

# **Pacemaker 1.1**

## **Clusters from Scratch**

**Step-by-Step Instructions for Building  
Your First High-Availability Cluster**



**Andrew Beekhof**

# **Pacemaker 1.1 Clusters from Scratch**

## **Step-by-Step Instructions for Building Your First High-Availability Cluster**

### **Edition 9**

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The purpose of this document is to provide a start-to-finish guide to building an example active/passive cluster with Pacemaker and show how it can be converted to an active/active one.

The example cluster will use:

1. CentOS 7.1 as the host operating system
2. Corosync to provide messaging and membership services,
3. Pacemaker to perform resource management,
4. DRBD as a cost-effective alternative to shared storage,
5. GFS2 as the cluster filesystem (in active/active mode)

Given the graphical nature of the install process, a number of screenshots are included. However the guide is primarily composed of commands, the reasons for executing them and their expected outputs.

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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](https://fedorahosted.org/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

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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: *Clusters\_from\_Scratch*

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.

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

# Read-Me-First

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### 1.1. The Scope of this Document

Computer clusters can be used to provide highly available services or resources. The redundancy of multiple machines is used to guard against failures of many types.

This document will walk through the installation and setup of simple clusters using the CentOS distribution, version 7.1.

The clusters described here will use Pacemaker and Corosync to provide resource management and messaging. Required packages and modifications to their configuration files are described along with the use of the Pacemaker command line tool for generating the XML used for cluster control.

Pacemaker is a central component and provides the resource management required in these systems. This management includes detecting and recovering from the failure of various nodes, resources and services under its control.

When more in depth information is required and for real world usage, please refer to the [Pacemaker Explained](#)<sup>1</sup> manual.

### 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>2</sup> or [Heartbeat](#)<sup>3</sup>), and possibly by utilizing other parts of the overall cluster stack.

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<sup>1</sup> <http://www.clusterlabs.org/doc/>

<sup>2</sup> <http://www.corosync.org/>

<sup>3</sup> <http://linux-ha.org/wiki/Heartbeat>



### 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:

- 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>4</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.

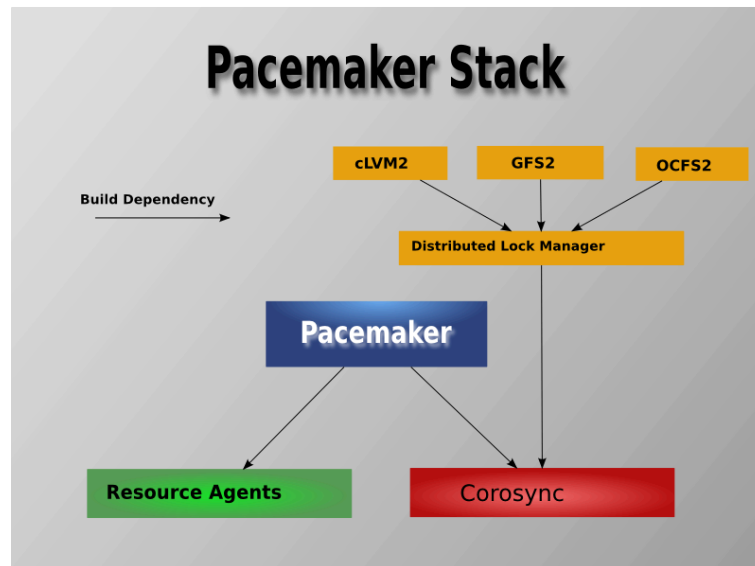


Figure 1.1. The Pacemaker Stack

### 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)*

<sup>4</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.

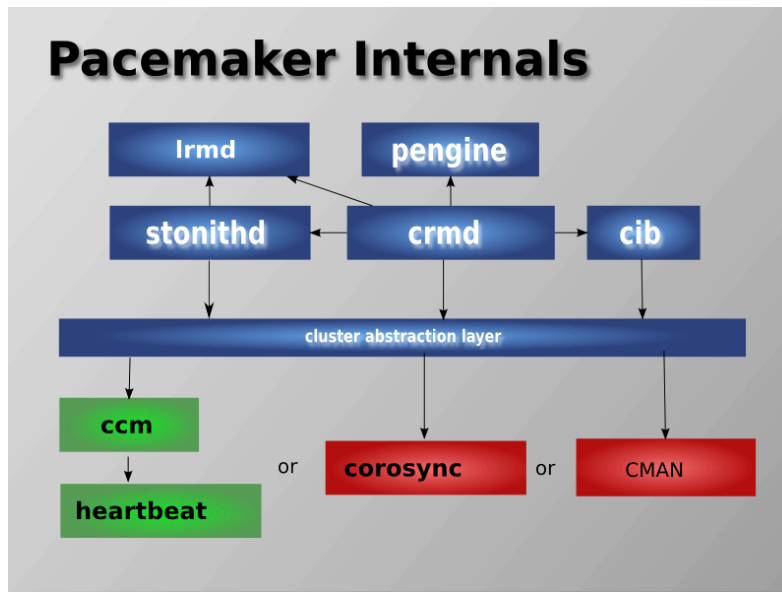


Figure 1.2. Internal Components

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>5</sup> including Active/Active, Active/Passive, N+1, N+M, N-to-1 and N-to-N.

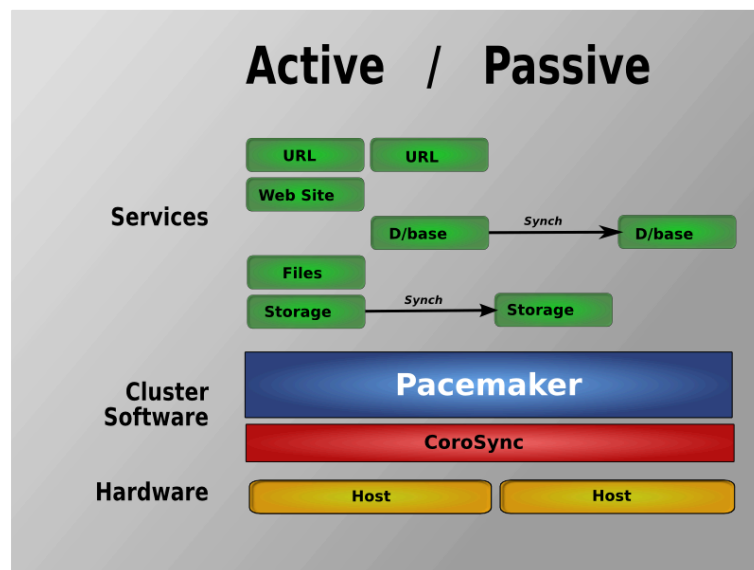


Figure 1.3. Active/Passive Redundancy

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

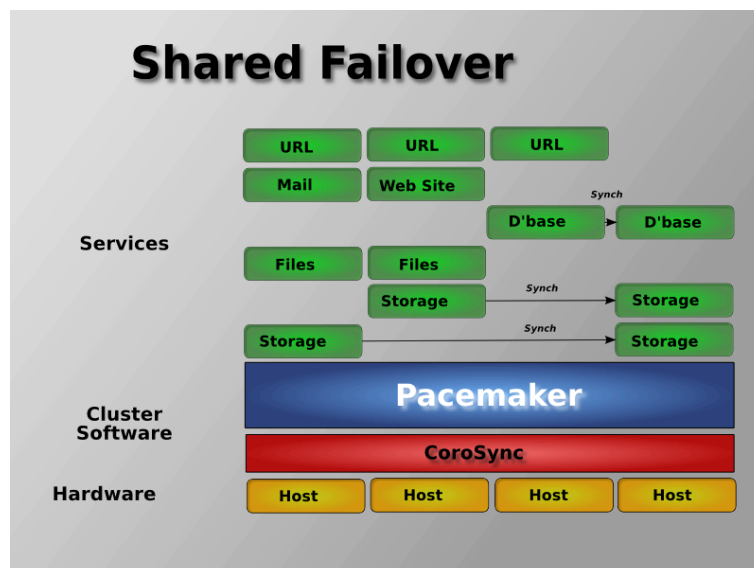


Figure 1.4. Shared Failover

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.

<sup>5</sup> [http://en.wikipedia.org/wiki/High-availability\\_cluster#Node\\_configurations](http://en.wikipedia.org/wiki/High-availability_cluster#Node_configurations)

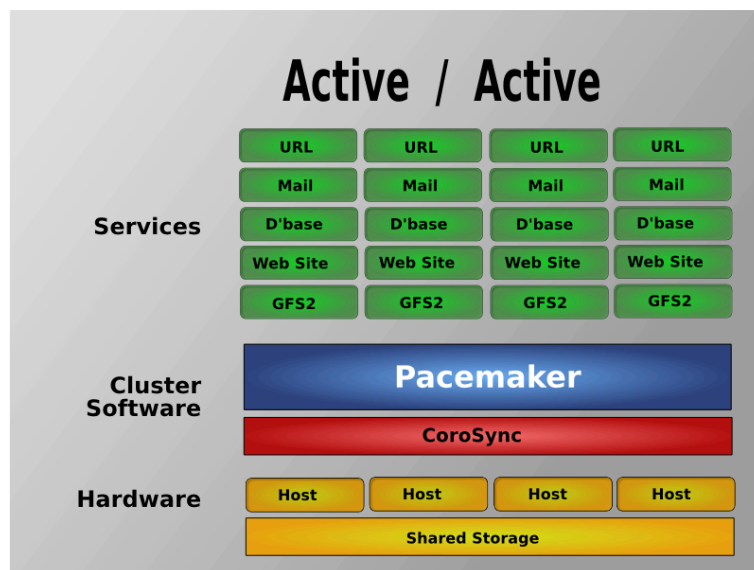


Figure 1.5. N to N Redundancy

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.

# Installation

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## 2.1. Install CentOS 7.1

### 2.1.1. Boot the Install Image

Download the 4GB [CentOS 7.1 DVD ISO](http://isoredirect.centos.org/centos/7/isos/x86_64/CentOS-7-x86_64-DVD-1503-01.iso)<sup>1</sup>. Use the image to boot a virtual machine, or burn it to a DVD or USB drive and boot a physical server from that.

After starting the installation, select your language and keyboard layout at the welcome screen.

<sup>1</sup> [http://isoredirect.centos.org/centos/7/isos/x86\\_64/CentOS-7-x86\\_64-DVD-1503-01.iso](http://isoredirect.centos.org/centos/7/isos/x86_64/CentOS-7-x86_64-DVD-1503-01.iso)

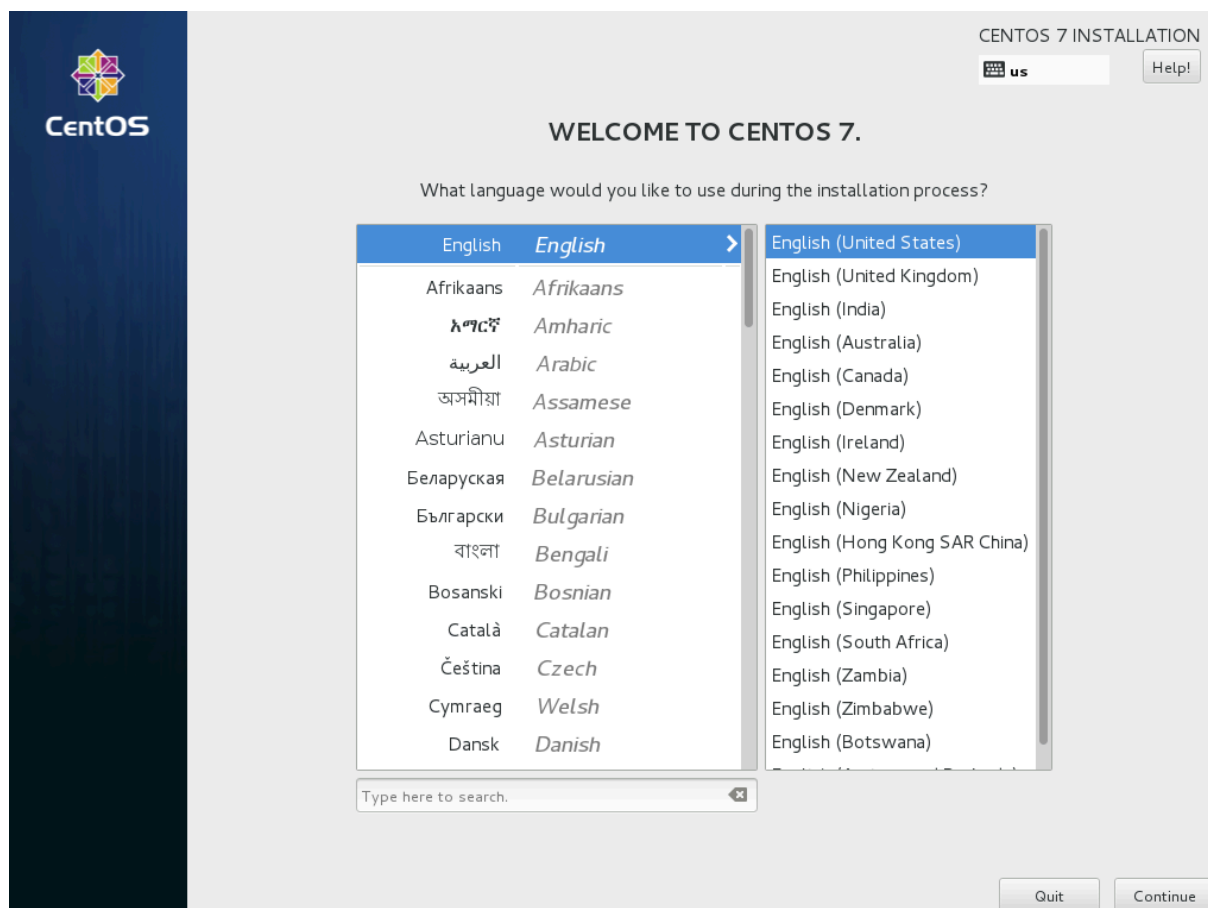


Figure 2.1. CentOS 7.1 Installation Welcome Screen

### 2.1.2. Installation Options

At this point, you get a chance to tweak the default installation options.

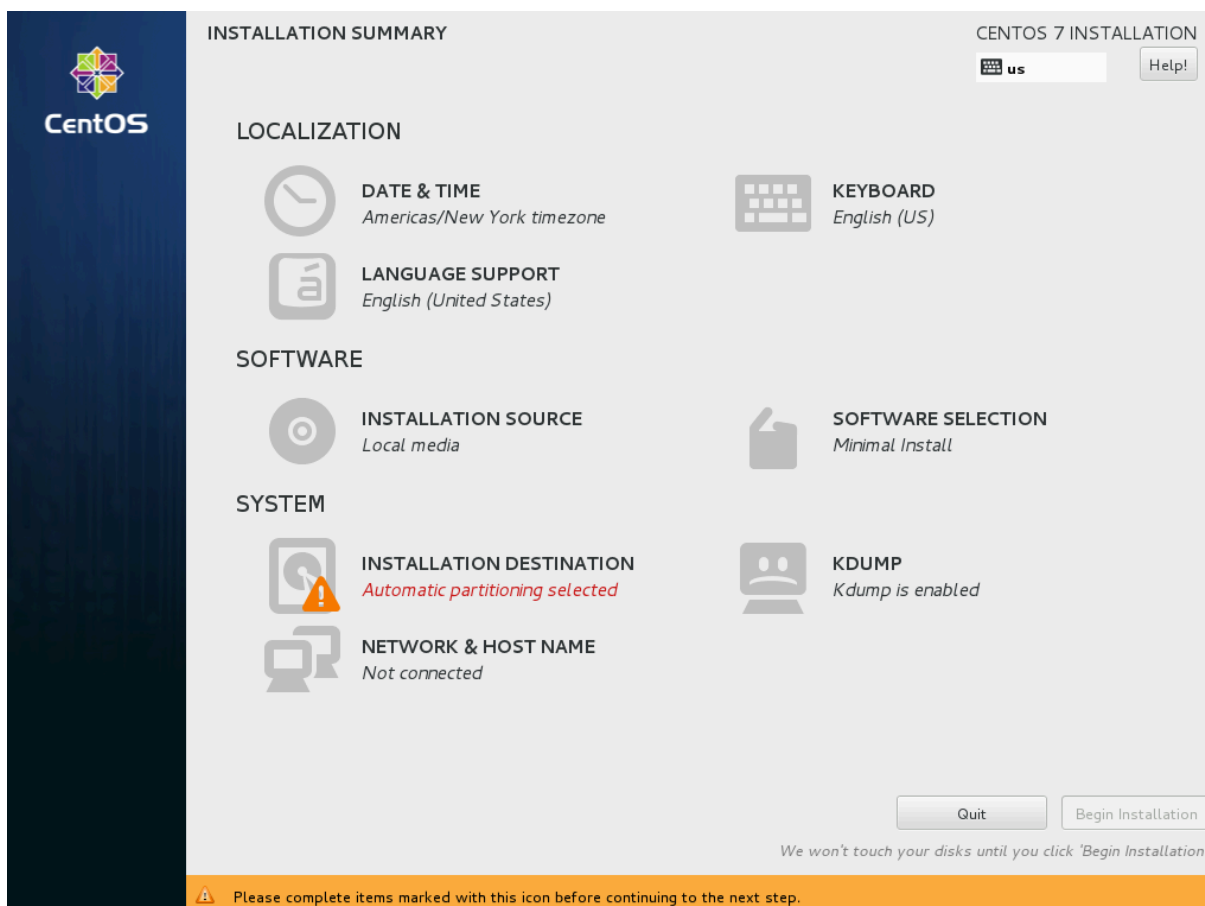


Figure 2.2. CentOS 7.1 Installation Summary Screen

Ignore the **SOFTWARE SELECTION** section (try saying that 10 times quickly). The **Infrastructure Server** environment does have add-ons with much of the software we need, but we will leave it as a **Minimal Install** here, so that we can see exactly what software is required later.

