
```

Once you've done whatever you needed to do, you can then re-enable it with

```
# cibadmin --modify --xml-text '<op id="public-ip-check" enabled="true"/>'
```

# Resource Constraints

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## 6.1. Scores

Scores of all kinds are integral to how the cluster works. Practically everything from moving a resource to deciding which resource to stop in a degraded cluster is achieved by manipulating scores in some way.

Scores are calculated per resource and node. Any node with a negative score for a resource can't run that resource. The cluster places a resource on the node with the highest score for it.

### 6.1.1. Infinity Math

Pacemaker implements **INFINITY** (or equivalently, **+INFINITY**) internally as a score of 1,000,000. Addition and subtraction with it follow these three basic rules:

- Any value + **INFINITY** = **INFINITY**
- Any value - **INFINITY** = **-INFINITY**
- **INFINITY** - **INFINITY** = **-INFINITY**

**Note**

What if you want to use a score higher than 1,000,000? Typically this possibility arises when someone wants to base the score on some external metric that might go above 1,000,000.

The short answer is you can't.

The long answer is it is sometimes possible work around this limitation creatively. You may be able to set the score to some computed value based on the external metric rather than use the metric directly. For nodes, you can store the metric as a node attribute, and query the attribute when computing the score (possibly as part of a custom resource agent).

## 6.2. Deciding Which Nodes a Resource Can Run On

*Location constraints* tell the cluster which nodes a resource can run on.

There are two alternative strategies. One way is to say that, by default, resources can run anywhere, and then the location constraints specify nodes that are not allowed (an *opt-out* cluster). The other way is to start with nothing able to run anywhere, and use location constraints to selectively enable allowed nodes (an *opt-in* cluster).

Whether you should choose opt-in or opt-out depends 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.

### 6.2.1. Location Properties

Table 6.1. Properties of a `rsc_location` Constraint

Field	Default	Description
<b>id</b>		A unique name for the constraint
<b>rsc</b>		The name of the resource to which this constraint applies
<b>rsc-pattern</b>		A regular expression matching the names of resources to which this constraint applies, if <b>rsc</b> is not specified; if the regular expression contains submatches and the constraint is governed by a rule (see <a href="#">Chapter 8, Rules</a> ), the submatches can be referenced as <b>%0</b> through <b>%9</b> in the rule's <b>score-attribute</b> or a rule expression's <b>attribute</b> (since 1.1.16)
<b>node</b>		A node's name
<b>score</b>		Positive values indicate a preference for running the affected resource(s) on this node — the higher the value, the stronger the preference. Negative values indicate the resource(s) should avoid this node (a value of <b>-INFINITY</b> changes "should" to "must").
<b>resource-discovery</b>	always	Whether Pacemaker should perform resource discovery (that is, check whether the resource is already running) for this resource on this node. This should normally be left as the default, so that rogue instances of a service

Field	Default	Description
		<p>can be stopped when they are running where they are not supposed to be. However, there are two situations where disabling resource discovery is a good idea: when a service is not installed on a node, discovery might return an error (properly written OCF agents will not, so this is usually only seen with other agent types); and when Pacemaker Remote is used to scale a cluster to hundreds of nodes, limiting resource discovery to allowed nodes can significantly boost performance. (<i>since 1.1.13</i>)</p> <ul style="list-style-type: none"> <li>• <b>always</b>: Always perform resource discovery for the specified resource on this node.</li> <li>• <b>never</b>: Never perform resource discovery for the specified resource on this node. This option should generally be used with a <code>-INFINITY</code> score, although that is not strictly required.</li> <li>• <b>exclusive</b>: Perform resource discovery for the specified resource only on this node (and other nodes similarly marked as <b>exclusive</b>). Multiple location constraints using <b>exclusive</b> discovery for the same resource across different nodes creates a subset of nodes resource-discovery is exclusive to. If a resource is marked for <b>exclusive</b> discovery on one or more nodes, that resource is only allowed to be placed within that subset of nodes.</li> </ul>



### Warning

Setting resource-discovery to **never** or **exclusive** removes Pacemaker's ability to detect and stop unwanted instances of a service running where it's not supposed to be. It is up to the system administrator (you!) to make sure that the service can *never* be active on nodes without resource-discovery (such as by leaving the relevant software uninstalled).

## 6.2.2. Asymmetrical "Opt-In" Clusters

To create an opt-in cluster, start by preventing resources from running anywhere by default:

```
# crm_attribute --name symmetric-cluster --update false
```

Then start enabling nodes. The following fragment says that the web server prefers **sles-1**, the database prefers **sles-2** and both can fail over to **sles-3** if their most preferred node fails.

### Example 6.1. Opt-in location constraints for two resources

```
<constraints>
```

```
<rsc_location id="loc-1" rsc="Webserver" node="sles-1" score="200"/>
<rsc_location id="loc-2" rsc="Webserver" node="sles-3" score="0"/>
<rsc_location id="loc-3" rsc="Database" node="sles-2" score="200"/>
<rsc_location id="loc-4" rsc="Database" node="sles-3" score="0"/>
</constraints>
```

### 6.2.3. Symmetrical "Opt-Out" Clusters

To create an opt-out cluster, start by allowing resources to run anywhere by default:

```
# crm_attribute --name symmetric-cluster --update true
```

Then start disabling nodes. The following fragment is the equivalent of the above opt-in configuration.

#### Example 6.2. Opt-out location constraints for two resources

```
<constraints>
  <rsc_location id="loc-1" rsc="Webserver" node="sles-1" score="200"/>
  <rsc_location id="loc-2-dont-run" rsc="Webserver" node="sles-2" score="-INFINITY"/>
  <rsc_location id="loc-3-dont-run" rsc="Database" node="sles-1" score="-INFINITY"/>
  <rsc_location id="loc-4" rsc="Database" node="sles-2" score="200"/>
</constraints>
```

### 6.2.4. What if Two Nodes Have the Same Score

If two nodes have the same score, then the cluster will choose one. This choice may seem random and may not be what was intended, however the cluster was not given enough information to know any better.

#### Example 6.3. Constraints where a resource prefers two nodes equally

```
<constraints>
  <rsc_location id="loc-1" rsc="Webserver" node="sles-1" score="INFINITY"/>
  <rsc_location id="loc-2" rsc="Webserver" node="sles-2" score="INFINITY"/>
  <rsc_location id="loc-3" rsc="Database" node="sles-1" score="500"/>
  <rsc_location id="loc-4" rsc="Database" node="sles-2" score="300"/>
  <rsc_location id="loc-5" rsc="Database" node="sles-2" score="200"/>
</constraints>
```

In the example above, assuming no other constraints and an inactive cluster, **Webserver** would probably be placed on **sles-1** and **Database** on **sles-2**. It would likely have placed **Webserver** based on the node's uname and **Database** based on the desire to spread the resource load evenly across the cluster. However other factors can also be involved in more complex configurations.

## 6.3. Specifying the Order in which Resources Should Start/Stop

*Ordering constraints* tell the cluster the order in which resources should start.



### Important

Ordering constraints affect *only* the ordering of resources; they do *not* require that the resources be placed on the same node. If you want resources to be started on the same node *and* in a specific order, you need both an ordering constraint *and* a colocation constraint (see [Section 6.4, “Placing Resources Relative to other Resources”](#)), or alternatively, a group (see [Section 10.1, “Groups - A Syntactic Shortcut”](#)).

## 6.3.1. Ordering Properties

Table 6.2. Properties of a `rsc_order` Constraint

Field	Default	Description
<b>id</b>		A unique name for the constraint
<b>first</b>		Name of the resource that the <b>then</b> resource depends on
<b>then</b>		Name of the dependent resource
<b>first-action</b>	start	The action that the <b>first</b> resource must complete before <b>then-action</b> can be initiated for the <b>then</b> resource. Allowed values: <b>start</b> , <b>stop</b> , <b>promote</b> , <b>demote</b> .
<b>then-action</b>	value of <b>first-action</b>	The action that the <b>then</b> resource can execute only after the <b>first-action</b> on the <b>first</b> resource has completed. Allowed values: <b>start</b> , <b>stop</b> , <b>promote</b> , <b>demote</b> .
<b>kind</b>		How to enforce the constraint. Allowed values: <ul style="list-style-type: none"> <li>• <b>Optional</b>: Just a suggestion. Only applies if both resources are executing the specified actions. Any change in state by the <b>first</b> resource will have no effect on the <b>then</b> resource.</li> <li>• <b>Mandatory</b>: Always. If <b>first</b> does not perform <b>first-action</b>, <b>then</b> will not be allowed to performed <b>then-action</b>. If <b>first</b> is restarted, <b>then</b> (if running) will be stopped beforehand and started afterward.</li> <li>• <b>Serialize</b>: Ensure that no two stop/start actions occur concurrently for the resources. <b>First</b> and <b>then</b> can start in either order, but one must complete starting before the other can be started. A typical use case is when resource start-up puts a high load on the host.</li> </ul>
<b>symmetrical</b>	TRUE	If true, the reverse of the constraint applies for the opposite action (for example, if B starts after A starts, then B stops before A stops).

**Promote** and **demote** apply to the master role of *multi-state* resources.

## 6.3.2. Optional and mandatory ordering

Here is an example of ordering constraints where **Database** *must* start before **Webserver**, and **IP** *should* start before **Webserver** if they both need to be started:

## Example 6.4. Optional and mandatory ordering constraints

```
<constraints>
<rsc_order id="order-1" first="IP" then="Webserver" kind="Optional"/>
<rsc_order id="order-2" first="Database" then="Webserver" kind="Mandatory" />
</constraints>
```

Because the above example lets **symmetrical** default to TRUE, **Webserver** must be stopped before **Database** can be stopped, and **Webserver** should be stopped before **IP** if they both need to be stopped.

## 6.4. Placing Resources Relative to other Resources

*Colocation constraints* tell the cluster that the location of one resource depends on the location of another one.

Colocation has an important side-effect: it affects the order in which resources are assigned to a node. Think about it: You can't place A relative to B unless you know where B is.<sup>1</sup>

So when you are creating colocation constraints, it is important to consider whether you should colocate A with B, or B with A.

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

For a detailed look at exactly how this occurs, see [Colocation Explained](#)<sup>2</sup>.



### Important

Colocation constraints affect *only* the placement of resources; they do *not* require that the resources be started in a particular order. If you want resources to be started on the same node *and* in a specific order, you need both an ordering constraint (see [Section 6.3, "Specifying the Order in which Resources Should Start/Stop"](#)) *and* a colocation constraint, or alternatively, a group (see [Section 10.1, "Groups - A Syntactic Shortcut"](#)).

### 6.4.1. Colocation Properties

Table 6.3. Properties of a `rsc_colocation` Constraint

Field	Default	Description
<b>id</b>		A unique name for the constraint (required).
<b>rsc</b>		The name of a resource that should be located relative to <b>with-rsc</b> (required).

<sup>1</sup> While the human brain is sophisticated enough to read the constraint in any order and choose the correct one depending on the situation, the cluster is not quite so smart. Yet.

<sup>2</sup> [http://clusterlabs.org/doc/Colocation\\_Explained.pdf](http://clusterlabs.org/doc/Colocation_Explained.pdf)

Field	Default	Description
<b>with-rsc</b>		The name of the resource used as the colocation target. The cluster will decide where to put this resource first and then decide where to put <b>rsc</b> (required).
<b>node-attribute</b>	#uname	The node attribute that must be the same on the node running <b>rsc</b> and the node running <b>with-rsc</b> for the constraint to be satisfied. (For details, see <a href="#">Section 6.4.4, "Colocation by Node Attribute"</a> .)
<b>score</b>		Positive values indicate the resources should run on the same node. Negative values indicate the resources should run on different nodes. Values of +/- <b>INFINITY</b> change "should" to "must".

## 6.4.2. Mandatory Placement

Mandatory placement occurs when the constraint's score is **+INFINITY** or **-INFINITY**. In such cases, if the constraint can't be satisfied, then the **rsc** resource is not permitted to run. For **score=INFINITY**, this includes cases where the **with-rsc** resource is not active.

If you need resource **A** to always run on the same machine as resource **B**, you would add the following constraint:

Example 6.5. Mandatory colocation constraint for two resources

```
<rsc_colocation id="colocate" rsc="A" with-rsc="B" score="INFINITY"/>
```

Remember, because **INFINITY** was used, if **B** can't run on any of the cluster nodes (for whatever reason) then **A** will not be allowed to run. Whether **A** is running or not has no effect on **B**.

Alternatively, you may want the opposite — that **A cannot** run on the same machine as **B**. In this case, use **score="-INFINITY"**.

Example 6.6. Mandatory anti-colocation constraint for two resources

```
<rsc_colocation id="anti-colocate" rsc="A" with-rsc="B" score="-INFINITY"/>
```

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

As with **INFINITY**, **B** can run even if **A** is stopped. However, in this case **A** also can run if **B** is stopped, because it still meets the constraint of **A** and **B** not running on the same node.

## 6.4.3. 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.

As in life, where if enough people prefer something it effectively becomes mandatory, advisory colocation constraints can combine with other elements of the configuration to behave as if they were mandatory.

Example 6.7. Advisory colocation constraint for two resources

```
<rsc_colocation id="colocate-maybe" rsc="A" with-rsc="B" score="500"/>
```

### 6.4.4. Colocation by Node Attribute

The **node+attribute** property of a colocation constraint allows you to express the requirement, "these resources must be on similar nodes".

As an example, imagine that you have two Storage Area Networks (SANs) that are not controlled by the cluster, and each node is connected to one or the other. You may have two resources **r1** and **r2** such that **r2** needs to use the same SAN as **r1**, but doesn't necessarily have to be on the same exact node. In such a case, you could define a *node attribute* named **san**, with the value **san1** or **san2** on each node as appropriate. Then, you could colocate **r2** with **r1** using **node-attribute** set to **san**.

## 6.5. Resource Sets

Resource sets allow multiple resources to be affected by a single constraint.

Example 6.8. A set of 3 resources

```
<resource_set id="resource-set-example">
  <resource_ref id="A"/>
  <resource_ref id="B"/>
  <resource_ref id="C"/>
</resource_set>
```

Resource sets are valid inside **rsc\_location**, **rsc\_order** (see [Section 6.6, "Ordering Sets of Resources"](#)), **rsc\_colocation** (see [Section 6.7, "Colocating Sets of Resources"](#)), and **rsc\_ticket** (see [Section 15.3, "Configuring Ticket Dependencies"](#)) constraints.

A resource set has a number of properties that can be set, though not all have an effect in all contexts.

Table 6.4. Properties of a resource\_set

Field	Default	Description
<b>id</b>		A unique name for the set
<b>sequential</b>	true	Whether the members of the set must be acted on in order. Meaningful within <b>rsc_order</b> and <b>rsc_colocation</b> .
<b>require-all</b>	true	Whether all members of the set must be active before continuing. With the current implementation, the cluster may continue even if only one member of the set is started, but if more than one member of the set is starting at the same time, the cluster will still wait until all of those have started before continuing (this may change in future versions). Meaningful within <b>rsc_order</b> . ( <i>since 1.1.7</i> )
<b>role</b>		Limit the effect of the constraint to the specified role. Meaningful within <b>rsc_location</b> , <b>rsc_colocation</b> and <b>rsc_ticket</b> .
<b>action</b>		Limit the effect of the constraint to the specified action. Meaningful within <b>rsc_order</b> .

Field	Default	Description
<b>score</b>		<i>Advanced use only.</i> Use a specific score for this set within the constraint.

## 6.6. Ordering Sets of Resources

A common situation is for an administrator to create a chain of ordered resources, such as:

Example 6.9. A chain of ordered resources

```
<constraints>
  <rsc_order id="order-1" first="A" then="B" />
  <rsc_order id="order-2" first="B" then="C" />
  <rsc_order id="order-3" first="C" then="D" />
</constraints>
```



Figure 6.1. Visual representation of the four resources' start order for the above constraints

### 6.6.1. Ordered Set

To simplify this situation, resource sets (see [Section 6.5, "Resource Sets"](#)) can be used within ordering constraints:

Example 6.10. A chain of ordered resources expressed as a set

```
<constraints>
  <rsc_order id="order-1">
    <resource_set id="ordered-set-example" sequential="true">
      <resource_ref id="A"/>
      <resource_ref id="B"/>
      <resource_ref id="C"/>
      <resource_ref id="D"/>
    </resource_set>
  </rsc_order>
</constraints>
```

While the set-based format is not less verbose, it is significantly easier to get right and maintain.



#### Important

If you use a higher-level tool, pay attention to how it exposes this functionality. Depending on the tool, creating a set **A B** may be equivalent to **A then B**, or **B then A**.

## 6.6.2. Ordering Multiple Sets

The syntax can be expanded to allow sets of resources to be ordered relative to each other, where the members of each individual set may be ordered or unordered (controlled by the **sequential** property). In the example below, **A** and **B** can both start in parallel, as can **C** and **D**, however **C** and **D** can only start once *both A and B* are active.

Example 6.11. Ordered sets of unordered resources

```
<constraints>
  <rsc_order id="order-1">
    <resource_set id="ordered-set-1" sequential="false">
      <resource_ref id="A"/>
      <resource_ref id="B"/>
    </resource_set>
    <resource_set id="ordered-set-2" sequential="false">
      <resource_ref id="C"/>
      <resource_ref id="D"/>
    </resource_set>
  </rsc_order>
</constraints>
```

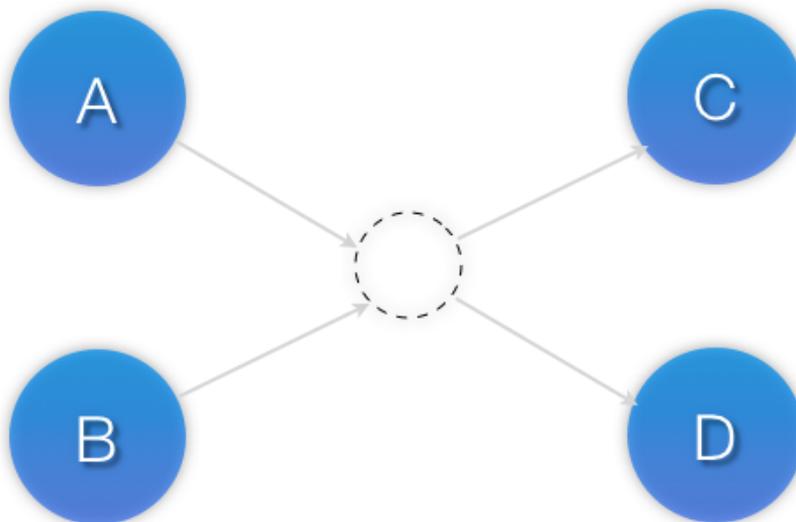


Figure 6.2. Visual representation of the start order for two ordered sets of unordered resources

Of course either set — or both sets — of resources can also be internally ordered (by setting **sequential="true"**) and there is no limit to the number of sets that can be specified.

Example 6.12. Advanced use of set ordering - Three ordered sets, two of which are internally unordered

```
<constraints>
  <rsc_order id="order-1">
    <resource_set id="ordered-set-1" sequential="false">
      <resource_ref id="A"/>
      <resource_ref id="B"/>
    </resource_set>
    <resource_set id="ordered-set-2" sequential="true">
      <resource_ref id="C"/>
      <resource_ref id="D"/>
    </resource_set>
  </rsc_order>
</constraints>
```

```

<resource_set id="ordered-set-3" sequential="false">
  <resource_ref id="E"/>
  <resource_ref id="F"/>
</resource_set>
</rsc_order>
</constraints>

```

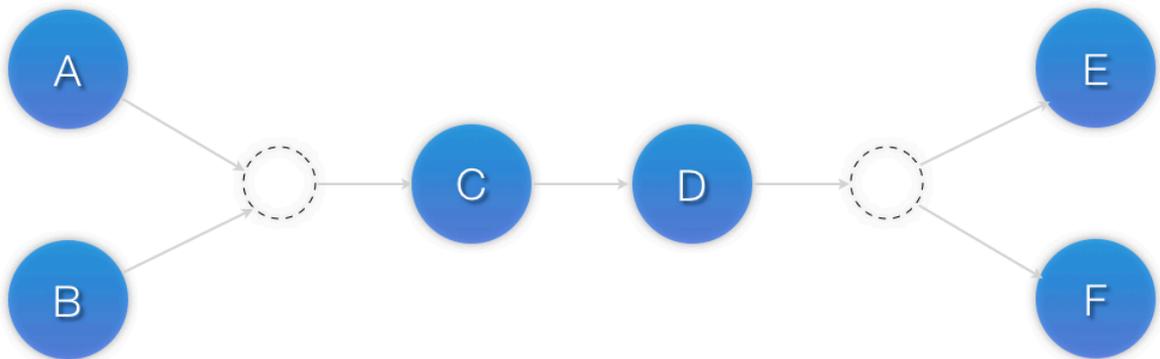


Figure 6.3. Visual representation of the start order for the three sets defined above



### Important

An ordered set with **sequential=false** makes sense only if there is another set in the constraint. Otherwise, the constraint has no effect.

### 6.6.3. Resource Set OR Logic

The unordered set logic discussed so far has all been "AND" logic. To illustrate this take the 3 resource set figure in the previous section. Those sets can be expressed, **(A and B) then (C) then (D) then (E and F)**.

Say for example we want to change the first set, **(A and B)**, to use "OR" logic so the sets look like this: **(A or B) then (C) then (D) then (E and F)**. This functionality can be achieved through the use of the **require-all** option. This option defaults to TRUE which is why the "AND" logic is used by default. Setting **require-all=false** means only one resource in the set needs to be started before continuing on to the next set.

Example 6.13. Resource Set "OR" logic: Three ordered sets, where the first set is internally unordered with "OR" logic

```

<constraints>
  <rsc_order id="order-1">
    <resource_set id="ordered-set-1" sequential="false" require-all="false">
      <resource_ref id="A"/>
      <resource_ref id="B"/>
    </resource_set>
    <resource_set id="ordered-set-2" sequential="true">
      <resource_ref id="C"/>
      <resource_ref id="D"/>
    </resource_set>
    <resource_set id="ordered-set-3" sequential="false">
      <resource_ref id="E"/>
      <resource_ref id="F"/>
    </resource_set>
  </rsc_order>
</constraints>

```

```
</rsc_order>
</constraints>
```



### Important

An ordered set with **require-all=false** makes sense only in conjunction with **sequential=false**. Think of it like this: **sequential=false** modifies the set to be an unordered set using "AND" logic by default, and adding **require-all=false** flips the unordered set's "AND" logic to "OR" logic.

## 6.7. Colocating Sets of Resources

Another common situation is for an administrator to create a set of colocated resources.

One way to do this would be to define a resource group (see [Section 10.1, "Groups - A Syntactic Shortcut"](#)), but that cannot always accurately express the desired state.

Another way would be to define each relationship as an individual constraint, but that causes a constraint explosion as the number of resources and combinations grow. An example of this approach:

### Example 6.14. Chain of colocated resources

```
<constraints>
  <rsc_colocation id="coloc-1" rsc="D" with-rsc="C" score="INFINITY"/>
  <rsc_colocation id="coloc-2" rsc="C" with-rsc="B" score="INFINITY"/>
  <rsc_colocation id="coloc-3" rsc="B" with-rsc="A" score="INFINITY"/>
</constraints>
```

To make things easier, resource sets (see [Section 6.5, "Resource Sets"](#)) can be used within colocation constraints. As with the chained version, a resource that can't be active prevents any resource that must be colocated with it from being active. For example, if **B** is not able to run, then both **C** and by inference **D** must also remain stopped. Here is an example **resource\_set**:

### Example 6.15. Equivalent colocation chain expressed using **resource\_set**

```
<constraints>
  <rsc_colocation id="coloc-1" score="INFINITY" >
    <resource_set id="colocated-set-example" sequential="true">
      <resource_ref id="A"/>
      <resource_ref id="B"/>
      <resource_ref id="C"/>
      <resource_ref id="D"/>
    </resource_set>
  </rsc_colocation>
</constraints>
```

**Important**

If you use a higher-level tool, pay attention to how it exposes this functionality. Depending on the tool, creating a set **A B** may be equivalent to **A with B**, or **B with A**.

This notation can also be used to tell the cluster that sets of resources must be colocated relative to each other, where the individual members of each set may or may not depend on each other being active (controlled by the **sequential** property).

In this example, **A**, **B**, and **C** will each be colocated with **D**. **D** must be active, but any of **A**, **B**, or **C** may be inactive without affecting any other resources.

**Example 6.16. Using colocated sets to specify a common peer**

```
<constraints>
  <rsc_colocation id="coloc-1" score="INFINITY" >
    <resource_set id="colocated-set-1" sequential="false">
      <resource_ref id="A"/>
      <resource_ref id="B"/>
      <resource_ref id="C"/>
    </resource_set>
    <resource_set id="colocated-set-2" sequential="true">
      <resource_ref id="D"/>
    </resource_set>
  </rsc_colocation>
</constraints>
```

**Important**

A colocated set with **sequential=false** makes sense only if there is another set in the constraint. Otherwise, the constraint has no effect.

There is no inherent limit to the number and size of the sets used. The only thing that matters is that in order for any member of one set in the constraint to be active, all members of sets listed after it must also be active (and naturally on the same node); and if a set has **sequential="true"**, then in order for one member of that set to be active, all members listed before it must also be active.

If desired, you can restrict the dependency to instances of multistate resources that are in a specific role, using the set's **role** property.

**Example 6.17. Colocation chain in which the members of the middle set have no interdependencies, and the last listed set (which the cluster places first) is restricted to instances in master status.**

```
<constraints>
  <rsc_colocation id="coloc-1" score="INFINITY" >
    <resource_set id="colocated-set-1" sequential="true">
      <resource_ref id="B"/>
      <resource_ref id="A"/>
    </resource_set>
```

```

<resource_set id="colocated-set-2" sequential="false">
  <resource_ref id="C"/>
  <resource_ref id="D"/>
  <resource_ref id="E"/>
</resource_set>
<resource_set id="colocated-set-3" sequential="true" role="Master">
  <resource_ref id="G"/>
  <resource_ref id="F"/>
</resource_set>
</rsc_colocation>
</constraints>

```

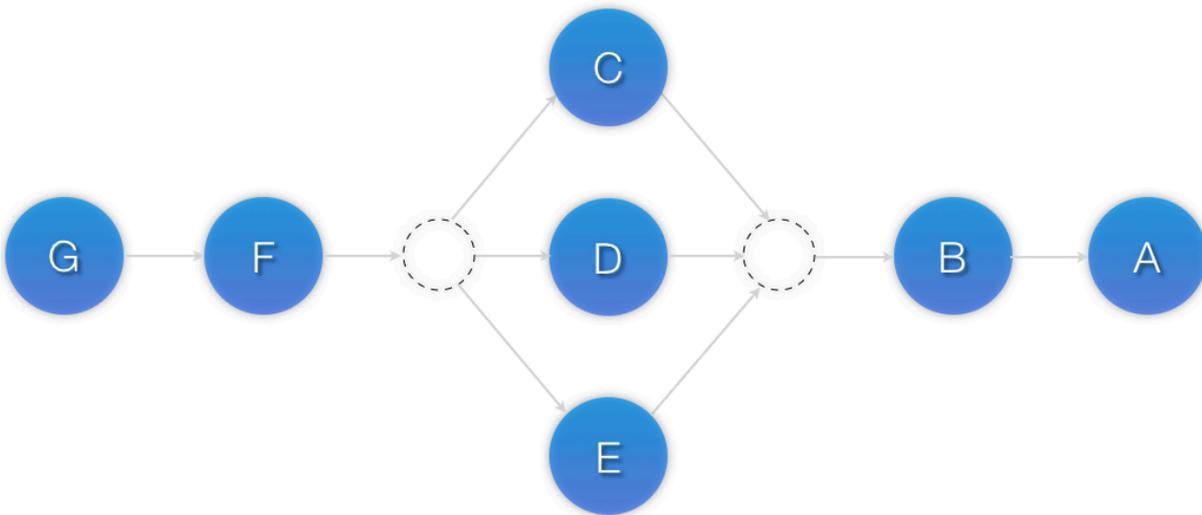


Figure 6.4. Visual representation the above example (resources to the left are placed first)



**Note**

Pay close attention to the order in which resources and sets are listed. While the colocation dependency for members of any one set is last-to-first, the colocation dependency for multiple sets is first-to-last. In the above example, **B** is colocated with **A**, but **colocated-set-1** is colocated with **colocated-set-2**.

Unlike ordered sets, colocated sets do not use the **require-all** option.

# Alerts

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*Alerts* (available since Pacemaker 1.1.15) may be configured to take some external action when a cluster event occurs (node failure, resource starting or stopping, etc.).

### 7.1. Alert Agents

As with resource agents, the cluster calls an external program (an *alert agent*) to handle alerts. The cluster passes information about the event to the agent via environment variables. Agents can do anything desired with this information (send an e-mail, log to a file, update a monitoring system, etc.).

#### Example 7.1. Simple alert configuration

