

# Highly Available NFS Storage with DRBD and Pacemaker

This document describes how to set up highly available NFS storage in a two-node cluster, using the following components of SUSE Linux Enterprise High Availability 12 SP5: DRBD\* (Distributed Replicated Block Device), LVM (Logical Volume Manager), and Pacemaker, the cluster resource management framework.

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# 1 Usage Scenario

This document helps you set up a highly available NFS server. The cluster used for the highly available NFS storage has the following properties:

- Two nodes: `alice` (IP: `192.168.1.1`) and `bob` (IP: `192.168.1.2`), connected to each other via network.
- Two floating, virtual IP addresses (`192.168.1.10` and `192.168.1.11`), allowing clients to connect to a service no matter which physical node it is running on. One IP address is used for cluster administration with Hawk2, and the other IP address is used exclusively for the NFS exports.
- A shared storage device, used as an SBD fencing mechanism. This avoids split brain scenarios.
- Failover of resources from one node to the other if the active host breaks down (*active/passive* setup).
- Local storage on each node. The data is synchronized between the nodes using DRBD on top of LVM.
- A file system exported through NFS and a separate file system used to track the NFS client states.

After installing and setting up the basic two-node cluster, and extending it with storage and cluster resources for NFS, you will have a highly available NFS storage server.

## 2 Preparing a Two-node Cluster

Before you can set up highly available NFS storage, you must prepare a High Availability cluster:

### PROCEDURE 1: PREPARING A TWO-NODE CLUSTER FOR NFS STORAGE

1. Install and set up a basic two-node cluster as described in [Installation and Setup Quick Start](https://documentation.suse.com/sle-ha/12-SP5/html/SLE-HA-all/article-installation.html) (<https://documentation.suse.com/sle-ha/12-SP5/html/SLE-HA-all/article-installation.html>) ↗.
2. On *both* nodes, install the package `nfs-kernel-server`:

```
# zypper install nfs-kernel-server
```

3. On *both* nodes, set the NFS server scope:

a. Create a new directory named `nfs-server.service.d`:

```
# mkdir -p /etc/systemd/system/nfs-server.service.d
```

b. Create the file `/etc/systemd/system/nfs-server.service.d/scope.conf` and add the following content:

```
[Service]
ExecStart= ❶
ExecStart=/usr/sbin/rpc.nfsd --scope SUSE $RPCNFSDARGS ❷
```

- ❶ A service can only have one `ExecStart` setting, so the empty `ExecStart` line in this override file is used to undo any existing `ExecStart` setting in the NFS service file.
- ❷ The scope must be the same on all nodes in the cluster that run the NFS server. All clusters using SUSE software can use the same scope, so we recommend setting the value to `SUSE`.

c. Reload the `systemd` files:

```
# systemctl daemon-reload
```

## 3 Creating LVM Devices

LVM (Logical Volume Manager) enables flexible distribution of storage space across several file systems.

Use `crm cluster run` to run these commands on both nodes at once.

### PROCEDURE 2: CREATING LVM DEVICES FOR DRBD

1. Check if the locking type of LVM2 is cluster-aware. The keyword `locking_type` in `/etc/lvm/lvm.conf` must contain the value `3` (the default is `1`). Copy the configuration to all nodes, if necessary.
2. Create an LVM physical volume, replacing `/dev/disk/by-id/DEVICE_ID` with your corresponding device for LVM:

```
# crm cluster run "pvcreate /dev/disk/by-id/DEVICE_ID"
```

3. Create an LVM volume group `nfs` that includes this physical volume:

```
# crm cluster run "vgcreate nfs /dev/disk/by-id/DEVICE_ID"
```

4. Create a logical volume named `share` in the volume group `nfs`:

```
# crm cluster run "lvcreate -n share -L 20G nfs"
```

This volume is for the NFS exports.

5. Create a logical volume named `state` in the volume group `nfs`:

```
# crm cluster run "lvcreate -n state -L 8G nfs"
```

This volume is for the NFS client states. The 8 GB volume size used in this example should support several thousand concurrent NFS clients.

6. Activate the volume group:

```
# crm cluster run "vgchange -ay nfs"
```

You should now see the following devices on the system: `/dev/nfs/share` and `/dev/nfs/state`.