### 2.1.3. Configure Network

In the **NETWORK & HOSTNAME** section:

- Edit **Host Name**: as desired. For this example, we will use **pcmk-1.localdomain**.
- Select your network device, press **Configure...**, and manually assign a fixed IP address. For this example, we'll use 192.168.122.101 under **IPv4 Settings** (with an appropriate netmask, gateway and DNS server).
- Flip the switch to turn your network device on.



#### Important

Do not accept the default network settings. Cluster machines should never obtain an IP address via DHCP, because DHCP's periodic address renewal will interfere with corosync.

### 2.1.4. Configure Disk

By default, the installer's automatic partitioning will use LVM (which allows us to dynamically change the amount of space allocated to a given partition). However, it allocates all free space to the / (aka. **root**) partition, which cannot be reduced in size later (dynamic increases are fine).

In order to follow the DRBD and GFS2 portions of this guide, we need to reserve space on each machine for a replicated volume.

Enter the **INSTALLATION DESTINATION** section, ensure the hard drive you want to install to is selected, select **I will configure partitioning**, and press **Done**.

In the **MANUAL PARTITIONING** screen that comes next, click the option to create mountpoints automatically. Select the / mountpoint, and reduce the desired capacity by 1GiB or so. Select **Modify...** by the volume group name, and change the **Size policy**: to **As large as possible**, to make the reclaimed space available inside the LVM volume group. We'll add the additional volume later.

### 2.1.5. Configure Time Synchronization

It is highly recommended to enable NTP on your cluster nodes. Doing so ensures all nodes agree on the current time and makes reading log files significantly easier.

CentOS will enable NTP automatically. If you want to change any time-related settings (such as time zone or NTP server), you can do this in the **TIME & DATE** section.

### 2.1.6. Finish Install

Select **Begin Installation**. Once it completes, set a root password, and reboot as instructed. For the purposes of this document, it is not necessary to create any additional users. After the node reboots, you'll see a login prompt on the console. Login using **root** and the password you created earlier.

A screenshot of a terminal window showing the CentOS 7.1 console prompt. The text displayed is: "CentOS Linux 7 (Core)", "Kernel 3.10.0-229.el7.x86\_64 on an x86\_64", and "pcmk-1 login: \_". The background is black and the text is white.

```
CentOS Linux 7 (Core)
Kernel 3.10.0-229.el7.x86_64 on an x86_64
pcmk-1 login: _
```

Figure 2.3. CentOS 7.1 Console Prompt



#### Note

From here on, we're going to be working exclusively from the terminal.

## 2.2. Configure the OS

### 2.2.1. Verify Networking

Ensure that the machine has the static IP address you configured earlier.

```
[root@pcmk-1 ~]# ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP qlen 1000
    link/ether 52:54:00:d7:d6:08 brd ff:ff:ff:ff:ff:ff
    inet 192.168.122.101/24 brd 192.168.122.255 scope global eth0
        valid_lft forever preferred_lft forever
    inet6 fe80::5054:ff:fed7:d608/64 scope link
        valid_lft forever preferred_lft forever
```



#### Note

If you ever need to change the node's IP address from the command line, follow

```
[root@pcmk-1 ~]# vi /etc/sysconfig/network-scripts/ifcfg-${device} # manually edit as
desired
[root@pcmk-1 ~]# nmcli dev disconnect ${device}
[root@pcmk-1 ~]# nmcli con reload ${device}
[root@pcmk-1 ~]# nmcli con up ${device}
```

This makes **NetworkManager** aware that a change was made on the config file.

Next, ensure that the routes are as expected:

```
[root@pcmk-1 ~]# ip route
default via 192.168.122.1 dev eth0 proto static metric 100
192.168.122.0/24 dev eth0 proto kernel scope link src 192.168.122.101 metric 100
```

If there is no line beginning with **default via**, then you may need to add a line such as

```
GATEWAY="192.168.122.1"
```

to the device configuration using the same process as described above for changing the IP address.

Now, check for connectivity to the outside world. Start small by testing whether we can reach the gateway we configured.

```
[root@pcmk-1 ~]# ping -c 1 192.168.122.1
PING 192.168.122.1 (192.168.122.1) 56(84) bytes of data.
64 bytes from 192.168.122.1: icmp_req=1 ttl=64 time=0.249 ms

--- 192.168.122.1 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.249/0.249/0.249/0.000 ms
```

Now try something external; choose a location you know should be available.

```
[root@pcmk-1 ~]# ping -c 1 www.google.com
PING www.l.google.com (173.194.72.106) 56(84) bytes of data.
64 bytes from tf-in-f106.1e100.net (173.194.72.106): icmp_req=1 ttl=41 time=167 ms

--- www.l.google.com ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 167.618/167.618/167.618/0.000 ms
```

### 2.2.2. Login Remotely

The console isn't a very friendly place to work from, so we will now switch to accessing the machine remotely via SSH where we can use copy and paste, etc.

From another host, check whether we can see the new host at all:

```
beekhof@f16 ~ # ping -c 1 192.168.122.101
PING 192.168.122.101 (192.168.122.101) 56(84) bytes of data.
64 bytes from 192.168.122.101: icmp_req=1 ttl=64 time=1.01 ms

--- 192.168.122.101 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 1.012/1.012/1.012/0.000 ms
```

Next, login as root via SSH.

```
beekhof@f16 ~ # ssh -l root 192.168.122.101
The authenticity of host '192.168.122.101 (192.168.122.101)' can't be established.
ECDSA key fingerprint is 6e:b7:8f:e2:4c:94:43:54:a8:53:cc:20:0f:29:a4:e0.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '192.168.122.101' (ECDSA) to the list of known hosts.
root@192.168.122.101's password:
Last login: Tue Aug 11 13:14:39 2015
[root@pcmk-1 ~]#
```

### 2.2.3. Apply Updates

Apply any package updates released since your installation image was created:

```
[root@pcmk-1 ~]# yum update
```

### 2.2.4. Use Short Node Names

During installation, we filled in the machine's fully qualified domain name (FQDN), which can be rather long when it appears in cluster logs and status output. See for yourself how the machine identifies itself:

```
[root@pcmk-1 ~]# uname -n
pcmk-1.localdomain
```

We can use the **hostnamectl** tool to strip off the domain name:

```
[root@pcmk-1 ~]# hostnamectl set-hostname $(uname -n | sed s/\\..*//)
```



Now, check that the machine is using the correct name:

```
[root@pcmk-1 ~]# uname -n
pcmk-1
```

## 2.3. Repeat for Second Node

Repeat the Installation steps so far, so that you have two nodes ready to have the cluster software installed.

For the purposes of this document, the additional node is called pcmk-2 with address 192.168.122.102.

## 2.4. Configure Communication Between Nodes

### 2.4.1. Configure Host Name Resolution

Confirm that you can communicate between the two new nodes:

```
[root@pcmk-1 ~]# ping -c 3 192.168.122.102
PING 192.168.122.102 (192.168.122.102) 56(84) bytes of data.
64 bytes from 192.168.122.102: icmp_seq=1 ttl=64 time=0.343 ms
64 bytes from 192.168.122.102: icmp_seq=2 ttl=64 time=0.402 ms
64 bytes from 192.168.122.102: icmp_seq=3 ttl=64 time=0.558 ms

--- 192.168.122.102 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2000ms
rtt min/avg/max/mdev = 0.343/0.434/0.558/0.092 ms
```

Now we need to make sure we can communicate with the machines by their name. If you have a DNS server, add additional entries for the two machines. Otherwise, you'll need to add the machines to **/etc/hosts** on both nodes. Below are the entries for my cluster nodes:

```
[root@pcmk-1 ~]# grep pcmk /etc/hosts
192.168.122.101 pcmk-1.clusterlabs.org pcmk-1
192.168.122.102 pcmk-2.clusterlabs.org pcmk-2
```

We can now verify the setup by again using ping:

```
[root@pcmk-1 ~]# ping -c 3 pcmk-2
PING pcmk-2.clusterlabs.org (192.168.122.101) 56(84) bytes of data.
64 bytes from pcmk-1.clusterlabs.org (192.168.122.101): icmp_seq=1 ttl=64 time=0.164 ms
64 bytes from pcmk-1.clusterlabs.org (192.168.122.101): icmp_seq=2 ttl=64 time=0.475 ms
64 bytes from pcmk-1.clusterlabs.org (192.168.122.101): icmp_seq=3 ttl=64 time=0.186 ms

--- pcmk-2.clusterlabs.org ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2001ms
rtt min/avg/max/mdev = 0.164/0.275/0.475/0.141 ms
```

### 2.4.2. Configure SSH

SSH is a convenient and secure way to copy files and perform commands remotely. For the purposes of this guide, we will create a key without a password (using the **-N** option) so that we can perform remote actions without being prompted.



### Warning

Unprotected SSH keys (those without a password) are not recommended for servers exposed to the outside world. We use them here only to simplify the demo.

Create a new key and allow anyone with that key to log in:

### Creating and Activating a new SSH Key

```
[root@pcmk-1 ~]# ssh-keygen -t dsa -f ~/.ssh/id_dsa -N ""
Generating public/private dsa key pair.
Your identification has been saved in /root/.ssh/id_dsa.
Your public key has been saved in /root/.ssh/id_dsa.pub.
The key fingerprint is:
91:09:5c:82:5a:6a:50:08:4e:b2:0c:62:de:cc:74:44 root@pcmk-1.clusterlabs.org
The key's randomart image is:
+--[ DSA 1024]-----+
|==.ooEo..          |
|X O + .o o         |
| * A   +           |
|  +   .            |
| .     S           |
|                   |
|                   |
|                   |
+-----+
[root@pcmk-1 ~]# cp ~/.ssh/id_dsa.pub ~/.ssh/authorized_keys
```

Install the key on the other node:

```
[root@pcmk-1 ~]# scp -r ~/.ssh pcmk-2:
The authenticity of host 'pcmk-2 (192.168.122.102)' can't be established.
ECDSA key fingerprint is a4:f5:b2:34:9d:86:2b:34:a2:87:37:b9:ca:68:52:ec.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added 'pcmk-2,192.168.122.102' (ECDSA) to the list of known hosts.
root@pcmk-2's password:
id_dsa.pub          100% 616      0.6KB/s   00:00
id_dsa              100% 672      0.7KB/s   00:00
known_hosts         100% 400      0.4KB/s   00:00
authorized_keys     100% 616      0.6KB/s   00:00
```

Test that you can now run commands remotely, without being prompted:

```
[root@pcmk-1 ~]# ssh pcmk-2 -- uname -n
pcmk-2
```

## 2.5. Install the Cluster Software

Fire up a shell on both nodes and run the following to install pacemaker, and while we're at it, some command-line tools to make our lives easier:

```
# yum install -y pacemaker pcs psmisc policycoreutils-python
```



### Important

This document will show commands that need to be executed on both nodes with a simple # prompt. Be sure to run them on each node individually.



### Note

This document uses **pcs** for cluster management. Other alternatives, such as **crmsh**, are available, but their syntax will differ from the examples used here.

## 2.6. Configure the Cluster Software

### 2.6.1. Allow cluster services through firewall

On each node, allow cluster-related services through the local firewall:

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



### Note

If you are using iptables directly, or some other firewall solution besides firewalld, simply open the following ports, which can be used by various clustering components: TCP ports 2224, 3121, and 21064, and UDP port 5405.

If you run into any problems during testing, you might want to disable the firewall and SELinux entirely until you have everything working. This may create significant security issues and should not be performed on machines that will be exposed to the outside world, but may be appropriate during development and testing on a protected host.

To disable security measures:

```
[root@pcmk-1 ~]# setenforce 0
[root@pcmk-1 ~]# sed -i.bak "s/SELINUX=enforcing/SELINUX=permissive/g" /etc/selinux/
config
[root@pcmk-1 ~]# systemctl disable firewalld.service
[root@pcmk-1 ~]# systemctl stop firewalld.service
[root@pcmk-1 ~]# iptables --flush
```

### 2.6.2. Enable pcs Daemon

Before the cluster can be configured, the pcs daemon must be started and enabled to start at boot time on each node. This daemon works with the pcs command-line interface to manage synchronizing the corosync configuration across all nodes in the cluster.

Start and enable the daemon by issuing the following commands on each node:

```
# systemctl start pcsd.service
# systemctl enable pcsd.service
ln -s '/usr/lib/systemd/system/pcsd.service' '/etc/systemd/system/multi-user.target.wants/pcsd.service'
```

The installed packages will create a **hacluster** user with a disabled password. While this is fine for running **pcs** commands locally, the account needs a login password in order to perform such tasks as syncing the corosync configuration, or starting and stopping the cluster on other nodes.

This tutorial will make use of such commands, so now we will set a password for the **hacluster** user, using the same password on both nodes:

```
# passwd hacluster
Changing password for user hacluster.
New password:
Retype new password:
passwd: all authentication tokens updated successfully.
```



#### Note

Alternatively, to script this process or set the password on a different machine from the one you're logged into, you can use the **--stdin** option for **passwd**:

```
[root@pcmk-1 ~]# ssh pcmk-2 -- 'echo redhat1 | passwd --stdin hacluster'
```

### 2.6.3. Configure Corosync

On either node, use **pcs cluster auth** to authenticate as the **hacluster** user:

```
[root@pcmk-1 ~]# pcs cluster auth pcmk-1 pcmk-2
Username: hacluster
Password:
pcmk-1: Authorized
pcmk-2: Authorized
```

Next, use **pcs cluster setup** on the same node to generate and synchronize the corosync configuration:

```
[root@pcmk-1 ~]# pcs cluster setup --name mycluster pcmk-1 pcmk-2
Shutting down pacemaker/corosync services...
Redirecting to /bin/systemctl stop pacemaker.service
Redirecting to /bin/systemctl stop corosync.service
Killing any remaining services...
Removing all cluster configuration files...
pcmk-1: Succeeded
pcmk-2: Succeeded
```

If you received an authorization error for either of those commands, make sure you configured the **hacluster** user account on each node with the same password.



### Note

Early versions of pcs required that **--name** be omitted from the above command.

If you are not using **pcs** for cluster administration, follow whatever procedures are appropriate for your tools to create a `corosync.conf` and copy it to all nodes.

The **pcs** command will configure corosync to use UDP unicast transport; if you choose to use multicast instead, choose a multicast address carefully.<sup>2</sup>

The final `/etc/corosync.conf` configuration on each node should look something like the sample in [Appendix B, Sample Corosync Configuration](#).

<sup>2</sup> For some subtle issues, see the now-defunct <http://web.archive.org/web/20101211210054/http://29west.com/docs/THPM/multicast-address-assignment.html> or the more detailed treatment in *Cisco's Guidelines for Enterprise IP Multicast Address Allocation* [[http://www.cisco.com/c/dam/en/us/support/docs/ip/ip-multicast/ipmlt\\_wp.pdf](http://www.cisco.com/c/dam/en/us/support/docs/ip/ip-multicast/ipmlt_wp.pdf)] paper.



# Pacemaker Tools

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### 3.1. Simplify administration using a cluster shell

In the dark past, configuring Pacemaker required the administrator to read and write XML. In true UNIX style, there were also a number of different commands that specialized in different aspects of querying and updating the cluster.

All of that has been greatly simplified with the creation of unified command-line shells (and GUIs) that hide all the messy XML scaffolding.

These shells take all the individual aspects required for managing and configuring a cluster, and pack them into one simple-to-use command line tool.

They even allow you to queue up several changes at once and commit them atomically.

Two popular command-line shells are **pcs** and **crmsh**. This edition of Clusters from Scratch is based on **pcs**.



#### Note

The two shells share many concepts but the scope, layout and syntax does differ, so make sure you read the version of this guide that corresponds to the software installed on your system.

### 3.2. Explore pcs

Start by taking some time to familiarize yourself with what **pcs** can do.

```
[root@pcmk-1 ~]# pcs
Usage: pcs [-f file] [-h] [commands]...
Control and configure pacemaker and corosync.

Options:
  -h, --help      Display usage and exit
  -f file         Perform actions on file instead of active CIB
  --debug         Print all network traffic and external commands run
  --version       Print pcs version information

Commands:
  cluster      Configure cluster options and nodes
  resource     Manage cluster resources
  stonith      Configure fence devices
  constraint   Set resource constraints
  property     Set pacemaker properties
  acl          Set pacemaker access control lists
  status       View cluster status
  config       View and manage cluster configuration
```

As you can see, the different aspects of cluster management are separated into categories: resource, cluster, stonith, property, constraint, and status. To discover the functionality available in each of these categories, one can issue the command **pcs category help**. Below is an example of all the options available under the status category.

```
[root@pcmk-1 ~]# pcs status help
Usage: pcs status [commands]...
View current cluster and resource status
Commands:
  [status] [--full]
    View all information about the cluster and resources (--full provides
    more details)

  resources
    View current status of cluster resources

  groups
    View currently configured groups and their resources

  cluster
    View current cluster status

  corosync
    View current membership information as seen by corosync

  nodes [corosync|both|config]
    View current status of nodes from pacemaker. If 'corosync' is
    specified, print nodes currently configured in corosync, if 'both'
    is specified, print nodes from both corosync & pacemaker. If 'config'
    is specified, print nodes from corosync & pacemaker configuration.

  pcsd <node> ...
    Show the current status of pcsd on the specified nodes

  xml
    View xml version of status (output from crm_mon -r -1 -X)
```

Additionally, if you are interested in the version and supported cluster stack(s) available with your Pacemaker installation, run:

```
[root@pcmk-1 ~]# pacemakerd --features
Pacemaker 1.1.12 (Build: a14efad)
Supporting v3.0.9: generated-manpages agent-manpages ascii-docs publican-docs ncurses
libqb-logging libqb-ipc upstart systemd nagios corosync-native atomic-atrdrd acfs
```



### Note

If the SNMP and/or email options are not listed, then Pacemaker was not built to support them. This may be by the choice of your distribution, or the required libraries may not have been available. Please contact whoever supplied you with the packages for more details.