```
<configuration>
  <alerts>
    <alert id="my-alert" path="/path/to/my-script.sh" />
  </alerts>
</configuration>
```

In the example above, the cluster will call **my-script.sh** for each event.

Multiple alert agents may be configured; the cluster will call all of them for each event.

Alert agents will be called only on cluster nodes. They will be called for events involving Pacemaker Remote nodes, but they will never be called *on* those nodes.

### 7.2. Alert Recipients

Usually alerts are directed towards a recipient. Thus each alert may be additionally configured with one or more recipients. The cluster will call the agent separately for each recipient.

#### Example 7.2. Alert configuration with recipient

```
<configuration>
  <alerts>
    <alert id="my-alert" path="/path/to/my-script.sh">
      <recipient id="my-alert-recipient" value="some-address"/>
    </alert>
  </alerts>
</configuration>
```

In the above example, the cluster will call `my-script.sh` for each event, passing the recipient `some-address` as an environment variable.

The recipient may be anything the alert agent can recognize — an IP address, an e-mail address, a file name, whatever the particular agent supports.

## 7.3. Alert Meta-Attributes

As with resource agents, meta-attributes can be configured for alert agents to affect how Pacemaker calls them.

Table 7.1. Meta-Attributes of an Alert

Meta-Attribute	Default	Description
<code>timestamp-format</code>	<code>%H:%M:%S.%06N</code>	Format the cluster will use when sending the event's timestamp to the agent. This is a string as used with the <code>date(1)</code> command.
<code>timeout</code>	30s	If the alert agent does not complete within this amount of time, it will be terminated.

Meta-attributes can be configured per alert agent and/or per recipient.

### Example 7.3. Alert configuration with meta-attributes

```
<configuration>
  <alerts>
    <alert id="my-alert" path="/path/to/my-script.sh">
      <meta_attributes id="my-alert-attributes">
        <nvpair id="my-alert-attributes-timeout" name="timeout"
          value="15s"/>
      </meta_attributes>
      <recipient id="my-alert-recipient1" value="someuser@example.com">
        <meta_attributes id="my-alert-recipient1-attributes">
          <nvpair id="my-alert-recipient1-timestamp-format"
            name="timestamp-format" value="%D %H:%M"/>
        </meta_attributes>
      </recipient>
      <recipient id="my-alert-recipient2" value="otheruser@example.com">
        <meta_attributes id="my-alert-recipient2-attributes">
          <nvpair id="my-alert-recipient2-timestamp-format"
            name="timestamp-format" value="%c"/>
        </meta_attributes>
      </recipient>
    </alert>
  </alerts>
</configuration>
```

In the above example, the `my-script.sh` will get called twice for each event, with each call using a 15-second timeout. One call will be passed the recipient `someuser@example.com` and a timestamp in the format `%D %H:%M`, while the other call will be passed the recipient `otheruser@example.com` and a timestamp in the format `%c`.

## 7.4. Alert Instance Attributes

As with resource agents, agent-specific configuration values may be configured as instance attributes. These will be passed to the agent as additional environment variables. The number, names and allowed values of these instance attributes are completely up to the particular agent.

Example 7.4. Alert configuration with instance attributes

```
<configuration>
  <alerts>
    <alert id="my-alert" path="/path/to/my-script.sh">
      <meta_attributes id="my-alert-attributes">
        <nvpair id="my-alert-attributes-timeout" name="timeout"
          value="15s"/>
      </meta_attributes>
      <instance_attributes id="my-alert-options">
        <nvpair id="my-alert-options-debug" name="debug" value="false"/>
      </instance_attributes>
      <recipient id="my-alert-recipient1" value="someuser@example.com"/>
    </alert>
  </alerts>
</configuration>
```

## 7.5. Alert Filters

By default, an alert agent will be called for node events, fencing events, and resource events. An agent may choose to ignore certain types of events, but there is still the overhead of calling it for those events. To eliminate that overhead, you may select which types of events the agent should receive (since version 1.1.18).

Example 7.5. Alert configuration to receive only node events and fencing events

```
<configuration>
  <alerts>
    <alert id="my-alert" path="/path/to/my-script.sh">
      <select>
        <select_nodes />
        <select_fencing />
      </select>
      <recipient id="my-alert-recipient1" value="someuser@example.com"/>
    </alert>
  </alerts>
</configuration>
```

The possible options within **<select>** are **<select\_nodes>**, **<select\_fencing>**, **<select\_resources>**, and **<select\_attributes>**.

With **<select\_attributes>** (the only event type not enabled by default), the agent will receive alerts when a node attribute changes. If you wish the agent to be called only when certain attributes change, you can configure that as well.

Example 7.6. Alert configuration to be called when certain node attributes change

```
<configuration>
  <alerts>
    <alert id="my-alert" path="/path/to/my-script.sh">
      <select>
        <select_attributes>
          <attribute id="alert-standby" name="standby" />
          <attribute id="alert-shutdown" name="shutdown" />
        </select_attributes>
      </select>
      <recipient id="my-alert-recipient1" value="someuser@example.com"/>
    </alert>
```

```

</alerts>
</configuration>

```

Node attribute alerts are currently considered experimental. Alerts may be limited to attributes set via `attrd_updater`, and agents may be called multiple times with the same attribute value.

## 7.6. Using the Sample Alert Agents

Pacemaker provides several sample alert agents, installed in `/usr/share/pacemaker/alerts` by default.

While these sample scripts may be copied and used as-is, they are provided mainly as templates to be edited to suit your purposes. See their source code for the full set of instance attributes they support.

### Example 7.7. Sending cluster events as SNMP traps

```

<configuration>
  <alerts>
    <alert id="snmp_alert" path="/path/to/alert_snmp.sh">
      <instance_attributes id="config_for_alert_snmp">
        <nvpair id="trap_node_states" name="trap_node_states" value="all"/>
      </instance_attributes>
      <meta_attributes id="config_for_timestamp">
        <nvpair id="ts_fmt" name="timestamp-format"
          value="%Y-%m-%d,%H:%M:%S.%01N"/>
      </meta_attributes>
      <recipient id="snmp_destination" value="192.168.1.2"/>
    </alert>
  </alerts>
</configuration>

```

### Example 7.8. Sending cluster events as e-mails

```

<configuration>
  <alerts>
    <alert id="smtp_alert" path="/path/to/alert_smtp.sh">
      <instance_attributes id="config_for_alert_smtp">
        <nvpair id="email_sender" name="email_sender"
          value="donotreply@example.com"/>
      </instance_attributes>
      <recipient id="smtp_destination" value="admin@example.com"/>
    </alert>
  </alerts>
</configuration>

```

## 7.7. Writing an Alert Agent

Table 7.2. Environment variables passed to alert agents

Environment Variable	Description
<code>CRM_alert_kind</code>	The type of alert ( <b>node</b> , <b>fencing</b> , <b>resource</b> , or <b>attribute</b> )
<code>CRM_alert_version</code>	The version of Pacemaker sending the alert
<code>CRM_alert_recipient</code>	The configured recipient

Environment Variable	Description
<b>CRM_alert_node_sequence</b>	A sequence number increased whenever an alert is being issued on the local node, which can be used to reference the order in which alerts have been issued by Pacemaker. An alert for an event that happened later in time reliably has a higher sequence number than alerts for earlier events. Be aware that this number has no cluster-wide meaning.
<b>CRM_alert_timestamp</b>	A timestamp created prior to executing the agent, in the format specified by the <b>timestamp-format</b> meta-attribute. This allows the agent to have a reliable, high-precision time of when the event occurred, regardless of when the agent itself was invoked (which could potentially be delayed due to system load, etc.).
<b>CRM_alert_node</b>	Name of affected node
<b>CRM_alert_desc</b>	Detail about event. For <b>node</b> alerts, this is the node's current state ( <b>member</b> or <b>lost</b> ). For <b>fencing</b> alerts, this is a summary of the requested fencing operation, including origin, target, and fencing operation error code, if any. For <b>resource</b> alerts, this is a readable string equivalent of <b>CRM_alert_status</b> .
<b>CRM_alert_nodeid</b>	ID of node whose status changed (provided with <b>node</b> alerts only)
<b>CRM_alert_task</b>	The requested fencing or resource operation (provided with <b>fencing</b> and <b>resource</b> alerts only)
<b>CRM_alert_rc</b>	The numerical return code of the fencing or resource operation (provided with <b>fencing</b> and <b>resource</b> alerts only)
<b>CRM_alert_rsc</b>	The name of the affected resource ( <b>resource</b> alerts only)
<b>CRM_alert_interval</b>	The interval of the resource operation ( <b>resource</b> alerts only)
<b>CRM_alert_target_rc</b>	The expected numerical return code of the operation ( <b>resource</b> alerts only)
<b>CRM_alert_status</b>	A numerical code used by Pacemaker to represent the operation result ( <b>resource</b> alerts only)
<b>CRM_alert_attribute_name</b>	The name of the node attribute that changed ( <b>attribute</b> alerts only)
<b>CRM_alert_attribute_value</b>	The new value of the node attribute that changed ( <b>attribute</b> alerts only)

Special concerns when writing alert agents:

- Alert agents may be called with no recipient (if none is configured), so the agent must be able to handle this situation, even if it only exits in that case. (Users may modify the configuration in stages, and add a recipient later.)
- If more than one recipient is configured for an alert, the alert agent will be called once per recipient. If an agent is not able to run concurrently, it should be configured with only a single recipient. The agent is free, however, to interpret the recipient as a list.
- When a cluster event occurs, all alerts are fired off at the same time as separate processes. Depending on how many alerts and recipients are configured, and on what is done within the alert agents, a significant load burst may occur. The agent could be written to take this into consideration,

for example by queueing resource-intensive actions into some other instance, instead of directly executing them.

- Alert agents are run as the **hacluster** user, which has a minimal set of permissions. If an agent requires additional privileges, it is recommended to configure **sudo** to allow the agent to run the necessary commands as another user with the appropriate privileges.
- As always, take care to validate and sanitize user-configured parameters, such as `CRM_alert_timestamp` (whose content is specified by the user-configured `timestamp-format`), `CRM_alert_recipient`, and all instance attributes. Mostly this is needed simply to protect against configuration errors, but if some user can modify the CIB without having `hacluster`-level access to the cluster nodes, it is a potential security concern as well, to avoid the possibility of code injection.



### Note

The alerts interface is designed to be backward compatible with the external scripts interface used by the `ocf:pacemaker:ClusterMon` resource, which is now deprecated. To preserve this compatibility, the environment variables passed to alert agents are available prepended with `CRM_notify_` as well as `CRM_alert_`. One break in compatibility is that ClusterMon ran external scripts as the **root** user, while alert agents are run as the **hacluster** user.

# Rules

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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.

## 8.1. Rule Properties

Table 8.1. Properties of a Rule

Field	Default	Description
<b>id</b>		A unique name for the rule (required)
<b>role</b>	<b>Started</b>	Limits the rule to apply only when the resource is in the specified role. Allowed values are <b>Started</b> , <b>Slave</b> , and <b>Master</b> . A rule with <b>role="Master"</b> cannot determine the initial location of a clone instance and will only affect which of the active instances will be promoted.
<b>score</b>		The score to apply if the rule evaluates to <b>true</b> . Limited to use in rules that are part of location constraints.
<b>score-attribute</b>		The node attribute to look up and use as a score if the rule evaluates to <b>true</b> . Limited to use in rules that are part of location constraints.
<b>boolean-op</b>	<b>and</b>	How to combine the result of multiple expression objects. Allowed values are <b>and</b> and <b>or</b> .

## 8.2. Node Attribute Expressions

Expression objects are used to control a resource based on the attributes defined by a node or nodes.

Table 8.2. Properties of an Expression

Field	Default	Description
<b>id</b>		A unique name for the expression (required)
<b>attribute</b>		The node attribute to test (required)
<b>type</b>	<b>string</b>	Determines how the value(s) should be tested. Allowed values are <b>string</b> , <b>integer</b> , and <b>version</b> .
<b>operation</b>		The comparison to perform (required). Allowed values: <ul style="list-style-type: none"> <li>• <b>lt</b>: True if the value of the node's <b>attribute</b> is less than <b>value</b></li> <li>• <b>gt</b>: True if the value of the node's <b>attribute</b> is greater than <b>value</b></li> <li>• <b>lte</b>: True if the value of the node's <b>attribute</b> is less than or equal to <b>value</b></li> <li>• <b>gte</b>: True if the value of the node's <b>attribute</b> is greater than or equal to <b>value</b></li> <li>• <b>eq</b>: True if the value of the node's <b>attribute</b> is equal to <b>value</b></li> <li>• <b>ne</b>: True if the value of the node's <b>attribute</b> is not equal to <b>value</b></li> <li>• <b>defined</b>: True if the node has the named attribute</li> <li>• <b>not_defined</b>: True if the node does not have the named attribute</li> </ul>
<b>value</b>		User-supplied value for comparison (required)
<b>value-source</b>	<b>literal</b>	How the <b>value</b> is derived ( <i>since 1.1.17</i> ). Allowed values: <ul style="list-style-type: none"> <li>• <b>literal</b>: <b>value</b> is a literal string to compare against</li> <li>• <b>param</b>: <b>value</b> is the name of a resource parameter to compare against (only valid in location constraints)</li> <li>• <b>meta</b>: <b>value</b> is the name of a resource meta-attribute to compare against (only valid in location constraints)</li> </ul>

In addition to any attributes added by the administrator, the cluster defines special, built-in node attributes for each node that can also be used.

Table 8.3. Built-in node attributes

Name	Value
<b>#uname</b>	Node <i>name</i>
<b>#id</b>	Node ID

Name	Value
<b>#kind</b>	Node type. Possible values are <b>cluster</b> , <b>remote</b> , and <b>container</b> . Kind is <b>remote</b> for Pacemaker Remote nodes created with the <b>ocf:pacemaker:remote</b> resource, and <b>container</b> for Pacemaker Remote guest nodes and bundle nodes ( <i>since 1.1.13</i> )
<b>#is_dc</b>	"true" if this node is a Designated Controller (DC), "false" otherwise
<b>#cluster-name</b>	The value of the <b>cluster-name</b> cluster property, if set
<b>#site-name</b>	The value of the <b>site-name</b> cluster property, if set, otherwise identical to <b>#cluster-name</b>
<b>#role</b>	The role the relevant multistate resource has on this node. Valid only within a rule for a location constraint for a multistate resource.

## 8.3. Time- and Date-Based Expressions

As the name suggests, **date\_expressions** are used to control a resource or cluster option based on the current date/time. They may contain an optional **date\_spec** and/or **duration** object depending on the context.

Table 8.4. Properties of a Date Expression

Field	Description
<b>start</b>	A date/time conforming to the <i>ISO8601</i> <sup>1</sup> specification.
<b>end</b>	A date/time conforming to the <i>ISO8601</i> <sup>2</sup> specification. Can be inferred by supplying a value for <b>start</b> and a <b>duration</b> .
<b>operation</b>	Compares the current date/time with the start and/or end date, depending on the context. Allowed values: <ul style="list-style-type: none"> <li>• <b>gt</b>: True if the current date/time is after <b>start</b></li> <li>• <b>lt</b>: True if the current date/time is before <b>end</b></li> <li>• <b>in_range</b>: True if the current date/time is after <b>start</b> and before <b>end</b></li> <li>• <b>date_spec</b>: True if the current date/time matches a <b>date_spec</b> object (described below)</li> </ul>



### Note

As these comparisons (except for **date\_spec**) include the time, the **eq**, **neq**, **gte** and **lte** operators have not been implemented since they would only be valid for a single second.

<sup>1</sup> [http://en.wikipedia.org/wiki/ISO\\_8601](http://en.wikipedia.org/wiki/ISO_8601)

<sup>2</sup> [http://en.wikipedia.org/wiki/ISO\\_8601](http://en.wikipedia.org/wiki/ISO_8601)

### 8.3.1. Date Specifications

**date\_spec** objects 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). At this time, multiple ranges (e.g. **weekdays="1, 2"** or **weekdays="1-2, 5-6"**) are not supported; depending on demand, this might be implemented in a future release.

Table 8.5. Properties of a Date Specification

Field	Description
<b>id</b>	A unique name for the object
<b>hours</b>	Allowed values: 0-23
<b>monthdays</b>	Allowed values: 1-31 (depending on month and year)
<b>weekdays</b>	Allowed values: 1-7 (1=Monday, 7=Sunday)
<b>yeardays</b>	Allowed values: 1-366 (depending on the year)
<b>months</b>	Allowed values: 1-12
<b>weeks</b>	Allowed values: 1-53 (depending on weekyear)
<b>years</b>	Year according to the Gregorian calendar
<b>weekyears</b>	Year in which the week started; e.g. 1 January 2005 can be specified as <i>2005-001 Ordinal</i> , <i>2005-01-01 Gregorian</i> or <i>2004-W53-6 Weekly</i> and thus would match <b>years="2005"</b> or <b>weekyears="2004"</b>
<b>moon</b>	Allowed values are 0-7 (0 is new, 4 is full moon). Seriously, you can use this. This was implemented to demonstrate the ease with which new comparisons could be added.

### 8.3.2. 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 (e.g. you can have a duration of 19 months). As with **date\_specs**, any field not supplied is ignored.

### 8.3.3. Sample Time-Based Expressions

A small sample of how time-based expressions can be used:

Example 8.1. True if now is any time in the year 2005

```
<rule id="rule1">
  <date_expression id="date_expr1" start="2005-001" operation="in_range">
    <duration years="1"/>
  </date_expression>
</rule>
```

## Example 8.2. Equivalent expression

```
<rule id="rule2">
  <date_expression id="date_expr2" operation="date_spec">
    <date_spec years="2005"/>
  </date_expression>
</rule>
```

## Example 8.3. 9am-5pm Monday-Friday

```
<rule id="rule3">
  <date_expression id="date_expr3" operation="date_spec">
    <date_spec hours="9-16" days="1-5"/>
  </date_expression>
</rule>
```

Please note that the **16** matches up to **16:59:59**, as the numeric value (hour) still matches!

## Example 8.4. 9am-6pm Monday through Friday or anytime Saturday

```
<rule id="rule4" boolean-op="or">
  <date_expression id="date_expr4-1" operation="date_spec">
    <date_spec hours="9-16" days="1-5"/>
  </date_expression>
  <date_expression id="date_expr4-2" operation="date_spec">
    <date_spec days="6"/>
  </date_expression>
</rule>
```

## Example 8.5. 9am-5pm or 9pm-12am Monday through Friday

```
<rule id="rule5" boolean-op="and">
  <rule id="rule5-nested1" boolean-op="or">
    <date_expression id="date_expr5-1" operation="date_spec">
      <date_spec hours="9-16"/>
    </date_expression>
    <date_expression id="date_expr5-2" operation="date_spec">
      <date_spec hours="21-23"/>
    </date_expression>
  </rule>
  <date_expression id="date_expr5-3" operation="date_spec">
    <date_spec days="1-5"/>
  </date_expression>
</rule>
```

## Example 8.6. Mondays in March 2005

```
<rule id="rule6" boolean-op="and">
  <date_expression id="date_expr6-1" operation="date_spec">
    <date_spec weekdays="1"/>
  </date_expression>
  <date_expression id="date_expr6-2" operation="in_range"
    start="2005-03-01" end="2005-04-01"/>
</rule>
```

**Note**

Because no time is specified with the above dates, 00:00:00 is implied. This means that the range includes all of 2005-03-01 but none of 2005-04-01. You may wish to write **end="2005-03-31T23:59:59"** to avoid confusion.

Example 8.7. A full moon on Friday the 13th

```
<rule id="rule7" boolean-op="and">
  <date_expression id="date_expr7" operation="date_spec">
    <date_spec weekdays="5" monthdays="13" moon="4"/>
  </date_expression>
</rule>
```

## 8.4. Using Rules to Determine Resource Location

A location constraint may contain rules. When the constraint's outermost rule evaluates to **false**, the cluster treats the constraint as if it were not there. When the rule evaluates to **true**, the node's preference for running the resource is updated with the score associated with the rule.

If this sounds familiar, it is because you have been using a simplified syntax for location constraint rules already. Consider the following location constraint:

Example 8.8. Prevent myApacheRsc from running on c001n03

```
<rsc_location id="dont-run-apache-on-c001n03" rsc="myApacheRsc"
  score="-INFINITY" node="c001n03"/>
```

This constraint can be more verbosely written as:

Example 8.9. Prevent myApacheRsc from running on c001n03 - expanded version

```
<rsc_location id="dont-run-apache-on-c001n03" rsc="myApacheRsc">
  <rule id="dont-run-apache-rule" score="-INFINITY">
    <expression id="dont-run-apache-expr" attribute="#uname"
      operation="eq" value="c00n03"/>
  </rule>
</rsc_location>
```

The advantage of using the expanded form is that one can then add extra clauses to the rule, such as limiting the rule such that it only applies during certain times of the day or days of the week.

### 8.4.1. Location Rules Based on Other Node Properties

The expanded form allows us to match on node properties other than its name. If we rated each machine's CPU power such that the cluster had the following nodes section:

Example 8.10. A sample nodes section for use with **score-attribute**

```
<nodes>
  <node id="uuid1" uname="c001n01" type="normal">
    <instance_attributes id="uuid1-custom_attrs">
      <nvpair id="uuid1-cpu_mips" name="cpu_mips" value="1234"/>
    </instance_attributes>
  </node>
  <node id="uuid2" uname="c001n02" type="normal">
    <instance_attributes id="uuid2-custom_attrs">
      <nvpair id="uuid2-cpu_mips" name="cpu_mips" value="5678"/>
    </instance_attributes>
  </node>
</nodes>
```

then we could prevent resources from running on underpowered machines with this rule:

```
<rule id="need-more-power-rule" score="-INFINITY">
  <expression id="need-more-power-expr" attribute="cpu_mips"
    operation="lt" value="3000"/>
</rule>
```

## 8.4.2. Using **score-attribute** Instead of **score**

When using **score-attribute** instead of **score**, each node matched by the rule has its score adjusted differently, according to its value for the named node attribute. Thus, in the previous example, if a rule used **score-attribute="cpu\_mips"**, **c001n01** would have its preference to run the resource increased by **1234** whereas **c001n02** would have its preference increased by **5678**.

## 8.5. Using Rules to Control Resource Options

Often some cluster nodes will be different from their peers. Sometimes, these differences — e.g. the location of a binary or the names of network interfaces — require resources to be configured differently depending on the machine they're hosted on.

By defining multiple **instance\_attributes** objects for the resource and adding a rule to each, we can easily handle these special cases.

In the example below, **mySpecialRsc** will use **eth1** and port **9999** when run on **node1**, **eth2** and port **8888** on **node2** and default to **eth0** and port **9999** for all other nodes.

Example 8.11. Defining different resource options based on the node name

```
<primitive id="mySpecialRsc" class="ocf" type="Special" provider="me">
  <instance_attributes id="special-node1" score="3">
    <rule id="node1-special-case" score="INFINITY" >
      <expression id="node1-special-case-expr" attribute="#uname"
        operation="eq" value="node1"/>
    </rule>
    <nvpair id="node1-interface" name="interface" value="eth1"/>
  </instance_attributes>
  <instance_attributes id="special-node2" score="2" >
    <rule id="node2-special-case" score="INFINITY">
      <expression id="node2-special-case-expr" attribute="#uname"
        operation="eq" value="node2"/>
    </rule>
  </instance_attributes>
</primitive>
```

```

<nvpair id="node2-interface" name="interface" value="eth2"/>
<nvpair id="node2-port" name="port" value="8888"/>
</instance_attributes>
<instance_attributes id="defaults" score="1" >
  <nvpair id="default-interface" name="interface" value="eth0"/>
  <nvpair id="default-port" name="port" value="9999"/>
</instance_attributes>
</primitive>

```

The order in which **instance\_attributes** objects are evaluated is determined by their score (highest to lowest). If not supplied, score defaults to zero, and objects with an equal score are processed in listed order. If the **instance\_attributes** object has no rule or a **rule** that evaluates to **true**, then for any parameter the resource does not yet have a value for, the resource will use the parameter values defined by the **instance\_attributes**.

For example, given the configuration above, if the resource is placed on node1:

1. **special-node1** has the highest score (3) and so is evaluated first; its rule evaluates to **true**, so **interface** is set to **eth1**.
2. **special-node2** is evaluated next with score 2, but its rule evaluates to **false**, so it is ignored.
3. **defaults** is evaluated last with score 1, and has no rule, so its values are examined; **interface** is already defined, so the value here is not used, but **port** is not yet defined, so **port** is set to **9999**.

## 8.6. Using Rules to Control Cluster Options

Controlling cluster options is achieved in much the same manner as specifying different resource options on different nodes.

The difference is that because they are cluster options, one cannot (or should not, because they won't work) use attribute-based expressions. The following example illustrates how to set a different **resource-stickiness** value during and outside work hours. This allows resources to automatically move back to their most preferred hosts, but at a time that (in theory) does not interfere with business activities.

Example 8.12. Change **resource-stickiness** during working hours

```

<rsc_defaults>
  <meta_attributes id="core-hours" score="2">
    <rule id="core-hour-rule" score="0">
      <date_expression id="nine-to-five-Mon-to-Fri" operation="date_spec">
        <date_spec id="nine-to-five-Mon-to-Fri-spec" hours="9-16" weekdays="1-5"/>
      </date_expression>
    </rule>
    <nvpair id="core-stickiness" name="resource-stickiness" value="INFINITY"/>
  </meta_attributes>
  <meta_attributes id="after-hours" score="1" >
    <nvpair id="after-stickiness" name="resource-stickiness" value="0"/>
  </meta_attributes>
</rsc_defaults>

```

## 8.7. Ensuring Time-Based Rules Take Effect

A Pacemaker cluster is an event-driven system. As such, it won't recalculate the best place for resources to run unless something (like a resource failure or configuration change) happens. This can mean that a location constraint that only allows resource X to run between 9am and 5pm is not enforced.

If you rely on time-based rules, the **cluster-recheck-interval** cluster option (which defaults to 15 minutes) is essential. This tells the cluster to periodically recalculate the ideal state of the cluster.

For example, if you set **cluster-recheck-interval="5m"**, then sometime between 09:00 and 09:05 the cluster would notice that it needs to start resource X, and between 17:00 and 17:05 it would realize that X needed to be stopped. The timing of the actual start and stop actions depends on what other actions the cluster may need to perform first.



# Advanced Configuration

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## 9.1. Connecting from a Remote Machine

Provided Pacemaker is installed on a machine, it is possible to connect to the cluster even if the machine itself is not in the same cluster. To do this, one simply sets up a number of environment variables and runs the same commands as when working on a cluster node.

Table 9.1. Environment Variables Used to Connect to Remote Instances of the CIB

Environment Variable	Default	Description
<b>CIB_user</b>	\$USER	The user to connect as. Needs to be part of the <b>haclient</b> group on the target host.
<b>CIB_passwd</b>		The user's password. Read from the command line if unset.
<b>CIB_server</b>	localhost	The host to contact
<b>CIB_port</b>		The port on which to contact the server; required.
<b>CIB_encrypted</b>	TRUE	Whether to encrypt network traffic

So, if **c001n01** is an active cluster node and is listening on port 1234 for connections, and **someuser** is a member of the **haclient** group, then the following would prompt for **someuser's** password and return the cluster's current configuration:

```
# export CIB_port=1234; export CIB_server=c001n01; export CIB_user=someuser;
# cibadmin -Q
```

For security reasons, the cluster does not listen for remote connections by default. If you wish to allow remote access, you need to set the **remote-tls-port** (encrypted) or **remote-clear-port** (unencrypted) CIB properties (i.e., those kept in the **cib** tag, like **num\_updates** and **epoch**).

Table 9.2. Extra top-level CIB properties for remote access

Field	Default	Description
<b>remote-tls-port</b>	<i>none</i>	Listen for encrypted remote connections on this port.
<b>remote-clear-port</b>	<i>none</i>	Listen for plaintext remote connections on this port.

## 9.2. Specifying When Recurring Actions are Performed

By default, recurring actions are scheduled relative to when the resource started. So if your resource was last started at 14:32 and you have a backup set to be performed every 24 hours, then the backup will always run in the middle of the business day — hardly desirable.

To specify a date and time that the operation should be relative to, set the operation's **interval-origin**. The cluster uses this point to calculate the correct **start-delay** such that the operation will occur at *origin + (interval \* N)*.

So, if the operation's interval is 24h, its interval-origin is set to 02:00 and it is currently 14:32, then the cluster would initiate the operation with a start delay of 11 hours and 28 minutes. If the resource is moved to another node before 2am, then the operation is cancelled.

The value specified for **interval** and **interval-origin** can be any date/time conforming to the [ISO8601 standard](http://en.wikipedia.org/wiki/ISO_8601)<sup>1</sup>. By way of example, to specify an operation that would run on the first Monday of 2009 and every Monday after that, you would add:

### Example 9.1. Specifying a Base for Recurring Action Intervals

```
<op id="my-weekly-action" name="custom-action" interval="P7D" interval-origin="2009-
W01-1"/>
```

## 9.3. Handling Resource Failure

By default, Pacemaker will attempt to recover failed resources by restarting them. However, failure recovery is highly configurable.

### 9.3.1. Failure Counts

Pacemaker tracks resource failures for each combination of node, resource, and operation (start, stop, monitor, etc.).

You can query the fail count for a particular node, resource, and/or operation using the **crm\_failcount** command. For example, to see how many times the 10-second monitor for **myrsc** has failed on **node1**, run:

```
# crm_failcount --query -r myrsc -N node1 -n monitor -I 10s
```

If you omit the node, **crm\_failcount** will use the local node. If you omit the operation and interval, **crm\_failcount** will display the sum of the fail counts for all operations on the resource.

You can use **crm\_resource --cleanup** or **crm\_failcount --delete** to clear fail counts. For example, to clear the above monitor failures, run:

<sup>1</sup> [http://en.wikipedia.org/wiki/ISO\\_8601](http://en.wikipedia.org/wiki/ISO_8601)

```
# crm_resource --cleanup -r myrsc -N node1 -n monitor -I 10s
```

If you omit the resource, **crm\_resource --cleanup** will clear failures for all resources. If you omit the node, it will clear failures on all nodes. If you omit the operation and interval, it will clear the failures for all operations on the resource.



### Note

Even when cleaning up only a single operation, all failed operations will disappear from the status display. This allows us to trigger a re-check of the resource's current status.

Higher-level tools may provide other commands for querying and clearing fail counts.

The **crm\_mon** tool shows the current cluster status, including any failed operations. To see the current fail counts for any failed resources, call **crm\_mon** with the **--failcounts** option. This shows the fail counts per resource (that is, the sum of any operation fail counts for the resource).

## 9.3.2. Failure Response

Normally, if a running resource fails, pacemaker will try to stop it and start it again. Pacemaker will choose the best location to start it each time, which may be the same node that it failed on.

However, if a resource fails repeatedly, it is possible that there is an underlying problem on that node, and you might desire trying a different node in such a case. Pacemaker allows you to set your preference via the **migration-threshold** resource meta-attribute.<sup>2</sup>

If you define **migration-threshold=N** for a resource, it will be banned from the original node after *N* failures.



### Note

The **migration-threshold** is per *resource*, even though fail counts are tracked per *operation*. The operation fail counts are added together to compare against the **migration-threshold**.

By default, fail counts remain until manually cleared by an administrator using **crm\_resource --cleanup** or **crm\_failcount --delete** (hopefully after first fixing the failure's cause). It is possible to have fail counts expire automatically by setting the **failure-timeout** resource meta-attribute.

<sup>2</sup> The naming of this option was perhaps unfortunate as it is easily confused with live migration, the process of moving a resource from one node to another without stopping it. Xen virtual guests are the most common example of resources that can be migrated in this manner.



### Important

A successful operation does not clear past failures. If a recurring monitor operation fails once, succeeds many times, then fails again days later, its fail count is 2. Fail counts are cleared only by manual intervention or failure timeout.

For example, a setting of **migration-threshold=2** and **failure-timeout=60s** would cause the resource to move to a new node after 2 failures, and allow it to move back (depending on stickiness and constraint scores) after one minute.



### Note

**failure-timeout** is measured since the most recent failure. That is, older failures do not individually time out and lower the fail count. Instead, all failures are timed out simultaneously (and the fail count is reset to 0) if there is no new failure for the timeout period.

There are two exceptions to the migration threshold concept: when a resource either fails to start or fails to stop.

If the cluster property **start-failure-is-fatal** is set to **true** (which is the default), start failures cause the fail count 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.



### Important

Please read [Section 8.7, “Ensuring Time-Based Rules Take Effect”](#) to understand how timeouts work before configuring a **failure-timeout**.

## 9.4. Moving Resources

### 9.4.1. Moving Resources Manually

There are primarily two occasions when you would want to move a resource from its current location: when the whole node is under maintenance, and when a single resource needs to be moved.

### 9.4.1.1. Standby Mode

Since everything eventually comes down to a score, you could create constraints for every resource to prevent them from running on one node. While pacemaker configuration can seem convoluted at times, not even we would require this of administrators.

Instead, one can set a special node attribute which tells the cluster "don't let anything run here". There is even a helpful tool to help query and set it, called **crm\_standby**. To check the standby status of the current machine, run:

```
# crm_standby -G
```

A value of **on** indicates that the node is *not* able to host any resources, while a value of **off** says that it *can*.

You can also check the status of other nodes in the cluster by specifying the **--node** option:

```
# crm_standby -G --node sles-2
```

To change the current node's standby status, use **-v** instead of **-G**:

```
# crm_standby -v on
```

Again, you can change another host's value by supplying a hostname with **--node**.

### 9.4.1.2. Moving One Resource

When only one resource is required to move, we could do this by creating location constraints. However, once again we provide a user-friendly shortcut as part of the **crm\_resource** command, which creates and modifies the extra constraints for you. If **Email** were running on **sles-1** and you wanted it moved to a specific location, the command would look something like:

```
# crm_resource -M -r Email -H sles-2
```

Behind the scenes, the tool will create the following location constraint:

```
<rsc_location rsc="Email" node="sles-2" score="INFINITY"/>
```

It is important to note that subsequent invocations of **crm\_resource -M** are not cumulative. So, if you ran these commands

```
# crm_resource -M -r Email -H sles-2
# crm_resource -M -r Email -H sles-3
```

then it is as if you had never performed the first command.

To allow the resource to move back again, use:

```
# crm_resource -U -r Email
```

Note the use of the word *allow*. The resource can move back to its original location but, depending on **resource-stickiness**, it might stay where it is. To be absolutely certain that it moves back to **sles-1**, move it there before issuing the call to **crm\_resource -U**:

```
# crm_resource -M -r Email -H sles-1
```

```
# crm_resource -U -r Email
```

Alternatively, if you only care that the resource should be moved from its current location, try:

```
# crm_resource -B -r Email
```

Which will instead create a negative constraint, like

```
<rsc_location rsc="Email" node="sles-1" score="-INFINITY"/>
```

This will achieve the desired effect, but will also have long-term consequences. As the tool will warn you, the creation of a **-INFINITY** constraint will prevent the resource from running on that node until **crm\_resource -U** is used. This includes the situation where every other cluster node is no longer available!

In some cases, such as when **resource-stickiness** is set to **INFINITY**, it is possible that you will end up with the problem described in [Section 6.2.4, “What if Two Nodes Have the Same Score”](#). The tool can detect some of these cases and deals with them by creating both positive and negative constraints. E.g.

**Email** prefers **sles-1** with a score of **-INFINITY**

**Email** prefers **sles-2** with a score of **INFINITY**

which has the same long-term consequences as discussed earlier.

### 9.4.2. Moving Resources Due to Connectivity Changes

You can configure the cluster to move resources when external connectivity is lost in two steps.

#### 9.4.2.1. Tell Pacemaker to Monitor Connectivity

First, add an **ocf:pacemaker:ping** resource to the cluster. The **ping** resource uses the system utility of the same name to test whether 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** by default.<sup>3</sup>



#### Note

Older versions of Heartbeat required users to add ping nodes to **ha.cf**, but this is no longer required.

Older versions of Pacemaker used a different agent **ocf:pacemaker:pingd** which is now deprecated in favor of **ping**. If your version of Pacemaker does not contain the **ping** resource agent, download the latest version from <https://github.com/ClusterLabs/pacemaker/tree/master/extra/resources/ping>

Normally, the ping resource should run on all cluster nodes, which means that you'll need to create a clone. A template for this can be found below along with a description of the most interesting parameters.

---

<sup>3</sup> The attribute name is customizable, in order to allow multiple ping groups to be defined.

Table 9.3. Common Options for a *ping* Resource

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

Example 9.2. An example ping cluster resource that checks node connectivity once every minute

```
<clone id="Connected">
  <primitive id="ping" provider="pacemaker" class="ocf" type="ping">
    <instance_attributes id="ping-attrs">
      <nvpair id="pingd-dampen" name="dampen" value="5s"/>
      <nvpair id="pingd-multiplier" name="multiplier" value="1000"/>
      <nvpair id="pingd-hosts" name="host_list" value="my.gateway.com www.bigcorp.com"/>
    </instance_attributes>
    <operations>
      <op id="ping-monitor-60s" interval="60s" name="monitor"/>
    </operations>
  </primitive>
</clone>
```



### Important

You're only half done. The next section deals with telling Pacemaker how to deal with the connectivity status that **ocf: pacemaker : ping** is recording.

#### 9.4.2.2. Tell Pacemaker How to Interpret the Connectivity Data



### Important

Before attempting the following, make sure you understand [Chapter 8, Rules](#).

There are a number of ways to use the connectivity data.

The most common setup is for people to have a single ping target (e.g. the service network's default gateway), to prevent the cluster from running a resource on any unconnected node.

Example 9.3. Don't run a resource on unconnected nodes

```
<rsc_location id="WebServer-no-connectivity" rsc="webserver">
  <rule id="ping-exclude-rule" score="-INFINITY" >
    <expression id="ping-exclude" attribute="pingd" operation="not_defined"/>
  </rule>
</rsc_location>
```

```
</rule>
</rsc_location>
```

A more complex setup is to have a number of ping targets configured. You can require the cluster to only run resources on nodes that can connect to all (or a minimum subset) of them.

**Example 9.4.** Run only on nodes connected to three or more ping targets.

```
<primitive id="ping" provider="pacemaker" class="ocf" type="ping">
... <!-- omitting some configuration to highlight important parts -->
  <nvpair id="pingd-multiplier" name="multiplier" value="1000"/>
...
</primitive>
...
<rsc_location id="WebServer-connectivity" rsc="Webserver">
  <rule id="ping-prefer-rule" score="-INFINITY" >
    <expression id="ping-prefer" attribute="pingd" operation="lt" value="3000"/>
  </rule>
</rsc_location>
```

Alternatively, you can tell the cluster only to *prefer* nodes with the best connectivity. Just be sure to set **multiplier** to a value higher than that of **resource-stickiness** (and don't set either of them to **INFINITY**).

**Example 9.5.** Prefer the node with the most connected ping nodes

```
<rsc_location id="WebServer-connectivity" rsc="Webserver">
  <rule id="ping-prefer-rule" score-attribute="pingd" >
    <expression id="ping-prefer" attribute="pingd" operation="defined"/>
  </rule>
</rsc_location>
```

It is perhaps easier to think of this in terms of the simple constraints that the cluster translates it into. For example, if **sles-1** is connected to all five ping nodes but **sles-2** is only connected to two, then it would be as if you instead had the following constraints in your configuration:

**Example 9.6.** How the cluster translates the above location constraint

```
<rsc_location id="ping-1" rsc="Webserver" node="sles-1" score="5000"/>
<rsc_location id="ping-2" rsc="Webserver" node="sles-2" score="2000"/>
```

The advantage is that you don't have to manually update any constraints whenever your network connectivity changes.

You can also combine the concepts above into something even more complex. The example below shows how you can prefer the node with the most connected ping nodes provided they have connectivity to at least three (again assuming that **multiplier** is set to 1000).

**Example 9.7.** A more complex example of choosing a location based on connectivity

```
<rsc_location id="WebServer-connectivity" rsc="Webserver">
  <rule id="ping-exclude-rule" score="-INFINITY" >
    <expression id="ping-exclude" attribute="pingd" operation="lt" value="3000"/>
  </rule>
</rsc_location>
```

```

</rule>
<rule id="ping-prefer-rule" score-attribute="pingd" >
  <expression id="ping-prefer" attribute="pingd" operation="defined"/>
</rule>
</rsc_location>

```

### 9.4.3. Migrating Resources

Normally, when the cluster needs to move a resource, it fully restarts the resource (i.e. stops the resource on the current node and starts it on the new node).

However, some types of resources, such as Xen virtual guests, are able to move to another location without loss of state (often referred to as live migration or hot migration). In pacemaker, this is called resource migration. Pacemaker can be configured to migrate a resource when moving it, rather than restarting it.

Not all resources are able to migrate; see the Migration Checklist below, and those that can, won't do so in all situations. Conceptually, there are two requirements from which the other prerequisites follow:

- The resource must be active and healthy at the old location; and
- everything required for the resource to run must be available on both the old and new locations.

The cluster is able to accommodate both *push* and *pull* migration models by requiring the resource agent to support two special actions: **migrate\_to** (performed on the current location) and **migrate\_from** (performed on the destination).

In push migration, the process on the current location transfers the resource to the new location where it is later activated. In this scenario, most of the work would be done in the **migrate\_to** action and, if anything, the activation would occur during **migrate\_from**.

Conversely for pull, the **migrate\_to** action is practically empty and **migrate\_from** does most of the work, extracting the relevant resource state from the old location and activating it.

There is no wrong or right way for a resource agent to implement migration, as long as it works.

#### Migration Checklist

- The resource may not be a clone.
- The resource must use an OCF style agent.
- The resource must not be in a failed or degraded state.
- The resource agent must support **migrate\_to** and **migrate\_from** actions, and advertise them in its metadata.
- The resource must have the **allow-migrate** meta-attribute set to **true** (which is not the default).

If an otherwise migratable resource depends on another resource via an ordering constraint, there are special situations in which it will be restarted rather than migrated.

For example, if the resource depends on a clone, and at the time the resource needs to be moved, the clone has instances that are stopping and instances that are starting, then the resource will be restarted. The Policy Engine is not yet able to model this situation correctly and so takes the safer (if less optimal) path.

In pacemaker 1.1.11 and earlier, a migratable resource will be restarted when moving if it directly or indirectly depends on *any* primitive or group resources.

Even in newer versions, if a migratable resource depends on a non-migratable resource, and both need to be moved, the migratable resource will be restarted.

## 9.5. Tracking Node Health

A node may be functioning adequately as far as cluster membership is concerned, and yet be "unhealthy" in some respect that makes it an undesirable location for resources. For example, a disk drive may be reporting SMART errors, or the CPU may be highly loaded.

Pacemaker offers a way to automatically move resources off unhealthy nodes.

### 9.5.1. Node Health Attributes

Pacemaker will treat any node attribute whose name starts with **#health** as an indicator of node health. Node health attributes may have one of the following values:

Table 9.4. Allowed Values for Node Health Attributes

Value	Intended significance
<b>red</b>	This indicator is unhealthy
<b>yellow</b>	This indicator is becoming unhealthy
<b>green</b>	This indicator is healthy
<i>integer</i>	A numeric score to apply to all resources on this node (0 or positive is healthy, negative is unhealthy)

### 9.5.2. Node Health Strategy

Pacemaker assigns a node health score to each node, as the sum of the values of all its node health attributes. This score will be used as a location constraint applied to this node for all resources.

The **node-health-strategy** cluster option controls how Pacemaker responds to changes in node health attributes, and how it translates **red**, **yellow**, and **green** to scores.

Allowed values are:

Table 9.5. Node Health Strategies

Value	Effect
<b>none</b>	Do not track node health attributes at all.
<b>migrate-on-red</b>	Assign the value of <b>-INFINITY</b> to <b>red</b> , and 0 to <b>yellow</b> and <b>green</b> . This will cause all resources to move off the node if any attribute is <b>red</b> .
<b>only-green</b>	Assign the value of <b>-INFINITY</b> to <b>red</b> and <b>yellow</b> , and 0 to <b>green</b> . This will cause all resources to move off the node if any attribute is <b>red</b> or <b>yellow</b> .
<b>progressive</b>	Assign the value of the <b>node-health-red</b> cluster option to <b>red</b> , the value of <b>node-health-yellow</b> to <b>yellow</b> , and the value of <b>node-health-green</b> to <b>green</b> . Each node is additionally assigned a score of <b>node-health-base</b> (this allows resources to start even if some attributes are <b>yellow</b> ). This strategy gives the administrator finer control over how important each value is.
<b>custom</b>	Track node health attributes using the same values as <b>progressive</b> for <b>red</b> , <b>yellow</b> , and <b>green</b> , but do not take them into account. The

Value	Effect
	administrator is expected to implement a policy by defining rules (see <a href="#">Chapter 8, Rules</a> ) referencing node health attributes.

### 9.5.3. Measuring Node Health

Since Pacemaker calculates node health based on node attributes, any method that sets node attributes may be used to measure node health. The most common ways are resource agents or separate daemons.

Pacemaker provides examples that can be used directly or as a basis for custom code. The **ocf:pacemaker:HealthCPU** and **ocf:pacemaker:HealthSMART** resource agents set node health attributes based on CPU and disk parameters. The **ipmiservicelogd** daemon sets node health attributes based on IPMI values (the **ocf:pacemaker:SystemHealth** resource agent can be used to manage the daemon as a cluster resource).

## 9.6. Reloading Services After a Definition Change

The cluster automatically detects changes to the definition of services it manages. The normal response is to stop the service (using the old definition) and start it again (with the new definition). This works well, but some services are smarter and can be told to use a new set of options without restarting.

To take advantage of this capability, the resource agent must:

1. Accept the **reload** operation and perform any required actions. *The actions here depend completely on your application!*

Example 9.8. The DRBD agent's logic for supporting **reload**

```
case $1 in
  start)
    drbd_start
    ;;
  stop)
    drbd_stop
    ;;
  reload)
    drbd_reload
    ;;
  monitor)
    drbd_monitor
    ;;
  *)
    drbd_usage
    exit $OCF_ERR_UNIMPLEMENTED
    ;;
esac
exit $?
```

2. Advertise the **reload** operation in the **actions** section of its metadata

Example 9.9. The DRBD Agent Advertising Support for the **reload** Operation

```
<?xml version="1.0"?>
<!DOCTYPE resource-agent SYSTEM "ra-api-1.dtd">
<resource-agent name="drbd">
  <version>1.1</version>
```

```
<longdesc>
  Master/Slave OCF Resource Agent for DRBD
</longdesc>

...

<actions>
  <action name="start"    timeout="240" />
  <action name="reload"  timeout="240" />
  <action name="promote"  timeout="90" />
  <action name="demote"   timeout="90" />
  <action name="notify"   timeout="90" />
  <action name="stop"    timeout="100" />
  <action name="meta-data" timeout="5" />
  <action name="validate-all" timeout="30" />
</actions>
</resource-agent>
```

3. Advertise one or more parameters that can take effect using **reload**.

Any parameter with the **unique** set to 0 is eligible to be used in this way.

### Example 9.10. Parameter that can be changed using reload

```
<parameter name="drbdconf" unique="0">
  <longdesc>Full path to the drbd.conf file.</longdesc>
  <shortdesc>Path to drbd.conf</shortdesc>
  <content type="string" default="{OCF_RESKEY_drbdconf_default}"/>
</parameter>
```

Once these requirements are satisfied, the cluster will automatically know to reload the resource (instead of restarting) when a non-unique field changes.



#### Note

Metadata will not be re-read unless the resource needs to be started. This may mean that the resource will be restarted the first time, even though you changed a parameter with **unique=0**.



#### Note

If both a unique and non-unique field are changed simultaneously, the resource will still be restarted.

# Advanced Resource Types

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## 10.1. Groups - A Syntactic Shortcut

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, we support the concept of groups.

**Example 10.1.** A group of two primitive resources

```
<group id="shortcut">
```

```
<primitive id="Public-IP" class="ocf" type="IPAddr" provider="heartbeat">
  <instance_attributes id="params-public-ip">
    <nvpair id="public-ip-addr" name="ip" value="192.0.2.2"/>
  </instance_attributes>
</primitive>
<primitive id="Email" class="lsb" type="exim"/>
</group>
```

Although the example above contains only two resources, there is no limit to the number of resources a group can contain. The example is also sufficient to explain the fundamental properties of a group:

- Resources are started in the order they appear in (**Public-IP** first, then **Email**)
- Resources are stopped in the reverse order to which they appear in (**Email** first, then **Public-IP**)

If a resource in the group can't run anywhere, then nothing after that is allowed to run, too.

- If **Public-IP** can't run anywhere, neither can **Email**;
- but if **Email** can't run anywhere, this does not affect **Public-IP** in any way

The group above is logically equivalent to writing:

Example 10.2. How the cluster sees a group resource

```
<configuration>
  <resources>
    <primitive id="Public-IP" class="ocf" type="IPAddr" provider="heartbeat">
      <instance_attributes id="params-public-ip">
        <nvpair id="public-ip-addr" name="ip" value="192.0.2.2"/>
      </instance_attributes>
    </primitive>
    <primitive id="Email" class="lsb" type="exim"/>
  </resources>
  <constraints>
    <rsc_colocation id="xxx" rsc="Email" with-rsc="Public-IP" score="INFINITY"/>
    <rsc_order id="yyy" first="Public-IP" then="Email"/>
  </constraints>
</configuration>
```

Obviously as the group grows bigger, the reduced configuration effort can become significant.

Another (typical) example of a group is a DRBD volume, the filesystem mount, an IP address, and an application that uses them.

### 10.1.1. Group Properties

Table 10.1. Properties of a Group Resource

Field	Description
<b>id</b>	A unique name for the group

### 10.1.2. Group Options

Groups inherit the **priority**, **target-role**, and **is-managed** properties from primitive resources. See [Section 5.4, "Resource Options"](#) for information about those properties.

### 10.1.3. Group Instance Attributes

Groups have no instance attributes. However, any that are set for the group object will be inherited by the group's children.

### 10.1.4. Group Contents

Groups may only contain a collection of cluster resources (see [Section 5.3, "Resource Properties"](#)). To refer to a child of a group resource, just use the child's `id` instead of the group's.

### 10.1.5. Group Constraints

Although it is possible to reference a group's children in constraints, it is usually preferable to reference the group itself.

Example 10.3. Some constraints involving groups

```
<constraints>
  <rsc_location id="group-prefers-node1" rsc="shortcut" node="node1" score="500"/>
  <rsc_colocation id="webserver-with-group" rsc="Webserver" with-rsc="shortcut"/>
  <rsc_order id="start-group-then-webserver" first="Webserver" then="shortcut"/>
</constraints>
```

### 10.1.6. 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.

## 10.2. Clones - Resources That Get Active on Multiple Hosts

Clones were initially conceived as a convenient way to start multiple instances of an IP address resource and have them distributed throughout the cluster for load balancing. They have turned out to be quite useful for a number of purposes including integrating with the Distributed Lock Manager (used by many cluster filesystems), the fencing subsystem, and OCFS2.

You can clone any resource, provided the resource agent supports it.

Three types of cloned resources exist:

- Anonymous
- Globally unique
- Stateful

*Anonymous* clones are the simplest. These behave completely identically everywhere they are running. Because of this, there can be only one copy of an anonymous clone active per machine.

*Globally unique* clones are distinct entities. A copy of the clone running on one machine is not equivalent to another instance on another node, nor would any two copies on the same node be equivalent.

Stateful clones are covered later in [Section 10.3, “Multi-state - Resources That Have Multiple Modes”](#).

Example 10.4. A clone of an LSB resource

```
<clone id="apache-clone">
  <meta_attributes id="apache-clone-meta">
    <nvpair id="apache-unique" name="globally-unique" value="false"/>
  </meta_attributes>
  <primitive id="apache" class="lsb" type="apache"/>
</clone>
```

### 10.2.1. Clone Properties

Table 10.2. Properties of a Clone Resource

Field	Description
<b>id</b>	A unique name for the clone

### 10.2.2. Clone Options

Options inherited from *primitive* resources: **priority**, **target-role**, **is-managed**

Table 10.3. Clone-specific configuration options

Field	Default	Description
<b>clone-max</b>	number of nodes in cluster	How many copies of the resource to start
<b>clone-node-max</b>	1	How many copies of the resource can be started on a single node
<b>clone-min</b>	1	Require at least this number of clone instances to be runnable before allowing resources depending on the clone to be runnable ( <i>since 1.1.14</i> )
<b>notify</b>	true	When stopping or starting a copy of the clone, tell all the other copies beforehand and again when the action was successful. Allowed values: <b>false</b> , <b>true</b>
<b>globally-unique</b>	false	Does each copy of the clone perform a different function? Allowed values: <b>false</b> , <b>true</b>
<b>ordered</b>	false	Should the copies be started in series (instead of in parallel)? Allowed values: <b>false</b> , <b>true</b>
<b>interleave</b>	false	If this clone depends on another clone via an ordering constraint, is it allowed to start after the local instance of the other clone starts, rather than wait for all instances of the other clone to start? Allowed values: <b>false</b> , <b>true</b>

### 10.2.3. Clone Instance Attributes

Clones have no instance attributes; however, any that are set here will be inherited by the clone's children.

### 10.2.4. Clone Contents

Clones must contain exactly one primitive or group resource.



## Warning

You should never reference the name of a clone's child. If you think you need to do this, you probably need to re-evaluate your design.

### 10.2.5. Clone Constraints

In most cases, a clone 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 from those for primitive resources except that the clone's **id** is used.

#### Example 10.5. Some constraints involving clones

```
<constraints>
  <rsc_location id="clone-prefers-node1" rsc="apache-clone" node="node1" score="500"/>
  <rsc_colocation id="stats-with-clone" rsc="apache-stats" with="apache-clone"/>
  <rsc_order id="start-clone-then-stats" first="apache-clone" then="apache-stats"/>
</constraints>
```

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

Colocation of a primitive 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. If one clone **A** is colocated with another clone **B**, the set of allowed locations for **A** is limited to nodes on which **B** is (or will be) active. Placement is then performed normally.

### 10.2.6. 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.

**Note**

For globally unique clones, this may result in multiple instances of the clone staying on a single node, even after another eligible node becomes active (for example, after being put into standby mode then made active again). If you do not want this behavior, specify a **resource-stickiness** of 0 for the clone temporarily and let the cluster adjust, then set it back to 1 if you want the default behavior to apply again.

### 10.2.7. Clone Resource Agent Requirements

Any resource can be used as an anonymous clone, as it requires no additional support from the resource agent. Whether it makes sense to do so depends on your resource and its resource agent.

Globally unique clones do require some additional support in the resource agent. In particular, it must only respond with **OCF\_SUCCESS** if the node has that exact instance active. All other probes for instances of the clone should result in **OCF\_NOT\_RUNNING** (or one of the other OCF error codes if they are failed).

Individual instances of a clone are identified by appending a colon and a numerical offset, e.g. **apache:2**.

Resource agents can find out how many copies there are by examining the **OCF\_RESKEY\_CRM\_meta\_clone\_max** environment variable and which copy it is by examining **OCF\_RESKEY\_CRM\_meta\_clone**.

The resource agent must not make any assumptions (based on **OCF\_RESKEY\_CRM\_meta\_clone**) about which numerical instances are active. In particular, the list of active copies will not always be an unbroken sequence, nor always start at 0.

#### 10.2.7.1. Clone Notifications

Supporting notifications requires the **notify** action to be implemented. If supported, the notify action will be passed a number of extra variables which, when combined with additional context, can be used to calculate the current state of the cluster and what is about to happen to it.

Table 10.4. Environment variables supplied with Clone notify actions

Variable	Description
OCF_RESKEY_CRM_meta_notify_type	Allowed values: <b>pre, post</b>
OCF_RESKEY_CRM_meta_notify_operation	Allowed values: <b>start, stop</b>
OCF_RESKEY_CRM_meta_notify_start_resource	Resources to be started
OCF_RESKEY_CRM_meta_notify_stop_resource	Resources to be stopped
OCF_RESKEY_CRM_meta_notify_active_resource	Resources that are running
OCF_RESKEY_CRM_meta_notify_inactive_resource	Resources that are not running
OCF_RESKEY_CRM_meta_notify_start_uname	Nodes on which resources will be started
OCF_RESKEY_CRM_meta_notify_stop_uname	Nodes on which resources will be stopped
OCF_RESKEY_CRM_meta_notify_active_uname	Nodes on which resources are running

The variables come in pairs, such as **OCF\_RESKEY\_CRM\_meta\_notify\_start\_resource** and **OCF\_RESKEY\_CRM\_meta\_notify\_start\_uname** and should be treated as an array of whitespace-separated elements.

**OCF\_RESKEY\_CRM\_meta\_notify\_inactive\_resource** is an exception as the matching **uname** variable does not exist since inactive resources are not running on any node.

Thus in order to indicate that **clone:0** will be started on **sles-1**, **clone:2** will be started on **sles-3**, and **clone:3** will be started on **sles-2**, the cluster would set

#### Example 10.6. Notification variables