# Start and Verify Cluster

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## 4.1. Start the Cluster

Now that corosync is configured, it is time to start the cluster. The command below will start corosync and pacemaker on both nodes in the cluster. If you are issuing the start command from a different node than the one you ran the **pcs cluster auth** command on earlier, you must authenticate on the current node you are logged into before you will be allowed to start the cluster.

```
[root@pcmk-1 ~]# pcs cluster start --all
pcmk-1: Starting Cluster...
pcmk-2: Starting Cluster...
```



### Note

An alternative to using the **pcs cluster start --all** command is to issue either of the below command sequences on each node in the cluster separately:

```
# pcs cluster start
Starting Cluster...
```

or

```
# systemctl start corosync.service
# systemctl start pacemaker.service
```



### Important

In this example, we are not enabling the corosync and pacemaker services to start at boot. If a cluster node fails or is rebooted, you will need to run **pcs cluster start nodename** (or **--all**) to start the cluster on it. While you could enable the services to start at boot, requiring a manual start of cluster services gives you the opportunity to do a post-mortem investigation of a node failure before returning it to the cluster.

## 4.2. Verify Corosync Installation

First, use **corosync-cfgtool** to check whether cluster communication is happy:

```
[root@pcmk-1 ~]# corosync-cfgtool -s
```

```
Printing ring status.
Local node ID 1
RING ID 0
    id      = 192.168.122.101
    status  = ring 0 active with no faults
```

We can see here that everything appears normal with our fixed IP address (not a 127.0.0.x loopback address) listed as the **id**, and **no faults** for the status.

If you see something different, you might want to start by checking the node's network, firewall and selinux configurations.

Next, check the membership and quorum APIs:

```
[root@pcmk-1 ~]# corosync-cmapctl | grep members
runtime.totem.pg.mrp.srp.members.1.config_version (u64) = 0
runtime.totem.pg.mrp.srp.members.1.ip (str) = r(0) ip(192.168.122.101)
runtime.totem.pg.mrp.srp.members.1.join_count (u32) = 1
runtime.totem.pg.mrp.srp.members.1.status (str) = joined
runtime.totem.pg.mrp.srp.members.2.config_version (u64) = 0
runtime.totem.pg.mrp.srp.members.2.ip (str) = r(0) ip(192.168.122.102)
runtime.totem.pg.mrp.srp.members.2.join_count (u32) = 2
runtime.totem.pg.mrp.srp.members.2.status (str) = joined

[root@pcmk-1 ~]# pcs status corosync
Membership information
-----
   Nodeid      Votes Name
     1          1 pcmk-1 (local)
     2          1 pcmk-2
```

You should see both nodes have joined the cluster.

### 4.3. Verify Pacemaker Installation

Now that we have confirmed that Corosync is functional, we can check the rest of the stack. Pacemaker has already been started, so verify the necessary processes are running:

```
[root@pcmk-1 ~]# ps axf
PID TTY      STAT   TIME COMMAND
  2 ?        S      0:00 [kthreadd]
...lots of processes...
1362 ?        Ss      0:35 corosync
1379 ?        Ss      0:00 /usr/sbin/pacemakerd -f
1380 ?        Ss      0:00 \_ /usr/libexec/pacemaker/cib
1381 ?        Ss      0:00 \_ /usr/libexec/pacemaker/stonithd
1382 ?        Ss      0:00 \_ /usr/libexec/pacemaker/lrmd
1383 ?        Ss      0:00 \_ /usr/libexec/pacemaker/attrd
1384 ?        Ss      0:00 \_ /usr/libexec/pacemaker/pengine
1385 ?        Ss      0:00 \_ /usr/libexec/pacemaker/crmd
```

If that looks OK, check the **pcs status** output:

```
[root@pcmk-1 ~]# pcs status
Cluster name: mycluster
WARNING: no stonith devices and stonith-enabled is not false
Last updated: Tue Dec 16 16:15:29 2014
Last change: Tue Dec 16 15:49:47 2014
Stack: corosync
Current DC: pcmk-2 (2) - partition with quorum
Version: 1.1.12-a14efad
```

```
2 Nodes configured
0 Resources configured

Online: [ pcmk-1 pcmk-2 ]

Full list of resources:

PCSD Status:
  pcmk-1: Online
  pcmk-2: Online

Daemon Status:
  corosync: active/disabled
  pacemaker: active/disabled
  pcsd: active/enabled
```

Finally, ensure there are no startup errors (aside from messages relating to not having STONITH configured, which are OK at this point):

```
[root@pcmk-1 ~]# journalctl | grep -i error
```



### Note

Other operating systems may report startup errors in other locations, for example **/var/log/messages**.

Repeat these checks on the other node. The results should be the same.



# Create an Active/Passive Cluster

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## 5.1. Explore the Existing Configuration

When Pacemaker starts up, it automatically records the number and details of the nodes in the cluster, as well as which stack is being used and the version of Pacemaker being used.

The first few lines of output should look like this:

```
[root@pcmk-1 ~]# pcs status
Cluster name: mycluster
WARNING: no stonith devices and stonith-enabled is not false
Last updated: Tue Dec 16 16:15:29 2014
Last change: Tue Dec 16 15:49:47 2014
Stack: corosync
Current DC: pcmk-2 (2) - partition with quorum
Version: 1.1.12-a14efad
2 Nodes configured
0 Resources configured

Online: [ pcmk-1 pcmk-2 ]
```

For those who are not afraid of XML, you can see the raw cluster configuration and status by using the **pcs cluster cib** command.

### Example 5.1. The last XML you'll see in this document

```
[root@pcmk-1 ~]# pcs cluster cib
```

```
<cib crm_feature_set="3.0.9" validate-with="pacemaker-2.3" epoch="5" num_updates="8"
admin_epoch="0" cib-last-written="Tue Dec 16 15:49:47 2014" have-quorum="1" dc-uuid="2">
  <configuration>
    <crm_config>
      <cluster_property_set id="cib-bootstrap-options">
        <nvpair id="cib-bootstrap-options-have-watchdog" name="have-watchdog"
value="false"/>
        <nvpair id="cib-bootstrap-options-dc-version" name="dc-version" value="1.1.12-
a14efad"/>
        <nvpair id="cib-bootstrap-options-cluster-infrastructure" name="cluster-
infrastructure" value="corosync"/>
        <nvpair id="cib-bootstrap-options-cluster-name" name="cluster-name"
value="mycluster"/>
      </cluster_property_set>
    </crm_config>
    <nodes>
      <node id="1" uname="pcmk-1"/>
      <node id="2" uname="pcmk-2"/>
    </nodes>
```

```
<resources/>
<constraints/>
</configuration>
<status>
  <node_state id="2" uname="pcmk-2" in_ccm="true" crmd="online" crm-debug-
origin="do_state_transition" join="member" expected="member">
    <lrmd id="2">
      <lrmd_resources/>
    </lrmd>
    <transient_attributes id="2">
      <instance_attributes id="status-2">
        <nvpair id="status-2-shutdown" name="shutdown" value="0"/>
        <nvpair id="status-2-probe_complete" name="probe_complete" value="true"/>
      </instance_attributes>
    </transient_attributes>
  </node_state>
  <node_state id="1" uname="pcmk-1" in_ccm="true" crmd="online" crm-debug-
origin="do_state_transition" join="member" expected="member">
    <lrmd id="1">
      <lrmd_resources/>
    </lrmd>
    <transient_attributes id="1">
      <instance_attributes id="status-1">
        <nvpair id="status-1-shutdown" name="shutdown" value="0"/>
        <nvpair id="status-1-probe_complete" name="probe_complete" value="true"/>
      </instance_attributes>
    </transient_attributes>
  </node_state>
</status>
</cib>
```

Before we make any changes, it's a good idea to check the validity of the configuration.

```
[root@pcmk-1 ~]# crm_verify -L -V
error: unpack_resources: Resource start-up disabled since no STONITH resources have been
defined
error: unpack_resources: Either configure some or disable STONITH with the stonith-enabled
option
error: unpack_resources: NOTE: Clusters with shared data need STONITH to ensure data
integrity
Errors found during check: config not valid
```

As you can see, the tool has found some errors.

In order to guarantee the safety of your data,<sup>1</sup> the default for STONITH<sup>2</sup> in Pacemaker is **enabled**. However, it also knows when no STONITH configuration has been supplied and reports this as a problem (since the cluster would not be able to make progress if a situation requiring node fencing arose).

We will disable this feature for now and configure it later.

To disable STONITH, set the **stonith-enabled** cluster option to false:

```
[root@pcmk-1 ~]# pcs property set stonith-enabled=false
[root@pcmk-1 ~]# crm_verify -L
```

With the new cluster option set, the configuration is now valid.

<sup>1</sup> If the data is corrupt, there is little point in continuing to make it available

<sup>2</sup> A common node fencing mechanism. Used to ensure data integrity by powering off "bad" nodes

**Warning**

The use of **stonith-enabled=false** is completely inappropriate for a production cluster. It tells the cluster to simply pretend that failed nodes are safely powered off. Some vendors will refuse to support clusters that have STONITH disabled.

We disable STONITH here only to defer the discussion of its configuration, which can differ widely from one installation to the next. See [Section 8.1, “What is STONITH?”](#) for information on why STONITH is important and details on how to configure it.

## 5.2. Add a Resource

Our first resource will be a unique IP address that the cluster can bring up on either node. Regardless of where any cluster service(s) are running, end users need a consistent address to contact them on. Here, I will choose 192.168.122.120 as the floating address, give it the imaginative name ClusterIP and tell the cluster to check whether it is running every 30 seconds.

**Warning**

The chosen address must not already be in use on the network. Do not reuse an IP address one of the nodes already has configured.

```
[root@pcmk-1 ~]# pcs resource create ClusterIP ocf:heartbeat:IPaddr2 \
    ip=192.168.122.120 cidr_netmask=32 op monitor interval=30s
```

Another important piece of information here is **ocf:heartbeat:IPaddr2**. This tells Pacemaker three things about the resource you want to add:

- The first field (**ocf** in this case) is the standard to which the resource script conforms and where to find it.
- The second field (**heartbeat** in this case) is standard-specific; for OCF resources, it tells the cluster which OCF namespace the resource script is in.
- The third field (**IPaddr2** in this case) is the name of the resource script.

To obtain a list of the available resource standards (the **ocf** part of **ocf:heartbeat:IPaddr2**), run:

```
[root@pcmk-1 ~]# pcs resource standards
ocf
lsb
service
systemd
stonith
```

To obtain a list of the available OCF resource providers (the **heartbeat** part of **ocf:heartbeat:IPaddr2**), run:

```
[root@pcmk-1 ~]# pcs resource providers
```

```
heartbeat
openstack
pacemaker
```

Finally, if you want to see all the resource agents available for a specific OCF provider (the **IPAddr2** part of **ocf:heartbeat:IPAddr2**), run:

```
[root@pcmk-1 ~]# pcs resource agents ocf:heartbeat
CTDB
Delay
Dummy
Filesystem
IPAddr
IPAddr2
.
. (skipping lots of resources to save space)
.
rsyncd
slapd
symlink
tomcat
```

Now, verify that the IP resource has been added, and display the cluster's status to see that it is now active:

```
[root@pcmk-1 ~]# pcs status
Cluster name: mycluster
Last updated: Tue Dec 16 17:44:40 2014
Last change: Tue Dec 16 17:44:26 2014
Stack: corosync
Current DC: pcmk-1 (1) - partition with quorum
Version: 1.1.12-a14efad
2 Nodes configured
1 Resources configured

Online: [ pcmk-1 pcmk-2 ]

Full list of resources:

ClusterIP      (ocf::heartbeat:IPAddr2):      Started pcmk-1

PCSD Status:
  pcmk-1: Online
  pcmk-2: Online

Daemon Status:
  corosync: active/disabled
  pacemaker: active/disabled
  pcsd: active/enabled
```

### 5.3. Perform a Failover

Since our ultimate goal is high availability, we should test failover of our new resource before moving on.

First, find the node on which the IP address is running.

```
[root@pcmk-1 ~]# pcs status
Cluster name: mycluster
Last updated: Tue Dec 16 17:44:40 2014
Last change: Tue Dec 16 17:44:26 2014
```



```
Stack: corosync
Current DC: pcmk-1 (1) - partition with quorum
Version: 1.1.12-a14efad
2 Nodes configured
1 Resources configured

Online: [ pcmk-1 pcmk-2 ]

Full list of resources:

ClusterIP      (ocf::heartbeat:IPaddr2):      Started pcmk-1
```

You can see that the status of the **ClusterIP** resource is **Started** on a particular node (in this example, **pcmk-1**). Shut down Pacemaker and Corosync on that machine to trigger a failover.

```
[root@pcmk-1 ~]# pcs cluster stop pcmk-1
Stopping Cluster...
```



### Note

A cluster command such as **pcs cluster stop *nodename*** can be run from any node in the cluster, not just the affected node.

Verify that pacemaker and corosync are no longer running:

```
[root@pcmk-1 ~]# pcs status
Error: cluster is not currently running on this node
```

Go to the other node, and check the cluster status.

```
[root@pcmk-2 ~]# pcs status
Cluster name: mycluster
Last updated: Wed Dec 17 10:30:56 2014
Last change: Tue Dec 16 17:44:26 2014
Stack: corosync
Current DC: pcmk-2 (2) - partition with quorum
Version: 1.1.12-a14efad
2 Nodes configured
1 Resources configured

Online: [ pcmk-2 ]
OFFLINE: [ pcmk-1 ]

Full list of resources:

ClusterIP      (ocf::heartbeat:IPaddr2):      Started pcmk-2

PCSD Status:
  pcmk-1: Online
  pcmk-2: Online

Daemon Status:
  corosync: active/disabled
  pacemaker: active/disabled
  pcsd: active/enabled
```

Notice that **pcmk-1** is **OFFLINE** for cluster purposes (its **PCSD** is still **Online**, allowing it to receive **pcs** commands, but it is not participating in the cluster).

Also notice that **ClusterIP** is now running on **pcmk-2** — failover happened automatically, and no errors are reported.



### Quorum

If a cluster splits into two (or more) groups of nodes that can no longer communicate with each other (aka. *partitions*), *quorum* is used to prevent resources from starting on more nodes than desired, which would risk data corruption.

A cluster has quorum when more than half of all known nodes are online in the same partition, or for the mathematically inclined, whenever the following equation is true:

$$\text{total\_nodes} < 2 * \text{active\_nodes}$$

For example, if a 5-node cluster split into 3- and 2-node partitions, the 3-node partition would have quorum and could continue serving resources. If a 6-node cluster split into two 3-node partitions, neither partition would have quorum; pacemaker's default behavior in such cases is to stop all resources, in order to prevent data corruption.

Two-node clusters are a special case. By the above definition, a two-node cluster would only have quorum when both nodes are running. This would make the creation of a two-node cluster pointless,<sup>3</sup> but corosync has the ability to treat two-node clusters as if only one node is required for quorum.

The **pcs cluster setup** command will automatically configure **two\_node: 1** in **corosync.conf**, so a two-node cluster will "just work".

If you are using a different cluster shell, you will have to configure **corosync.conf** appropriately yourself. If you are using older versions of corosync, you will have to ignore quorum at the pacemaker level, using **pcs property set no-quorum-policy=ignore** (or the equivalent command if you are using a different cluster shell).

Now, simulate node recovery by restarting the cluster stack on **pcmk-1**, and check the cluster's status. (It may take a little while before the cluster gets going on the node, but it eventually will look like the below.)

```
[root@pcmk-1 ~]# pcs cluster start pcmk-1
pcmk-1: Starting Cluster...
[root@pcmk-1 ~]# pcs status
Cluster name: mycluster
Last updated: Wed Dec 17 10:50:11 2014
Last change: Tue Dec 16 17:44:26 2014
Stack: corosync
Current DC: pcmk-2 (2) - partition with quorum
Version: 1.1.12-a14efad
2 Nodes configured
1 Resources configured
```

<sup>3</sup> Some would argue that two-node clusters are always pointless, but that is an argument for another time

```
Online: [ pcmk-1 pcmk-2 ]

Full list of resources:

ClusterIP      (ocf::heartbeat:IPaddr2):      Started pcmk-2

PCSD Status:
  pcmk-1: Online
  pcmk-2: Online

Daemon Status:
  corosync: active/disabled
  pacemaker: active/disabled
  pcsd: active/enabled
```



### Note

With older versions of pacemaker, the cluster might move the IP back to its original location (**pcmk-1**). Usually, this is no longer the case.

## 5.4. Prevent Resources from Moving after Recovery

In most circumstances, it is highly desirable to prevent healthy resources from being moved around the cluster. Moving resources almost always requires a period of downtime. For complex services such as databases, this period can be quite long.

To address this, Pacemaker has the concept of resource *stickiness*, which controls how strongly a service prefers to stay running where it is. You may like to think of it as the "cost" of any downtime. By default, Pacemaker assumes there is zero cost associated with moving resources and will do so to achieve "optimal" <sup>4</sup> resource placement. We can specify a different stickiness for every resource, but it is often sufficient to change the default.

```
[root@pcmk-1 ~]# pcs resource defaults resource-stickiness=100
[root@pcmk-1 ~]# pcs resource defaults
resource-stickiness: 100
```



### Note

Older versions of **pcs** required that **rsc** be added after **resource** in the above commands.

<sup>4</sup> Pacemaker's definition of optimal may not always agree with that of a human's. The order in which Pacemaker processes lists of resources and nodes creates implicit preferences in situations where the administrator has not explicitly specified them.



# Add Apache as a Cluster Service

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Now that we have a basic but functional active/passive two-node cluster, we're ready to add some real services. We're going to start with Apache because it is a feature of many clusters and relatively simple to configure.

## 6.1. Install Apache

Before continuing, we need to make sure Apache is installed on both hosts. We also need the `wget` tool in order for the cluster to be able to check the status of the Apache server.

```
# yum install -y httpd wget
# firewall-cmd --permanent --add-service=http
# firewall-cmd --reload
```



### Important

Do **not** enable the `httpd` service. Services that are intended to be managed via the cluster software should never be managed by the OS.

It is often useful, however, to manually start the service, verify that it works, then stop it again, before adding it to the cluster. This allows you to resolve any non-cluster-related problems before continuing. Since this is a simple example, we'll skip that step here.

## 6.2. Create Website Documents

We need to create a page for Apache to serve. On CentOS 7.1, the default Apache document root is `/var/www/html`, so we'll create an index file there. For the moment, we will simplify things by serving a static site and manually synchronizing the data between the two nodes, so run this command on both nodes:

```
# cat <<-END >/var/www/html/index.html
<html>
<body>My Test Site - ${hostname}</body>
</html>
END
```

### 6.3. Enable the Apache status URL

In order to monitor the health of your Apache instance, and recover it if it fails, the resource agent used by Pacemaker assumes the server-status URL is available. On both nodes, enable the URL with:

```
# cat <<-END >/etc/httpd/conf.d/status.conf
<Location /server-status>
    SetHandler server-status
    Order deny,allow
    Deny from all
    Allow from 127.0.0.1
</Location>
END
```



#### Note

If you are using a different operating system, server-status may already be enabled or may be configurable in a different location.

### 6.4. Configure the Cluster

At this point, Apache is ready to go, and all that needs to be done is to add it to the cluster. Let's call the resource WebSite. We need to use an OCF resource script called `apache` in the `heartbeat` namespace.<sup>1</sup> The script's only required parameter is the path to the main Apache configuration file, and we'll tell the cluster to check once a minute that Apache is still running.

```
[root@pcmk-1 ~]# pcs resource create WebSite ocf:heartbeat:apache \
    configfile=/etc/httpd/conf/httpd.conf \
    statusurl="http://localhost/server-status" \
    op monitor interval=1min
```

By default, the operation timeout for all resources' start, stop, and monitor operations is 20 seconds. In many cases, this timeout period is less than a particular resource's advised timeout period. For the purposes of this tutorial, we will adjust the global operation timeout default to 240 seconds.

```
[root@pcmk-1 ~]# pcs resource op defaults timeout=240s
[root@pcmk-1 ~]# pcs resource op defaults
timeout: 240s
```



#### Note

In a production cluster, it is usually better to adjust each resource's start, stop, and monitor timeouts to values that are appropriate to the behavior observed in your environment, rather than adjust the global default.

<sup>1</sup> Compare the key used here, `ocf:heartbeat:apache`, with the one we used earlier for the IP address, `ocf:heartbeat:IPaddr2`

After a short delay, we should see the cluster start Apache.

```
[root@pcmk-1 ~]# pcs status
Cluster name: mycluster
Last updated: Wed Dec 17 12:40:41 2014
Last change: Wed Dec 17 12:40:05 2014
Stack: corosync
Current DC: pcmk-2 (2) - partition with quorum
Version: 1.1.12-a14efad
2 Nodes configured
2 Resources configured

Online: [ pcmk-1 pcmk-2 ]

Full list of resources:

ClusterIP      (ocf::heartbeat:IPaddr2):      Started pcmk-2
WebSite        (ocf::heartbeat:apache):      Started pcmk-1

PCSD Status:
  pcmk-1: Online
  pcmk-2: Online

Daemon Status:
  corosync: active/disabled
  pacemaker: active/disabled
  pcsd: active/enabled
```

Wait a moment, the WebSite resource isn't running on the same host as our IP address!



### Note

If, in the **pcs status** output, you see the WebSite resource has failed to start, then you've likely not enabled the status URL correctly. You can check whether this is the problem by running:

```
wget -O - http://127.0.0.1/server-status
```

If you see **Connection refused** in the output, then this is likely the problem. Ensure that **Allow from 127.0.0.1** is present for the **<Location /server-status>** block.

## 6.5. Ensure Resources Run on the Same Host

To reduce the load on any one machine, Pacemaker will generally try to spread the configured resources across the cluster nodes. However, we can tell the cluster that two resources are related and need to run on the same host (or not at all). Here, we instruct the cluster that WebSite can only run on the host that ClusterIP is active on.

To achieve this, we use a *colocation constraint* that indicates it is mandatory for WebSite to run on the same node as ClusterIP. The "mandatory" part of the colocation constraint is indicated by using a score of INFINITY. The INFINITY score also means that if ClusterIP is not active anywhere, WebSite will not be permitted to run.



### Note

If ClusterIP is not active anywhere, WebSite will not be permitted to run anywhere.



### Important

Colocation constraints are "directional", in that they imply certain things about the order in which the two resources will have a location chosen. In this case, we're saying that **WebSite** needs to be placed on the same machine as **ClusterIP**, which implies that the cluster must know the location of **ClusterIP** before choosing a location for **WebSite**.

```
[root@pcmk-1 ~]# pcs constraint colocation add WebSite with ClusterIP INFINITY
[root@pcmk-1 ~]# pcs constraint
Location Constraints:
Ordering Constraints:
Colocation Constraints:
  WebSite with ClusterIP (score:INFINITY)
[root@pcmk-1 ~]# pcs status
Cluster name: mycluster
Last updated: Wed Dec 17 13:57:58 2014
Last change: Wed Dec 17 13:57:22 2014
Stack: corosync
Current DC: pcmk-2 (2) - partition with quorum
Version: 1.1.12-a14efad
2 Nodes configured
2 Resources configured

Online: [ pcmk-1 pcmk-2 ]

Full list of resources:

ClusterIP      (ocf::heartbeat:IPaddr2):      Started pcmk-2
WebSite        (ocf::heartbeat:apache):      Started pcmk-2

PCSD Status:
  pcmk-1: Online
  pcmk-2: Online

Daemon Status:
  corosync: active/disabled
  pacemaker: active/disabled
  pcsd: active/enabled
```

## 6.6. Ensure Resources Start and Stop in Order

Like many services, Apache can be configured to bind to specific IP addresses on a host or to the wildcard IP address. If Apache binds to the wildcard, it doesn't matter whether an IP address is added before or after Apache starts; Apache will respond on that IP just the same. However, if Apache binds only to certain IP address(es), the order matters: If the address is added after Apache starts, Apache won't respond on that address.



To be sure our WebSite responds regardless of Apache's address configuration, we need to make sure ClusterIP not only runs on the same node, but starts before WebSite. A colocation constraint only ensures the resources run together, not the order in which they are started and stopped.

We do this by adding an ordering constraint. By default, all order constraints are mandatory, which means that the recovery of ClusterIP will also trigger the recovery of WebSite.

```
[root@pcmk-1 ~]# pcs constraint order ClusterIP then WebSite
Adding ClusterIP WebSite (kind: Mandatory) (Options: first-action=start then-action=start)
[root@pcmk-1 ~]# pcs constraint
Location Constraints:
Ordering Constraints:
    start ClusterIP then start WebSite (kind:Mandatory)
Colocation Constraints:
    WebSite with ClusterIP (score:INFINITY)
```

## 6.7. Prefer One Node Over Another

Pacemaker does not rely on any sort of hardware symmetry between nodes, so it may well be that one machine is more powerful than the other. In such cases, it makes sense to host the resources on the more powerful node if it is available. To do this, we create a location constraint.

In the location constraint below, we are saying the WebSite resource prefers the node pcmk-1 with a score of 50. Here, the score indicates how badly we'd like the resource to run at this location.

```
[root@pcmk-1 ~]# pcs constraint location WebSite prefers pcmk-1=50
[root@pcmk-1 ~]# pcs constraint
Location Constraints:
    Resource: WebSite
        Enabled on: pcmk-1 (score:50)
Ordering Constraints:
    start ClusterIP then start WebSite (kind:Mandatory)
Colocation Constraints:
    WebSite with ClusterIP (score:INFINITY)
[root@pcmk-1 ~]# pcs status
Cluster name: mycluster
Last updated: Wed Dec 17 14:11:49 2014
Last change: Wed Dec 17 14:11:20 2014
Stack: corosync
Current DC: pcmk-2 (2) - partition with quorum
Version: 1.1.12-a14efad
2 Nodes configured
2 Resources configured

Online: [ pcmk-1 pcmk-2 ]

Full list of resources:

ClusterIP      (ocf::heartbeat:IPaddr2):      Started pcmk-2
WebSite        (ocf::heartbeat:apache):      Started pcmk-2

PCSD Status:
pcmk-1: Online
pcmk-2: Online

Daemon Status:
corosync: active/disabled
pacemaker: active/disabled
pcsd: active/enabled
```

Wait a minute, the resources are still on pcmk-2!

Even though WebSite now prefers to run on pcmk-1, that preference is (intentionally) less than the resource stickiness (how much we preferred not to have unnecessary downtime).

To see the current placement scores, you can use a tool called `crm_simulate`.

```
[root@pcmk-1 ~]# crm_simulate -sL

Current cluster status:
Online: [ pcmk-1 pcmk-2 ]

ClusterIP      (ocf::heartbeat:IPaddr2):      Started pcmk-2
WebSite        (ocf::heartbeat:apache):          Started pcmk-2

Allocation scores:
native_color: ClusterIP allocation score on pcmk-1: 50
native_color: ClusterIP allocation score on pcmk-2: 200
native_color: WebSite allocation score on pcmk-1: -INFINITY
native_color: WebSite allocation score on pcmk-2: 100

Transition Summary:
```

### 6.8. Move Resources Manually

There are always times when an administrator needs to override the cluster and force resources to move to a specific location. In this example, we will force the WebSite to move to pcmk-1 by updating our previous location constraint with a score of INFINITY.

```
[root@pcmk-1 ~]# pcs constraint location WebSite prefers pcmk-1=INFINITY
[root@pcmk-1 ~]# pcs constraint
Location Constraints:
  Resource: WebSite
    Enabled on: pcmk-1 (score:INFINITY)
Ordering Constraints:
  start ClusterIP then start WebSite (kind:Mandatory)
Colocation Constraints:
  WebSite with ClusterIP (score:INFINITY)
[root@pcmk-1 ~]# pcs status
Cluster name: mycluster
Last updated: Wed Dec 17 14:19:34 2014
Last change: Wed Dec 17 14:18:37 2014
Stack: corosync
Current DC: pcmk-2 (2) - partition with quorum
Version: 1.1.12-a14efad
2 Nodes configured
2 Resources configured

Online: [ pcmk-1 pcmk-2 ]

Full list of resources:

ClusterIP      (ocf::heartbeat:IPaddr2):      Started pcmk-1
WebSite        (ocf::heartbeat:apache):          Started pcmk-1

PCSD Status:
  pcmk-1: Online
  pcmk-2: Online

Daemon Status:
  corosync: active/disabled
  pacemaker: active/disabled
  pcsd: active/enabled
```

Once we've finished whatever activity required us to move the resources to pcmk-1 (in our case nothing), we can then allow the cluster to resume normal operation by removing the new constraint. Since we previously configured a default stickiness, the resources will remain on pcmk-1.

First, use the **--full** option to get the constraint's ID:

```
[root@pcmk-1 ~]# pcs constraint --full
Location Constraints:
  Resource: WebSite
    Enabled on: pcmk-1 (score:INFINITY) (id:location-WebSite-pcmk-1-INFINITY)
Ordering Constraints:
  start ClusterIP then start WebSite (kind:Mandatory) (id:order-ClusterIP-WebSite-mandatory)
Colocation Constraints:
  WebSite with ClusterIP (score:INFINITY) (id:colocation-WebSite-ClusterIP-INFINITY)
```

Then remove the desired constraint using its ID:

```
[root@pcmk-1 ~]# pcs constraint remove location-WebSite-pcmk-1-INFINITY
[root@pcmk-1 ~]# pcs constraint
Location Constraints:
Ordering Constraints:
  start ClusterIP then start WebSite (kind:Mandatory)
Colocation Constraints:
  WebSite with ClusterIP (score:INFINITY)
```

Note that the location constraint is now gone. If we check the cluster status, we can also see that (as expected) the resources are still active on pcmk-1.

```
# pcs status
Cluster name: mycluster
Last updated: Wed Dec 17 14:25:21 2014
Last change: Wed Dec 17 14:24:29 2014
Stack: corosync
Current DC: pcmk-2 (2) - partition with quorum
Version: 1.1.12-a14efad
2 Nodes configured
2 Resources configured

Online: [ pcmk-1 pcmk-2 ]

Full list of resources:

ClusterIP      (ocf::heartbeat:IPaddr2):      Started pcmk-1
WebSite        (ocf::heartbeat:apache):       Started pcmk-1

PCSD Status:
  pcmk-1: Online
  pcmk-2: Online

Daemon Status:
  corosync: active/disabled
  pacemaker: active/disabled
  pcsd: active/enabled
```



# Replicate Storage Using DRBD

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Even if you're serving up static websites, having to manually synchronize the contents of that website to all the machines in the cluster is not ideal. For dynamic websites, such as a wiki, it's not even an option. Not everyone care afford network-attached storage, but somehow the data needs to be kept in sync.

Enter DRBD, which can be thought of as network-based RAID-1.<sup>1</sup>

## 7.1. Install the DRBD Packages

DRBD itself is included in the upstream kernel,<sup>2</sup> but we do need some utilities to use it effectively.

CentOS does not ship these utilities, so we need to enable a third-party repository to get them. Supported packages for many OSes are available from DRBD's maker [LINBIT](http://www.linbit.com/)<sup>3</sup>, but here we'll use the free [ELRepo](http://elrepo.org/)<sup>4</sup> repository.

On both nodes, import the ELRepo package signing key, and enable the repository:

```
# rpm --import https://www.elrepo.org/RPM-GPG-KEY-elrepo.org
# rpm -Uvh http://www.elrepo.org/elrepo-release-7.0-2.el7.elrepo.noarch.rpm
```

Now, we can install the DRBD kernel module and utilities:

```
# yum install -y kmod-drbd84 drbd84-utils
```

<sup>1</sup> See <http://www.drbd.org/> for details.

<sup>2</sup> Since version 2.6.33

<sup>3</sup> <http://www.linbit.com/>

<sup>4</sup> <http://elrepo.org/>



### Important

The version of drbd84-utils shipped with CentOS 7.1 has a bug in the Pacemaker integration script. Until a fix is packaged, download the affected script directly from the upstream, on both nodes:

```
# curl -o /usr/lib/ocf/resource.d/linbit/drbd 'http://
git.linbit.com/gitweb.cgi?p=drbd-utils.git;a=blob_plain;f=scripts/
drbd.ocf;h=cf6b966341377a993d1bf5f585a5b9fe72eaa5f2;hb=c11ba026bbbbc647b8112543df142f2185cb4b4b'
```

This is a temporary fix that will be overwritten if the package is upgraded.

DRBD will not be able to run under the default SELinux security policies. If you are familiar with SELinux, you can modify the policies in a more fine-grained manner, but here we will simply exempt DRBD processes from SELinux control:

```
# semanage permissive -a drbd_t
```

We will configure DRBD to use port 7789, so allow that port from each host to the other:

```
[root@pcmk-1 ~]# firewall-cmd --permanent --add-rich-rule='rule family="ipv4" source
address="192.168.122.102" port port="7789" protocol="tcp" accept'
success
[root@pcmk-1 ~]# firewall-cmd --reload
success
```

```
[root@pcmk-2 ~]# firewall-cmd --permanent --add-rich-rule='rule family="ipv4" source
address="192.168.122.101" port port="7789" protocol="tcp" accept'
success
[root@pcmk-2 ~]# firewall-cmd --reload
success
```



### Note

In this example, we have only two nodes, and all network traffic is on the same LAN. In production, it is recommended to use a dedicated, isolated network for cluster-related traffic, so the firewall configuration would likely be different; one approach would be to add the dedicated network interfaces to the trusted zone.

## 7.2. Allocate a Disk Volume for DRBD

DRBD will need its own block device on each node. This can be a physical disk partition or logical volume, of whatever size you need for your data. For this document, we will use a 1GiB logical volume, which is more than sufficient for a single HTML file and (later) GFS2 metadata.

```
[root@pcmk-1 ~]# vgdisplay | grep -e Name -e Free
```

```

VG Name          centos_pcmk-1
Free PE / Size   382 / 1.49 GiB
[root@pcmk-1 ~]# lvcreate --name drbd-demo --size 1G centos_pcmk-1
Logical volume "drbd-demo" created
[root@pcmk-1 ~]# lvs
  LV      VG          Attr      LSize Pool Origin Data%  Meta%  Move Log Cpy%Sync
Convert
drbd-demo centos_pcmk-1 -wi-a----- 1.00g
root      centos_pcmk-1 -wi-ao----- 5.00g
swap      centos_pcmk-1 -wi-ao----- 1.00g

```

Repeat for the second node, making sure to use the same size:

```

[root@pcmk-1 ~]# ssh pcmk-2 -- lvcreate --name drbd-demo --size 1G centos_pcmk-2
Logical volume "drbd-demo" created

```

## 7.3. Configure DRBD

There is no series of commands for building a DRBD configuration, so simply run this on both nodes to use this sample configuration:

```

# cat <<END >/etc/drbd.d/wwwdata.res
resource wwwdata {
    protocol C;
    meta-disk internal;
    device /dev/drbd1;
    syncer {
        verify-alg sha1;
    }
    net {
        allow-two-primaries;
    }
    on pcmk-1 {
        disk /dev/centos_pcmk-1/drbd-demo;
        address 192.168.122.101:7789;
    }
    on pcmk-2 {
        disk /dev/centos_pcmk-2/drbd-demo;
        address 192.168.122.102:7789;
    }
}
END

```



### Important

Edit the file to use the hostnames, IP addresses and logical volume paths of your nodes if they differ from the ones used in this guide.



### Note

Detailed information on the directives used in this configuration (and other alternatives) is available at <http://www.drbd.org/users-guide/ch-configure.html>

The **allow-two-primaries** option would not normally be used in an active/passive cluster. We are adding it here for the convenience of changing to an active/active cluster later.

## 7.4. Initialize DRBD

With the configuration in place, we can now get DRBD running.