```
OCF_RESKEY_CRM_meta_notify_start_resource="clone:0 clone:2 clone:3"
OCF_RESKEY_CRM_meta_notify_start_uname="sles-1 sles-3 sles-2"
```

### 10.2.7.2. Proper Interpretation of Notification Environment Variables

Pre-notification (stop):

- Active resources: **\$OCF\_RESKEY\_CRM\_meta\_notify\_active\_resource**
- Inactive resources: **\$OCF\_RESKEY\_CRM\_meta\_notify\_inactive\_resource**
- Resources to be started: **\$OCF\_RESKEY\_CRM\_meta\_notify\_start\_resource**
- Resources to be stopped: **\$OCF\_RESKEY\_CRM\_meta\_notify\_stop\_resource**

Post-notification (stop) / Pre-notification (start):

- Active resources
  - **\$OCF\_RESKEY\_CRM\_meta\_notify\_active\_resource**
  - minus **\$OCF\_RESKEY\_CRM\_meta\_notify\_stop\_resource**
- Inactive resources
  - **\$OCF\_RESKEY\_CRM\_meta\_notify\_inactive\_resource**
  - plus **\$OCF\_RESKEY\_CRM\_meta\_notify\_stop\_resource**
- Resources that were started: **\$OCF\_RESKEY\_CRM\_meta\_notify\_start\_resource**
- Resources that were stopped: **\$OCF\_RESKEY\_CRM\_meta\_notify\_stop\_resource**

Post-notification (start):

- Active resources:
  - **\$OCF\_RESKEY\_CRM\_meta\_notify\_active\_resource**
  - minus **\$OCF\_RESKEY\_CRM\_meta\_notify\_stop\_resource**
  - plus **\$OCF\_RESKEY\_CRM\_meta\_notify\_start\_resource**
- Inactive resources:
  - **\$OCF\_RESKEY\_CRM\_meta\_notify\_inactive\_resource**
  - plus **\$OCF\_RESKEY\_CRM\_meta\_notify\_stop\_resource**

- minus `$OCF_RESKEY_CRM_meta_notify_start_resource`
- Resources that were started: `$OCF_RESKEY_CRM_meta_notify_start_resource`
- Resources that were stopped: `$OCF_RESKEY_CRM_meta_notify_stop_resource`

### 10.3. Multi-state - Resources That Have Multiple Modes

Multi-state resources are a specialization of clone resources; please ensure you understand [Section 10.2, “Clones - Resources That Get Active on Multiple Hosts”](#) before continuing!

Multi-state resources allow the instances to be in one of two operating modes (called *roles*). The roles are called *master* and *slave*, but can mean whatever you wish them to mean. The only limitation is that when an instance is started, it must come up in the slave role.

#### 10.3.1. Multi-state Properties

Table 10.5. Properties of a Multi-State Resource

Field	Description
<code>id</code>	Your name for the multi-state resource

#### 10.3.2. Multi-state Options

Options inherited from *primitive* resources: `priority`, `target-role`, `is-managed`

Options inherited from *clone* resources: `clone-max`, `clone-node-max`, `notify`, `globally-unique`, `ordered`, `interleave`

Table 10.6. Multi-state-specific resource configuration options

Field	Default	Description
<code>master-max</code>	1	How many copies of the resource can be promoted to the <code>master</code> role
<code>master-node-max</code>	1	How many copies of the resource can be promoted to the <code>master</code> role on a single node

#### 10.3.3. Multi-state Instance Attributes

Multi-state resources have no instance attributes; however, any that are set here will be inherited by a master’s children.

#### 10.3.4. Multi-state Contents

Masters must contain exactly one primitive or group resource.



## Warning

You should never reference the name of a master's child. If you think you need to do this, you probably need to re-evaluate your design.

### 10.3.5. Monitoring Multi-State Resources

The usual monitor actions are insufficient to monitor a multi-state resource, because pacemaker needs to verify not only that the resource is active, but also that its actual role matches its intended one.

Define two monitoring actions: the usual one will cover the slave role, and an additional one with **role="master"** will cover the master role.

#### Example 10.7. Monitoring both states of a multi-state resource

```

<master id="myMasterRsc">
  <primitive id="myRsc" class="ocf" type="myApp" provider="myCorp">
    <operations>
      <op id="public-ip-slave-check" name="monitor" interval="60"/>
      <op id="public-ip-master-check" name="monitor" interval="61" role="Master"/>
    </operations>
  </primitive>
</master>

```



## Important

It is crucial that every monitor operation has a different interval! Pacemaker currently differentiates between operations only by resource and interval; so if (for example) a master/slave resource had the same monitor interval for both roles, Pacemaker would ignore the role when checking the status — which would cause unexpected return codes, and therefore unnecessary complications.

### 10.3.6. Multi-state Constraints

In most cases, 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 from those for primitive resources except that the master's **id** is used.

When considering multi-state resources in constraints, for most purposes it is sufficient to treat them as clones. The exception is that the **first-action** and/or **then-action** fields for ordering constraints may be set to **promote** or **demote** to constrain the master role, and colocation constraints may contain **rsc-role** and/or **with-rsc-role** fields.

Table 10.7. Additional colocation constraint options for multi-state resources

Field	Default	Description
<b>rsc-role</b>	Started	An additional attribute of colocation constraints that specifies the role that <b>rsc</b> must be in. Allowed values: <b>Started, Master, Slave</b> .
<b>with-rsc-role</b>	Started	An additional attribute of colocation constraints that specifies the role that <b>with-rsc</b> must be in. Allowed values: <b>Started, Master, Slave</b> .

## Example 10.8. Constraints involving multi-state resources

```
<constraints>
  <rsc_location id="db-prefers-node1" rsc="database" node="node1" score="500"/>
  <rsc_colocation id="backup-with-db-slave" rsc="backup"
    with-rsc="database" with-rsc-role="Slave"/>
  <rsc_colocation id="myapp-with-db-master" rsc="myApp"
    with-rsc="database" with-rsc-role="Master"/>
  <rsc_order id="start-db-before-backup" first="database" then="backup"/>
  <rsc_order id="promote-db-then-app" first="database" first-action="promote"
    then="myApp" then-action="start"/>
</constraints>
```

In the example above, **myApp** will wait until one of the database copies has been started and promoted to master before being started itself on the same node. Only if no copies can be promoted will **myApp** be prevented from being active. Additionally, the cluster will wait for **myApp** to be stopped before demoting the database.

Colocation of a primitive or group resource with a multi-state resource means that it can run on any machine with an active copy of the multi-state resource that has the specified role (**master** or **slave**). In the example above, the cluster will choose a location based on where database is running as a **master**, and if there are multiple **master** instances it will also factor in **myApp**'s own location preferences when deciding which location to choose.

Colocation with regular clones and other multi-state resources is also possible. In such cases, the set of allowed locations for the **rsc** clone is (after role filtering) limited to nodes on which the **with-rsc** multi-state resource is (or will be) in the specified role. Placement is then performed as normal.

### 10.3.6.1. Using Multi-state Resources in Colocation Sets

Table 10.8. Additional colocation set options relevant to multi-state resources

Field	Default	Description
<b>role</b>	Started	The role that <i>all members</i> of the set must be in. Allowed values: <b>Started, Master, Slave</b> .

In the following example **B**'s master must be located on the same node as **A**'s master. Additionally resources **C** and **D** must be located on the same node as **A**'s and **B**'s masters.

## Example 10.9. Colocate C and D with A's and B's master instances

```
<constraints>
  <rsc_colocation id="coloc-1" score="INFINITY" >
    <resource_set id="colocated-set-example-1" sequential="true" role="Master">
      <resource_ref id="A"/>
      <resource_ref id="B"/>
    </resource_set>
  </rsc_colocation>
```

```

</resource_set>
<resource_set id="colocated-set-example-2" sequential="true">
  <resource_ref id="C"/>
  <resource_ref id="D"/>
</resource_set>
</rsc_colocation>
</constraints>

```

### 10.3.6.2. Using Multi-state Resources in Ordering Sets

Table 10.9. Additional ordered set options relevant to multi-state resources

Field	Default	Description
<b>action</b>	value of <b>first-action</b>	An additional attribute of ordering constraint sets that specifies the action that applies to <i>all members</i> of the set. Allowed values: <b>start</b> , <b>stop</b> , <b>promote</b> , <b>demote</b> .

Example 10.10. Start C and D after first promoting A and B

```

<constraints>
  <rsc_order id="order-1" score="INFINITY" >
    <resource_set id="ordered-set-1" sequential="true" action="promote">
      <resource_ref id="A"/>
      <resource_ref id="B"/>
    </resource_set>
    <resource_set id="ordered-set-2" sequential="true" action="start">
      <resource_ref id="C"/>
      <resource_ref id="D"/>
    </resource_set>
  </rsc_order>
</constraints>

```

In the above example, **B** cannot be promoted to a master role until **A** has been promoted. Additionally, resources **C** and **D** must wait until **A** and **B** have been promoted before they can start.

### 10.3.7. Multi-state Stickiness

As with regular clones, multi-state resources are slightly sticky by default. See [Section 10.2.6, "Clone Stickiness"](#) for details.

### 10.3.8. Which Resource Instance is Promoted

During the start operation, most resource agents should call the **crm\_master** utility. This tool automatically detects both the resource and host and should be used to set a preference for being promoted. Based on this, **master-max**, and **master-node-max**, the instance(s) with the highest preference will be promoted.

An alternative is to create a location constraint that indicates which nodes are most preferred as masters.

Example 10.11. Explicitly preferring node1 to be promoted to master

```

<rsc_location id="master-location" rsc="myMasterRsc">
  <rule id="master-rule" score="100" role="Master">
    <expression id="master-exp" attribute="#uname" operation="eq" value="node1"/>
  </rule>

```

```
</rsc_location>
```

### 10.3.9. Requirements for Multi-state Resource Agents

Since multi-state resources are an extension of cloned resources, all the requirements for resource agents that support clones are also requirements for resource agents that support multi-state resources.

Additionally, multi-state resources require two extra actions, **demote** and **promote**, which are responsible for changing the state of the resource. Like **start** and **stop**, they should return **OCF\_SUCCESS** if they completed successfully or a relevant error code if they did not.

The states can mean whatever you wish, but when the resource is started, it must come up in the mode called **slave**. From there the cluster will decide which instances to promote to **master**.

In addition to the clone requirements for monitor actions, agents must also *accurately* report which state they are in. The cluster relies on the agent to report its status (including role) accurately and does not indicate to the agent what role it currently believes it to be in.

Table 10.10. Role implications of OCF return codes

Monitor Return Code	Description
OCF_NOT_RUNNING	Stopped
OCF_SUCCESS	Running (Slave)
OCF_RUNNING_MASTER	Running (Master)
OCF_FAILED_MASTER	Failed (Master)
Other	Failed (Slave)

#### 10.3.9.1. Multi-state Notifications

Like clones, supporting notifications requires the **notify** action to be implemented. If supported, the notify action will be passed a number of extra variables which, when combined with additional context, can be used to calculate the current state of the cluster and what is about to happen to it.

Table 10.11. Environment variables supplied with multi-state notify actions <sup>1</sup>

Variable	Description
OCF_RESKEY_CRM_meta_notify_type	Allowed values: <b>pre</b> , <b>post</b>
OCF_RESKEY_CRM_meta_notify_operation	Allowed values: <b>start</b> , <b>stop</b>
OCF_RESKEY_CRM_meta_notify_active_resource	Resources that are running
OCF_RESKEY_CRM_meta_notify_inactive_resource	Resources that are not running
<i>OCF_RESKEY_CRM_meta_notify_master_resource</i>	Resources that are running in <b>Master</b> mode
<i>OCF_RESKEY_CRM_meta_notify_slave_resource</i>	Resources that are running in <b>Slave</b> mode
OCF_RESKEY_CRM_meta_notify_start_resource	Resources to be started
OCF_RESKEY_CRM_meta_notify_stop_resource	Resources to be stopped
<i>OCF_RESKEY_CRM_meta_notify_promote_resource</i>	Resources to be promoted
<i>OCF_RESKEY_CRM_meta_notify_demote_resource</i>	Resources to be demoted
OCF_RESKEY_CRM_meta_notify_start_uname	Nodes on which resources will be started

Variable	Description
OCF_RESKEY_CRM_meta_notify_stop_uname	Nodes on which resources will be stopped
<i>OCF_RESKEY_CRM_meta_notify_promote_uname</i>	Nodes on which resources will be promoted
<i>OCF_RESKEY_CRM_meta_notify_demote_uname</i>	Nodes on which resources will be demoted
OCF_RESKEY_CRM_meta_notify_active_uname	Nodes on which resources are running
<i>OCF_RESKEY_CRM_meta_notify_master_uname</i>	Nodes on which resources are running in <b>Master</b> mode
<i>OCF_RESKEY_CRM_meta_notify_slave_uname</i>	Nodes on which resources are running in <b>Slave</b> mode

<sup>1</sup> Emphasized variables are specific to **Master** resources, and all behave in the same manner as described for Clone resources.

### 10.3.9.2. Proper Interpretation of Multi-state Notification Environment Variables

Pre-notification (demote):

- **Active** resources: **\$OCF\_RESKEY\_CRM\_meta\_notify\_active\_resource**
- **Master** resources: **\$OCF\_RESKEY\_CRM\_meta\_notify\_master\_resource**
- **Slave** resources: **\$OCF\_RESKEY\_CRM\_meta\_notify\_slave\_resource**
- Inactive resources: **\$OCF\_RESKEY\_CRM\_meta\_notify\_inactive\_resource**
- Resources to be started: **\$OCF\_RESKEY\_CRM\_meta\_notify\_start\_resource**
- Resources to be promoted: **\$OCF\_RESKEY\_CRM\_meta\_notify\_promote\_resource**
- Resources to be demoted: **\$OCF\_RESKEY\_CRM\_meta\_notify\_demote\_resource**
- Resources to be stopped: **\$OCF\_RESKEY\_CRM\_meta\_notify\_stop\_resource**

Post-notification (demote) / Pre-notification (stop):

- **Active** resources: **\$OCF\_RESKEY\_CRM\_meta\_notify\_active\_resource**
- **Master** resources:
  - **\$OCF\_RESKEY\_CRM\_meta\_notify\_master\_resource**
  - minus **\$OCF\_RESKEY\_CRM\_meta\_notify\_demote\_resource**
- **Slave** resources: **\$OCF\_RESKEY\_CRM\_meta\_notify\_slave\_resource**
- Inactive resources: **\$OCF\_RESKEY\_CRM\_meta\_notify\_inactive\_resource**
- Resources to be started: **\$OCF\_RESKEY\_CRM\_meta\_notify\_start\_resource**
- Resources to be promoted: **\$OCF\_RESKEY\_CRM\_meta\_notify\_promote\_resource**
- Resources to be demoted: **\$OCF\_RESKEY\_CRM\_meta\_notify\_demote\_resource**

- Resources to be stopped: **\$OCF\_RESKEY\_CRM\_meta\_notify\_stop\_resource**
- Resources that were demoted: **\$OCF\_RESKEY\_CRM\_meta\_notify\_demote\_resource**

### Post-notification (stop) / Pre-notification (start)

- **Active** resources:
  - **\$OCF\_RESKEY\_CRM\_meta\_notify\_active\_resource**
  - minus **\$OCF\_RESKEY\_CRM\_meta\_notify\_stop\_resource**
- **Master** resources:
  - **\$OCF\_RESKEY\_CRM\_meta\_notify\_master\_resource**
  - minus **\$OCF\_RESKEY\_CRM\_meta\_notify\_demote\_resource**
- **Slave** resources:
  - **\$OCF\_RESKEY\_CRM\_meta\_notify\_slave\_resource**
  - minus **\$OCF\_RESKEY\_CRM\_meta\_notify\_stop\_resource**
- Inactive resources:
  - **\$OCF\_RESKEY\_CRM\_meta\_notify\_inactive\_resource**
  - plus **\$OCF\_RESKEY\_CRM\_meta\_notify\_stop\_resource**
- Resources to be started: **\$OCF\_RESKEY\_CRM\_meta\_notify\_start\_resource**
- Resources to be promoted: **\$OCF\_RESKEY\_CRM\_meta\_notify\_promote\_resource**
- Resources to be demoted: **\$OCF\_RESKEY\_CRM\_meta\_notify\_demote\_resource**
- Resources to be stopped: **\$OCF\_RESKEY\_CRM\_meta\_notify\_stop\_resource**
- Resources that were demoted: **\$OCF\_RESKEY\_CRM\_meta\_notify\_demote\_resource**
- Resources that were stopped: **\$OCF\_RESKEY\_CRM\_meta\_notify\_stop\_resource**

### Post-notification (start) / Pre-notification (promote)

- **Active** resources:
  - **\$OCF\_RESKEY\_CRM\_meta\_notify\_active\_resource**
  - minus **\$OCF\_RESKEY\_CRM\_meta\_notify\_stop\_resource**
  - plus **\$OCF\_RESKEY\_CRM\_meta\_notify\_start\_resource**
- **Master** resources:
  - **\$OCF\_RESKEY\_CRM\_meta\_notify\_master\_resource**
  - minus **\$OCF\_RESKEY\_CRM\_meta\_notify\_demote\_resource**
- **Slave** resources:
  - **\$OCF\_RESKEY\_CRM\_meta\_notify\_slave\_resource**

- minus **\$OCF\_RESKEY\_CRM\_meta\_notify\_stop\_resource**
- plus **\$OCF\_RESKEY\_CRM\_meta\_notify\_start\_resource**
- Inactive resources:
  - **\$OCF\_RESKEY\_CRM\_meta\_notify\_inactive\_resource**
  - plus **\$OCF\_RESKEY\_CRM\_meta\_notify\_stop\_resource**
  - minus **\$OCF\_RESKEY\_CRM\_meta\_notify\_start\_resource**
- Resources to be started: **\$OCF\_RESKEY\_CRM\_meta\_notify\_start\_resource**
- Resources to be promoted: **\$OCF\_RESKEY\_CRM\_meta\_notify\_promote\_resource**
- Resources to be demoted: **\$OCF\_RESKEY\_CRM\_meta\_notify\_demote\_resource**
- Resources to be stopped: **\$OCF\_RESKEY\_CRM\_meta\_notify\_stop\_resource**
- Resources that were started: **\$OCF\_RESKEY\_CRM\_meta\_notify\_start\_resource**
- Resources that were demoted: **\$OCF\_RESKEY\_CRM\_meta\_notify\_demote\_resource**
- Resources that were stopped: **\$OCF\_RESKEY\_CRM\_meta\_notify\_stop\_resource**

#### Post-notification (promote)

- **Active** resources:
  - **\$OCF\_RESKEY\_CRM\_meta\_notify\_active\_resource**
  - minus **\$OCF\_RESKEY\_CRM\_meta\_notify\_stop\_resource**
  - plus **\$OCF\_RESKEY\_CRM\_meta\_notify\_start\_resource**
- **Master** resources:
  - **\$OCF\_RESKEY\_CRM\_meta\_notify\_master\_resource**
  - minus **\$OCF\_RESKEY\_CRM\_meta\_notify\_demote\_resource**
  - plus **\$OCF\_RESKEY\_CRM\_meta\_notify\_promote\_resource**
- **Slave** resources:
  - **\$OCF\_RESKEY\_CRM\_meta\_notify\_slave\_resource**
  - minus **\$OCF\_RESKEY\_CRM\_meta\_notify\_stop\_resource**
  - plus **\$OCF\_RESKEY\_CRM\_meta\_notify\_start\_resource**
  - minus **\$OCF\_RESKEY\_CRM\_meta\_notify\_promote\_resource**
- Inactive resources:
  - **\$OCF\_RESKEY\_CRM\_meta\_notify\_inactive\_resource**
  - plus **\$OCF\_RESKEY\_CRM\_meta\_notify\_stop\_resource**

- minus `$OCF_RESKEY_CRM_meta_notify_start_resource`
- Resources to be started: `$OCF_RESKEY_CRM_meta_notify_start_resource`
- Resources to be promoted: `$OCF_RESKEY_CRM_meta_notify_promote_resource`
- Resources to be demoted: `$OCF_RESKEY_CRM_meta_notify_demote_resource`
- Resources to be stopped: `$OCF_RESKEY_CRM_meta_notify_stop_resource`
- Resources that were started: `$OCF_RESKEY_CRM_meta_notify_start_resource`
- Resources that were promoted: `$OCF_RESKEY_CRM_meta_notify_promote_resource`
- Resources that were demoted: `$OCF_RESKEY_CRM_meta_notify_demote_resource`
- Resources that were stopped: `$OCF_RESKEY_CRM_meta_notify_stop_resource`

### 10.4. Bundles - Isolated Environments

Pacemaker supports a special syntax for launching a *container*<sup>2</sup> with any infrastructure it requires: the *bundle*.

Pacemaker bundles support *Docker*<sup>3</sup> (since version 1.1.17) and *rkt*<sup>4</sup> (since version 1.1.18) container technologies.<sup>4</sup>

#### Example 10.12. A bundle for a containerized web server

```
<bundle id="httpd-bundle">
  <docker image="pcmk:http" replicas="3"/>
  <network ip-range-start="192.168.122.131"
          host-netmask="24"
          host-interface="eth0">
    <port-mapping id="httpd-port" port="80"/>
  </network>
  <storage>
    <storage-mapping id="httpd-syslog"
                    source-dir="/dev/log"
                    target-dir="/dev/log"
                    options="rw"/>
    <storage-mapping id="httpd-root"
                    source-dir="/srv/html"
                    target-dir="/var/www/html"
                    options="rw"/>
    <storage-mapping id="httpd-logs"
                    source-dir-root="/var/log/pacemaker/bundles"
                    target-dir="/etc/httpd/logs"
                    options="rw"/>
  </storage>
  <primitive class="ocf" id="httpd" provider="heartbeat" type="apache"/>
</bundle>
```

<sup>2</sup> [https://en.wikipedia.org/wiki/Operating-system-level\\_virtualization](https://en.wikipedia.org/wiki/Operating-system-level_virtualization)

<sup>3</sup> <https://www.docker.com/>

<sup>4</sup> <https://coreos.com/rkt/>

<sup>4</sup> Docker is a trademark of Docker, Inc. No endorsement by or association with Docker, Inc. is implied.

## 10.4.1. Bundle Properties

Table 10.12. Properties of a Bundle

Field	Description
<b>id</b>	A unique name for the bundle (required)
<b>description</b>	Arbitrary text (not used by Pacemaker)

A bundle must contain exactly one **<docker>** or **<rkt>** element.

## 10.4.2. Docker Properties

Before configuring a Docker bundle in Pacemaker, the user must install Docker and supply a fully configured Docker image on every node allowed to run the bundle.

Pacemaker will create an implicit **ocf:heartbeat:docker** resource to manage a bundle's Docker container. The user must ensure that resource agent is installed on every node allowed to run the bundle.

Table 10.13. Properties of a Bundle's Docker Element

Field	Default	Description
<b>image</b>		Docker image tag (required)
<b>replicas</b>	Value of <b>masters</b> if that is positive, else 1	A positive integer specifying the number of container instances to launch
<b>replicas-per-host</b>	1	A positive integer specifying the number of container instances allowed to run on a single node
<b>masters</b>	0	A non-negative integer that, if positive, indicates that the containerized service should be treated as a multistate service, with this many replicas allowed to run the service in the master role
<b>network</b>		If specified, this will be passed to <b>docker run</b> as the <i>network setting</i> <sup>6</sup> for the Docker container.
<b>run-command</b>	<b>/usr/sbin/pacemaker_remotd</b> if bundle contains a <b>primitive</b> , otherwise none	This command will be run inside the container when launching it ("PID 1"). If the bundle contains a <b>primitive</b> , this command <i>must</i> start <b>pacemaker_remotd</b> (but could, for example, be a script that does other stuff, too).
<b>options</b>		Extra command-line options to pass to <b>docker run</b>

<sup>6</sup> <https://docs.docker.com/engine/reference/run/#network-settings>

### 10.4.3. rkt Properties

Before configuring a rkt bundle in Pacemaker, the user must install rkt and supply a fully configured container image on every node allowed to run the bundle.

Pacemaker will create an implicit `ocf:heartbeat:rkt` resource to manage a bundle's rkt container. The user must ensure that resource agent is installed on every node allowed to run the bundle.

Table 10.14. Properties of a Bundle's rkt Element

Field	Default	Description
<b>image</b>		Container image tag (required)
<b>replicas</b>	Value of <b>masters</b> if that is positive, else 1	A positive integer specifying the number of container instances to launch
<b>replicas-per-host</b>	1	A positive integer specifying the number of container instances allowed to run on a single node
<b>masters</b>	0	A non-negative integer that, if positive, indicates that the containerized service should be treated as a multistate service, with this many replicas allowed to run the service in the master role
<b>network</b>		If specified, this will be passed to <b>rkt run</b> as the network setting for the rkt container.
<b>run-command</b>	<code>/usr/sbin/pacemaker_remoted</code> if bundle contains a <b>primitive</b> , otherwise none	This command will be run inside the container when launching it ("PID 1"). If the bundle contains a <b>primitive</b> , this command <i>must</i> start <code>pacemaker_remoted</code> (but could, for example, be a script that does other stuff, too).
<b>options</b>		Extra command-line options to pass to <b>rkt run</b>

### 10.4.4. Bundle Network Properties

A bundle may optionally contain one `<network>` element.

Table 10.15. Properties of a Bundle's Network Element

Field	Default	Description
<b>ip-range-start</b>		If specified, Pacemaker will create an implicit <code>ocf:heartbeat:IPaddr2</code> resource for each container instance, starting with this IP address, using up to <b>replicas</b> sequential addresses. These addresses can be used from the host's network to reach the service inside the container, though it is not visible within the container itself. Only IPv4 addresses are currently supported.

Field	Default	Description
<b>host-netmask</b>	32	If <b>ip-range-start</b> is specified, the IP addresses are created with this CIDR netmask (as a number of bits).
<b>host-interface</b>		If <b>ip-range-start</b> is specified, the IP addresses are created on this host interface (by default, it will be determined from the IP address).
<b>control-port</b>	3121	If the bundle contains a <b>primitive</b> , the cluster will use this integer TCP port for communication with Pacemaker Remote inside the container. Changing this is useful when the container is unable to listen on the default port, for example, when the container uses the host's network rather than <b>ip-range-start</b> (in which case <b>replicas-per-host</b> must be 1), or when the bundle may run on a Pacemaker Remote node that is already listening on the default port. Any <code>PCMK_remote_port</code> environment variable set on the host or in the container is ignored for bundle connections.



### Note

If **ip-range-start** is used, Pacemaker will automatically ensure that `/etc/hosts` inside the containers has entries for each replica and its assigned IP. Replicas are named by the bundle id plus a dash and an integer counter starting with zero. For example, if a bundle named **httpd-bundle** has **replicas=2**, its containers will be named **httpd-bundle-0** and **httpd-bundle-1**.

Additionally, a `<network>` element may optionally contain one or more `<port-mapping>` elements.

Table 10.16. Properties of a Bundle's Port-Mapping Element

Field	Default	Description
<b>id</b>		A unique name for the port mapping (required)
<b>port</b>		If this is specified, connections to this TCP port number on the host network (on the container's assigned IP address, if <b>ip-range-start</b> is specified) will be forwarded to the container network. Exactly one of <b>port</b> or <b>range</b> must be specified in a <b>port-mapping</b> .
<b>internal-port</b>	value of <b>port</b>	If <b>port</b> and this are specified, connections to <b>port</b> on the host's network will be forwarded to this port on the container network.
<b>range</b>		If this is specified, connections to these TCP port numbers (expressed as <i>first_port-last_port</i> ) on the host network (on the container's assigned IP address, if <b>ip-range-start</b> is specified) will be forwarded to the same ports in the container network.

Field	Default	Description
		Exactly one of <b>port</b> or <b>range</b> must be specified in a <b>port-mapping</b> .



**Note**

If the bundle contains a **primitive**, Pacemaker will automatically map the **control-port**, so it is not necessary to specify that port in a **port-mapping**.

### 10.4.5. Bundle Storage Properties

A bundle may optionally contain one `<storage>` element. A `<storage>` element has no properties of its own, but may contain one or more `<storage-mapping>` elements.

Table 10.17. Properties of a Bundle's Storage-Mapping Element

Field	Default	Description
<b>id</b>		A unique name for the storage mapping (required)
<b>source-dir</b>		The absolute path on the host's filesystem that will be mapped into the container. Exactly one of <b>source-dir</b> and <b>source-dir-root</b> must be specified in a <b>storage-mapping</b> .
<b>source-dir-root</b>		The start of a path on the host's filesystem that will be mapped into the container, using a different subdirectory on the host for each container instance. The subdirectory will be named the same as the bundle host name, as described in <a href="#">the note for ip-range-start</a> . Exactly one of <b>source-dir</b> and <b>source-dir-root</b> must be specified in a <b>storage-mapping</b> .
<b>target-dir</b>		The path name within the container where the host storage will be mapped (required)
<b>options</b>		File system mount options to use when mapping the storage



**Note**

Pacemaker does not define the behavior if the source directory does not already exist on the host. However, it is expected that the container technology and/or its resource agent will create the source directory in that case.

**Note**

If the bundle contains a **primitive**, Pacemaker will automatically map the equivalent of **source-dir=/etc/pacemaker/authkey target-dir=/etc/pacemaker/authkey** and **source-dir-root=/var/log/pacemaker/bundles target-dir=/var/log** into the container, so it is not necessary to specify those paths in a **storage-mapping**.

**Important**

The **PCMK\_authkey\_location** environment variable must not be set to anything other than the default of **/etc/pacemaker/authkey** on any node in the cluster.

### 10.4.6. Bundle Primitive

A bundle may optionally contain one **<primitive>** resource (see [Section 5.1, “What is a Cluster Resource?”](#)). The primitive may have operations, instance attributes and meta-attributes defined, as usual.

If a bundle contains a primitive resource, the container image must include the Pacemaker Remote daemon, and at least one of **ip-range-start** or **control-port** must be configured in the bundle. Pacemaker will create an implicit **ocf:pacemaker:remote** resource for the connection, launch Pacemaker Remote within the container, and monitor and manage the primitive resource via Pacemaker Remote.

If the bundle has more than one container instance (replica), the primitive resource will function as an implicit clone (see [Section 10.2, “Clones - Resources That Get Active on Multiple Hosts”](#)) — a multistate clone if the bundle has **masters** greater than zero (see [Section 10.3, “Multi-state - Resources That Have Multiple Modes”](#)).

**Important**

Containers in bundles with a **primitive** must have an accessible networking environment, so that Pacemaker on the cluster nodes can contact Pacemaker Remote inside the container. For example, the Docker option **--net=none** should not be used with a **primitive**. The default (using a distinct network space inside the container) works in combination with **ip-range-start**. If the Docker option **--net=host** is used (making the container share the host's network space), a unique **control-port** should be specified for each bundle. Any firewall must allow access to the **control-port**.

### 10.4.7. Bundle Node Attributes

If the bundle has a **primitive**, the primitive's resource agent may want to set node attributes such as [master scores](#). However, with containers, it is not apparent which node should get the attribute.

If the container uses shared storage that is the same no matter which node the container is hosted on, then it is appropriate to use the master score on the bundle node itself.

On the other hand, if the container uses storage exported from the underlying host, then it may be more appropriate to use the master score on the underlying host.

Since this depends on the particular situation, the **container-attribute-target** resource meta-attribute allows the user to specify which approach to use. If it is set to **host**, then user-defined node attributes will be checked on the underlying host. If it is anything else, the local node (in this case the bundle node) is used as usual.

This only applies to user-defined attributes; the cluster will always check the local node for cluster-defined attributes such as **#uname**.

If **container-attribute-target** is **host**, the cluster will pass additional environment variables to the primitive's resource agent that allow it to set node attributes appropriately: **container\_attribute\_target** (identical to the meta-attribute value) and **physical\_host** (the name of the underlying host).



### Note

It is up to the resource agent to check for the additional variables and use them when setting node attributes.

### 10.4.8. Bundle Meta-Attributes

Any meta-attribute set on a bundle will be inherited by the bundle's primitive and any resources implicitly created by Pacemaker for the bundle.

This includes options such as **priority**, **target-role**, and **is-managed**. See [Section 5.4, "Resource Options"](#) for more information.

### 10.4.9. Limitations of Bundles

Restarting pacemaker while a bundle is unmanaged or the cluster is in maintenance mode may cause the bundle to fail.

Bundles may not be cloned or included in groups. This includes the bundle's primitive and any resources implicitly created by Pacemaker for the bundle.

Bundles do not have instance attributes, utilization attributes, or operations, though a bundle's primitive may have them.

A bundle with a primitive can run on a Pacemaker Remote node only if the bundle uses a distinct **control-port**.

# Reusing Parts of the Configuration

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Pacemaker provides multiple ways to simplify the configuration XML by reusing parts of it in multiple places.

Besides simplifying the XML, this also allows you to manipulate multiple configuration elements with a single reference.

## 11.1. Reusing Resource Definitions

If you want to create lots of resources with similar configurations, defining a *resource template* simplifies the task. Once defined, it can be referenced in primitives or in certain types of constraints.

### 11.1.1. Configuring Resources with Templates

The primitives referencing the template will inherit all meta-attributes, instance attributes, utilization attributes and operations defined in the template. And you can define specific attributes and operations for any of the primitives. If any of these are defined in both the template and the primitive, the values defined in the primitive will take precedence over the ones defined in the template.

Hence, resource templates help to reduce the amount of configuration work. If any changes are needed, they can be done to the template definition and will take effect globally in all resource definitions referencing that template.

Resource templates have a syntax similar to that of primitives.

#### Example 11.1. Resource template for a migratable Xen virtual machine