These commands create the local metadata for the DRBD resource, ensure the DRBD kernel module is loaded, and bring up the DRBD resource. Run them on one node:

```
[root@pcmk-1 ~]# drbdadm create-md wwwdata
initializing activity log
NOT initializing bitmap
Writing meta data...
New drbd meta data block successfully created.
[root@pcmk-1 ~]# modprobe drbd
[root@pcmk-1 ~]# drbdadm up wwwdata
```

We can confirm DRBD's status on this node:

```
[root@pcmk-1 ~]# cat /proc/drbd
version: 8.4.6 (api:1/proto:86-101)
GIT-hash: 833d830e0152d1e457fa7856e71e11248ccf3f70 build by phil@Build64R7, 2015-04-10
05:13:52

1: cs:WfConnection ro:Secondary/Unknown ds:Inconsistent/DUnknown C r----s
   ns:0 nr:0 dw:0 dr:0 al:0 bm:0 lo:0 pe:0 ua:0 ap:0 ep:1 wo:f oos:1048508
```

Because we have not yet initialized the data, this node's data is marked as **Inconsistent**. Because we have not yet initialized the second node, the local state is **WfConnection** (waiting for connection), and the partner node's status is marked as **Unknown**.

Now, repeat the above commands on the second node. This time, when we check the status, it shows:

```
[root@pcmk-2 ~]# cat /proc/drbd
version: 8.4.6 (api:1/proto:86-101)
GIT-hash: 833d830e0152d1e457fa7856e71e11248ccf3f70 build by phil@Build64R7, 2015-04-10
05:13:52

1: cs:Connected ro:Secondary/Secondary ds:Inconsistent/Inconsistent C r-----
   ns:0 nr:0 dw:0 dr:0 al:0 bm:0 lo:0 pe:0 ua:0 ap:0 ep:1 wo:f oos:1048508
```

You can see the state has changed to **Connected**, meaning the two DRBD nodes are communicating properly, and both nodes are in **Secondary** role with **Inconsistent** data.

To make the data consistent, we need to tell DRBD which node should be considered to have the correct data. In this case, since we are creating a new resource, both have garbage, so we'll just pick **pcmk-1** and run this command on it:



```
[root@pcmk-1 ~]# drbdadm primary --force wwwdata
```



## Note

If you are using an older version of DRBD, the required syntax may be different. See the documentation for your version for how to perform these commands.

If we check the status immediately, we'll see something like this:

```
[root@pcmk-1 ~]# cat /proc/drbd
version: 8.4.6 (api:1/proto:86-101)
GIT-hash: 833d830e0152d1e457fa7856e71e11248ccf3f70 build by phil@Build64R7, 2015-04-10
05:13:52

1: cs:SyncSource ro:Primary/Secondary ds:UpToDate/Inconsistent C r-----
   ns:2872 nr:0 dw:0 dr:3784 al:0 bm:0 lo:0 pe:0 ua:0 ap:0 ep:1 wo:f oos:1045636
   [>.....] sync'ed: 0.4% (1045636/1048508)K
   finish: 0:10:53 speed: 1,436 (1,436) K/sec
```

We can see that this node has the **Primary** role, the partner node has the **Secondary** role, this node's data is now considered **UpToDate**, the partner node's data is still **Inconsistent**, and a progress bar shows how far along the partner node is in synchronizing the data.

After a while, the sync should finish, and you'll see something like:

```
[root@pcmk-1 ~]# cat /proc/drbd
version: 8.4.6 (api:1/proto:86-101)
GIT-hash: 833d830e0152d1e457fa7856e71e11248ccf3f70 build by phil@Build64R7, 2015-04-10
05:13:52

1: cs:Connected ro:Primary/Secondary ds:UpToDate/UpToDate C r-----
   ns:1048508 nr:0 dw:0 dr:1049420 al:0 bm:0 lo:0 pe:0 ua:0 ap:0 ep:1 wo:f oos:0
```

Both sets of data are now **UpToDate**, and we can proceed to creating and populating a filesystem for our WebSite resource's documents.

## 7.5. Populate the DRBD Disk

On the node with the primary role (pcmk-1 in this example), create a filesystem on the DRBD device:

```
[root@pcmk-1 ~]# mkfs.xfs /dev/drbd1
meta-data=/dev/drbd1          isize=256    agcount=4, agsize=65532 blks
                        =               sectsz=512   attr=2, projid32bit=1
                        =               crc=0        finobt=0
data        =               bsize=4096   blocks=262127, imaxpct=25
                        =               sunit=0      swidth=0 blks
naming      =version 2        bsize=4096   ascii-ci=0 ftype=0
log         =internal log    bsize=4096   blocks=853, version=2
                        =               sectsz=512   sunit=0 blks, lazy-count=1
realtime    =none            extsz=4096   blocks=0, rtextents=0
```



### Note

In this example, we create an xfs filesystem with no special options. In a production environment, you should choose a filesystem type and options that are suitable for your application.

Mount the newly created filesystem, populate it with our web document, give it the same SELinux policy as the web document root, then unmount it (the cluster will handle mounting and unmounting it later):

```
[root@pcmk-1 ~]# mount /dev/drbd1 /mnt
[root@pcmk-1 ~]# cat <<-END >/mnt/index.html
<html>
  <body>My Test Site - DRBD</body>
</html>
END
[root@pcmk-1 ~]# chcon -R --reference=/var/www/html /mnt
[root@pcmk-1 ~]# umount /dev/drbd1
```

## 7.6. Configure the Cluster for the DRBD device

One handy feature **pcs** has is the ability to queue up several changes into a file and commit those changes atomically. To do this, start by populating the file with the current raw XML config from the CIB.

```
[root@pcmk-1 ~]# pcs cluster cib drbd_cfg
```

Using the **pcs -f** option, make changes to the configuration saved in the **drbd\_cfg** file. These changes will not be seen by the cluster until the **drbd\_cfg** file is pushed into the live cluster's CIB later.

Here, we create a cluster resource for the DRBD device, and an additional *clone* resource to allow the resource to run on both nodes at the same time.

```
[root@pcmk-1 ~]# pcs -f drbd_cfg resource create WebData ocf:linbit:drbd \
  drbd_resource=wwwwdata op monitor interval=60s
[root@pcmk-1 ~]# pcs -f drbd_cfg resource master WebDataClone WebData \
  master-max=1 master-node-max=1 clone-max=2 clone-node-max=1 \
  notify=true
[root@pcmk-1 ~]# pcs -f drbd_cfg resource show
ClusterIP      (ocf::heartbeat:IPaddr2):      Started
WebSite        (ocf::heartbeat:apache):        Started
Master/Slave Set: WebDataClone [WebData]
  Stopped: [ pcmk-1 pcmk-2 ]
```

After you are satisfied with all the changes, you can commit them all at once by pushing the **drbd\_cfg** file into the live CIB.

```
[root@pcmk-1 ~]# pcs cluster cib-push drbd_cfg
CIB updated
```

**Note**

Early versions of **pcs** required **push cib** in place of **cib-push** above.

Let's see what the cluster did with the new configuration:

```
[root@pcmk-1 ~]# pcs status
Cluster name: mycluster
Last updated: Fri Aug 14 09:29:41 2015
Last change: Fri Aug 14 09:29:25 2015
Stack: corosync
Current DC: pcmk-1 (1) - partition with quorum
Version: 1.1.12-a14efad
2 Nodes configured
4 Resources configured

Online: [ pcmk-1 pcmk-2 ]

Full list of resources:

ClusterIP      (ocf::heartbeat:IPaddr2):      Started pcmk-1
WebSite        (ocf::heartbeat:apache):      Started pcmk-1
Master/Slave Set: WebDataClone [WebData]
  Masters: [ pcmk-1 ]
  Slaves: [ pcmk-2 ]

PCSD Status:
  pcmk-1: Online
  pcmk-2: Online

Daemon Status:
  corosync: active/disabled
  pacemaker: active/disabled
  pcsd: active/enabled
```

We can see that **WebDataClone** (our DRBD device) is running as master (DRBD's primary role) on **pcmk-1** and slave (DRBD's secondary role) on **pcmk-2**.

**Important**

The resource agent should load the DRBD module when needed if it's not already loaded. If that does not happen, configure your operating system to load the module at boot time. For CentOS 7.1, you would run this on both nodes:

```
# echo drbd >/etc/modules-load.d/drbd.conf
```

## 7.7. Configure the Cluster for the Filesystem

Now that we have a working DRBD device, we need to mount its filesystem.

In addition to defining the filesystem, we also need to tell the cluster where it can be located (only on the DRBD Primary) and when it is allowed to start (after the Primary was promoted).

We are going to take a shortcut when creating the resource this time. Instead of explicitly saying we want the **ocf:heartbeat:Filesystem** script, we are only going to ask for **Filesystem**. We can do this because we know there is only one resource script named **Filesystem** available to pacemaker, and that pcs is smart enough to fill in the **ocf:heartbeat:** portion for us correctly in the configuration. If there were multiple **Filesystem** scripts from different OCF providers, we would need to specify the exact one we wanted.

Once again, we will queue our changes to a file and then push the new configuration to the cluster as the final step.

```
[root@pcmk-1 ~]# pcs cluster cib fs_cfg
[root@pcmk-1 ~]# pcs -f fs_cfg resource create WebFS Filesystem \
    device="/dev/drbd1" directory="/var/www/html" fstype="xfs"
[root@pcmk-1 ~]# pcs -f fs_cfg constraint colocation add WebFS with WebDataClone INFINITY
    with-rsc-role=Master
[root@pcmk-1 ~]# pcs -f fs_cfg constraint order promote WebDataClone then start WebFS
Adding WebDataClone WebFS (kind: Mandatory) (Options: first-action=promote then-action=start)
```

We also need to tell the cluster that Apache needs to run on the same machine as the filesystem and that it must be active before Apache can start.

```
[root@pcmk-1 ~]# pcs -f fs_cfg constraint colocation add WebSite with WebFS INFINITY
[root@pcmk-1 ~]# pcs -f fs_cfg constraint order WebFS then WebSite
Adding WebFS WebSite (kind: Mandatory) (Options: first-action=start then-action=start)
```

Review the updated configuration.

```
[root@pcmk-1 ~]# pcs -f fs_cfg constraint
Location Constraints:
Ordering Constraints:
    start ClusterIP then start WebSite (kind:Mandatory)
    promote WebDataClone then start WebFS (kind:Mandatory)
    start WebFS then start WebSite (kind:Mandatory)
Colocation Constraints:
    WebSite with ClusterIP (score:INFINITY)
    WebFS with WebDataClone (score:INFINITY) (with-rsc-role:Master)
    WebSite with WebFS (score:INFINITY)
```

```
[root@pcmk-1 ~]# pcs -f fs_cfg resource show
ClusterIP      (ocf::heartbeat:IPaddr2):      Started
WebSite        (ocf::heartbeat:apache):        Started
Master/Slave Set: WebDataClone [WebData]
    Masters: [ pcmk-1 ]
    Slaves: [ pcmk-2 ]
WebFS (ocf::heartbeat:Filesystem):  Stopped
```

After reviewing the new configuration, upload it and watch the cluster put it into effect.

```
[root@pcmk-1 ~]# pcs cluster cib-push fs_cfg
[root@pcmk-1 ~]# pcs status
Last updated: Fri Aug 14 09:34:11 2015
Last change: Fri Aug 14 09:34:09 2015
Stack: corosync
Current DC: pcmk-1 (1) - partition with quorum
Version: 1.1.12-a14efad
2 Nodes configured
```

```

5 Resources configured

Online: [ pcmk-1 pcmk-2 ]

Full list of resources:

ClusterIP      (ocf::heartbeat:IPaddr2):      Started pcmk-1
WebSite        (ocf::heartbeat:apache):        Started pcmk-1
Master/Slave Set: WebDataClone [WebData]
  Masters: [ pcmk-1 ]
  Slaves: [ pcmk-2 ]
WebFS (ocf::heartbeat:Filesystem): Started pcmk-1

PCSD Status:
  pcmk-1: Online
  pcmk-2: Online

Daemon Status:
  corosync: active/disabled
  pacemaker: active/disabled
  pcsd: active/enabled

```

## 7.8. Test Cluster Failover

Previously, we used **pcs cluster stop pcmk-1** to stop all cluster services on **pcmk-1**, failing over the cluster resources, but there is another way to safely simulate node failure.

We can put the node into *standby mode*. Nodes in this state continue to run corosync and pacemaker but are not allowed to run resources. Any resources found active there will be moved elsewhere. This feature can be particularly useful when performing system administration tasks such as updating packages used by cluster resources.

Put the active node into standby mode, and observe the cluster move all the resources to the other node. The node's status will change to indicate that it can no longer host resources.

```

[root@pcmk-1 ~]# pcs cluster standby pcmk-1
[root@pcmk-1 ~]# pcs status
Cluster name: mycluster
Last updated: Fri Aug 14 09:36:49 2015
Last change: Fri Aug 14 09:36:43 2015
Stack: corosync
Current DC: pcmk-1 (1) - partition with quorum
Version: 1.1.12-a14efad
2 Nodes configured
5 Resources configured

Node pcmk-1 (1): standby
Online: [ pcmk-2 ]

Full list of resources:

ClusterIP      (ocf::heartbeat:IPaddr2):      Started pcmk-2
WebSite        (ocf::heartbeat:apache):        Started pcmk-2
Master/Slave Set: WebDataClone [WebData]
  Masters: [ pcmk-2 ]
  Stopped: [ pcmk-1 ]
WebFS (ocf::heartbeat:Filesystem): Started pcmk-2

PCSD Status:
  pcmk-1: Online
  pcmk-2: Online

```

```
Daemon Status:
corosync: active/disabled
pacemaker: active/disabled
pcsd: active/enabled
```

Once we've done everything we needed to on `pcmk-1` (in this case nothing, we just wanted to see the resources move), we can allow the node to be a full cluster member again.

```
[root@pcmk-1 ~]# pcs cluster unstandby pcmk-1
[root@pcmk-1 ~]# pcs status
Cluster name: mycluster
Last updated: Fri Aug 14 09:38:02 2015
Last change: Fri Aug 14 09:37:56 2015
Stack: corosync
Current DC: pcmk-1 (1) - partition with quorum
Version: 1.1.12-a14efad
2 Nodes configured
5 Resources configured

Online: [ pcmk-1 pcmk-2 ]

Full list of resources:

ClusterIP      (ocf::heartbeat:IPaddr2):      Started pcmk-2
WebSite        (ocf::heartbeat:apache):       Started pcmk-2
Master/Slave Set: WebDataClone [WebData]
  Masters: [ pcmk-2 ]
  Slaves: [ pcmk-1 ]
WebFS (ocf::heartbeat:Filesystem): Started pcmk-2

PCSD Status:
pcmk-1: Online
pcmk-2: Online

Daemon Status:
corosync: active/disabled
pacemaker: active/disabled
pcsd: active/enabled
```

Notice that **pcmk-1** is back to the **Online** state, and that the cluster resources stay where they are due to our resource stickiness settings configured earlier.

# Configure STONITH

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## 8.1. What is STONITH?

STONITH (Shoot The Other Node In The Head aka. fencing) protects your data from being corrupted by rogue nodes or unintended concurrent access.

Just because a node is unresponsive doesn't mean it has stopped accessing your data. The only way to be 100% sure that your data is safe, is to use STONITH to ensure 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.

## 8.2. Choose a STONITH Device

It is crucial that your STONITH device can allow the cluster to differentiate between a node failure and a network failure.

A common mistake people make when 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. If the power fails in such a case, the cluster cannot be sure whether the node is really offline, or active and suffering from a network fault, so the cluster will stop all resources to avoid a possible split-brain situation.

Likewise, any device that relies on the machine being active (such as SSH-based "devices" sometimes used during testing) is inappropriate.

## 8.3. Configure the Cluster for STONITH

1. Install the STONITH agent(s). To see what packages are available, run **yum search fence-.** Be sure to install the package(s) on all cluster nodes.
2. Configure the STONITH device itself to be able to fence your nodes and accept fencing requests. This includes any necessary configuration on the device and on the nodes, and any firewall or SELinux changes needed. Test the communication between the device and your nodes.
3. Find the correct STONITH agent script: **pcs stonith list**
4. Find the parameters associated with the device: **pcs stonith describe agent\_name**
5. Create a local copy of the CIB: **pcs cluster cib stonith\_cfg**
6. Create the fencing resource: **pcs -f stonith\_cfg stonith create stonith\_id stonith\_device\_type [stonith\_device\_options]**

Any flags that do not take arguments, such as `--ssl`, should be passed as `ssl=1`.

7. Enable STONITH in the cluster: `pcs -f stonith_cfg property set stonith-enabled=true`
8. 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.
9. 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.
10. 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.
11. Commit the new configuration: `pcs cluster cib-push stonith_cfg`
12. Once the STONITH resource is running, test it (you might want to stop the cluster on that machine first): `stonith_admin --reboot nodename`

### 8.4. Example

For this example, assume we have a chassis containing four nodes and an IPMI device active on 10.0.0.1. Following the steps above would go something like this:

Step 1: Install the **fence-agents-ipmilan** package on both nodes.

Step 2: Configure the IP address, authentication credentials, etc. in the IPMI device itself.

Step 3: Choose the **fence\_ipmilan** STONITH agent.