```
<template id="vm-template" class="ocf" provider="heartbeat" type="Xen">
  <meta_attributes id="vm-template-meta_attributes">
    <nvpair id="vm-template-meta_attributes-allow-migrate" name="allow-migrate"
value="true"/>
  </meta_attributes>
  <utilization id="vm-template-utilization">
    <nvpair id="vm-template-utilization-memory" name="memory" value="512"/>
  </utilization>
  <operations>
    <op id="vm-template-monitor-15s" interval="15s" name="monitor" timeout="60s"/>
    <op id="vm-template-start-0" interval="0" name="start" timeout="60s"/>
  </operations>
</template>
```

Once you define a resource template, you can use it in primitives by specifying the **template** property.

### Example 11.2. Xen primitive resource using a resource template

```
<primitive id="vm1" template="vm-template">
  <instance_attributes id="vm1-instance_attributes">
    <nvpair id="vm1-instance_attributes-name" name="name" value="vm1"/>
    <nvpair id="vm1-instance_attributes-xmfile" name="xmfile" value="/etc/xen/shared-vm/
vm1"/>
  </instance_attributes>
</primitive>
```

In the example above, the new primitive **vm1** will inherit everything from **vm-template**. For example, the equivalent of the above two examples would be:

### Example 11.3. Equivalent Xen primitive resource not using a resource template

```
<primitive id="vm1" class="ocf" provider="heartbeat" type="Xen">
  <meta_attributes id="vm-template-meta_attributes">
    <nvpair id="vm-template-meta_attributes-allow-migrate" name="allow-migrate"
value="true"/>
  </meta_attributes>
  <utilization id="vm-template-utilization">
    <nvpair id="vm-template-utilization-memory" name="memory" value="512"/>
  </utilization>
  <operations>
    <op id="vm-template-monitor-15s" interval="15s" name="monitor" timeout="60s"/>
    <op id="vm-template-start-0" interval="0" name="start" timeout="60s"/>
  </operations>
  <instance_attributes id="vm1-instance_attributes">
    <nvpair id="vm1-instance_attributes-name" name="name" value="vm1"/>
    <nvpair id="vm1-instance_attributes-xmfile" name="xmfile" value="/etc/xen/shared-vm/
vm1"/>
  </instance_attributes>
</primitive>
```

If you want to overwrite some attributes or operations, add them to the particular primitive's definition.

### Example 11.4. Xen resource overriding template values

```
<primitive id="vm2" template="vm-template">
  <meta_attributes id="vm2-meta_attributes">
    <nvpair id="vm2-meta_attributes-allow-migrate" name="allow-migrate" value="false"/>
  </meta_attributes>
  <utilization id="vm2-utilization">
    <nvpair id="vm2-utilization-memory" name="memory" value="1024"/>
  </utilization>
  <instance_attributes id="vm2-instance_attributes">
    <nvpair id="vm2-instance_attributes-name" name="name" value="vm2"/>
    <nvpair id="vm2-instance_attributes-xmfile" name="xmfile" value="/etc/xen/shared-vm/
vm2"/>
  </instance_attributes>
  <operations>
    <op id="vm2-monitor-30s" interval="30s" name="monitor" timeout="120s"/>
    <op id="vm2-stop-0" interval="0" name="stop" timeout="60s"/>
  </operations>
</primitive>
```

In the example above, the new primitive **vm2** has special attribute values. Its **monitor** operation has a longer **timeout** and **interval**, and the primitive has an additional **stop** operation.

To see the resulting definition of a resource, run:

```
# crm_resource --query-xml --resource vm2
```

To see the raw definition of a resource in the CIB, run:

```
# crm_resource --query-xml-raw --resource vm2
```

### 11.1.2. Using Templates in Constraints

A resource template can be referenced in the following types of constraints:

- **order** constraints (see [Section 6.3, “Specifying the Order in which Resources Should Start/Stop”](#))
- **colocation** constraints (see [Section 6.4, “Placing Resources Relative to other Resources”](#))
- **rsc\_ticket** constraints (for multi-site clusters as described in [Section 15.3, “Configuring Ticket Dependencies”](#))

Resource templates referenced in constraints stand for all primitives which are derived from that template. This means, the constraint applies to all primitive resources referencing the resource template. Referencing resource templates in constraints is an alternative to resource sets and can simplify the cluster configuration considerably.

For example, given the example templates earlier in this section:

```
<rsc_colocation id="vm-template-colo-base-rsc" rsc="vm-template" rsc-role="Started" with-
rsc="base-rsc" score="INFINITY"/>
```

would colocate all VMs with **base-rsc** and is the equivalent of the following constraint configuration:

```
<rsc_colocation id="vm-colo-base-rsc" score="INFINITY">
  <resource_set id="vm-colo-base-rsc-0" sequential="false" role="Started">
    <resource_ref id="vm1"/>
    <resource_ref id="vm2"/>
  </resource_set>
  <resource_set id="vm-colo-base-rsc-1">
    <resource_ref id="base-rsc"/>
  </resource_set>
</rsc_colocation>
```



#### Note

In a colocation constraint, only one template may be referenced from either **rsc** or **with-rsc**; the other reference must be a regular resource.

### 11.1.3. Using Templates in Resource Sets

Resource templates can also be referenced in resource sets.

For example, given the example templates earlier in this section, then:

```
<rsc_order id="order1" score="INFINITY">
  <resource_set id="order1-0">
    <resource_ref id="base-rsc"/>
    <resource_ref id="vm-template"/>
    <resource_ref id="top-rsc"/>
  </resource_set>
</rsc_order>
```

is the equivalent of the following constraint using a sequential resource set:

```
<rsc_order id="order1" score="INFINITY">
  <resource_set id="order1-0">
    <resource_ref id="base-rsc"/>
    <resource_ref id="vm1"/>
    <resource_ref id="vm2"/>
    <resource_ref id="top-rsc"/>
  </resource_set>
</rsc_order>
```

Or, if the resources referencing the template can run in parallel, then:

```
<rsc_order id="order2" score="INFINITY">
  <resource_set id="order2-0">
    <resource_ref id="base-rsc"/>
  </resource_set>
  <resource_set id="order2-1" sequential="false">
    <resource_ref id="vm-template"/>
  </resource_set>
  <resource_set id="order2-2">
    <resource_ref id="top-rsc"/>
  </resource_set>
</rsc_order>
```

is the equivalent of the following constraint configuration:

```
<rsc_order id="order2" score="INFINITY">
  <resource_set id="order2-0">
    <resource_ref id="base-rsc"/>
  </resource_set>
  <resource_set id="order2-1" sequential="false">
    <resource_ref id="vm1"/>
    <resource_ref id="vm2"/>
  </resource_set>
  <resource_set id="order2-2">
    <resource_ref id="top-rsc"/>
  </resource_set>
</rsc_order>
```

## 11.2. Reusing Rules, Options and Sets of Operations

Sometimes a number of constraints need to use the same set of rules, and resources need to set the same options and parameters. To simplify this situation, you can refer to an existing object using an **id-ref** instead of an **id**.

So if for one resource you have

```
<rsc_location id="WebServer-connectivity" rsc="Webserver">
  <rule id="ping-prefer-rule" score-attribute="pingd" >
    <expression id="ping-prefer" attribute="pingd" operation="defined"/>
```

```
</rule>
</rsc_location>
```

Then instead of duplicating the rule for all your other resources, you can instead specify:

#### Example 11.5. Referencing rules from other constraints

```
<rsc_location id="WebDB-connectivity" rsc="WebDB">
  <rule id-ref="ping-prefer-rule"/>
</rsc_location>
```



### Important

The cluster will insist that the **rule** exists somewhere. Attempting to add a reference to a non-existing rule will cause a validation failure, as will attempting to remove a **rule** that is referenced elsewhere.

The same principle applies for **meta\_attributes** and **instance\_attributes** as illustrated in the example below:

#### Example 11.6. Referencing attributes, options, and operations from other resources

```
<primitive id="mySpecialRsc" class="ocf" type="Special" provider="me">
  <instance_attributes id="mySpecialRsc-attrs" score="1" >
    <nvpair id="default-interface" name="interface" value="eth0"/>
    <nvpair id="default-port" name="port" value="9999"/>
  </instance_attributes>
  <meta_attributes id="mySpecialRsc-options">
    <nvpair id="failure-timeout" name="failure-timeout" value="5m"/>
    <nvpair id="migration-threshold" name="migration-threshold" value="1"/>
    <nvpair id="stickiness" name="resource-stickiness" value="0"/>
  </meta_attributes>
  <operations id="health-checks">
    <op id="health-check" name="monitor" interval="60s"/>
    <op id="health-check" name="monitor" interval="30min"/>
  </operations>
</primitive>
<primitive id="myOther1Rsc" class="ocf" type="Other" provider="me">
  <instance_attributes id-ref="mySpecialRsc-attrs"/>
  <meta_attributes id-ref="mySpecialRsc-options"/>
  <operations id-ref="health-checks"/>
</primitive>
```

## 11.3. Tagging Configuration Elements

Pacemaker allows you to *tag* any configuration element that has an XML ID.

The main purpose of tagging is to support higher-level user interface tools; Pacemaker itself only uses tags within constraints. Therefore, what you can do with tags mostly depends on the tools you use.

### 11.3.1. Configuring Tags

A tag is simply a named list of XML IDs.

### Example 11.7. Tag referencing three resources

```
<tags>
  <tag id="all-vm">
    <obj_ref id="vm1"/>
    <obj_ref id="vm2"/>
    <obj_ref id="vm3"/>
  </tag>
</tags>
```

What you can do with this new tag depends on what your higher-level tools support. For example, a tool might allow you to enable or disable all of the tagged resources at once, or show the status of just the tagged resources.

A single configuration element can be listed in any number of tags.

### 11.3.2. Using Tags in Constraints and Resource Sets

Pacemaker itself only uses tags in constraints. If you supply a tag name instead of a resource name in any constraint, the constraint will apply to all resources listed in that tag.

### Example 11.8. Constraint using a tag

```
<rsc_order id="order1" first="storage" then="all-vm" kind="Mandatory" />
```

In the example above, assuming the **all-vm** tag is defined as in the previous example, the constraint will behave the same as:

### Example 11.9. Equivalent constraints without tags

```
<rsc_order id="order1-1" first="storage" then="vm1" kind="Mandatory" />
<rsc_order id="order1-2" first="storage" then="vm2" kind="Mandatory" />
<rsc_order id="order1-3" first="storage" then="vm2" kind="Mandatory" />
```

A tag may be used directly in the constraint, or indirectly by being listed in a *resource set* used in the constraint. When used in a resource set, an expanded tag will honor the set's **sequential** property.

# Utilization and Placement Strategy

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Pacemaker decides where to place a resource according to the resource allocation scores on every node. The resource will be allocated to the node where the resource has the highest score.

If the resource allocation scores on all the nodes are equal, by the default placement strategy, Pacemaker will choose a node with the least number of allocated resources for balancing the load. If the number of resources on each node is equal, the first eligible node listed in the CIB will be chosen to run the resource.

Often, in real-world situations, different resources use significantly different proportions of a node's capacities (memory, I/O, etc.). We cannot balance the load ideally just according to the number of resources allocated to a node. Besides, if resources are placed such that their combined requirements exceed the provided capacity, they may fail to start completely or run with degraded performance.

To take these factors into account, Pacemaker allows you to configure:

1. The capacity a certain node provides.
2. The capacity a certain resource requires.
3. An overall strategy for placement of resources.

## 12.1. Utilization attributes

To configure the capacity that a node provides or a resource requires, you can use *utilization attributes* in **node** and **resource** objects. You can name utilization attributes according to your preferences and define as many name/value pairs as your configuration needs. However, the attributes' values must be integers.

Example 12.1. Specifying CPU and RAM capacities of two nodes

```
<node id="node1" type="normal" uname="node1">
  <utilization id="node1-utilization">
    <nvpair id="node1-utilization-cpu" name="cpu" value="2"/>
    <nvpair id="node1-utilization-memory" name="memory" value="2048"/>
  </utilization>
</node>
<node id="node2" type="normal" uname="node2">
  <utilization id="node2-utilization">
    <nvpair id="node2-utilization-cpu" name="cpu" value="4"/>
    <nvpair id="node2-utilization-memory" name="memory" value="4096"/>
  </utilization>
</node>
```

## Example 12.2. Specifying CPU and RAM consumed by several resources

```

<primitive id="rsc-small" class="ocf" provider="pacemaker" type="Dummy">
  <utilization id="rsc-small-utilization">
    <nvpair id="rsc-small-utilization-cpu" name="cpu" value="1"/>
    <nvpair id="rsc-small-utilization-memory" name="memory" value="1024"/>
  </utilization>
</primitive>
<primitive id="rsc-medium" class="ocf" provider="pacemaker" type="Dummy">
  <utilization id="rsc-medium-utilization">
    <nvpair id="rsc-medium-utilization-cpu" name="cpu" value="2"/>
    <nvpair id="rsc-medium-utilization-memory" name="memory" value="2048"/>
  </utilization>
</primitive>
<primitive id="rsc-large" class="ocf" provider="pacemaker" type="Dummy">
  <utilization id="rsc-large-utilization">
    <nvpair id="rsc-large-utilization-cpu" name="cpu" value="3"/>
    <nvpair id="rsc-large-utilization-memory" name="memory" value="3072"/>
  </utilization>
</primitive>

```

A node is considered eligible for a resource if it has sufficient free capacity to satisfy the resource's requirements. The nature of the required or provided capacities is completely irrelevant to Pacemaker — it just makes sure that all capacity requirements of a resource are satisfied before placing a resource to a node.

## 12.2. Placement Strategy

After you have configured the capacities your nodes provide and the capacities your resources require, you need to set the **placement-strategy** in the global cluster options, otherwise the capacity configurations have *no effect*.

Four values are available for the **placement-strategy**:

### default

Utilization values are not taken into account at all. Resources are allocated according to allocation scores. If scores are equal, resources are evenly distributed across nodes.

### utilization

Utilization values are taken into account *only* when deciding whether a node is considered eligible (i.e. whether it has sufficient free capacity to satisfy the resource's requirements). Load-balancing is still done based on the number of resources allocated to a node.

### balanced

Utilization values are taken into account when deciding whether a node is eligible to serve a resource *and* when load-balancing, so an attempt is made to spread the resources in a way that optimizes resource performance.

### minimal

Utilization values are taken into account *only* when deciding whether a node is eligible to serve a resource. For load-balancing, an attempt is made to concentrate the resources on as few nodes as possible, thereby enabling possible power savings on the remaining nodes.

Set **placement-strategy** with **crm\_attribute**:

```
# crm_attribute --name placement-strategy --update balanced
```

---

Now Pacemaker will ensure the load from your resources will be distributed evenly throughout the cluster, without the need for convoluted sets of colocation constraints.

## 12.3. Allocation Details

### 12.3.1. Which node is preferred to get consumed first when allocating resources?

- The node with the highest node weight gets consumed first. Node weight is a score maintained by the cluster to represent node health.
- If multiple nodes have the same node weight:
  - If **placement-strategy** is **default** or **utilization**, the node that has the least number of allocated resources gets consumed first.
    - If their numbers of allocated resources are equal, the first eligible node listed in the CIB gets consumed first.
  - If **placement-strategy** is **balanced**, the node that has the most free capacity gets consumed first.
    - If the free capacities of the nodes are equal, the node that has the least number of allocated resources gets consumed first.
      - If their numbers of allocated resources are equal, the first eligible node listed in the CIB gets consumed first.
  - If **placement-strategy** is **minimal**, the first eligible node listed in the CIB gets consumed first.

### 12.3.2. Which node has more free capacity?

If only one type of utilization attribute has been defined, free capacity is a simple numeric comparison.

If multiple types of utilization attributes have been defined, then the node that is numerically highest in the the most attribute types has the most free capacity. For example:

- If **nodeA** has more free **cpus**, and **nodeB** has more free **memory**, then their free capacities are equal.
- If **nodeA** has more free **cpus**, while **nodeB** has more free **memory** and **storage**, then **nodeB** has more free capacity.

### 12.3.3. Which resource is preferred to be assigned first?

- The resource that has the highest **priority** (see [Section 5.4, "Resource Options"](#)) gets allocated first.
- If their priorities are equal, check whether they are already running. The resource that has the highest score on the node where it's running gets allocated first, to prevent resource shuffling.
- If the scores above are equal or the resources are not running, the resource has the highest score on the preferred node gets allocated first.
- If the scores above are equal, the first runnable resource listed in the CIB gets allocated first.

### 12.4. Limitations and Workarounds

The type of problem Pacemaker is dealing with here is known as the *knapsack problem*<sup>1</sup> and falls into the *NP-complete*<sup>2</sup> category of computer science problems — a fancy way of saying "it takes a really long time to solve".

Clearly in a HA cluster, it's not acceptable to spend minutes, let alone hours or days, finding an optimal solution while services remain unavailable.

So instead of trying to solve the problem completely, Pacemaker uses a *best effort* algorithm for determining which node should host a particular service. This means it arrives at a solution much faster than traditional linear programming algorithms, but by doing so at the price of leaving some services stopped.

In the contrived example at the start of this section:

- **rsc-small** would be allocated to **node1**
- **rsc-medium** would be allocated to **node2**
- **rsc-large** would remain inactive

Which is not ideal.

There are various approaches to dealing with the limitations of pacemaker's placement strategy:

Ensure you have sufficient physical capacity.

It might sound obvious, but if the physical capacity of your nodes is (close to) maxed out by the cluster under normal conditions, then failover isn't going to go well. Even without the utilization feature, you'll start hitting timeouts and getting secondary failures.

Build some buffer into the capabilities advertised by the nodes.

Advertise slightly more resources than we physically have, on the (usually valid) assumption that a resource will not use 100% of the configured amount of CPU, memory and so forth *all* the time. This practice is sometimes called *overcommit*.

Specify resource priorities.

If the cluster is going to sacrifice services, it should be the ones you care about (comparatively) the least. Ensure that resource priorities are properly set so that your most important resources are scheduled first.

---

<sup>1</sup> [http://en.wikipedia.org/wiki/Knapsack\\_problem](http://en.wikipedia.org/wiki/Knapsack_problem)

<sup>2</sup> <http://en.wikipedia.org/wiki/NP-complete>

# STONITH

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### 13.1. What Is STONITH?

STONITH (an acronym for "Shoot The Other Node In The Head"), also called *fencing*, protects your data from being corrupted by rogue nodes or concurrent access.

Just because a node is unresponsive, this doesn't mean it isn't accessing your data. The only way to be 100% sure that your data is safe, is to use 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.

### 13.2. What STONITH Device Should You Use?

It is crucial that the STONITH device can allow the cluster to differentiate between a node failure and a network one.

The biggest mistake people make in choosing a STONITH device is to use a remote power switch (such as many on-board IPMI controllers) that shares power with the node it controls. In such cases, the cluster cannot be sure if the node is really offline, or active and suffering from a network fault.

Likewise, any device that relies on the machine being active (such as SSH-based "devices" used during testing) are inappropriate.

### 13.3. Special Treatment of STONITH Resources

STONITH resources are somewhat special in Pacemaker.

STONITH may be initiated by pacemaker or by other parts of the cluster (such as resources like DRBD or DLM). To accommodate this, pacemaker does not require the STONITH resource to be in the *started* state in order to be used, thus allowing reliable use of STONITH devices in such a case.

**Note**

In pacemaker versions 1.1.9 and earlier, this feature either did not exist or did not work well. Only "running" STONITH resources could be used by Pacemaker for fencing, and if another component tried to fence a node while Pacemaker was moving STONITH resources, the fencing could fail.

All nodes have access to STONITH devices' definitions and instantiate them on-the-fly when needed, but preference is given to *verified* instances, which are the ones that are *started* according to the cluster's knowledge.

In the case of a cluster split, the partition with a verified instance will have a slight advantage, because the STONITH daemon in the other partition will have to hear from all its current peers before choosing a node to perform the fencing.

Fencing resources do work the same as regular resources in some respects:

- **target-role** can be used to enable or disable the resource
- Location constraints can be used to prevent a specific node from using the resource

**Important**

Currently there is a limitation that fencing resources may only have one set of meta-attributes and one set of instance attributes. This can be revisited if it becomes a significant limitation for people.

See the table below or run **man stonithd** to see special instance attributes that may be set for any fencing resource, regardless of fence agent.

Table 13.1. Additional Properties of Fencing Resources

Field	Type	Default	Description
<b>stonith-timeout</b>	NA	NA	Older versions used this to override the default period to wait for a STONITH (reboot, on, off) action to complete for this device. It has been replaced by the <b>pcmk_reboot_timeout</b> and <b>pcmk_off_timeout</b> properties.
<b>provides</b>	string		Any special capability provided by the fence device. Currently, only one such capability is meaningful: <b>unfencing</b> (see <a href="#">Section 13.4, "Unfencing"</a> ).
<b>pcmk_host_map</b>	string		A mapping of host names to ports numbers for devices that do not support host names. Example: <b>node1:1;node2:2,3</b> tells the cluster to use port 1 for <b>node1</b> and ports 2 and 3 for <b>node2</b> .

Field	Type	Default	Description
<b>pcmk_host_list</b>	string		A list of machines controlled by this device (optional unless <b>pcmk_host_check</b> is <b>static-list</b> ).
<b>pcmk_host_check</b>	string	dynamic-list	How to determine which machines are controlled by the device. Allowed values: <ul style="list-style-type: none"> <li>• <b>dynamic-list</b>: query the device</li> <li>• <b>static-list</b>: check the <b>pcmk_host_list</b> attribute</li> <li>• <b>none</b>: assume every device can fence every machine</li> </ul>
<b>pcmk_delay_max</b>	time	0s	Enable a random delay of up to the time specified before executing stonith actions. This is sometimes used in two-node clusters to ensure that the nodes don't fence each other at the same time. The overall delay introduced by pacemaker is derived from this random delay value adding a static delay so that the sum is kept below the maximum delay.
<b>pcmk_delay_base</b>	time	0s	Enable a static delay before executing stonith actions. This can be used e.g. in two-node clusters to ensure that the nodes don't fence each other, by having separate fencing resources with different values. The node that is fenced with the shorter delay will lose a fencing race. The overall delay introduced by pacemaker is derived from this value plus a random delay such that the sum is kept below the maximum delay.
<b>pcmk_action_limit</b>	integer	1	The maximum number of actions that can be performed in parallel on this device, if the cluster option <b>concurrent-fencing</b> is <b>true</b> . -1 is unlimited. ( <i>since 1.1.15</i> )
<b>pcmk_host_argument</b>	string	port	<i>Advanced use only.</i> Which parameter should be supplied to the resource agent to identify the node to be fenced. Some devices do not support the standard <b>port</b> parameter or may provide additional ones. Use this to specify an alternate, device-specific parameter. A value of <b>none</b> tells the cluster not to supply any additional parameters.

Field	Type	Default	Description
<b>pcmk_reboot_action</b>	string	reboot	<i>Advanced use only.</i> The command to send to the resource agent in order to reboot a node. Some devices do not support the standard commands or may provide additional ones. Use this to specify an alternate, device-specific command.
<b>pcmk_reboot_timeout</b>	time	60s	<i>Advanced use only.</i> Specify an alternate timeout to use for <b>reboot</b> actions instead of the value of <b>stonith-timeout</b> . Some devices need much more or less time to complete than normal. Use this to specify an alternate, device-specific timeout.
<b>pcmk_reboot_retries</b>	integer	2	<i>Advanced use only.</i> The maximum number of times to retry the <b>reboot</b> command within the timeout period. Some devices do not support multiple connections, and 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 before giving up.
<b>pcmk_off_action</b>	string	off	<i>Advanced use only.</i> The command to send to the resource agent in order to shut down a node. Some devices do not support the standard commands or may provide additional ones. Use this to specify an alternate, device-specific command.
<b>pcmk_off_timeout</b>	time	60s	<i>Advanced use only.</i> Specify an alternate timeout to use for <b>off</b> actions instead of the value of <b>stonith-timeout</b> . Some devices need much more or less time to complete than normal. Use this to specify an alternate, device-specific timeout.
<b>pcmk_off_retries</b>	integer	2	<i>Advanced use only.</i> The maximum number of times to retry the <b>off</b> command within the timeout period. Some devices do not support multiple connections, and 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 before giving up.
<b>pcmk_list_action</b>	string	list	<i>Advanced use only.</i> The command to send to the resource agent in order to list nodes. Some devices do not support the standard commands or may provide additional ones. Use this to specify an alternate, device-specific command.
<b>pcmk_list_timeout</b>	time	60s	<i>Advanced use only.</i> Specify an alternate timeout to use for <b>list</b> actions instead of the

Field	Type	Default	Description
			value of <b>stonith-timeout</b> . Some devices need much more or less time to complete than normal. Use this to specify an alternate, device-specific timeout.
<b>pcmk_list_retries</b>	integer	2	<i>Advanced use only.</i> The maximum number of times to retry the <b>list</b> command within the timeout period. Some devices do not support multiple connections, and 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 before giving up.
<b>pcmk_monitor_action</b>	string	monitor	<i>Advanced use only.</i> The command to send to the resource agent in order to report extended status. Some devices do not support the standard commands or may provide additional ones. Use this to specify an alternate, device-specific command.
<b>pcmk_monitor_timeout</b>	time	60s	<i>Advanced use only.</i> Specify an alternate timeout to use for <b>monitor</b> actions instead of the value of <b>stonith-timeout</b> . Some devices need much more or less time to complete than normal. Use this to specify an alternate, device-specific timeout.
<b>pcmk_monitor_retries</b>	integer	2	<i>Advanced use only.</i> The maximum number of times to retry the <b>monitor</b> command within the timeout period. Some devices do not support multiple connections, and 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 before giving up.
<b>pcmk_status_action</b>	string	status	<i>Advanced use only.</i> The command to send to the resource agent in order to report status. Some devices do not support the standard commands or may provide additional ones. Use this to specify an alternate, device-specific command.
<b>pcmk_status_timeout</b>	time	60s	<i>Advanced use only.</i> Specify an alternate timeout to use for <b>status</b> actions instead of the value of <b>stonith-timeout</b> . Some devices need much more or less time to complete than normal. Use this to specify an alternate, device-specific timeout.
<b>pcmk_status_retries</b>	integer	2	<i>Advanced use only.</i> The maximum number of times to retry the <b>status</b> command within the timeout period. Some devices do not support multiple connections, and operations may

Field	Type	Default	Description
			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 before giving up.

### 13.4. Unfencing

Most fence devices cut the power to the target. By contrast, fence devices that perform *fabric fencing* cut off a node's access to some critical resource, such as a shared disk or a network switch.

With fabric fencing, it is expected that the cluster will fence the node, and then a system administrator must manually investigate what went wrong, correct any issues found, then reboot (or restart the cluster services on) the node.

Once the node reboots and rejoins the cluster, some fabric fencing devices require that an explicit command to restore the node's access to the critical resource. This capability is called *unfencing* and is typically implemented as the fence agent's **on** command.

If any cluster resource has **requires** set to **unfencing**, then that resource will not be probed or started on a node until that node has been unfenced.

### 13.5. Configuring STONITH



#### Note

Higher-level configuration shells include functionality to simplify the process below, particularly the step for deciding which parameters are required. However since this document deals only with core components, you should refer to the STONITH section of the [Clusters from Scratch](#)<sup>1</sup> guide for those details.

1. Find the correct driver:

```
# stonith_admin --list-installed
```

2. Find the required parameters associated with the device (replacing \$AGENT\_NAME with the name obtained from the previous step):

```
# stonith_admin --metadata --agent $AGENT_NAME
```

3. Create a file called **stonith.xml** containing a primitive resource with a class of **stonith**, a type equal to the agent name obtained earlier, and a parameter for each of the values returned in the previous step.

<sup>1</sup> <http://www.clusterlabs.org/doc/>

4. If the device does not know how to fence nodes based on their uname, you may also need to set the special **pcmk\_host\_map** parameter. See **man stonithd** for details.
5. If the device does not support the **list** command, you may also need to set the special **pcmk\_host\_list** and/or **pcmk\_host\_check** parameters. See **man stonithd** for details.
6. If the device does not expect the victim to be specified with the **port** parameter, you may also need to set the special **pcmk\_host\_argument** parameter. See **man stonithd** for details.
7. Upload it into the CIB using **cibadmin**:

```
# cibadmin -C -o resources --xml-file stonith.xml
```

8. Set **stonith-enabled** to true:

```
# crm_attribute -t crm_config -n stonith-enabled -v true
```

9. Once the stonith resource is running, you can test it by executing the following (although you might want to stop the cluster on that machine first):

```
# stonith_admin --reboot nodename
```

### 13.5.1. Example STONITH Configuration

Assume we have an chassis containing four nodes and an IPMI device active on 192.0.2.1. We would choose the **fence\_ipmilan** driver, and obtain the following list of parameters:

#### Example 13.1. Obtaining a list of STONITH Parameters

```
# stonith_admin --metadata -a fence_ipmilan
```

```
<resource-agent name="fence_ipmilan" shortdesc="Fence agent for IPMI over LAN">
  <symlink name="fence_ilo3" shortdesc="Fence agent for HP iLO3"/>
  <symlink name="fence_ilo4" shortdesc="Fence agent for HP iLO4"/>
  <symlink name="fence_idrac" shortdesc="Fence agent for Dell iDRAC"/>
  <symlink name="fence_imm" shortdesc="Fence agent for IBM Integrated Management Module"/>
  <longdesc>
  </longdesc>
  <vendor-url>
  </vendor-url>
  <parameters>
    <parameter name="auth" unique="0" required="0">
      <getopt mixed="-A"/>
      <content type="string"/>
      <shortdesc>
      </shortdesc>
    </parameter>
    <parameter name="ipaddr" unique="0" required="1">
      <getopt mixed="-a"/>
      <content type="string"/>
      <shortdesc>
      </shortdesc>
    </parameter>
    <parameter name="passwd" unique="0" required="0">
      <getopt mixed="-p"/>
      <content type="string"/>
      <shortdesc>
      </shortdesc>
  </parameters>
</resource-agent>
```

```
</parameter>
<parameter name="passwd_script" unique="0" required="0">
  <getopt mixed="-S"/>
  <content type="string"/>
  <shortdesc>
</shortdesc>
</parameter>
<parameter name="lanplus" unique="0" required="0">
  <getopt mixed="-P"/>
  <content type="boolean"/>
  <shortdesc>
</shortdesc>
</parameter>
<parameter name="login" unique="0" required="0">
  <getopt mixed="-l"/>
  <content type="string"/>
  <shortdesc>
</shortdesc>
</parameter>
<parameter name="action" unique="0" required="0">
  <getopt mixed="-o"/>
  <content type="string" default="reboot"/>
  <shortdesc>
</shortdesc>
</parameter>
<parameter name="timeout" unique="0" required="0">
  <getopt mixed="-t"/>
  <content type="string"/>
  <shortdesc>
</shortdesc>
</parameter>
<parameter name="cipher" unique="0" required="0">
  <getopt mixed="-C"/>
  <content type="string"/>
  <shortdesc>
</shortdesc>
</parameter>
<parameter name="method" unique="0" required="0">
  <getopt mixed="-M"/>
  <content type="string" default="onoff"/>
  <shortdesc>
</shortdesc>
</parameter>
<parameter name="power_wait" unique="0" required="0">
  <getopt mixed="-T"/>
  <content type="string" default="2"/>
  <shortdesc>
</shortdesc>
</parameter>
<parameter name="delay" unique="0" required="0">
  <getopt mixed="-f"/>
  <content type="string"/>
  <shortdesc>
</shortdesc>
</parameter>
<parameter name="privlvl" unique="0" required="0">
  <getopt mixed="-L"/>
  <content type="string"/>
  <shortdesc>
</shortdesc>
</parameter>
<parameter name="verbose" unique="0" required="0">
  <getopt mixed="-v"/>
  <content type="boolean"/>
  <shortdesc>
</shortdesc>
</parameter>
```

```

</parameters>
<actions>
  <action name="on"/>
  <action name="off"/>
  <action name="reboot"/>
  <action name="status"/>
  <action name="diag"/>
  <action name="list"/>
  <action name="monitor"/>
  <action name="metadata"/>
  <action name="stop" timeout="20s"/>
  <action name="start" timeout="20s"/>
</actions>
</resource-agent>

```

Based on that, we would create a STONITH resource fragment that might look like this:

#### Example 13.2. An IPMI-based STONITH Resource

```

<primitive id="Fencing" class="stonith" type="fence_ipmilan" >
  <instance_attributes id="Fencing-params" >
    <nvpair id="Fencing-passwd" name="passwd" value="testuser" />
    <nvpair id="Fencing-login" name="login" value="abc123" />
    <nvpair id="Fencing-ipaddr" name="ipaddr" value="192.0.2.1" />
    <nvpair id="Fencing-pcmk_host_list" name="pcm_host_list" value="pcm-1 pcm-2" />
  </instance_attributes>
  <operations >
    <op id="Fencing-monitor-10m" interval="10m" name="monitor" timeout="300s" />
  </operations>
</primitive>

```

Finally, we need to enable STONITH:

```
# crm_attribute -t crm_config -n stonith-enabled -v true
```

## 13.6. Advanced STONITH Configurations

Some people consider that having one fencing device is a single point of failure<sup>2</sup>; others prefer removing the node from the storage and network instead of turning it off.

Whatever the reason, Pacemaker supports fencing nodes with multiple devices through a feature called *fencing topologies*.

Simply create the individual devices as you normally would, then define one or more **fencing-level** entries in the **fencing-topology** section of the configuration.

- Each fencing level is attempted in order of ascending **index**. Allowed values are 1 through 9.
- 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 the operation succeeds for all the listed devices in a level, the level is deemed to have passed.

<sup>2</sup> Not true, since a node or resource must fail before fencing even has a chance to

- The operation is finished when a level has passed (success), or all levels have been attempted (failed).
- If the operation failed, the next step is determined by the Policy Engine and/or **crmd**.

Some possible uses of topologies include:

- Try poison-pill and fail back to power
- Try disk and network, and fall back to power if either fails
- Initiate a kdump and then poweroff the node

Table 13.2. Properties of Fencing Levels

Field	Description
<b>id</b>	A unique name for the level
<b>target</b>	The name of a single node to which this level applies
<b>target-pattern</b>	A regular expression matching the names of nodes to which this level applies ( <i>since 1.1.14</i> )
<b>target-attribute</b>	The name of a node attribute that is set (to <b>target-value</b> ) for nodes to which this level applies ( <i>since 1.1.14</i> )
<b>target-value</b>	The node attribute value (of <b>target-attribute</b> ) that is set for nodes to which this level applies ( <i>since 1.1.14</i> )
<b>index</b>	The order in which to attempt the levels. Levels are attempted in ascending order <i>until one succeeds</i> . Valid values are 1 through 9.
<b>devices</b>	A comma-separated list of devices that must all be tried for this level

Example 13.3. Fencing topology with different devices for different nodes

```
<cib crm_feature_set="3.0.6" validate-with="pacemaker-1.2" admin_epoch="1" epoch="0"
num_updates="0">
  <configuration>
    ...
    <fencing-topology>
      <!-- For pcmk-1, try poison-pill and fail back to power -->
      <fencing-level id="f-p1.1" target="pcmk-1" index="1" devices="poison-pill"/>
      <fencing-level id="f-p1.2" target="pcmk-1" index="2" devices="power"/>

      <!-- For pcmk-2, try disk and network, and fail back to power -->
      <fencing-level id="f-p2.1" target="pcmk-2" index="1" devices="disk,network"/>
      <fencing-level id="f-p2.2" target="pcmk-2" index="2" devices="power"/>
    </fencing-topology>
    ...
  </configuration>
  <status/>
</cib>
```

### 13.6.1. Example Dual-Layer, Dual-Device Fencing Topologies

The following example illustrates an advanced use of **fencing-topology** in a cluster with the following properties:

- 3 nodes (2 active prod-mysql nodes, 1 prod\_mysql-rep in standby for quorum purposes)
- the active nodes have an IPMI-controlled power board reached at 192.0.2.1 and 192.0.2.2

- the active nodes also have two independent PSUs (Power Supply Units) connected to two independent PDUs (Power Distribution Units) reached at 198.51.100.1 (port 10 and port 11) and 203.0.113.1 (port 10 and port 11)
- the first fencing method uses the **fence\_ipmi** agent
- the second fencing method uses the **fence\_apc\_snmp** agent targetting 2 fencing devices (one per PSU, either port 10 or 11)
- fencing is only implemented for the active nodes and has location constraints
- fencing topology is set to try IPMI fencing first then default to a "sure-kill" dual PDU fencing

In a normal failure scenario, STONITH will first select **fence\_ipmi** to try to kill the faulty node. Using a fencing topology, if that first method fails, STONITH will then move on to selecting **fence\_apc\_snmp** twice:

- once for the first PDU
- again for the second PDU

The fence action is considered successful only if both PDUs report the required status. If any of them fails, STONITH loops back to the first fencing method, **fence\_ipmi**, and so on until the node is fenced or fencing action is cancelled.

### First fencing method: single IPMI device

Each cluster node has its own dedicated IPMI channel that can be called for fencing using the following primitives:

```
<primitive class="stonith" id="fence_prod-mysql1_ipmi" type="fence_ipmilan">
  <instance_attributes id="fence_prod-mysql1_ipmi-instance_attributes">
    <nvpair id="fence_prod-mysql1_ipmi-instance_attributes-ipaddr" name="ipaddr"
value="192.0.2.1"/>
    <nvpair id="fence_prod-mysql1_ipmi-instance_attributes-action" name="action" value="off"/>
  >
    <nvpair id="fence_prod-mysql1_ipmi-instance_attributes-login" name="login"
value="fencing"/>
    <nvpair id="fence_prod-mysql1_ipmi-instance_attributes-passwd" name="passwd"
value="finishme"/>
    <nvpair id="fence_prod-mysql1_ipmi-instance_attributes-verbose" name="verbose"
value="true"/>
    <nvpair id="fence_prod-mysql1_ipmi-instance_attributes-pcmk_host_list"
name="pcm_k_host_list" value="prod-mysql1"/>
    <nvpair id="fence_prod-mysql1_ipmi-instance_attributes-lanplus" name="lanplus"
value="true"/>
  </instance_attributes>
</primitive>
<primitive class="stonith" id="fence_prod-mysql2_ipmi" type="fence_ipmilan">
  <instance_attributes id="fence_prod-mysql2_ipmi-instance_attributes">
    <nvpair id="fence_prod-mysql2_ipmi-instance_attributes-ipaddr" name="ipaddr"
value="192.0.2.2"/>
    <nvpair id="fence_prod-mysql2_ipmi-instance_attributes-action" name="action" value="off"/>
  >
    <nvpair id="fence_prod-mysql2_ipmi-instance_attributes-login" name="login"
value="fencing"/>
    <nvpair id="fence_prod-mysql2_ipmi-instance_attributes-passwd" name="passwd"
value="finishme"/>
    <nvpair id="fence_prod-mysql2_ipmi-instance_attributes-verbose" name="verbose"
value="true"/>
    <nvpair id="fence_prod-mysql2_ipmi-instance_attributes-pcmk_host_list"
name="pcm_k_host_list" value="prod-mysql2"/>
  </instance_attributes>
</primitive>
```

```

    <nvpair id="fence_prod-mysql2_ipmi-instance_attributes-lanplus" name="lanplus"
    value="true"/>
  </instance_attributes>
</primitive>

```

## Second fencing method: dual PDU devices

Each cluster node also has two distinct power channels controlled by two distinct PDUs. That means a total of 4 fencing devices configured as follows:

- Node 1, PDU 1, PSU 1 @ port 10
- Node 1, PDU 2, PSU 2 @ port 10
- Node 2, PDU 1, PSU 1 @ port 11
- Node 2, PDU 2, PSU 2 @ port 11

The matching fencing agents are configured as follows:

```

<primitive class="stonith" id="fence_prod-mysql1_apc1" type="fence_apc_snmp">
  <instance_attributes id="fence_prod-mysql1_apc1-instance_attributes">
    <nvpair id="fence_prod-mysql1_apc1-instance_attributes-ipaddr" name="ipaddr"
    value="198.51.100.1"/>
    <nvpair id="fence_prod-mysql1_apc1-instance_attributes-action" name="action" value="off"/>
  >
    <nvpair id="fence_prod-mysql1_apc1-instance_attributes-port" name="port" value="10"/>
    <nvpair id="fence_prod-mysql1_apc1-instance_attributes-login" name="login"
    value="fencing"/>
    <nvpair id="fence_prod-mysql1_apc1-instance_attributes-passwd" name="passwd"
    value="fencing"/>
    <nvpair id="fence_prod-mysql1_apc1-instance_attributes-pcmk_host_list"
    name="pcm_k_host_list" value="prod-mysql1"/>
  </instance_attributes>
</primitive>
<primitive class="stonith" id="fence_prod-mysql1_apc2" type="fence_apc_snmp">
  <instance_attributes id="fence_prod-mysql1_apc2-instance_attributes">
    <nvpair id="fence_prod-mysql1_apc2-instance_attributes-ipaddr" name="ipaddr"
    value="203.0.113.1"/>
    <nvpair id="fence_prod-mysql1_apc2-instance_attributes-action" name="action" value="off"/>
  >
    <nvpair id="fence_prod-mysql1_apc2-instance_attributes-port" name="port" value="10"/>
    <nvpair id="fence_prod-mysql1_apc2-instance_attributes-login" name="login"
    value="fencing"/>
    <nvpair id="fence_prod-mysql1_apc2-instance_attributes-passwd" name="passwd"
    value="fencing"/>
    <nvpair id="fence_prod-mysql1_apc2-instance_attributes-pcmk_host_list"
    name="pcm_k_host_list" value="prod-mysql1"/>
  </instance_attributes>
</primitive>
<primitive class="stonith" id="fence_prod-mysql2_apc1" type="fence_apc_snmp">
  <instance_attributes id="fence_prod-mysql2_apc1-instance_attributes">
    <nvpair id="fence_prod-mysql2_apc1-instance_attributes-ipaddr" name="ipaddr"
    value="198.51.100.1"/>
    <nvpair id="fence_prod-mysql2_apc1-instance_attributes-action" name="action" value="off"/>
  >
    <nvpair id="fence_prod-mysql2_apc1-instance_attributes-port" name="port" value="11"/>
    <nvpair id="fence_prod-mysql2_apc1-instance_attributes-login" name="login"
    value="fencing"/>
    <nvpair id="fence_prod-mysql2_apc1-instance_attributes-passwd" name="passwd"
    value="fencing"/>
    <nvpair id="fence_prod-mysql2_apc1-instance_attributes-pcmk_host_list"
    name="pcm_k_host_list" value="prod-mysql2"/>
  </instance_attributes>

```

```

</primitive>
<primitive class="stonith" id="fence_prod-mysql2_apc2" type="fence_apc_snmp">
  <instance_attributes id="fence_prod-mysql2_apc2-instance_attributes">
    <nvpair id="fence_prod-mysql2_apc2-instance_attributes-ipaddr" name="ipaddr"
value="203.0.113.1"/>
    <nvpair id="fence_prod-mysql2_apc2-instance_attributes-action" name="action" value="off"/>
  >
    <nvpair id="fence_prod-mysql2_apc2-instance_attributes-port" name="port" value="11"/>
    <nvpair id="fence_prod-mysql2_apc2-instance_attributes-login" name="login"
value="fencing"/>
    <nvpair id="fence_prod-mysql2_apc2-instance_attributes-passwd" name="passwd"
value="fencing"/>
    <nvpair id="fence_prod-mysql2_apc2-instance_attributes-pcmk_host_list"
name="pcmck_host_list" value="prod-mysql2"/>
  </instance_attributes>
</primitive>

```

## Location Constraints

To prevent STONITH from trying to run a fencing agent on the same node it is supposed to fence, constraints are placed on all the fencing primitives:

```

<constraints>
  <rsc_location id="l_fence_prod-mysql1_ipmi" node="prod-mysql1" rsc="fence_prod-mysql1_ipmi"
score="-INFINITY"/>
  <rsc_location id="l_fence_prod-mysql2_ipmi" node="prod-mysql2" rsc="fence_prod-mysql2_ipmi"
score="-INFINITY"/>
  <rsc_location id="l_fence_prod-mysql1_apc2" node="prod-mysql1" rsc="fence_prod-mysql1_apc2"
score="-INFINITY"/>
  <rsc_location id="l_fence_prod-mysql1_apc1" node="prod-mysql1" rsc="fence_prod-mysql1_apc1"
score="-INFINITY"/>
  <rsc_location id="l_fence_prod-mysql2_apc1" node="prod-mysql2" rsc="fence_prod-mysql2_apc1"
score="-INFINITY"/>
  <rsc_location id="l_fence_prod-mysql2_apc2" node="prod-mysql2" rsc="fence_prod-mysql2_apc2"
score="-INFINITY"/>
</constraints>

```

## Fencing topology

Now that all the fencing resources are defined, it's time to create the right topology. We want to first fence using IPMI and if that does not work, fence both PDUs to effectively and surely kill the node.

```

<fencing-topology>
  <fencing-level devices="fence_prod-mysql1_ipmi" id="fencing-2" index="1" target="prod-
mysql1"/>
  <fencing-level devices="fence_prod-mysql1_apc1,fence_prod-mysql1_apc2" id="fencing-3"
index="2" target="prod-mysql1"/>
  <fencing-level devices="fence_prod-mysql2_ipmi" id="fencing-0" index="1" target="prod-
mysql2"/>
  <fencing-level devices="fence_prod-mysql2_apc1,fence_prod-mysql2_apc2" id="fencing-1"
index="2" target="prod-mysql2"/>
</fencing-topology>

```

Please note, in **fencing-topology**, the lowest **index** value determines the priority of the first fencing method.

## Final configuration

Put together, the configuration looks like this:

```

<cib admin_epoch="0" crm_feature_set="3.0.7" epoch="292" have-quorum="1" num_updates="29"
  validate-with="pacemaker-1.2">
  <configuration>
    <crm_config>
      <cluster_property_set id="cib-bootstrap-options">
        <nvpair id="cib-bootstrap-options-stonith-enabled" name="stonith-enabled"
value="true"/>
        <nvpair id="cib-bootstrap-options-stonith-action" name="stonith-action" value="off"/>
        <nvpair id="cib-bootstrap-options-expected-quorum-votes" name="expected-quorum-votes"
value="3"/>
        ...
      </cluster_property_set>
    </crm_config>
    <nodes>
      <node id="prod-mysql1" uname="prod-mysql1">
      <node id="prod-mysql2" uname="prod-mysql2"/>
      <node id="prod-mysql-rep1" uname="prod-mysql-rep1"/>
        <instance_attributes id="prod-mysql-rep1">
          <nvpair id="prod-mysql-rep1-standby" name="standby" value="on"/>
        </instance_attributes>
      </node>
    </nodes>
    <resources>
      <primitive class="stonith" id="fence_prod-mysql1_ipmi" type="fence_ipmilan">
        <instance_attributes id="fence_prod-mysql1_ipmi-instance_attributes">
          <nvpair id="fence_prod-mysql1_ipmi-instance_attributes-ipaddr" name="ipaddr"
value="192.0.2.1"/>
          <nvpair id="fence_prod-mysql1_ipmi-instance_attributes-action" name="action"
value="off"/>
          <nvpair id="fence_prod-mysql1_ipmi-instance_attributes-login" name="login"
value="fencing"/>
          <nvpair id="fence_prod-mysql1_ipmi-instance_attributes-passwd" name="passwd"
value="finishme"/>
          <nvpair id="fence_prod-mysql1_ipmi-instance_attributes-verbose" name="verbose"
value="true"/>
          <nvpair id="fence_prod-mysql1_ipmi-instance_attributes-pcmk_host_list"
name="pcmk_host_list" value="prod-mysql1"/>
          <nvpair id="fence_prod-mysql1_ipmi-instance_attributes-lanplus" name="lanplus"
value="true"/>
        </instance_attributes>
      </primitive>
      <primitive class="stonith" id="fence_prod-mysql2_ipmi" type="fence_ipmilan">
        <instance_attributes id="fence_prod-mysql2_ipmi-instance_attributes">
          <nvpair id="fence_prod-mysql2_ipmi-instance_attributes-ipaddr" name="ipaddr"
value="192.0.2.2"/>
          <nvpair id="fence_prod-mysql2_ipmi-instance_attributes-action" name="action"
value="off"/>
          <nvpair id="fence_prod-mysql2_ipmi-instance_attributes-login" name="login"
value="fencing"/>
          <nvpair id="fence_prod-mysql2_ipmi-instance_attributes-passwd" name="passwd"
value="finishme"/>
          <nvpair id="fence_prod-mysql2_ipmi-instance_attributes-verbose" name="verbose"
value="true"/>
          <nvpair id="fence_prod-mysql2_ipmi-instance_attributes-pcmk_host_list"
name="pcmk_host_list" value="prod-mysql2"/>
          <nvpair id="fence_prod-mysql2_ipmi-instance_attributes-lanplus" name="lanplus"
value="true"/>
        </instance_attributes>
      </primitive>
      <primitive class="stonith" id="fence_prod-mysql1_apc1" type="fence_apc_snmp">
        <instance_attributes id="fence_prod-mysql1_apc1-instance_attributes">
          <nvpair id="fence_prod-mysql1_apc1-instance_attributes-ipaddr" name="ipaddr"
value="198.51.100.1"/>
          <nvpair id="fence_prod-mysql1_apc1-instance_attributes-action" name="action"
value="off"/>

```

```

        <nvpair id="fence_prod-mysql1_apc1-instance_attributes-port" name="port"
value="10"/>
        <nvpair id="fence_prod-mysql1_apc1-instance_attributes-login" name="login"
value="fencing"/>
        <nvpair id="fence_prod-mysql1_apc1-instance_attributes-passwd" name="passwd"
value="fencing"/>
        <nvpair id="fence_prod-mysql1_apc1-instance_attributes-pcmk_host_list"
name="pcm_k_host_list" value="prod-mysql1"/>
    </instance_attributes>
</primitive>
<primitive class="stonith" id="fence_prod-mysql1_apc2" type="fence_apc_snmp">
    <instance_attributes id="fence_prod-mysql1_apc2-instance_attributes">
        <nvpair id="fence_prod-mysql1_apc2-instance_attributes-ipaddr" name="ipaddr"
value="203.0.113.1"/>
        <nvpair id="fence_prod-mysql1_apc2-instance_attributes-action" name="action"
value="off"/>
        <nvpair id="fence_prod-mysql1_apc2-instance_attributes-port" name="port"
value="10"/>
        <nvpair id="fence_prod-mysql1_apc2-instance_attributes-login" name="login"
value="fencing"/>
        <nvpair id="fence_prod-mysql1_apc2-instance_attributes-passwd" name="passwd"
value="fencing"/>
        <nvpair id="fence_prod-mysql1_apc2-instance_attributes-pcmk_host_list"
name="pcm_k_host_list" value="prod-mysql1"/>
    </instance_attributes>
</primitive>
<primitive class="stonith" id="fence_prod-mysql2_apc1" type="fence_apc_snmp">
    <instance_attributes id="fence_prod-mysql2_apc1-instance_attributes">
        <nvpair id="fence_prod-mysql2_apc1-instance_attributes-ipaddr" name="ipaddr"
value="198.51.100.1"/>
        <nvpair id="fence_prod-mysql2_apc1-instance_attributes-action" name="action"
value="off"/>
        <nvpair id="fence_prod-mysql2_apc1-instance_attributes-port" name="port"
value="11"/>
        <nvpair id="fence_prod-mysql2_apc1-instance_attributes-login" name="login"
value="fencing"/>
        <nvpair id="fence_prod-mysql2_apc1-instance_attributes-passwd" name="passwd"
value="fencing"/>
        <nvpair id="fence_prod-mysql2_apc1-instance_attributes-pcmk_host_list"
name="pcm_k_host_list" value="prod-mysql2"/>
    </instance_attributes>
</primitive>
<primitive class="stonith" id="fence_prod-mysql2_apc2" type="fence_apc_snmp">
    <instance_attributes id="fence_prod-mysql2_apc2-instance_attributes">
        <nvpair id="fence_prod-mysql2_apc2-instance_attributes-ipaddr" name="ipaddr"
value="203.0.113.1"/>
        <nvpair id="fence_prod-mysql2_apc2-instance_attributes-action" name="action"
value="off"/>
        <nvpair id="fence_prod-mysql2_apc2-instance_attributes-port" name="port"
value="11"/>
        <nvpair id="fence_prod-mysql2_apc2-instance_attributes-login" name="login"
value="fencing"/>
        <nvpair id="fence_prod-mysql2_apc2-instance_attributes-passwd" name="passwd"
value="fencing"/>
        <nvpair id="fence_prod-mysql2_apc2-instance_attributes-pcmk_host_list"
name="pcm_k_host_list" value="prod-mysql2"/>
    </instance_attributes>
</primitive>
</resources>
<constraints>
    <rsc_location id="l_fence_prod-mysql1_ipmi" node="prod-mysql1" rsc="fence_prod-
mysql1_ipmi" score="-INFINITY"/>
    <rsc_location id="l_fence_prod-mysql2_ipmi" node="prod-mysql2" rsc="fence_prod-
mysql2_ipmi" score="-INFINITY"/>
    <rsc_location id="l_fence_prod-mysql1_apc2" node="prod-mysql1" rsc="fence_prod-
mysql1_apc2" score="-INFINITY"/>

```