Step 4: Obtain the agent's possible parameters:

```
[root@pcmk-1 ~]# pcs stonith describe fence_ipmilan
Stonith options for: fence_ipmilan
  ipport: TCP/UDP port to use for connection with device
  inet6_only: Forces agent to use IPv6 addresses only
  ipaddr (required): IP Address or Hostname
  passwd_script: Script to retrieve password
  method: Method to fence (onoff|cycle)
  inet4_only: Forces agent to use IPv4 addresses only
  passwd: Login password or passphrase
  lanplus: Use Lanplus to improve security of connection
  auth: IPMI Lan Auth type.
  cipher: Ciphersuite to use (same as ipmitool -C parameter)
  privlvl: Privilege level on IPMI device
  action (required): Fencing Action
  login: Login Name
  verbose: Verbose mode
  debug: Write debug information to given file
  version: Display version information and exit
  help: Display help and exit
  power_wait: Wait X seconds after issuing ON/OFF
  login_timeout: Wait X seconds for cmd prompt after login
  power_timeout: Test X seconds for status change after ON/OFF
  delay: Wait X seconds before fencing is started
  ipmitool_path: Path to ipmitool binary
  shell_timeout: Wait X seconds for cmd prompt after issuing command
  retry_on: Count of attempts to retry power on
  sudo: Use sudo (without password) when calling 3rd party software.
  stonith-timeout: How long to wait for the STONITH action (reboot, on, off) to complete per
a stonith device.
```



```
priority: The priority of the stonith resource. Devices are tried in order of highest
priority to lowest.
pcmk_host_map: A mapping of host names to ports numbers for devices that do not support
host names.
pcmk_host_list: A list of machines controlled by this device (Optional unless
pcmk_host_check=static-list).
pcmk_host_check: How to determine which machines are controlled by the device.
```

Step 5: **pcs cluster cib stonith\_cfg**

Step 6: Here are example parameters for creating our STONITH resource:

```
[root@pcmk-1 ~]# pcs -f stonith_cfg stonith create ipmi-fencing fence_ipmilan \
    pcmk_host_list="pcmk-1 pcmk-2" ipaddr=10.0.0.1 login=testuser \
    passwd=acd123 op monitor interval=60s
[root@pcmk-1 ~]# pcs -f stonith_cfg stonith
ipmi-fencing (stonith:fence_ipmilan):          Stopped
```

Steps 7-10: Enable STONITH in the cluster:

```
[root@pcmk-1 ~]# pcs -f stonith_cfg property set stonith-enabled=true
[root@pcmk-1 ~]# pcs -f stonith_cfg property
Cluster Properties:
cluster-infrastructure: corosync
cluster-name: mycluster
dc-version: 1.1.12-a14efad
have-watchdog: false
stonith-enabled: true
```

Step 11: **pcs cluster cib-push stonith\_cfg**

Step 12: Test:

```
[root@pcmk-1 ~]# pcs cluster stop pcmk-2
[root@pcmk-1 ~]# stonith_admin --reboot pcmk-2
```

After a successful test, login to any rebooted nodes, and start the cluster (with **pcs cluster start**).



# Convert Cluster to Active/Active

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The primary requirement for an Active/Active cluster is that the data required for your services is available, simultaneously, on both machines. Pacemaker makes no requirement on how this is achieved; you could use a SAN if you had one available, but since DRBD supports multiple Primaries, we can continue to use it here.

## 9.1. Install Cluster Filesystem Software

The only hitch is that we need to use a cluster-aware filesystem. The one we used earlier with DRBD, xfs, is not one of those. Both OCFS2 and GFS2 are supported; here, we will use GFS2.

On both nodes, install the GFS2 command-line utilities and the Distributed Lock Manager (DLM) required by cluster filesystems:

```
# yum install -y gfs2-utils dlm
```

## 9.2. Configure the Cluster for the DLM

The DLM needs to run on both nodes, so we'll start by creating a resource for it (using the **ocf:pacemaker:controld** resource script), and clone it:

```
[root@pcmk-1 ~]# pcs cluster cib dlm_cfg
[root@pcmk-1 ~]# pcs -f dlm_cfg resource create dlm ocf:pacemaker:controld op monitor
interval=60s
[root@pcmk-1 ~]# pcs -f dlm_cfg resource clone dlm clone-max=2 clone-node-max=1
[root@pcmk-1 ~]# pcs -f dlm_cfg resource show
ClusterIP      (ocf::heartbeat:IPaddr2):      Started
WebSite        (ocf::heartbeat:apache):        Started
Master/Slave Set: WebDataClone [WebData]
  Masters: [ pcmk-2 ]
  Slaves: [ pcmk-1 ]
WebFS (ocf::heartbeat:Filesystem): Started
Clone Set: dlm-clone [dlm]
  Stopped: [ pcmk-1 pcmk-2 ]
```

Activate our new configuration, and see how the cluster responds:

```
[root@pcmk-1 ~]# pcs cluster cib-push dlm_cfg
CIB updated
[root@pcmk-1 ~]# pcs status
Cluster name: mycluster
Last updated: Fri Aug 14 11:19:36 2015
```

```
Last change: Fri Aug 14 11:19:28 2015
Stack: corosync
Current DC: pcmk-1 (1) - partition with quorum
Version: 1.1.12-a14efad
2 Nodes configured
8 Resources configured

Online: [ pcmk-1 pcmk-2 ]

Full list of resources:

ClusterIP      (ocf::heartbeat:IPaddr2):      Started pcmk-2
WebSite        (ocf::heartbeat:apache):      Started pcmk-2
Master/Slave Set: WebDataClone [WebData]
  Masters: [ pcmk-2 ]
  Slaves: [ pcmk-1 ]
WebFS (ocf::heartbeat:Filesystem): Started pcmk-2
ipmi-fencing  (stonith:fence_ipmilan): Started pcmk-1
Clone Set: dlm-clone [dlm]
  Started: [ pcmk-1 pcmk-2 ]

PCSD Status:
  pcmk-1: Online
  pcmk-2: Online

Daemon Status:
  corosync: active/disabled
  pacemaker: active/disabled
  pcsd: active/enabled
```

### 9.3. Create and Populate GFS2 Filesystem

Before we do anything to the existing partition, we need to make sure it is unmounted. We do this by telling the cluster to stop the WebFS resource. This will ensure that other resources (in our case, Apache) using WebFS are not only stopped, but stopped in the correct order.

```
[root@pcmk-1 ~]# pcs resource disable WebFS
[root@pcmk-1 ~]# pcs resource
ClusterIP      (ocf::heartbeat:IPaddr2):      Started
WebSite        (ocf::heartbeat:apache):      Stopped
Master/Slave Set: WebDataClone [WebData]
  Masters: [ pcmk-2 ]
  Slaves: [ pcmk-1 ]
WebFS (ocf::heartbeat:Filesystem):      Stopped
Clone Set: dlm-clone [dlm]
  Started: [ pcmk-1 pcmk-2 ]
```

You can see that both Apache and WebFS have been stopped, and that **pcmk-2** is the current master for the DRBD device.

Now we can create a new GFS2 filesystem on the DRBD device.



#### Warning

This will erase all previous content stored on the DRBD device. Ensure you have a copy of any important data.



### Important

Run the next command on whichever node has the DRBD Primary role. Otherwise, you will receive the message:

```
/dev/drbd1: Read-only file system
```

```
[root@pcmk-2 ~]# mkfs.gfs2 -p lock_dlm -j 2 -t mycluster:web /dev/drbd1
It appears to contain an existing filesystem (xfs)
This will destroy any data on /dev/drbd1
Are you sure you want to proceed? [y/n]y
Device:                /dev/drbd1
Block size:            4096
Device size:           1.00 GB (262127 blocks)
Filesystem size:       1.00 GB (262126 blocks)
Journals:              2
Resource groups:       5
Locking protocol:      "lock_dlm"
Lock table:            "mycluster:web"
UUID:                  9a72c488-d8a7-24c9-ceee-add7a8ca52c2
```

The `mkfs.gfs2` command required a number of additional parameters:

- **-p lock\_dlm** specifies that we want to use the kernel's DLM.
- **-j 2** indicates that the filesystem should reserve enough space for two journals (one for each node that will access the filesystem).
- **-t mycluster:web** specifies the lock table name. The format for this field is **clustername:fsname**. For **clustername**, we need to use the same value we specified originally with `pcs cluster setup --name` (which is also the value of **cluster\_name** in `/etc/corosync/corosync.conf`). If you are unsure what your cluster name is, you can look in `/etc/corosync/corosync.conf` or execute the command `pcs cluster corosync pcmk-1 | grep cluster_name`.

Now we can (re-)populate the new filesystem with data (web pages). We'll create yet another variation on our home page.

```
[root@pcmk-2 ~]# mount /dev/drbd1 /mnt
[root@pcmk-2 ~]# cat <<-END >/mnt/index.html
<html>
<body>My Test Site - GFS2</body>
</html>
END
[root@pcmk-2 ~]# chcon -R --reference=/var/www/html /mnt
[root@pcmk-2 ~]# umount /dev/drbd1
[root@pcmk-2 ~]# drbdadm verify wwwdata
```

## 9.4. Reconfigure the Cluster for GFS2

With the WebFS resource stopped, let's update the configuration.

```
[root@pcmk-1 ~]# pcs resource show WebFS
```

```
Resource: WebFS (class=ocf provider=heartbeat type=Filesystem)
Attributes: device=/dev/drbd1 directory=/var/www/html fstype=xfs
Meta Attrs: target-role=Stopped
Operations: start interval=0s timeout=60 (WebFS-start-timeout-60)
            stop interval=0s timeout=60 (WebFS-stop-timeout-60)
            monitor interval=20 timeout=40 (WebFS-monitor-interval-20)
```

The `fstype` option needs to be updated to **gfs2** instead of **xfs**.

```
[root@pcmk-1 ~]# pcs resource update WebFS fstype=gfs2
[root@pcmk-1 ~]# pcs resource show WebFS
Resource: WebFS (class=ocf provider=heartbeat type=Filesystem)
Attributes: device=/dev/drbd1 directory=/var/www/html fstype=gfs2
Meta Attrs: target-role=Stopped
Operations: start interval=0s timeout=60 (WebFS-start-timeout-60)
            stop interval=0s timeout=60 (WebFS-stop-timeout-60)
            monitor interval=20 timeout=40 (WebFS-monitor-interval-20)
```

GFS2 requires that DLM be running, so we also need to set up new colocation and ordering constraints for it:

```
[root@pcmk-1 ~]# pcs constraint colocation add WebFS with dlm-clone INFINITY
[root@pcmk-1 ~]# pcs constraint order dlm-clone then WebFS
Adding dlm-clone WebFS (kind: Mandatory) (Options: first-action=start then-action=start)
```

## 9.5. Clone the IP address

There's no point making the services active on both locations if we can't reach them both, so let's clone the IP address.

The **IPAddr2** resource agent has built-in intelligence for when it is configured as a clone. It will utilize a multicast MAC address to have the local switch send the relevant packets to all nodes in the cluster, together with **iptables clusterip** rules on the nodes so that any given packet will be grabbed by exactly one node. This will give us a simple but effective form of load-balancing requests between our two nodes.

Let's start a new config, and clone our IP:

```
[root@pcmk-1 ~]# pcs cluster cib loadbalance_cfg
[root@pcmk-1 ~]# pcs -f loadbalance_cfg resource clone ClusterIP \
    clone-max=2 clone-node-max=2 globally-unique=true
```

- **clone-max=2** tells the resource agent to split packets this many ways. This should equal the number of nodes that can host the IP.
- **clone-node-max=2** says that one node can run up to 2 instances of the clone. This should also equal the number of nodes that can host the IP, so that if any node goes down, another node can take over the failed node's "request bucket". Otherwise, requests intended for the failed node would be discarded.
- **globally-unique=true** tells the cluster that one clone isn't identical to another (each handles a different "bucket"). This also tells the resource agent to insert **iptables** rules so each host only processes packets in its bucket(s).

Notice that when the ClusterIP becomes a clone, the constraints referencing ClusterIP now reference the clone. This is done automatically by pcs.

```
[root@pcmk-1 ~]# pcs -f loadbalance_cfg constraint
Location Constraints:
Ordering Constraints:
    start ClusterIP-clone then start WebSite (kind:Mandatory)
    promote WebDataClone then start WebFS (kind:Mandatory)
    start WebFS then start WebSite (kind:Mandatory)
    start dlm-clone then start WebFS (kind:Mandatory)
Colocation Constraints:
    WebSite with ClusterIP-clone (score:INFINITY)
    WebFS with WebDataClone (score:INFINITY) (with-rsc-role:Master)
    WebSite with WebFS (score:INFINITY)
    WebFS with dlm-clone (score:INFINITY)
```

Now we must tell the resource how to decide which requests are processed by which hosts. To do this, we specify the **clusterip\_hash** parameter. The value of **sourceip** means that the source IP address of incoming packets will be hashed; each node will process a certain range of hashes.

```
[root@pcmk-1 ~]# pcs -f loadbalance_cfg resource update ClusterIP clusterip_hash=sourceip
```

Load our configuration to the cluster, and see how it responds.

```
[root@pcmk-1 ~]# pcs cluster cib-push loadbalance_cfg
CIB updated
[root@pcmk-1 ~]# pcs status
Cluster name: mycluster
Last updated: Fri Aug 14 11:32:07 2015
Last change: Fri Aug 14 11:32:04 2015
Stack: corosync
Current DC: pcmk-1 (1) - partition with quorum
Version: 1.1.12-a14efad
2 Nodes configured
9 Resources configured

Online: [ pcmk-1 pcmk-2 ]

Full list of resources:

WebSite          (ocf::heartbeat:apache):      Stopped
Master/Slave Set: WebDataClone [WebData]
    Masters: [ pcmk-1 ]
    Slaves:  [ pcmk-2 ]
WebFS (ocf::heartbeat:Filesystem):      Stopped
ipmi-fencing (stonith:fence_ipmilan):      Started pcmk-1
Clone Set: dlm-clone [dlm]
    Started: [ pcmk-1 pcmk-2 ]
Clone Set: ClusterIP-clone [ClusterIP] (unique)
    ClusterIP:0      (ocf::heartbeat:IPaddr2):      Started pcmk-1
    ClusterIP:1      (ocf::heartbeat:IPaddr2):      Started pcmk-2

PCSD Status:
pcmk-1: Online
pcmk-2: Online

Daemon Status:
corosync: active/disabled
pacemaker: active/disabled
pcsd: active/enabled
```

If desired, you can demonstrate that all request buckets are working by using a tool such as **arping** from several source hosts to see which host responds to each.

## 9.6. Clone the Filesystem and Apache Resources

Now that we have a cluster filesystem ready to go, and our nodes can load-balance requests to a shared IP address, we can configure the cluster so both nodes mount the filesystem and respond to web requests.

Clone the filesystem and Apache resources in a new configuration. Notice how pcs automatically updates the relevant constraints again.

```
[root@pcmk-1 ~]# pcs cluster cib active_cfg
[root@pcmk-1 ~]# pcs -f active_cfg resource clone WebFS
[root@pcmk-1 ~]# pcs -f active_cfg resource clone WebSite
[root@pcmk-1 ~]# pcs -f active_cfg constraint
Location Constraints:
Ordering Constraints:
    start ClusterIP-clone then start WebSite-clone (kind:Mandatory)
    promote WebDataClone then start WebFS-clone (kind:Mandatory)
    start WebFS-clone then start WebSite-clone (kind:Mandatory)
    start dlm-clone then start WebFS-clone (kind:Mandatory)
Colocation Constraints:
    WebSite-clone with ClusterIP-clone (score:INFINITY)
    WebFS-clone with WebDataClone (score:INFINITY) (with-rsc-role:Master)
    WebSite-clone with WebFS-clone (score:INFINITY)
    WebFS-clone with dlm-clone (score:INFINITY)
```

Tell the cluster that it is now allowed to promote both instances to be DRBD Primary (aka. master).

```
[root@pcmk-1 ~]# pcs -f active_cfg resource update WebDataClone master-max=2
```

Finally, load our configuration to the cluster, and re-enable the WebFS resource (which we disabled earlier).

```
[root@pcmk-1 ~]# pcs cluster cib-push active_cfg
CIB updated
[root@pcmk-1 ~]# pcs resource enable WebFS
```

After all the processes are started, the status should look similar to this.

```
[root@pcmk-1 ~]# pcs resource
Master/Slave Set: WebDataClone [WebData]
    Masters: [ pcmk-1 pcmk-2 ]
Clone Set: dlm-clone [dlm]
    Started: [ pcmk-1 pcmk-2 ]
Clone Set: ClusterIP-clone [ClusterIP] (unique)
    ClusterIP:0      (ocf::heartbeat:IPaddr2):      Started
    ClusterIP:1      (ocf::heartbeat:IPaddr2):      Started
Clone Set: WebFS-clone [WebFS]
    Started: [ pcmk-1 pcmk-2 ]
Clone Set: WebSite-clone [WebSite]
    Started: [ pcmk-1 pcmk-2 ]
```

## 9.7. Test Failover

Testing failover is left as an exercise for the reader. For example, you can put one node into standby mode, use **pcs status** to confirm that its ClusterIP clone was moved to the other node, and use **arping** to verify that packets are not being lost from any source host.