```

<rsc_location id="l_fence_prod-mysql1_apc1" node="prod-mysql1" rsc="fence_prod-
mysql1_apc1" score="-INFINITY"/>
<rsc_location id="l_fence_prod-mysql2_apc1" node="prod-mysql2" rsc="fence_prod-
mysql2_apc1" score="-INFINITY"/>
<rsc_location id="l_fence_prod-mysql2_apc2" node="prod-mysql2" rsc="fence_prod-
mysql2_apc2" score="-INFINITY"/>
</constraints>
<fencing-topology>
  <fencing-level devices="fence_prod-mysql1_ipmi" id="fencing-2" index="1" target="prod-
mysql1"/>
  <fencing-level devices="fence_prod-mysql1_apc1,fence_prod-mysql1_apc2" id="fencing-3"
index="2" target="prod-mysql1"/>
  <fencing-level devices="fence_prod-mysql2_ipmi" id="fencing-0" index="1" target="prod-
mysql2"/>
  <fencing-level devices="fence_prod-mysql2_apc1,fence_prod-mysql2_apc2" id="fencing-1"
index="2" target="prod-mysql2"/>
</fencing-topology>
...
</configuration>
</cib>

```

## 13.7. Remapping Reboots

When the cluster needs to reboot a node, whether because **stonith-action** is **reboot** or because a reboot was manually requested (such as by **stonith\_admin --reboot**), it will remap that to other commands in two cases:

1. If the chosen fencing device does not support the **reboot** command, the cluster will ask it to perform **off** instead.
2. If a fencing topology level with multiple devices must be executed, the cluster will ask all the devices to perform **off**, then ask the devices to perform **on**.

To understand the second case, consider the example of a node with redundant power supplies connected to intelligent power switches. Rebooting one switch and then the other would have no effect on the node. Turning both switches off, and then on, actually reboots the node.

In such a case, the fencing operation will be treated as successful as long as the **off** commands succeed, because then it is safe for the cluster to recover any resources that were on the node. Timeouts and errors in the **on** phase will be logged but ignored.

When a reboot operation is remapped, any action-specific timeout for the remapped action will be used (for example, **pcmk\_off\_timeout** will be used when executing the **off** command, not **pcmk\_reboot\_timeout**).



### Note

In Pacemaker versions 1.1.13 and earlier, reboots will not be remapped in the second case. To achieve the same effect, separate fencing devices for off and on actions must be configured.

# Status — Here be dragons

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Most users never need to understand the contents of the status section and can be happy with the output from `crm_mon`.

However for those with a curious inclination, this section attempts to provide an overview of its contents.

## 14.1. Node Status

In addition to the cluster's configuration, the CIB holds an up-to-date representation of each cluster node in the `status` section.

Example 14.1. A bare-bones status entry for a healthy node `cl-virt-1`

```
<node_state id="cl-virt-1" uname="cl-virt-2" ha="active" in_ccm="true" crmd="online"
join="member" expected="member" crm-debug-origin="do_update_resource">
  <transient_attributes id="cl-virt-1"/>
  <lrm id="cl-virt-1"/>
</node_state>
```

Users are highly recommended *not* to modify any part of a node's state *directly*. The cluster will periodically regenerate the entire section from authoritative sources, so any changes should be done with the tools appropriate to those sources.

Table 14.1. Authoritative Sources for State Information

CIB Object	Authoritative Source
<code>node_state</code>	crmd
<code>transient_attributes</code>	attrd
<code>lrm</code>	lrmd

The fields used in the `node_state` objects are named as they are largely for historical reasons and are rooted in Pacemaker's origins as the Heartbeat resource manager. They have remained unchanged to preserve compatibility with older versions.

Table 14.2. Node Status Fields

Field	Description
<code>id</code>	Unique identifier for the node. Corosync-based clusters use a numeric counter, while Heartbeat clusters use a (barely) human-readable UUID.
<code>uname</code>	The node's machine name (output from <code>uname -n</code> ).

Field	Description
<b>ha</b>	Is the cluster software active on this node? Allowed values: <b>active</b> , <b>dead</b> .
<b>in_ccm</b>	Is the node a member of the cluster? Allowed values: <b>true</b> , <b>false</b> .
<b>crmd</b>	Is the crmd process active on the node? Allowed values: <b>online</b> , <b>offline</b> .
<b>join</b>	Does the node participate in hosting resources? Allowed values: <b>down</b> , <b>pending</b> , <b>member</b> , <b>banned</b> .
<b>expected</b>	Expected value for <b>join</b> .
<b>crm-debug-origin</b>	The origin of the most recent change(s). For diagnostic purposes.

The cluster uses these fields to determine whether, at the node level, the node is healthy or is in a failed state and needs to be fenced.

## 14.2. Transient Node Attributes

Like regular *node attributes*, the name/value pairs listed in the **transient\_attributes** section help to describe the node. However they are forgotten by the cluster when the node goes offline. This can be useful, for instance, when you want a node to be in standby mode (not able to run resources) just until the next reboot.

In addition to any values the administrator sets, the cluster will also store information about failed resources here.

### Example 14.2. A set of transient node attributes for node **cl-virt-1**

```
<transient_attributes id="cl-virt-1">
  <instance_attributes id="status-cl-virt-1">
    <nvpair id="status-cl-virt-1-pingd" name="pingd" value="3"/>
    <nvpair id="status-cl-virt-1-probe_complete" name="probe_complete" value="true"/>
    <nvpair id="status-cl-virt-1-fail-count-pingd:0.monitor_30000" name="fail-count-
pingd:0#monitor_30000" value="1"/>
    <nvpair id="status-cl-virt-1-last-failure-pingd:0" name="last-failure-pingd:0"
value="1239009742"/>
  </instance_attributes>
</transient_attributes>
```

In the above example, we can see that a monitor on the **pingd:0** resource has failed once, at 09:22:22 UTC 6 April 2009.<sup>1</sup> We also see that the node is connected to three **pingd** peers and that all known resources have been checked for on this machine (**probe\_complete**).

## 14.3. Operation History

A node's resource history is held in the **lrm\_resources** tag (a child of the **lrm** tag). The information stored here includes enough information for the cluster to stop the resource safely if it is removed from the **configuration** section. Specifically, the resource's **id**, **class**, **type** and **provider** are stored.

<sup>1</sup> You can use the standard **date** command to print a human-readable version of any seconds-since-epoch value, for example **date -d @1239009742**.

Example 14.3. A record of the **apcstonith** resource

```
<lr_resource id="apcstonith" type="apcmastersnmp" class="stonith"/>
```

Additionally, we store the last job for every combination of **resource**, **action** and **interval**. The concatenation of the values in this tuple are used to create the id of the **lr\_rsc\_op** object.

Table 14.3. Contents of an **lr\_rsc\_op** job

Field	Description
<b>id</b>	Identifier for the job constructed from the resource's <b>id</b> , <b>operation</b> and <b>interval</b> .
<b>call-id</b>	The job's ticket number. Used as a sort key to determine the order in which the jobs were executed.
<b>operation</b>	The action the resource agent was invoked with.
<b>interval</b>	The frequency, in milliseconds, at which the operation will be repeated. A one-off job is indicated by 0.
<b>op-status</b>	The job's status. Generally this will be either 0 (done) or -1 (pending). Rarely used in favor of <b>rc-code</b> .
<b>rc-code</b>	The job's result. Refer to <a href="#">Section B.4, "OCF Return Codes"</a> for details on what the values here mean and how they are interpreted.
<b>last-run</b>	Machine-local date/time, in seconds since epoch, at which the job was executed. For diagnostic purposes.
<b>last-rc-change</b>	Machine-local date/time, in seconds since epoch, at which the job first returned the current value of <b>rc-code</b> . For diagnostic purposes.
<b>exec-time</b>	Time, in milliseconds, that the job was running for. For diagnostic purposes.
<b>queue-time</b>	Time, in seconds, that the job was queued for in the LRMD. For diagnostic purposes.

Field	Description
<b>crm_feature_set</b>	The version which this job description conforms to. Used when processing <b>op-digest</b> .
<b>transition-key</b>	A concatenation of the job's graph action number, the graph number, the expected result and the UUID of the crmd instance that scheduled it. This is used to construct <b>transition-magic</b> (below).
<b>transition-magic</b>	A concatenation of the job's <b>op-status</b> , <b>rc-code</b> and <b>transition-key</b> . Guaranteed to be unique for the life of the cluster (which ensures it is part of CIB update notifications) and contains all the information needed for the crmd to correctly analyze and process the completed job. Most importantly, the decomposed elements tell the crmd if the job entry was expected and whether it failed.
<b>op-digest</b>	An MD5 sum representing the parameters passed to the job. Used to detect changes to the configuration, to restart resources if necessary.
<b>crm-debug-origin</b>	The origin of the current values. For diagnostic purposes.

### 14.3.1. Simple Operation History Example

Example 14.4. A monitor operation (determines current state of the **apcstonith** resource)

```
<lrms_resource id="apcstonith" type="apcmastersnmp" class="stonith">
  <lrms_rsc_op id="apcstonith_monitor_0" operation="monitor" call-id="2"
    rc-code="7" op-status="0" interval="0"
    crm-debug-origin="do_update_resource" crm_feature_set="3.0.1"
    op-digest="2e3da9274d3550dc6526fb24bfcba0"
    transition-key="22:2:7:2668bbeb-06d5-40f9-936d-24cb7f87006a"
    transition-magic="0:7;22:2:7:2668bbeb-06d5-40f9-936d-24cb7f87006a"
    last-run="1239008085" last-rc-change="1239008085" exec-time="10" queue-time="0"/>
</lrms_resource>
```

In the above example, the job is a non-recurring monitor operation often referred to as a "probe" for the **apcstonith** resource.

The cluster schedules probes for every configured resource on a node when the node first starts, in order to determine the resource's current state before it takes any further action.

From the **transition-key**, we can see that this was the 22nd action of the 2nd graph produced by this instance of the crmd (2668bbeb-06d5-40f9-936d-24cb7f87006a).

The third field of the **transition-key** contains a 7, which indicates that the job expects to find the resource inactive. By looking at the **rc-code** property, we see that this was the case.

As that is the only job recorded for this node, we can conclude that the cluster started the resource elsewhere.

## 14.3.2. Complex Operation History Example

Example 14.5. Resource history of a **pingd** clone with multiple jobs

```
<lr_resource id="pingd:0" type="pingd" class="ocf" provider="pacemaker">
  <lr_rsc_op id="pingd:0_monitor_30000" operation="monitor" call-id="34"
    rc-code="0" op-status="0" interval="30000"
    crm-debug-origin="do_update_resource" crm_feature_set="3.0.1"
    transition-key="10:11:0:2668bbeb-06d5-40f9-936d-24cb7f87006a"
    ...
    last-run="1239009741" last-rc-change="1239009741" exec-time="10" queue-time="0"/>
  <lr_rsc_op id="pingd:0_stop_0" operation="stop"
    crm-debug-origin="do_update_resource" crm_feature_set="3.0.1" call-id="32"
    rc-code="0" op-status="0" interval="0"
    transition-key="11:11:0:2668bbeb-06d5-40f9-936d-24cb7f87006a"
    ...
    last-run="1239009741" last-rc-change="1239009741" exec-time="10" queue-time="0"/>
  <lr_rsc_op id="pingd:0_start_0" operation="start" call-id="33"
    rc-code="0" op-status="0" interval="0"
    crm-debug-origin="do_update_resource" crm_feature_set="3.0.1"
    transition-key="31:11:0:2668bbeb-06d5-40f9-936d-24cb7f87006a"
    ...
    last-run="1239009741" last-rc-change="1239009741" exec-time="10" queue-time="0" />
  <lr_rsc_op id="pingd:0_monitor_0" operation="monitor" call-id="3"
    rc-code="0" op-status="0" interval="0"
    crm-debug-origin="do_update_resource" crm_feature_set="3.0.1"
    transition-key="23:2:7:2668bbeb-06d5-40f9-936d-24cb7f87006a"
    ...
    last-run="1239008085" last-rc-change="1239008085" exec-time="20" queue-time="0"/>
</lr_resource>
```

When more than one job record exists, it is important to first sort them by **call-id** before interpreting them.

Once sorted, the above example can be summarized as:

1. A non-recurring monitor operation returning 7 (not running), with a **call-id** of 3
2. A stop operation returning 0 (success), with a **call-id** of 32
3. A start operation returning 0 (success), with a **call-id** of 33
4. A recurring monitor returning 0 (success), with a **call-id** of 34

The cluster processes each job record to build up a picture of the resource's state. After the first and second entries, it is considered stopped, and after the third it considered active.

Based on the last operation, we can tell that the resource is currently active.

Additionally, from the presence of a **stop** operation with a lower **call-id** than that of the **start** operation, we can conclude that the resource has been restarted. Specifically this occurred as part of actions 11 and 31 of transition 11 from the crmd instance with the key **2668bbeb....** This information can be helpful for locating the relevant section of the logs when looking for the source of a failure.



# Multi-Site Clusters and Tickets

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Apart from local clusters, Pacemaker also supports multi-site clusters. That means you can have multiple, geographically dispersed sites, each with a local cluster. Failover between these clusters can be coordinated manually by the administrator, or automatically by a higher-level entity called a *Cluster Ticket Registry (CTR)*.

## 15.1. Challenges for Multi-Site Clusters

Typically, multi-site environments are too far apart to support synchronous communication and data replication between the sites. That leads to significant challenges:

- How do we make sure that a cluster site is up and running?
- How do we make sure that resources are only started once?
- How do we make sure that quorum can be reached between the different sites and a split-brain scenario avoided?
- How do we manage failover between sites?
- How do we deal with high latency in case of resources that need to be stopped?

In the following sections, learn how to meet these challenges.

## 15.2. Conceptual Overview

Multi-site clusters can be considered as “overlay” clusters where each cluster site corresponds to a cluster node in a traditional cluster. The overlay cluster can be managed by a CTR in order to guarantee that any cluster resource will be active on no more than one cluster site. This is achieved by using *tickets* that are treated as failover domain between cluster sites, in case a site should be down.

The following sections explain the individual components and mechanisms that were introduced for multi-site clusters in more detail.

### 15.2.1. Ticket

Tickets are, essentially, cluster-wide attributes. A ticket grants the right to run certain resources on a specific cluster site. Resources can be bound to a certain ticket by `rsc_ticket` constraints. Only if

the ticket is available at a site can the respective resources be started there. Vice versa, if the ticket is revoked, the resources depending on that ticket must be stopped.

The ticket thus is similar to a *site quorum*, i.e. the permission to manage/own resources associated with that site. (One can also think of the current **have-quorum** flag as a special, cluster-wide ticket that is granted in case of node majority.)

Tickets can be granted and revoked either manually by administrators (which could be the default for classic enterprise clusters), or via the automated CTR mechanism described below.

A ticket can only be owned by one site at a time. Initially, none of the sites has a ticket. Each ticket must be granted once by the cluster administrator.

The presence or absence of tickets for a site is stored in the CIB as a cluster status. With regards to a certain ticket, there are only two states for a site: **true** (the site has the ticket) or **false** (the site does not have the ticket). The absence of a certain ticket (during the initial state of the multi-site cluster) is the same as the value **false**.

### 15.2.2. Dead Man Dependency

A site can only activate resources safely if it can be sure that the other site has deactivated them. However after a ticket is revoked, it can take a long time until all resources depending on that ticket are stopped "cleanly", especially in case of cascaded resources. To cut that process short, the concept of a *Dead Man Dependency* was introduced.

If a dead man dependency is in force, if a ticket is revoked from a site, the nodes that are hosting dependent resources are fenced. This considerably speeds up the recovery process of the cluster and makes sure that resources can be migrated more quickly.

This can be configured by specifying a **loss-policy="fence"** in **rsc\_ticket** constraints.

### 15.2.3. Cluster Ticket Registry

A CTR is a coordinated group of network daemons that automatically handles granting, revoking, and timing out tickets (instead of the administrator revoking the ticket somewhere, waiting for everything to stop, and then granting it on the desired site).

Pacemaker does not implement its own CTR, but interoperates with external software designed for that purpose (similar to how resource and fencing agents are not directly part of pacemaker).

Participating clusters run the CTR daemons, which connect to each other, exchange information about their connectivity, and vote on which sites gets which tickets.

A ticket is granted to a site only once the CTR is sure that the ticket has been relinquished by the previous owner, implemented via a timer in most scenarios. If a site loses connection to its peers, its tickets time out and recovery occurs. After the connection timeout plus the recovery timeout has passed, the other sites are allowed to re-acquire the ticket and start the resources again.

This can also be thought of as a "quorum server", except that it is not a single quorum ticket, but several.

### 15.2.4. Configuration Replication

As usual, the CIB is synchronized within each cluster, but it is *not* synchronized across cluster sites of a multi-site cluster. You have to configure the resources that will be highly available across the multi-site cluster for every site accordingly.

## 15.3. Configuring Ticket Dependencies

The **rsc\_ticket** constraint lets you specify the resources depending on a certain ticket. Together with the constraint, you can set a **loss-policy** that defines what should happen to the respective resources if the ticket is revoked.

The attribute **loss-policy** can have the following values:

- **fence**: Fence the nodes that are running the relevant resources.
- **stop**: Stop the relevant resources.
- **freeze**: Do nothing to the relevant resources.
- **demote**: Demote relevant resources that are running in master mode to slave mode.

Example 15.1. Constraint that fences node if **ticketA** is revoked

```
<rsc_ticket id="rsc1-req-ticketA" rsc="rsc1" ticket="ticketA" loss-policy="fence"/>
```

The example above creates a constraint with the ID **rsc1-req-ticketA**. It defines that the resource **rsc1** depends on **ticketA** and that the node running the resource should be fenced if **ticketA** is revoked.

If resource **rsc1** were a multi-state resource (i.e. it could run in master or slave mode), you might want to configure that only master mode depends on **ticketA**. With the following configuration, **rsc1** will be demoted to slave mode if **ticketA** is revoked:

Example 15.2. Constraint that demotes **rsc1** if **ticketA** is revoked

```
<rsc_ticket id="rsc1-req-ticketA" rsc="rsc1" rsc-role="Master" ticket="ticketA" loss-policy="demote"/>
```

You can create multiple **rsc\_ticket** constraints to let multiple resources depend on the same ticket. However, **rsc\_ticket** also supports resource sets (see [Section 6.5, "Resource Sets"](#)), so one can easily list all the resources in one **rsc\_ticket** constraint instead.

Example 15.3. Ticket constraint for multiple resources

```
<rsc_ticket id="resources-dep-ticketA" ticket="ticketA" loss-policy="fence">
  <resource_set id="resources-dep-ticketA-0" role="Started">
    <resource_ref id="rsc1"/>
    <resource_ref id="group1"/>
    <resource_ref id="clone1"/>
  </resource_set>
  <resource_set id="resources-dep-ticketA-1" role="Master">
    <resource_ref id="ms1"/>
  </resource_set>
</rsc_ticket>
```

In the example above, there are two resource sets, so we can list resources with different roles in a single **rsc\_ticket** constraint. There's no dependency between the two resource sets, and there's no dependency among the resources within a resource set. Each of the resources just depends on **ticketA**.

Referencing resource templates in `rsc_ticket` constraints, and even referencing them within resource sets, is also supported.

If you want other resources to depend on further tickets, create as many constraints as necessary with `rsc_ticket`.

## 15.4. Managing Multi-Site Clusters

### 15.4.1. Granting and Revoking Tickets Manually

You can grant tickets to sites or revoke them from sites manually. If you want to re-distribute a ticket, you should wait for the dependent resources to stop cleanly at the previous site before you grant the ticket to the new site.

Use the `crm_ticket` command line tool to grant and revoke tickets.

To grant a ticket to this site:

```
# crm_ticket --ticket ticketA --grant
```

To revoke a ticket from this site:

```
# crm_ticket --ticket ticketA --revoke
```



#### Important

If you are managing tickets manually, use the `crm_ticket` command with great care, because it cannot check whether the same ticket is already granted elsewhere.

### 15.4.2. Granting and Revoking Tickets via a Cluster Ticket Registry

We will use *Booth*<sup>1</sup> here as an example of software that can be used with pacemaker as a Cluster Ticket Registry. Booth implements the *Raft*<sup>2</sup> algorithm to guarantee the distributed consensus among different cluster sites, and manages the ticket distribution (and thus the failover process between sites).

Each of the participating clusters and *arbitrators* runs the Booth daemon `boothd`.

An *arbitrator* is the multi-site equivalent of a quorum-only node in a local cluster. If you have a setup with an even number of sites, you need an additional instance to reach consensus about decisions such as failover of resources across sites. In this case, add one or more arbitrators running at additional sites. Arbitrators are single machines that run a booth instance in a special mode. An arbitrator is especially important for a two-site scenario, otherwise there is no way for one site to distinguish between a network failure between it and the other site, and a failure of the other site.

The most common multi-site scenario is probably a multi-site cluster with two sites and a single arbitrator on a third site. However, technically, there are no limitations with regards to the number of sites and the number of arbitrators involved.

---

<sup>1</sup> <https://github.com/ClusterLabs/booth>

<sup>2</sup> [http://en.wikipedia.org/wiki/Raft\\_%28computer\\_science%29](http://en.wikipedia.org/wiki/Raft_%28computer_science%29)

**Boothd** at each site connects to its peers running at the other sites and exchanges connectivity details. Once a ticket is granted to a site, the booth mechanism will manage the ticket automatically: If the site which holds the ticket is out of service, the booth daemons will vote which of the other sites will get the ticket. To protect against brief connection failures, sites that lose the vote (either explicitly or implicitly by being disconnected from the voting body) need to relinquish the ticket after a time-out. Thus, it is made sure that a ticket will only be re-distributed after it has been relinquished by the previous site. The resources that depend on that ticket will fail over to the new site holding the ticket. The nodes that have run the resources before will be treated according to the **loss-policy** you set within the **rsc\_ticket** constraint.

Before the booth can manage a certain ticket within the multi-site cluster, you initially need to grant it to a site manually via the **booth** command-line tool. After you have initially granted a ticket to a site, **boothd** will take over and manage the ticket automatically.



### Important

The **booth** command-line tool can be used to grant, list, or revoke tickets and can be run on any machine where **boothd** is running. If you are managing tickets via Booth, use only **booth** for manual intervention, not **crm\_ticket**. That ensures the same ticket will only be owned by one cluster site at a time.

#### 15.4.2.1. Booth Requirements

- All clusters that will be part of the multi-site cluster must be based on Pacemaker.
- Booth must be installed on all cluster nodes and on all arbitrators that will be part of the multi-site cluster.
- Nodes belonging to the same cluster site should be synchronized via NTP. However, time synchronization is not required between the individual cluster sites.

#### 15.4.3. General Management of Tickets

Display the information of tickets:

```
# crm_ticket --info
```

Or you can monitor them with:

```
# crm_mon --tickets
```

Display the **rsc\_ticket** constraints that apply to a ticket:

```
# crm_ticket --ticket ticketA --constraints
```

When you want to do maintenance or manual switch-over of a ticket, revoking the ticket would trigger the loss policies. If **loss-policy="fence"**, the dependent resources could not be gracefully stopped/demoted, and other unrelated resources could even be affected.

The proper way is making the ticket *standby* first with:

```
# crm_ticket --ticket ticketA --standby
```

Then the dependent resources will be stopped or demoted gracefully without triggering the loss policies.

If you have finished the maintenance and want to activate the ticket again, you can run:

```
# crm_ticket --ticket ticketA --activate
```

### 15.5. For more information

- [SUSE's Geo Clustering quick start](#)<sup>3</sup>
- [Booth](#)<sup>4</sup>

---

<sup>3</sup> [https://www.suse.com/documentation/sle-ha-geo-12/art\\_ha\\_geo\\_quick/data/art\\_ha\\_geo\\_quick.html](https://www.suse.com/documentation/sle-ha-geo-12/art_ha_geo_quick/data/art_ha_geo_quick.html)

<sup>4</sup> <https://github.com/ClusterLabs/booth>

---

# Appendix A. FAQ

---

**Q:** Why is the Project Called Pacemaker?

**A:** First of all, the reason it's not called the CRM is because of the abundance of terms<sup>1</sup> that are commonly abbreviated to those three letters. The Pacemaker name came from Kham,<sup>2</sup> a good friend of Pacemaker developer Andrew Beekhof's, and was originally used by a Java GUI that Beekhof was prototyping in early 2007. Alas, other commitments prevented the GUI from progressing much and, when it came time to choose a name for this project, Lars Marowsky-Bree suggested it was an even better fit for an independent CRM. The idea stems from the analogy between the role of this software and that of the little device that keeps the human heart pumping. Pacemaker monitors the cluster and intervenes when necessary to ensure the smooth operation of the services it provides. There were a number of other names (and acronyms) tossed around, but suffice to say "Pacemaker" was the best.

---

**Q:** Why was the Pacemaker Project Created?

**A:** The decision was made to spin-off the CRM into its own project after the 2.1.3 Heartbeat release in order to:

- support both the Corosync and Heartbeat cluster stacks equally
- decouple the release cycles of two projects at very different stages of their life-cycles
- foster clearer package boundaries, thus leading to better and more stable interfaces

---

**Q:** What Messaging Layers are Supported?

**A:**

- [Corosync](#)<sup>3</sup>
  - [Heartbeat](#)<sup>4</sup>
- 

**Q:** Can I Choose Which Messaging Layer to Use at Run Time?

**A:** Yes. The CRM will automatically detect which started it and behave accordingly.

---

**Q:** Can I Have a Mixed Heartbeat-Corosync Cluster?

**A:** No.

---

**Q:** Which Messaging Layer Should I Choose?

**A:** You can choose from multiple messaging layers, including heartbeat, corosync 1 (with or without CMAN), and corosync 2. Corosync 2 is the current state of the art due to its more advanced features and better support for pacemaker, but often the best choice is to use whatever comes with your Linux distribution, and follow the distribution's setup instructions.

---

<sup>1</sup> <http://en.wikipedia.org/wiki/CRM>  
<sup>2</sup> <http://khamsook.souvanlasy.com/>  
<sup>3</sup> <http://www.corosync.org/>  
<sup>4</sup> <http://linux-ha.org/>

## Appendix A. FAQ

---

.....

**Q:** Where Can I Get Pre-built Packages?

**A:** Most major Linux distributions have pacemaker packages in their standard package repositories. See the [Install wiki page](#)<sup>5</sup> for details.

.....

**Q:** What Versions of Pacemaker Are Supported?

**A:** Some Linux distributions (such as Red Hat Enterprise Linux and SUSE Linux Enterprise) offer technical support for their customers; contact them for details of such support. For help within the community (mailing lists, IRC, etc.) from Pacemaker developers and users, refer to the [Releases wiki page](#)<sup>6</sup> for an up-to-date list of versions considered to be supported by the project. When seeking assistance, please try to ensure you have one of these versions.

---

<sup>5</sup> <http://clusterlabs.org/wiki/Install>

<sup>6</sup> <http://clusterlabs.org/wiki/Releases>

---

# Appendix B. More About OCF Resource Agents

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### B.1. Location of Custom Scripts

OCF Resource Agents are found in `/usr/lib/ocf/resource.d/provider`

When creating your own agents, you are encouraged to create a new directory under `/usr/lib/ocf/resource.d/` so that they are not confused with (or overwritten by) the agents shipped by existing providers.

So, for example, if you choose the provider name of `bigCorp` and want a new resource named `bigApp`, you would create a resource agent called `/usr/lib/ocf/resource.d/bigCorp/bigApp` and define a resource:

```
<primitive id="custom-app" class="ocf" provider="bigCorp" type="bigApp"/>
```

### B.2. Actions

All OCF resource agents are required to implement the following actions.

Table B.1. Required Actions for OCF Agents

Action	Description	Instructions
<b>start</b>	Start the resource	Return 0 on success and an appropriate error code otherwise. Must not report success until the resource is fully active.
<b>stop</b>	Stop the resource	Return 0 on success and an appropriate error code otherwise. Must not report success until the resource is fully stopped.
<b>monitor</b>	Check the resource's state	Exit 0 if the resource is running, 7 if it is stopped, and anything else if it is failed.  NOTE: The monitor script should test the state of the resource on the local machine only.
<b>meta-data</b>	Describe the resource	Provide information about this resource as an XML snippet. Exit with 0.  NOTE: This is <i>not</i> performed as root.
<b>validate-all</b>	Verify the supplied parameters	Return 0 if parameters are valid, 2 if not valid, and 6 if resource is not configured.

Additional requirements (not part of the OCF specification) are placed on agents that will be used for advanced concepts such as [clones](#) and [multi-state](#) resources.

Table B.2. Optional Actions for OCF Resource Agents

Action	Description	Instructions
<b>promote</b>	Promote the local instance of a multi-state resource to the master (primary) state.	Return 0 on success
<b>demote</b>	Demote the local instance of a multi-state resource to the slave (secondary) state.	Return 0 on success
<b>notify</b>	Used by the cluster to send the agent pre- and post-notification events telling the resource what has happened and will happen.	Must not fail. Must exit with 0

One action specified in the OCF specs, **recover**, is not currently used by the cluster. It is intended to be a variant of the **start** action that tries to recover a resource locally.



**Important**

If you create a new OCF resource agent, use **ocf-tester** to verify that the agent complies with the OCF standard properly.

### B.3. How are OCF Return Codes Interpreted?

The first thing the cluster does is to check the return code against the expected result. If the result does not match the expected value, then the operation is considered to have failed, and recovery action is initiated.

There are three types of failure recovery:

Table B.3. Types of recovery performed by the cluster

Type	Description	Action Taken by the Cluster
<b>soft</b>	A transient error occurred	Restart the resource or move it to a new location
<b>hard</b>	A non-transient error that may be specific to the current node occurred	Move the resource elsewhere and prevent it from being retried on the current node
<b>fatal</b>	A non-transient error that will be common to all cluster nodes (e.g. a bad configuration was specified)	Stop the resource and prevent it from being started on any cluster node

### B.4. OCF Return Codes

The following table outlines the different OCF return codes and the type of recovery the cluster will initiate when a failure code is received. Although counterintuitive, even actions that return 0 (aka. **OCF\_SUCCESS**) can be considered to have failed, if 0 was not the expected return value.

Table B.4. OCF Return Codes and their Recovery Types

RC	OCF Alias	Description	RT
<b>0</b>	<b>OCF_SUCCESS</b>	Success. The command completed successfully. This is the expected result for all start, stop, promote and demote commands.	<b>soft</b>

RC	OCF Alias	Description	RT
1	<b>OCF_ERR_GENERIC</b>	Generic "there was a problem" error code.	<b>soft</b>
2	<b>OCF_ERR_ARGS</b>	The resource's configuration is not valid on this machine. E.g. it refers to a location not found on the node.	<b>hard</b>
3	<b>OCF_ERR_UNIMPLEMENTED</b>	The requested action is not implemented.	<b>hard</b>
4	<b>OCF_ERR_PERM</b>	The resource agent does not have sufficient privileges to complete the task.	<b>hard</b>
5	<b>OCF_ERR_INSTALLED</b>	The tools required by the resource are not installed on this machine.	<b>hard</b>
6	<b>OCF_ERR_CONFIGURED</b>	The resource's configuration is invalid. E.g. required parameters are missing.	<b>fatal</b>
7	<b>OCF_NOT_RUNNING</b>	The resource is safely stopped. The cluster will not attempt to stop a resource that returns this for any action.	<b>N/A</b>
8	<b>OCF_RUNNING_MASTER</b>	The resource is running in master mode.	<b>soft</b>
9	<b>OCF_FAILED_MASTER</b>	The resource is in master mode but has failed. The resource will be demoted, stopped and then started (and possibly promoted) again.	<b>soft</b>
<b>other</b>	<b>N/A</b>	Custom error code.	<b>soft</b>

Exceptions to the recovery handling described above:

- Probes (non-recurring monitor actions) that find a resource active (or in master mode) will not result in recovery action unless it is also found active elsewhere.
- The recovery action taken when a resource is found active more than once is determined by the resource's **multiple-active** property (see [Section 5.4, "Resource Options"](#)).
- Recurring actions that return **OCF\_ERR\_UNIMPLEMENTED** do not cause any type of recovery.



---

# Appendix C. Installing

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## C.1. Installing the Software

Most major Linux distributions have pacemaker packages in their standard package repositories, or the software can be built from source code. See the [Install wiki page](#)<sup>1</sup> for details.

See [Which Messaging Layer Should I Choose?](#) for information about choosing a messaging layer.

## C.2. Enabling Pacemaker

### C.2.1. Enabling Pacemaker For Corosync 2.x

High-level cluster management tools are available that can configure corosync for you. This document focuses on the lower-level details if you want to configure corosync yourself.

Corosync configuration is normally located in `/etc/corosync/corosync.conf`.

Example C.1. Corosync 2.x configuration file for two nodes **myhost1** and **myhost2**

```
totem {
  version: 2
  secauth: off
  cluster_name: mycluster
  transport: udpu
}

nodelist {
  node {
    ring0_addr: myhost1
    nodeid: 1
  }
  node {
    ring0_addr: myhost2
    nodeid: 2
  }
}

quorum {
  provider: corosync_votequorum
  two_node: 1
}

logging {
  to_syslog: yes
}
```

---

<sup>1</sup> <http://clusterlabs.org/wiki/Install>

```
}
```

### Example C.2. Corosync 2.x configuration file for three nodes **myhost1**, **myhost2** and **myhost3**

```
totem {
  version: 2
  secauth: off
  cluster_name: mycluster
  transport: udpu
}

nodelist {
  node {
    ring0_addr: myhost1
    nodeid: 1
  }
  node {
    ring0_addr: myhost2
    nodeid: 2
  }
  node {
    ring0_addr: myhost3
    nodeid: 3
  }
}

quorum {
  provider: corosync_votequorum
}

logging {
  to_syslog: yes
}
```

In the above examples, the **totem** section defines what protocol version and options (including encryption) to use,<sup>2</sup> and gives the cluster a unique name (**mycluster** in these examples).

The **node** section lists the nodes in this cluster. (See [Section 4.2, “Where Pacemaker Gets the Node Name”](#) for how this affects pacemaker.)

The **quorum** section defines how the cluster uses quorum. The important thing is that two-node clusters must be handled specially, so **two\_node: 1** must be defined for two-node clusters (and only for two-node clusters).

The **logging** section should be self-explanatory.

## C.2.2. Enabling Pacemaker For Corosync 1.x

### Example C.3. Corosync 1.x configuration file for a cluster with all nodes on the **192.0.2.0/24** network

```
totem {
  version: 2
```

<sup>2</sup> Please consult the Corosync website (<http://www.corosync.org>) and documentation for details on enabling encryption and peer authentication for the cluster.

```

secauth: off
threads: 0
interface {
    ringnumber: 0
    bindnetaddr: 192.0.2.0
    mcastaddr: 239.255.1.1
    mcastport: 1234
}
}
logging {
    fileline: off
    to_syslog: yes
    syslog_facility: daemon
}
}
amf {
    mode: disabled
}
}

```

With corosync 1.x, the **totem** section contains the protocol version and options as with 2.x. However, nodes are also listed here, in the **interface** section. The **bindnetaddr** option is usually the *network* address, thus allowing the same configuration file to be used on all nodes. IPv4 or IPv6 addresses can be used with corosync.

The **amf** section refers to the Availability Management Framework and is not covered in this document.

The above corosync configuration is enough for corosync to operate by itself, but corosync 1.x additionally needs to be told when it is being used in conjunction with Pacemaker. This can be accomplished in one of two ways:

- Via the CMAN software provided with Red Hat Enterprise Linux 6 and its derivatives
- Via the pacemaker corosync plugin

To use CMAN, consult its documentation.

To use the pacemaker corosync plugin, add the following fragment to the corosync configuration and restart the cluster.

#### Example C.4. Corosync 1.\_x\_ configuration fragment to enable Pacemaker plugin

```

aisexec {
    user: root
    group: root
}
service {
    name: pacemaker
    ver: 0
}
}

```

The cluster needs to be run as root so that its child processes (the **lrm** in particular) have sufficient privileges to perform the actions requested of it. After all, a cluster manager that can't add an IP address or start apache is of little use.

The second directive is the one that actually instructs the cluster to run Pacemaker.

### C.2.3. Enabling Pacemaker For Heartbeat

See the heartbeat documentation for how to set up a **ha.cf** configuration file.

## Appendix C. Installing

---

To enable the use of pacemaker with heartbeat, add the following to a functional **ha.cf** configuration file and restart Heartbeat:

### Example C.5. Heartbeat configuration fragment to enable Pacemaker

```
crm respawn
```

---

# Appendix D. Upgrading

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## D.1. Upgrading Cluster Software

There are three approaches to upgrading a cluster, each with advantages and disadvantages.

Table D.1. Upgrade Methods

Method	Available between all versions	Can be used with Pacemaker Remote nodes	Service outage during upgrade	Service recovery during upgrade	Exercises failover logic	Allows change of messaging layer <sup>1</sup>
<b>Complete cluster shutdown</b>	yes	yes	always	N/A	no	yes
<b>Rolling (node by node)</b>	no	yes	always <sup>2</sup>	yes	yes	no
<b>Detach and reattach</b>	yes	no	only due to failure	no	no	yes

<sup>1</sup> For example, switching from Heartbeat to Corosync.

<sup>2</sup> Any active resources will be moved off the node being upgraded, so there will be at least a brief outage unless all resources can be migrated "live".

### D.1.1. Complete Cluster Shutdown

In this scenario, one shuts down all cluster nodes and resources, then upgrades all the nodes before restarting the cluster.

1. On each node:
  - a. Shutdown the cluster software (pacemaker and the messaging layer).
  - b. Upgrade the Pacemaker software. This may also include upgrading the messaging layer and/or the underlying operating system.
  - c. Check the configuration with the `crm_verify` tool.

2. On each node:
  - a. Start the cluster software. The messaging layer can be either Corosync or Heartbeat and does not need to be the same one before the upgrade.

One variation of this approach is to build a new cluster on new hosts. This allows the new version to be tested beforehand, and minimizes downtime by having the new nodes ready to be placed in production as soon as the old nodes are shut down.

### D.1.2. Rolling (node by node)

In this scenario, each node is removed from the cluster, upgraded, and then brought back online, until all nodes are running the newest version.

If you plan to upgrade other cluster software — such as the messaging layer — at the same time, consult that software's documentation for its compatibility with a rolling upgrade.

Pacemaker has three version numbers that affect rolling upgrades:

- **Pacemaker release version:** Rolling upgrades are possible as long as the major version number (the *x* in *x.y.z*) stays the same. For example, a rolling upgrade may be done from 1.0.8 to 1.1.15, but not from 0.6.7 to 1.0.0.
- **CRM feature set:** This version number applies to the communication between full cluster nodes.

It increases when a cluster node running the older version would have problems if the cluster's Designated Controller (DC) has the newer version. To avoid these problems, Pacemaker ensures that the longest-running node is the DC, and that nodes with an older feature set cannot join the cluster.

Therefore, if the CRM feature set is changing in the Pacemaker version you are upgrading to, you should run a mixed-version cluster only during a small rolling upgrade window. If one of the older nodes drops out of the cluster for any reason, it will not be able to rejoin until it is upgraded.

- **LRMD protocol version:** This version number applies to communication between a Pacemaker Remote node and the cluster. It increases when an older cluster node would have problems hosting the connection to a newer Pacemaker Remote node. To avoid these problems, Pacemaker Remote nodes will accept connections only from cluster nodes with the same or newer LRMD protocol version.

For rolling upgrades, this means that all cluster nodes should be upgraded before upgrading any Pacemaker Remote nodes.

Unlike with CRM feature set differences between full cluster nodes, mixed LRMD protocol versions between Pacemaker Remote nodes and full cluster nodes are fine, as long as the Pacemaker Remote nodes have the older version. This can be useful, for example, to host a legacy application in an older operating system version used as a Pacemaker Remote node.

See the ClusterLabs wiki's [Release Calendar](http://clusterlabs.org/wiki/ReleaseCalendar)<sup>1</sup> to figure out whether the CRM feature set and/or LRMD protocol version changed between the the Pacemaker release versions in your rolling upgrade.

---

<sup>1</sup> <http://clusterlabs.org/wiki/ReleaseCalendar>



## Warning

The interpretation of the LRMD protocol version changed in Pacemaker 1.1.15. If you are planning a rolling upgrade from an earlier Pacemaker version to Pacemaker 1.1.15 or later involving Pacemaker Remote nodes, you will need to take special precautions to avoid problems. See [Upgrading to Pacemaker 1.1.15 or later from an earlier version](#)<sup>2</sup> on the ClusterLabs wiki.

To perform a rolling upgrade, on each node in turn:

1. Put the node into standby mode, and wait for any active resources to be moved cleanly to another node. (This step is optional, but allows you to deal with any resource issues before the upgrade.)
2. Shutdown the cluster software (pacemaker and the messaging layer) on the node.
3. Upgrade the Pacemaker software. This may also include upgrading the messaging layer and/or the underlying operating system.
4. If this is the first node to be upgraded, check the configuration with the `crm_verify` tool.
5. Start the messaging layer. This must be the same messaging layer (Corosync or Heartbeat) that the rest of the cluster is using.



## Note

Rolling upgrades were not always possible with older heartbeat and pacemaker versions. Rolling upgrades that cross compatibility boundaries listed in the following table must be performed in multiple steps.

Table D.2. Version Compatibility Table

Version being Installed	Oldest Compatible Version
Pacemaker 1.x.y	Pacemaker 1.0.0
Pacemaker 0.7.x	Pacemaker 0.6 or Heartbeat 2.1.3
Pacemaker 0.6.x	Heartbeat 2.0.8
Heartbeat 2.1.3 (or less)	Heartbeat 2.0.4
Heartbeat 2.0.4 (or less)	Heartbeat 2.0.0
Heartbeat 2.0.0	None. Use an alternate upgrade strategy.

### D.1.3. Detach and Reattach

The reattach method is a variant of a complete cluster shutdown, where the resources are left active and get re-detected when the cluster is restarted.

This method may not be used if the cluster contains any Pacemaker Remote nodes.

<sup>2</sup> [http://clusterlabs.org/wiki/Upgrading\\_to\\_Pacemaker\\_1.1.15\\_or\\_later\\_from\\_an\\_earlier\\_version](http://clusterlabs.org/wiki/Upgrading_to_Pacemaker_1.1.15_or_later_from_an_earlier_version)

1. Tell the cluster to stop managing services. This is required to allow the services to remain active after the cluster shuts down.

```
# crm_attribute --name maintenance-mode --update true
```

2. On each node, shutdown the cluster software (pacemaker and the messaging layer), and upgrade the Pacemaker software. This may also include upgrading the messaging layer. While the underlying operating system may be upgraded at the same time, that will be more likely to cause outages in the detached services (certainly, if a reboot is required).
3. Check the configuration with the **crm\_verify** tool.
4. On each node, start the cluster software. The messaging layer can be either Corosync or Heartbeat and does not need to be the same one as before the upgrade.
5. Verify that the cluster re-detected all resources correctly.
6. Allow the cluster to resume managing resources again:

```
# crm_attribute --name maintenance-mode --delete
```



### Note

Support for maintenance mode was added in Pacemaker 1.0.0. If you are upgrading from an earlier version, you can detach by setting **is-managed** to **false** for all resources.

## D.2. Upgrading the Configuration

Pacemaker's configuration — the Configuration Information Base (CIB) — has its own XML schema version, independent of the Pacemaker software version.

After cluster software is upgraded, the cluster will continue to use the older schema version that it was previously using. This can be useful, for example, when administrators have written tools that modify the configuration, and are based on the older syntax.

However, when using an older syntax, new features may be unavailable, and there is a performance impact, since the cluster must do a non-persistent configuration upgrade before each transition. So while using the old syntax is possible, it is not advisable to continue using it indefinitely.

Even if you wish to continue using the old syntax, it is a good idea to follow the upgrade procedure outlined below, except for the last step, to ensure that the new software has no problems with your existing configuration (since it will perform much the same task internally).

If you are brave, it is sufficient simply to run **cibadmin --upgrade**.

A more cautious approach would proceed like this:

1. Create a shadow copy of the configuration. The later commands will automatically operate on this copy, rather than the live configuration.

```
# crm_shadow --create shadow
```

2. Verify the configuration is valid with the new software (which may be stricter about syntax mistakes, or may have dropped support for deprecated features):

```
# crm_verify --live-check
```

3. Fix any errors or warnings.
4. Perform the upgrade:

```
# cibadmin --upgrade
```

5. If this step fails, there are three main possibilities:
  - a. The configuration was not valid to start with (did you do steps 2 and 3?).
  - b. The transformation failed - [report a bug](#)<sup>3</sup> or [email the project](#)<sup>4</sup>.
  - c. The transformation was successful but produced an invalid result.

If the result of the transformation is invalid, you may see a number of errors from the validation library. If these are not helpful, visit the [Validation FAQ wiki page](#)<sup>5</sup> and/or try the manual upgrade procedure described below.

6. Check the changes:

```
# crm_shadow --diff
```

If at this point there is anything about the upgrade that you wish to fine-tune (for example, to change some of the automatic IDs), now is the time to do so:

```
# crm_shadow --edit
```

This will open the configuration in your favorite editor (whichever is specified by the standard **\$EDITOR** environment variable).

7. Preview how the cluster will react:

```
# crm_simulate --live-check --save-dotfile shadow.dot -S  
# graphviz shadow.dot
```

Verify that either no resource actions will occur or that you are happy with any that are scheduled. If the output contains actions you do not expect (possibly due to changes to the score calculations), you may need to make further manual changes. See [Section 2.5, "Testing Your Configuration Changes"](#) for further details on how to interpret the output of **crm\_simulate** and **graphviz**.

8. Upload the changes:

---

<sup>3</sup> <http://bugs.clusterlabs.org/>

<sup>4</sup> <mailto:users@clusterlabs.org?subject=Transformation%20failed%20during%20upgrade>

<sup>5</sup> [http://clusterlabs.org/wiki/Validation\\_FAQ](http://clusterlabs.org/wiki/Validation_FAQ)

```
# crm_shadow --commit shadow --force
```

In the unlikely event this step fails, please report a bug.



### Note

It is also possible to perform the configuration upgrade steps manually:

1. Locate the **upgrade\*.xsl** conversion scripts provided with the source code. These will often be installed in a location such as `/usr/share/pacemaker`, or may be obtained from the [source repository](#)<sup>6</sup>.
2. Run the conversion scripts that apply to your older version, for example:

```
# xsltproc /path/to/upgrade06.xsl config06.xml > config10.xml
```

3. Locate the **pacemaker.rng** script (from the same location as the xsl files).
4. Check the XML validity:

```
# xmllint --relaxng /path/to/pacemaker.rng config10.xml
```

The advantage of this method is that it can be performed without the cluster running, and any validation errors are often more informative.

## D.3. What Changed in 1.0

### D.3.1. New

- Failure timeouts. See [Section 9.3, “Handling Resource Failure”](#)
- New section for resource and operation defaults. See [Section 5.4.2, “Setting Global Defaults for Resource Meta-Attributes”](#) and [Section 5.5.3, “Setting Global Defaults for Operations”](#)
- Tool for making offline configuration changes. See [Section 2.4, “Making Configuration Changes in a Sandbox”](#)
- **Rules**, **instance\_attributes**, **meta\_attributes** and sets of operations can be defined once and referenced in multiple places. See [Section 11.2, “Reusing Rules, Options and Sets of Operations”](#)
- The CIB now accepts XPath-based create/modify/delete operations. See the **cibadmin** help text.
- Multi-dimensional colocation and ordering constraints. See [Section 6.6, “Ordering Sets of Resources”](#) and [Section 6.7, “Colocating Sets of Resources”](#)

---

<sup>6</sup> <https://github.com/ClusterLabs/pacemaker/tree/master/xml>

- 
- The ability to connect to the CIB from non-cluster machines. See [Section 9.1, “Connecting from a Remote Machine”](#)
  - Allow recurring actions to be triggered at known times. See [Section 9.2, “Specifying When Recurring Actions are Performed”](#)

### D.3.2. Changed

- Syntax
  - All resource and cluster options now use dashes (-) instead of underscores (\_)
  - **master\_slave** was renamed to **master**
  - The **attributes** container tag was removed
  - The operation field **pre-req** has been renamed **requires**
  - All operations must have an **interval**, **start/stop** must have it set to zero
- The **stonith-enabled** option now defaults to true.
- The cluster will refuse to start resources if **stonith-enabled** is true (or unset) and no STONITH resources have been defined
- The attributes of colocation and ordering constraints were renamed for clarity. See [Section 6.3, “Specifying the Order in which Resources Should Start/Stop”](#) and [Section 6.4, “Placing Resources Relative to other Resources”](#)
- **resource-failure-stickiness** has been replaced by **migration-threshold**. See [Section 9.3, “Handling Resource Failure”](#)
- The parameters for command-line tools have been made consistent
- Switched to *RelaxNG* schema validation and *libxml2* parser
  - id fields are now XML IDs which have the following limitations:
    - id's cannot contain colons (:)
    - id's cannot begin with a number
    - id's must be globally unique (not just unique for that tag)
  - Some fields (such as those in constraints that refer to resources) are IDREFs.

This means that they must reference existing resources or objects in order for the configuration to be valid. Removing an object which is referenced elsewhere will therefore fail.
- The CIB representation, from which a MD5 digest is calculated to verify CIBs on the nodes, has changed.

This means that every CIB update will require a full refresh on any upgraded nodes until the cluster is fully upgraded to 1.0. This will result in significant performance degradation and it is therefore highly inadvisable to run a mixed 1.0/0.6 cluster for any longer than absolutely necessary.
- Ping node information no longer needs to be added to *ha.cf*.

Simply include the lists of hosts in your ping resource(s).

### D.3.3. Removed

- Syntax
  - It is no longer possible to set resource meta options as top-level attributes. Use meta attributes instead.
  - Resource and operation defaults are no longer read from **crm\_config**. See [Section 5.4.2, “Setting Global Defaults for Resource Meta-Attributes”](#) and [Section 5.5.3, “Setting Global Defaults for Operations”](#) instead.

---

# Appendix E. Init Script LSB Compliance

The relevant part of the [LSB specifications](#)<sup>1</sup> includes a description of all the return codes listed here.

Assuming **some\_service** is configured correctly and currently inactive, the following sequence will help you determine if it is LSB-compatible:

1. Start (stopped):

```
# /etc/init.d/some_service start ; echo "result: $?"
```

- a. Did the service start?
- b. Did the command print **result: 0** (in addition to its usual output)?

2. Status (running):

```
# /etc/init.d/some_service status ; echo "result: $?"
```

- a. Did the script accept the command?
- b. Did the script indicate the service was running?
- c. Did the command print **result: 0** (in addition to its usual output)?

3. Start (running):

```
# /etc/init.d/some_service start ; echo "result: $?"
```

- a. Is the service still running?
- b. Did the command print **result: 0** (in addition to its usual output)?

4. Stop (running):

```
# /etc/init.d/some_service stop ; echo "result: $?"
```

- a. Was the service stopped?
- b. Did the command print **result: 0** (in addition to its usual output)?

5. Status (stopped):

```
# /etc/init.d/some_service status ; echo "result: $?"
```

- a. Did the script accept the command?
- b. Did the script indicate the service was not running?
- c. Did the command print **result: 3** (in addition to its usual output)?

6. Stop (stopped):

---

<sup>1</sup> <http://refspecs.linuxfoundation.org/lbs.shtml>

## Appendix E. Init Script LSB Compliance

---

```
# /etc/init.d/some_service stop ; echo "result: $?"
```

- a. Is the service still stopped?
- b. Did the command print **result: 0** (in addition to its usual output)?

### 7. Status (failed):

- a. This step is not readily testable and relies on manual inspection of the script.

The script can use one of the error codes (other than 3) listed in the LSB spec to indicate that it is active but failed. This tells the cluster that before moving the resource to another node, it needs to stop it on the existing one first.

If the answer to any of the above questions is no, then the script is not LSB-compliant. Your options are then to either fix the script or write an OCF agent based on the existing script.

---

# Appendix F. Sample Configurations

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### F.1. Empty

#### Example F.1. An Empty Configuration

```
<cib crm_feature_set="3.0.7" validate-with="pacemaker-1.2" admin_epoch="1" epoch="0"
num_updates="0">
  <configuration>
    <crm_config/>
    <nodes/>
    <resources/>
    <constraints/>
  </configuration>
  <status/>
</cib>
```

### F.2. Simple

#### Example F.2. A simple configuration with two nodes, some cluster options and a resource

```
<cib crm_feature_set="3.0.7" validate-with="pacemaker-1.2" admin_epoch="1" epoch="0"
num_updates="0">
  <configuration>
    <crm_config>
      <cluster_property_set id="cib-bootstrap-options">
        <nvpair id="option-1" name="symmetric-cluster" value="true"/>
        <nvpair id="option-2" name="no-quorum-policy" value="stop"/>
        <nvpair id="option-3" name="stonith-enabled" value="0"/>
      </cluster_property_set>
    </crm_config>
    <nodes>
      <node id="xxx" uname="c001n01" type="normal"/>
      <node id="yyy" uname="c001n02" type="normal"/>
    </nodes>
    <resources>
      <primitive id="myAddr" class="ocf" provider="heartbeat" type="IPAddr">
        <operations>
          <op id="myAddr-monitor" name="monitor" interval="300s"/>
        </operations>
        <instance_attributes id="myAddr-params">
          <nvpair id="myAddr-ip" name="ip" value="192.0.2.10"/>
        </instance_attributes>
      </primitive>
    </resources>
    <constraints>
      <rsc_location id="myAddr-prefer" rsc="myAddr" node="c001n01" score="INFINITY"/>
    </constraints>
    <rsc_defaults>
      <meta_attributes id="rsc_defaults-options">
```

```

    <nvpair id="rsc-default-1" name="resource-stickiness" value="100"/>
    <nvpair id="rsc-default-2" name="migration-threshold" value="10"/>
  </meta_attributes>
</rsc_defaults>
<op_defaults>
  <meta_attributes id="op_defaults-options">
    <nvpair id="op-default-1" name="timeout" value="30s"/>
  </meta_attributes>
</op_defaults>
</configuration>
<status/>
</cib>

```

In the above example, we have one resource (an IP address) that we check every five minutes and will run on host **c001n01** until either the resource fails 10 times or the host shuts down.

### F.3. Advanced Configuration

Example F.3. An advanced configuration with groups, clones and STONITH

```

<cib crm_feature_set="3.0.7" validate-with="pacemaker-1.2" admin_epoch="1" epoch="0"
num_updates="0">
  <configuration>
    <crm_config>
      <cluster_property_set id="cib-bootstrap-options">
        <nvpair id="option-1" name="symmetric-cluster" value="true"/>
        <nvpair id="option-2" name="no-quorum-policy" value="stop"/>
        <nvpair id="option-3" name="stonith-enabled" value="true"/>
      </cluster_property_set>
    </crm_config>
    <nodes>
      <node id="xxx" uname="c001n01" type="normal"/>
      <node id="yyy" uname="c001n02" type="normal"/>
      <node id="zzz" uname="c001n03" type="normal"/>
    </nodes>
    <resources>
      <primitive id="myAddr" class="ocf" provider="heartbeat" type="IPaddr">
        <operations>
          <op id="myAddr-monitor" name="monitor" interval="300s"/>
        </operations>
        <instance_attributes id="myAddr-attrs">
          <nvpair id="myAddr-attr-1" name="ip" value="192.0.2.10"/>
        </instance_attributes>
      </primitive>
      <group id="myGroup">
        <primitive id="database" class="lsb" type="oracle">
          <operations>
            <op id="database-monitor" name="monitor" interval="300s"/>
          </operations>
        </primitive>
        <primitive id="webserver" class="lsb" type="apache">
          <operations>
            <op id="webserver-monitor" name="monitor" interval="300s"/>
          </operations>
        </primitive>
      </group>
      <clone id="STONITH">
        <meta_attributes id="stonith-options">
          <nvpair id="stonith-option-1" name="globally-unique" value="false"/>
        </meta_attributes>
        <primitive id="stonithclone" class="stonith" type="external/ssh">
          <operations>

```

```
        <op id="stonith-op-mon" name="monitor" interval="5s"/>
    </operations>
    <instance_attributes id="stonith-attrs">
        <nvpair id="stonith-attr-1" name="hostlist" value="c001n01,c001n02"/>
    </instance_attributes>
</primitive>
</clone>
</resources>
<constraints>
    <rsc_location id="myAddr-prefer" rsc="myAddr" node="c001n01"
        score="INFINITY"/>
    <rsc_colocation id="group-with-ip" rsc="myGroup" with-rsc="myAddr"
        score="INFINITY"/>
</constraints>
<op_defaults>
    <meta_attributes id="op_defaults-options">
        <nvpair id="op-default-1" name="timeout" value="30s"/>
    </meta_attributes>
</op_defaults>
<rsc_defaults>
    <meta_attributes id="rsc_defaults-options">
        <nvpair id="rsc-default-1" name="resource-stickiness" value="100"/>
        <nvpair id="rsc-default-2" name="migration-threshold" value="10"/>
    </meta_attributes>
</rsc_defaults>
</configuration>
<status/>
</cib>
```



---

# Appendix G. Further Reading

- Project Website: <http://www.clusterlabs.org/>
- Project Documentation: <http://www.clusterlabs.org/wiki/Documentation>
- SUSE High Availability Guide: [http://www.suse.com/documentation/sle\\_ha/book\\_sleha/data/book\\_sleha.html](http://www.suse.com/documentation/sle_ha/book_sleha/data/book_sleha.html)
- Heartbeat configuration: <http://www.linux-ha.org/>
- Corosync Configuration: <http://www.corosync.org/>





## Appendix H. Revision History

---

Update for Pacemaker 1.1.18

---

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