**Note**

You may find that when a failed node rejoins the cluster, both ClusterIP clones stay on one node, due to the resource stickiness. While this works fine, it effectively eliminates load-balancing and returns the cluster to an active-passive setup again. You can avoid this by disabling stickiness for the IP address resource:

```
[root@pcmk-1 ~]# pcs resource meta ClusterIP resource-stickiness=0
```



---

# Appendix A. Configuration Recap

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## A.1. Final Cluster Configuration

```
[root@pcmk-1 ~]# pcs resource
Master/Slave Set: WebDataClone [WebData]
  Masters: [ pcmk-1 pcmk-2 ]
Clone Set: dlm-clone [dlm]
  Started: [ pcmk-1 pcmk-2 ]
Clone Set: ClusterIP-clone [ClusterIP] (unique)
  ClusterIP:0      (ocf::heartbeat:IPaddr2):      Started
  ClusterIP:1      (ocf::heartbeat:IPaddr2):      Started
Clone Set: WebFS-clone [WebFS]
  Started: [ pcmk-1 pcmk-2 ]
Clone Set: WebSite-clone [WebSite]
  Started: [ pcmk-1 pcmk-2 ]
```

```
[root@pcmk-1 ~]# pcs resource op defaults
timeout: 240s
```

```
[root@pcmk-1 ~]# pcs stonith
impi-fencing (stonith:fence_ipmilan) Started
```

```
[root@pcmk-1 ~]# pcs constraint
Location Constraints:
Ordering Constraints:
  start ClusterIP-clone then start WebSite-clone (kind:Mandatory)
  promote WebDataClone then start WebFS-clone (kind:Mandatory)
  start WebFS-clone then start WebSite-clone (kind:Mandatory)
  start dlm-clone then start WebFS-clone (kind:Mandatory)
Colocation Constraints:
  WebSite-clone with ClusterIP-clone (score:INFINITY)
  WebFS-clone with WebDataClone (score:INFINITY) (with-rsc-role:Master)
  WebSite-clone with WebFS-clone (score:INFINITY)
  WebFS-clone with dlm-clone (score:INFINITY)
```

```
[root@pcmk-1 ~]# pcs status
Cluster name: mycluster
Last updated: Fri Aug 14 12:05:37 2015
Last change: Fri Aug 14 11:49:29 2015
```

## Appendix A. Configuration Recap

```
Stack: corosync
Current DC: pcmk-1 (1) - partition with quorum
Version: 1.1.12-a14efad
2 Nodes configured
11 Resources configured

Online: [ pcmk-1 pcmk-2 ]

Full list of resources:

  impi-fencing    (stonith:fence_ipmilan):      Started pcmk-1
Master/Slave Set: WebDataClone [WebData]
  Masters: [ pcmk-1 pcmk-2 ]
Clone Set: dlm-clone [dlm]
  Started: [ pcmk-1 pcmk-2 ]
Clone Set: ClusterIP-clone [ClusterIP] (unique)
  ClusterIP:0      (ocf::heartbeat:IPaddr2):    Started pcmk-2
  ClusterIP:1      (ocf::heartbeat:IPaddr2):    Started pcmk-1
Clone Set: WebFS-clone [WebFS]
  Started: [ pcmk-1 pcmk-2 ]
Clone Set: WebSite-clone [WebSite]
  Started: [ pcmk-1 pcmk-2 ]

PCSD Status:
  pcmk-1: Online
  pcmk-2: Online

Daemon Status:
  corosync: active/disabled
  pacemaker: active/disabled
  pcsd: active/enabled
```

```
[root@pcmk-1 ~]# pcs cluster cib
```

```
<cib crm_feature_set="3.0.9" validate-with="pacemaker-2.3" epoch="51" num_updates="16"
  admin_epoch="0" cib-last-written="Fri Aug 14 11:49:29 2015" have-quorum="1" dc-uuid="1">
  <crm_config>
    <cluster_property_set id="cib-bootstrap-options">
      <nvpair id="cib-bootstrap-options-have-watchdog" name="have-watchdog" value="false"/>
      <nvpair id="cib-bootstrap-options-dc-version" name="dc-version" value="1.1.12-a14efad"/>
      <nvpair id="cib-bootstrap-options-cluster-infrastructure" name="cluster-infrastructure" value="corosync"/>
      <nvpair id="cib-bootstrap-options-cluster-name" name="cluster-name" value="mycluster"/>
      <nvpair id="cib-bootstrap-options-last-lrm-refresh" name="last-lrm-refresh" value="1419129162"/>
      <nvpair id="cib-bootstrap-options-stonith-enabled" name="stonith-enabled" value="true"/>
    </cluster_property_set>
  </crm_config>
  <nodes>
    <node id="1" uname="pcmk-1">
      <instance_attributes id="nodes-1"/>
    </node>
    <node id="2" uname="pcmk-2">
      <instance_attributes id="nodes-2"/>
    </node>
  </nodes>
  <resources>
    <primitive class="stonith" id="impi-fencing" type="fence_ipmilan">
      <instance_attributes id="impi-fencing-instance_attributes">
        <nvpair id="impi-fencing-instance_attributes-pcmk_host_list" name="pcmk_host_list" value="pcmk-1 pcmk-2"/>
      </instance_attributes>
    </primitive>
  </resources>
</cib>
```

```

        <nvpair id="impi-fencing-instance_attributes-ipaddr" name="ipaddr"
value="10.0.0.1"/>
        <nvpair id="impi-fencing-instance_attributes-login" name="login" value="testuser"/>
        <nvpair id="impi-fencing-instance_attributes-passwd" name="passwd" value="acd123"/>
    </instance_attributes>
    <operations>
        <op id="impi-fencing-interval-60s" interval="60s" name="monitor"/>
    </operations>
</primitive>
<master id="WebDataClone">
    <primitive class="ocf" id="WebData" provider="linbit" type="drbd">
        <instance_attributes id="WebData-instance_attributes">
            <nvpair id="WebData-instance_attributes-drbd_resource" name="drbd_resource"
value="wwwdata"/>
        </instance_attributes>
        <operations>
            <op id="WebData-start-timeout-240" interval="0s" name="start" timeout="240"/>
            <op id="WebData-promote-timeout-90" interval="0s" name="promote" timeout="90"/>
            <op id="WebData-demote-timeout-90" interval="0s" name="demote" timeout="90"/>
            <op id="WebData-stop-timeout-100" interval="0s" name="stop" timeout="100"/>
            <op id="WebData-monitor-interval-60s" interval="60s" name="monitor"/>
        </operations>
    </primitive>
    <meta_attributes id="WebDataClone-meta_attributes">
        <nvpair id="WebDataClone-meta_attributes-master-max" name="master-max" value="2"/>
        <nvpair id="WebDataClone-meta_attributes-master-node-max" name="master-node-max"
value="1"/>
        <nvpair id="WebDataClone-meta_attributes-clone-max" name="clone-max" value="2"/>
        <nvpair id="WebDataClone-meta_attributes-clone-node-max" name="clone-node-max"
value="1"/>
        <nvpair id="WebDataClone-meta_attributes-notify" name="notify" value="true"/>
    </meta_attributes>
</master>
<clone id="dlm-clone">
    <primitive class="ocf" id="dlm" provider="pacemaker" type="controld">
        <instance_attributes id="dlm-instance_attributes"/>
        <operations>
            <op id="dlm-start-timeout-90" interval="0s" name="start" timeout="90"/>
            <op id="dlm-stop-timeout-100" interval="0s" name="stop" timeout="100"/>
            <op id="dlm-monitor-interval-60s" interval="60s" name="monitor"/>
        </operations>
    </primitive>
    <meta_attributes id="dlm-clone-meta">
        <nvpair id="dlm-clone-max" name="clone-max" value="2"/>
        <nvpair id="dlm-clone-node-max" name="clone-node-max" value="1"/>
    </meta_attributes>
</clone>
<clone id="ClusterIP-clone">
    <primitive class="ocf" id="ClusterIP" provider="heartbeat" type="IPAddr2">
        <instance_attributes id="ClusterIP-instance_attributes">
            <nvpair id="ClusterIP-instance_attributes-ip" name="ip" value="192.168.122.120"/>
            <nvpair id="ClusterIP-instance_attributes-cidr_netmask" name="cidr_netmask"
value="32"/>
            <nvpair id="ClusterIP-instance_attributes-clusterip_hash" name="clusterip_hash"
value="sourceip"/>
        </instance_attributes>
        <operations>
            <op id="ClusterIP-start-timeout-20s" interval="0s" name="start" timeout="20s"/>
            <op id="ClusterIP-stop-timeout-20s" interval="0s" name="stop" timeout="20s"/>
            <op id="ClusterIP-monitor-interval-30s" interval="30s" name="monitor"/>
        </operations>
        <meta_attributes id="ClusterIP-meta_attributes"/>
    </primitive>
    <meta_attributes id="ClusterIP-clone-meta">
        <nvpair id="ClusterIP-clone-max" name="clone-max" value="2"/>
        <nvpair id="ClusterIP-clone-node-max" name="clone-node-max" value="2"/>
        <nvpair id="ClusterIP-globally-unique" name="globally-unique" value="true"/>
    </meta_attributes>
</clone>

```

```

    </meta_attributes>
  </clone>
  <clone id="WebFS-clone">
    <primitive class="ocf" id="WebFS" provider="heartbeat" type="Filesystem">
      <instance_attributes id="WebFS-instance_attributes">
        <nvpair id="WebFS-instance_attributes-device" name="device" value="/dev/drbd1"/>
        <nvpair id="WebFS-instance_attributes-directory" name="directory" value="/var/
www/html"/>
        <nvpair id="WebFS-instance_attributes-fstype" name="fstype" value="gfs2"/>
      </instance_attributes>
      <operations>
        <op id="WebFS-start-timeout-60" interval="0s" name="start" timeout="60"/>
        <op id="WebFS-stop-timeout-60" interval="0s" name="stop" timeout="60"/>
        <op id="WebFS-monitor-interval-20" interval="20" name="monitor" timeout="40"/>
      </operations>
      <meta_attributes id="WebFS-meta_attributes"/>
    </primitive>
    <meta_attributes id="WebFS-clone-meta"/>
  </clone>
  <clone id="WebSite-clone">
    <primitive class="ocf" id="WebSite" provider="heartbeat" type="apache">
      <instance_attributes id="WebSite-instance_attributes">
        <nvpair id="WebSite-instance_attributes-configfile" name="configfile" value="/
etc/httpd/conf/httpd.conf"/>
        <nvpair id="WebSite-instance_attributes-statusurl" name="statusurl"
value="http://localhost/server-status"/>
      </instance_attributes>
      <operations>
        <op id="WebSite-start-timeout-40s" interval="0s" name="start" timeout="40s"/>
        <op id="WebSite-stop-timeout-60s" interval="0s" name="stop" timeout="60s"/>
        <op id="WebSite-monitor-interval-1min" interval="1min" name="monitor"/>
      </operations>
    </primitive>
    <meta_attributes id="WebSite-clone-meta"/>
  </clone>
</resources>
<constraints>
  <rsc_colocation id="colocation-WebSite-ClusterIP-INFINITY" rsc="WebSite-clone"
score="INFINITY" with-rsc="ClusterIP-clone"/>
  <rsc_order first="ClusterIP-clone" first-action="start" id="order-ClusterIP-WebSite-
mandatory" then="WebSite-clone" then-action="start"/>
  <rsc_colocation id="colocation-WebFS-WebDataClone-INFINITY" rsc="WebFS-clone"
score="INFINITY" with-rsc="WebDataClone" with-rsc-role="Master"/>
  <rsc_order first="WebDataClone" first-action="promote" id="order-WebDataClone-WebFS-
mandatory" then="WebFS-clone" then-action="start"/>
  <rsc_colocation id="colocation-WebSite-WebFS-INFINITY" rsc="WebSite-clone"
score="INFINITY" with-rsc="WebFS-clone"/>
  <rsc_order first="WebFS-clone" first-action="start" id="order-WebFS-WebSite-mandatory"
then="WebSite-clone" then-action="start"/>
  <rsc_colocation id="colocation-WebFS-clone-dlm-clone-INFINITY" rsc="WebFS-clone"
score="INFINITY" with-rsc="dlm-clone"/>
  <rsc_order first="dlm-clone" first-action="start" id="order-dlm-clone-WebFS-clone-
mandatory" then="WebFS-clone" then-action="start"/>
</constraints>
<rsc_defaults>
  <meta_attributes id="rsc_defaults-options">
    <nvpair id="rsc_defaults-options-resource-stickiness" name="resource-stickiness"
value="100"/>
  </meta_attributes>
</rsc_defaults>
<op_defaults>
  <meta_attributes id="op_defaults-options">
    <nvpair id="op_defaults-options-timeout" name="timeout" value="240s"/>
  </meta_attributes>
</op_defaults>
</configuration>
<status>

```

```

<node_state id="1" uname="pcmk-1" in_ccm="true" crmd="online" crm-debug-
origin="do_update_resource" join="member" expected="member">
  <lrmd id="1">
    <lrmd_resources>
      <lrmd_resource id="WebData" type="drbd" class="ocf" provider="linbit">
        <lrmd_rsc_op id="WebData_last_0" operation_key="WebData_promote_0"
operation="promote" crm-debug-origin="do_update_resource" crm_feature_set="3.0.9"
transition-key="13:4:0:225c8bc5-8fb0-49b6-9f75-337085b080de" transition-
magic="0:0;13:4:0:225c8bc5-8fb0-49b6-9f75-337085b080de" call-id="44" rc-code="0" op-
status="0" interval="0" last-run="1419264508" last-rc-change="1419264508" exec-time="26"
queue-time="0" op-digest="bc5c2e08730036ec602d79a958821da4" on_node="pcmk-1"/>
      </lrmd_resource>
      <lrmd_resource id="dlm" type="controld" class="ocf" provider="pacemaker">
        <lrmd_rsc_op id="dlm_last_0" operation_key="dlm_start_0"
operation="start" crm-debug-origin="do_update_resource" crm_feature_set="3.0.9"
transition-key="37:2:0:225c8bc5-8fb0-49b6-9f75-337085b080de" transition-
magic="0:0;37:2:0:225c8bc5-8fb0-49b6-9f75-337085b080de" call-id="37" rc-code="0" op-
status="0" interval="0" last-run="1419264506" last-rc-change="1419264506" exec-time="1041"
queue-time="0" op-digest="f2317cad3d54cec5d7d7aa7d0bf35cf8" on_node="pcmk-1"/>
        <lrmd_rsc_op id="dlm_monitor_60000" operation_key="dlm_monitor_60000"
operation="monitor" crm-debug-origin="do_update_resource" crm_feature_set="3.0.9"
transition-key="39:3:0:225c8bc5-8fb0-49b6-9f75-337085b080de" transition-
magic="0:0;39:3:0:225c8bc5-8fb0-49b6-9f75-337085b080de" call-id="38" rc-code="0" op-
status="0" interval="60000" last-rc-change="1419264507" exec-time="11" queue-time="0" op-
digest="968cc450c09e98fdac3043cb6a194d3d" on_node="pcmk-1"/>
      </lrmd_resource>
      <lrmd_resource id="ClusterIP:0" type="IPAddr2" class="ocf" provider="heartbeat">
        <lrmd_rsc_op id="ClusterIP:0_last_0" operation_key="ClusterIP:0_monitor_0"
operation="monitor" crm-debug-origin="do_update_resource" crm_feature_set="3.0.9"
transition-key="7:0:7:225c8bc5-8fb0-49b6-9f75-337085b080de" transition-
magic="0:7;7:0:7:225c8bc5-8fb0-49b6-9f75-337085b080de" call-id="19" rc-code="7" op-status="0"
interval="0" last-run="1419264506" last-rc-change="1419264506" exec-time="28" queue-time="0"
op-digest="ac61ecc765070218997f6d876fa1d76c" on_node="pcmk-1"/>
      </lrmd_resource>
      <lrmd_resource id="ClusterIP:1" type="IPAddr2" class="ocf" provider="heartbeat">
        <lrmd_rsc_op id="ClusterIP:1_last_0" operation_key="ClusterIP:1_start_0"
operation="start" crm-debug-origin="do_update_resource" crm_feature_set="3.0.9"
transition-key="49:3:0:225c8bc5-8fb0-49b6-9f75-337085b080de" transition-
magic="0:0;49:3:0:225c8bc5-8fb0-49b6-9f75-337085b080de" call-id="40" rc-code="0" op-
status="0" interval="0" last-run="1419264507" last-rc-change="1419264507" exec-time="190"
queue-time="0" op-digest="ac61ecc765070218997f6d876fa1d76c" on_node="pcmk-1"/>
        <lrmd_rsc_op id="ClusterIP:1_monitor_30000"
operation_key="ClusterIP:1_monitor_30000" operation="monitor" crm-
debug-origin="do_update_resource" crm_feature_set="3.0.9" transition-
key="50:3:0:225c8bc5-8fb0-49b6-9f75-337085b080de" transition-
magic="0:0;50:3:0:225c8bc5-8fb0-49b6-9f75-337085b080de" call-id="41" rc-code="0" op-
status="0" interval="30000" last-rc-change="1419264507" exec-time="27" queue-time="0" op-
digest="8ce33853c31576b708595f1d8a4a215c" on_node="pcmk-1"/>
      </lrmd_resource>
      <lrmd_resource id="WebFS" type="Filesystem" class="ocf" provider="heartbeat">
        <lrmd_rsc_op id="WebFS_last_0" operation_key="WebFS_start_0"
operation="start" crm-debug-origin="do_update_resource" crm_feature_set="3.0.9"
transition-key="62:5:0:225c8bc5-8fb0-49b6-9f75-337085b080de" transition-
magic="0:0;62:5:0:225c8bc5-8fb0-49b6-9f75-337085b080de" call-id="46" rc-code="0" op-
status="0" interval="0" last-run="1419264508" last-rc-change="1419264508" exec-time="585"
queue-time="0" op-digest="9d797b0e3b7f9729195992c0dafb5a9e" on_node="pcmk-1"/>
        <lrmd_rsc_op id="WebFS_monitor_20000" operation_key="WebFS_monitor_20000"
operation="monitor" crm-debug-origin="do_update_resource" crm_feature_set="3.0.9"
transition-key="62:6:0:225c8bc5-8fb0-49b6-9f75-337085b080de" transition-
magic="0:0;62:6:0:225c8bc5-8fb0-49b6-9f75-337085b080de" call-id="47" rc-code="0" op-
status="0" interval="20000" last-rc-change="1419264508" exec-time="21" queue-time="1" op-
digest="099af723b175851f09e5391e0c13854e" on_node="pcmk-1"/>
      </lrmd_resource>
      <lrmd_resource id="WebSite" type="apache" class="ocf" provider="heartbeat">
        <lrmd_rsc_op id="WebSite_last_0" operation_key="WebSite_start_0"
operation="start" crm-debug-origin="do_update_resource" crm_feature_set="3.0.9"
transition-key="72:6:0:225c8bc5-8fb0-49b6-9f75-337085b080de" transition-

```

```

magic="0:0;72:6:0:225c8bc5-8fb0-49b6-9f75-337085b080de" call-id="48" rc-code="0" op-
status="0" interval="0" last-run="1419264508" last-rc-change="1419264508" exec-time="65"
queue-time="0" op-digest="49ba395a3f2c142631c2ef2c431a29d9" on_node="pcmk-1"/>
  <lrmsrc_op id="WebSite_monitor_60000" operation_key="WebSite_monitor_60000"
operation="monitor" crm-debug-origin="do_update_resource" crm_feature_set="3.0.9"
transition-key="73:6:0:225c8bc5-8fb0-49b6-9f75-337085b080de" transition-
magic="0:0;73:6:0:225c8bc5-8fb0-49b6-9f75-337085b080de" call-id="49" rc-code="0" op-
status="0" interval="60000" last-rc-change="1419264508" exec-time="26" queue-time="0" op-
digest="eddc33bef3f1592ad847638ee485316f" on_node="pcmk-1"/>
  </lrmsrc_op>
</lrmsrc_opes>
</lrm>
<transient_attributes id="1">
  <instance_attributes id="status-1">
    <nvpair id="status-1-shutdown" name="shutdown" value="0"/>
    <nvpair id="status-1-probe_complete" name="probe_complete" value="true"/>
    <nvpair id="status-1-master-WebData" name="master-WebData" value="10000"/>
  </instance_attributes>
</transient_attributes>
</node_state>
<node_state id="2" uname="pcmk-2" in_ccm="true" crmd="online" crm-debug-
origin="do_update_resource" join="member" expected="member">
  <transient_attributes id="2">
    <instance_attributes id="status-2">
      <nvpair id="status-2-shutdown" name="shutdown" value="0"/>
      <nvpair id="status-2-probe_complete" name="probe_complete" value="true"/>
      <nvpair id="status-2-master-WebData" name="master-WebData" value="10000"/>
    </instance_attributes>
  </transient_attributes>
  <lrm id="2">
    <lrm_resources>
      <lrm_resource id="WebData" type="drbd" class="ocf" provider="linbit">
        <lrmsrc_op id="WebData_last_0" operation_key="WebData_promote_0"
operation="promote" crm-debug-origin="do_update_resource" crm_feature_set="3.0.9"
transition-key="16:4:0:225c8bc5-8fb0-49b6-9f75-337085b080de" transition-
magic="0:0;16:4:0:225c8bc5-8fb0-49b6-9f75-337085b080de" call-id="41" rc-code="0" op-
status="0" interval="0" last-run="1419264508" last-rc-change="1419264508" exec-time="26"
queue-time="0" op-digest="bc5c2e08730036ec602d79a958821da4" on_node="pcmk-2"/>
        </lrmsrc_op>
      <lrm_resource id="dml" type="controld" class="ocf" provider="pacemaker">
        <lrmsrc_op id="dml_last_0" operation_key="dml_start_0"
operation="start" crm-debug-origin="do_update_resource" crm_feature_set="3.0.9"
transition-key="35:2:0:225c8bc5-8fb0-49b6-9f75-337085b080de" transition-
magic="0:0;35:2:0:225c8bc5-8fb0-49b6-9f75-337085b080de" call-id="34" rc-code="0" op-
status="0" interval="0" last-run="1419264506" last-rc-change="1419264506" exec-time="1053"
queue-time="0" op-digest="f2317cad3d54cec5d7d7aa7d0bf35cf8" on_node="pcmk-2"/>
        <lrmsrc_op id="dml_monitor_60000" operation_key="dml_monitor_60000"
operation="monitor" crm-debug-origin="do_update_resource" crm_feature_set="3.0.9"
transition-key="42:3:0:225c8bc5-8fb0-49b6-9f75-337085b080de" transition-
magic="0:0;42:3:0:225c8bc5-8fb0-49b6-9f75-337085b080de" call-id="35" rc-code="0" op-
status="0" interval="60000" last-rc-change="1419264507" exec-time="19" queue-time="0" op-
digest="968cc450c09e98fdac3043cb6a194d3d" on_node="pcmk-2"/>
        </lrmsrc_op>
      <lrm_resource id="ClusterIP:0" type="IPaddr2" class="ocf" provider="heartbeat">
        <lrmsrc_op id="ClusterIP:0_last_0" operation_key="ClusterIP:0_start_0"
operation="start" crm-debug-origin="do_update_resource" crm_feature_set="3.0.9"
transition-key="47:3:0:225c8bc5-8fb0-49b6-9f75-337085b080de" transition-
magic="0:0;47:3:0:225c8bc5-8fb0-49b6-9f75-337085b080de" call-id="36" rc-code="0" op-
status="0" interval="0" last-run="1419264507" last-rc-change="1419264507" exec-time="237"
queue-time="0" op-digest="ac61ecc765070218997f6d876fa1d76c" on_node="pcmk-2"/>
        <lrmsrc_op id="ClusterIP:0_monitor_30000"
operation_key="ClusterIP:0_monitor_30000" operation="monitor" crm-
debug-origin="do_update_resource" crm_feature_set="3.0.9" transition-
key="51:4:0:225c8bc5-8fb0-49b6-9f75-337085b080de" transition-
magic="0:0;51:4:0:225c8bc5-8fb0-49b6-9f75-337085b080de" call-id="39" rc-code="0" op-
status="0" interval="30000" last-rc-change="1419264507" exec-time="34" queue-time="0" op-
digest="8ce33853c31576b708595f1d8a4a215c" on_node="pcmk-2"/>
      </lrm_resource>
    </lrm_resources>
  </lrm>
</node_state>
</node>

```



```

</lrm_resource>
<lrm_resource id="ClusterIP:1" type="IPaddr2" class="ocf" provider="heartbeat">
  <lrm_rsc_op id="ClusterIP:1_last_0" operation_key="ClusterIP:1_monitor_0"
    operation="monitor" crm-debug-origin="do_update_resource" crm_feature_set="3.0.9"
    transition-key="16:0:7:225c8bc5-8fb0-49b6-9f75-337085b080de" transition-
    magic="0:7;16:0:7:225c8bc5-8fb0-49b6-9f75-337085b080de" call-id="23" rc-code="7" op-
    status="0" interval="0" last-run="1419264506" last-rc-change="1419264506" exec-time="28"
    queue-time="0" op-digest="ac61ecc765070218997f6d876fa1d76c" on_node="pcmk-2"/>
</lrm_resource>
<lrm_resource id="WebFS" type="Filesystem" class="ocf" provider="heartbeat">
  <lrm_rsc_op id="WebFS_last_0" operation_key="WebFS_start_0"
    operation="start" crm-debug-origin="do_update_resource" crm_feature_set="3.0.9"
    transition-key="60:5:0:225c8bc5-8fb0-49b6-9f75-337085b080de" transition-
    magic="0:0;60:5:0:225c8bc5-8fb0-49b6-9f75-337085b080de" call-id="43" rc-code="0" op-
    status="0" interval="0" last-run="1419264508" last-rc-change="1419264508" exec-time="662"
    queue-time="0" op-digest="9d797b0e3b7f9729195992c0dafb5a9e" on_node="pcmk-2"/>
  <lrm_rsc_op id="WebFS_monitor_20000" operation_key="WebFS_monitor_20000"
    operation="monitor" crm-debug-origin="do_update_resource" crm_feature_set="3.0.9"
    transition-key="65:6:0:225c8bc5-8fb0-49b6-9f75-337085b080de" transition-
    magic="0:0;65:6:0:225c8bc5-8fb0-49b6-9f75-337085b080de" call-id="44" rc-code="0" op-
    status="0" interval="20000" last-rc-change="1419264508" exec-time="29" queue-time="0" op-
    digest="099af723b175851f09e5391e0c13854e" on_node="pcmk-2"/>
</lrm_resource>
<lrm_resource id="WebSite" type="apache" class="ocf" provider="heartbeat">
  <lrm_rsc_op id="WebSite_last_0" operation_key="WebSite_start_0"
    operation="start" crm-debug-origin="do_update_resource" crm_feature_set="3.0.9"
    transition-key="70:6:0:225c8bc5-8fb0-49b6-9f75-337085b080de" transition-
    magic="0:0;70:6:0:225c8bc5-8fb0-49b6-9f75-337085b080de" call-id="45" rc-code="0" op-
    status="0" interval="0" last-run="1419264508" last-rc-change="1419264508" exec-time="64"
    queue-time="0" op-digest="49ba395a3f2c142631c2ef2c431a29d9" on_node="pcmk-2"/>
  <lrm_rsc_op id="WebSite_monitor_60000" operation_key="WebSite_monitor_60000"
    operation="monitor" crm-debug-origin="do_update_resource" crm_feature_set="3.0.9"
    transition-key="71:6:0:225c8bc5-8fb0-49b6-9f75-337085b080de" transition-
    magic="0:0;71:6:0:225c8bc5-8fb0-49b6-9f75-337085b080de" call-id="46" rc-code="0" op-
    status="0" interval="60000" last-rc-change="1419264508" exec-time="28" queue-time="0" op-
    digest="eddc33bef3f1592ad847638ee485316f" on_node="pcmk-2"/>
</lrm_resource>
</lrm_resources>
</lrm>
</node_state>
</status>
</cib>

```

## A.2. Node List

```

[root@pcmk-1 ~]# pcs status nodes
Pacemaker Nodes:
  Online: pcmk-1 pcmk-2
  Standby:
  Offline:

```

## A.3. Cluster Options

```

[root@pcmk-1 ~]# pcs property
Cluster Properties:
  cluster-infrastructure: corosync
  cluster-name: mycluster
  dc-version: 1.1.12-a14efad
  have-watchdog: false
  last-lrm-refresh: 1439569053
  stonith-enabled: true

```

The output shows state information automatically obtained about the cluster, including:

- **cluster-infrastructure** - the cluster communications layer in use (heartbeat or corosync)
- **cluster-name** - the cluster name chosen by the administrator when the cluster was created
- **dc-version** - the version (including upstream source-code hash) of Pacemaker used on the Designated Controller

The output also shows options set by the administrator that control the way the cluster operates, including:

- **stonith-enabled=true** - whether the cluster is allowed to use STONITH resources

## A.4. Resources

### A.4.1. Default Options

```
[root@pcmk-1 ~]# pcs resource defaults
resource-stickiness: 100
```

This shows cluster option defaults that apply to every resource that does not explicitly set the option itself. Above:

- **resource-stickiness** - Specify the aversion to moving healthy resources to other machines

### A.4.2. Fencing

```
[root@pcmk-1 ~]# pcs stonith show
ipmi-fencing (stonith:fence_ipmilan) Started
[root@pcmk-1 ~]# pcs stonith show ipmi-fencing
Resource: ipmi-fencing (class=stonith type=fence_ipmilan)
Attributes: ipaddr="10.0.0.1" login="testuser" passwd="acd123" pcmk_host_list="pcmk-1
pcmk-2"
Operations: monitor interval=60s (fence-monitor-interval-60s)
```

### A.4.3. Service Address

Users of the services provided by the cluster require an unchanging address with which to access it. Additionally, we cloned the address so it will be active on both nodes. An iptables rule (created as part of the resource agent) is used to ensure that each request only gets processed by one of the two clone instances. The additional meta options tell the cluster that we want two instances of the clone (one "request bucket" for each node) and that if one node fails, then the remaining node should hold both.

```
[root@pcmk-1 ~]# pcs resource show ClusterIP-clone
Clone: ClusterIP-clone
Meta Attrs: clone-max=2 clone-node-max=2 globally-unique=true
Resource: ClusterIP (class=ocf provider=heartbeat type=IPAddr2)
Attributes: ip=192.168.122.120 cidr_netmask=32 clusterip_hash=sourceip
Operations: start interval=0s timeout=20s (ClusterIP-start-timeout-20s)
            stop interval=0s timeout=20s (ClusterIP-stop-timeout-20s)
            monitor interval=30s (ClusterIP-monitor-interval-30s)
```

### A.4.4. DRBD - Shared Storage

Here, we define the DRBD service and specify which DRBD resource (from `/etc/drbd.d/*.res`) it should manage. We make it a master/slave resource and, in order to have an active/active setup, allow both instances to be promoted to master at the same time. We also set the notify option so that the cluster will tell DRBD agent when its peer changes state.

```
[root@pcmk-1 ~]# pcs resource show WebDataClone
Master: WebDataClone
Meta Attrs: master-max=2 master-node-max=1 clone-max=2 clone-node-max=1 notify=true
Resource: WebData (class=ocf provider=linbit type=drbd)
Attributes: drbd_resource=wwwdata
Operations: start interval=0s timeout=240 (WebData-start-timeout-240)
             promote interval=0s timeout=90 (WebData-promote-timeout-90)
             demote interval=0s timeout=90 (WebData-demote-timeout-90)
             stop interval=0s timeout=100 (WebData-stop-timeout-100)
             monitor interval=60s (WebData-monitor-interval-60s)
[root@pcmk-1 ~]# pcs constraint ref WebDataClone
Resource: WebDataClone
colocation-WebFS-WebDataClone-INFINITY
order-WebDataClone-WebFS-mandatory
```

### A.4.5. Cluster Filesystem

The cluster filesystem ensures that files are read and written correctly. We need to specify the block device (provided by DRBD), where we want it mounted and that we are using GFS2. Again, it is a clone because it is intended to be active on both nodes. The additional constraints ensure that it can only be started on nodes with active DLM and DRBD instances.

```
[root@pcmk-1 ~]# pcs resource show WebFS-clone
Clone: WebFS-clone
Resource: WebFS (class=ocf provider=heartbeat type=Filesystem)
Attributes: device=/dev/drbd1 directory=/var/www/html fstype=gfs2
Operations: start interval=0s timeout=60 (WebFS-start-timeout-60)
             stop interval=0s timeout=60 (WebFS-stop-timeout-60)
             monitor interval=20 (WebFS-monitor-interval-20)
[root@pcmk-1 ~]# pcs constraint ref WebFS-clone
Resource: WebFS-clone
colocation-WebFS-WebDataClone-INFINITY
colocation-WebSite-WebFS-INFINITY
colocation-WebFS-clone-dlm-clone-INFINITY
order-WebDataClone-WebFS-mandatory
order-WebFS-WebSite-mandatory
order-dlm-clone-WebFS-clone-mandatory
```

### A.4.6. Apache

Lastly, we have the actual service, Apache. We need only tell the cluster where to find its main configuration file and restrict it to running on nodes that have the required filesystem mounted and the IP address active.

```
[root@pcmk-1 ~]# pcs resource show WebSite-clone
Clone: WebSite-clone
Resource: WebSite (class=ocf provider=heartbeat type=apache)
Attributes: configfile=/etc/httpd/conf/httpd.conf statusurl=http://localhost/server-status
Operations: start interval=0s timeout=40s (WebSite-start-timeout-40s)
             stop interval=0s timeout=60s (WebSite-stop-timeout-60s)
             monitor interval=1min (WebSite-monitor-interval-1min)
[root@pcmk-1 ~]# pcs constraint ref WebSite-clone
Resource: WebSite-clone
```

## Appendix A. Configuration Recap

---

```
colocation-WebSite-ClusterIP-INFINITY  
colocation-WebSite-WebFS-INFINITY  
order-ClusterIP-WebSite-mandatory  
order-WebFS-WebSite-mandatory
```

---

# Appendix B. Sample Corosync Configuration

Sample `corosync.conf` for two-node cluster created by pcs.

```
totem {
  version: 2
  secauth: off
  cluster_name: mycluster
  transport: udpu
}

nodelist {
  node {
    ring0_addr: pcmk-1
    nodeid: 1
  }
  node {
    ring0_addr: pcmk-2
    nodeid: 2
  }
}

quorum {
  provider: corosync_votequorum
  two_node: 1
}

logging {
  to_syslog: yes
}
```



---

## Appendix C. Further Reading

- Project Website <http://www.clusterlabs.org/>
- SuSE has a comprehensive guide to cluster commands (though using the **crmsh** command-line shell rather than **pcs**) at: [https://www.suse.com/documentation/sle\\_ha/book\\_sleha/data/book\\_sleha.html](https://www.suse.com/documentation/sle_ha/book_sleha/data/book_sleha.html)
- Corosync <http://www.corosync.org/>

---



---

# Appendix D. Revision History

<b>Revision 1-0</b>	<b>Mon May 17 2010</b>	<b>Andrew Beekhof</b> <a href="mailto:andrew@beekhof.net">andrew@beekhof.net</a>
Import from Pages.app		
<b>Revision 2-0</b>	<b>Wed Sep 22 2010</b>	<b>Raoul Scarazzini</b> <a href="mailto:rasca@miamammausainux.org">rasca@miamammausainux.org</a>
Italian translation		
<b>Revision 3-0</b>	<b>Wed Feb 9 2011</b>	<b>Andrew Beekhof</b> <a href="mailto:andrew@beekhof.net">andrew@beekhof.net</a>
Updated for Fedora 13		
<b>Revision 4-0</b>	<b>Wed Oct 5 2011</b>	<b>Andrew Beekhof</b> <a href="mailto:andrew@beekhof.net">andrew@beekhof.net</a>
Update the GFS2 section to use CMAN		
<b>Revision 5-0</b>	<b>Fri Feb 10 2012</b>	<b>Andrew Beekhof</b> <a href="mailto:andrew@beekhof.net">andrew@beekhof.net</a>
Generate docbook content from asciidoc sources		
<b>Revision 6-0</b>	<b>Tues July 3 2012</b>	<b>Andrew Beekhof</b> <a href="mailto:andrew@beekhof.net">andrew@beekhof.net</a>
Updated for Fedora 17		
<b>Revision 7-0</b>	<b>Fri Sept 14 2012</b>	<b>David Vossel</b> <a href="mailto:davidvossel@gmail.com">davidvossel@gmail.com</a>
Updated for pcs		
<b>Revision 8-0</b>	<b>Mon Jan 05 2015</b>	<b>Ken Gaillot</b> <a href="mailto:kgaillet@redhat.com">kgaillet@redhat.com</a>
Updated for Fedora 21		
<b>Revision 8-1</b>	<b>Thu Jan 08 2015</b>	<b>Ken Gaillot</b> <a href="mailto:kgaillet@redhat.com">kgaillet@redhat.com</a>
Minor corrections, plus use include file for intro		
<b>Revision 9-0</b>	<b>Fri Aug 14 2015</b>	<b>Ken Gaillot</b> <a href="mailto:kgaillet@redhat.com">kgaillet@redhat.com</a>
Update for CentOS 7.1 and leaving firewalld/SELinux enabled		



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