## 4 Creating DRBD Devices

This section describes how to set up DRBD devices on top of LVM. Using LVM as a back-end of DRBD has the following benefits:

- Easier setup than with LVM on top of DRBD.
- Easier administration in case the LVM disks need to be resized or more disks are added to the volume group.

The following procedures result in two DRBD devices: one device for the NFS exports, and a second device to track the NFS client states.

### 4.1 Creating the DRBD Configuration

DRBD configuration files are kept in the `/etc/drbd.d/` directory and must end with a `.res` extension. In this procedure, the configuration file is named `/etc/drbd.d/nfs.res`.

### PROCEDURE 3: CREATING A DRBD CONFIGURATION

1. Create the file `/etc/drbd.d/nfs.res` with the following contents:

```
resource nfs {
  volume 0 { ❶
    device      /dev/drbd0; ❷
    disk        /dev/nfs/state; ❸
    meta-disk   internal; ❹
  }
  volume 1 {
    device      /dev/drbd1;
    disk        /dev/nfs/share;
    meta-disk   internal;
  }

  net {
    protocol    C; ❺
    fencing:    resource-and-stonith; ❻
  }

  handlers { ❼
    fence-peer "/usr/lib/drbd/crm-fence-peer.9.sh";
    after-resync-target "/usr/lib/drbd/crm-unfence-peer.9.sh";
  }

  connection-mesh { ❽
    hosts      alice bob;
  }

  on alice { ❾
    address    192.168.1.1:7790;
    node-id    0;
  }
  on bob {
    address    192.168.1.2:7790;
    node-id    1;
  }
}
```

- ❶ The volume number for each DRBD device you want to create.
- ❷ The DRBD device that applications will access.
- ❸ The lower-level block device used by DRBD to store the actual data. This is the LVM device that was created in [Section 3, “Creating LVM Devices”](#).
- ❹ Where the metadata is stored. Using `internal`, the metadata is stored together with the user data on the same device. See the man page for further information.

- 5 The protocol to use for this connection. Protocol `C` is the default option. It provides better data availability and does not consider a write to be complete until it has reached all local and remote disks.
  - 6 Specifies the fencing policy `resource-and-stonith` at the DRBD level. This policy immediately suspends active I/O operations until STONITH completes.
  - 7 Enables resource-level fencing to prevent Pacemaker from starting a service with outdated data. If the DRBD replication link becomes disconnected, the `crm-fence-peer.9.sh` script stops the DRBD resource from being promoted to another node until the replication link becomes connected again and DRBD completes its synchronization process.
  - 8 Defines all nodes of a mesh. The `hosts` parameter contains all host names that share the same DRBD setup.
  - 9 Contains the IP address and a unique identifier for each node.
2. Open `/etc/csync2/csync2.cfg` and check whether the following two lines exist:

```
include /etc/drbd.conf;  
include /etc/drbd.d;
```

If not, add them to the file.

3. Copy the file to the other nodes:

```
# csync2 -xv
```

For information about Csync2, see *Book "Administration Guide", Chapter 4 "Using the YaST Cluster Module", Section 4.7 "Transferring the Configuration to All Nodes"*.

## 4.2 Activating the DRBD Devices

After preparing the DRBD configuration, activate the devices:

### PROCEDURE 4: ACTIVATING DRBD DEVICES

1. If you use a firewall in the cluster, open port `7790` in the firewall configuration.
2. Initialize the metadata storage:

```
# crm cluster run "drbdadm create-md nfs"
```

3. Create the DRBD devices:

```
# crm cluster run "drbdadm up nfs"
```

4. The devices do not have data yet, so you can run these commands to skip the initial synchronization:

```
# drbdadm new-current-uuid --clear-bitmap nfs/0
# drbdadm new-current-uuid --clear-bitmap nfs/1
```

5. Make alice primary:

```
# drbdadm primary --force nfs
```

6. Check the DRBD status of nfs:

```
# drbdadm status nfs
```

This returns the following message:

```
nfs role:Primary
  volume:0 disk:UpToDate
  volume:1 disk:UpToDate
bob  role:Secondary
  volume:0 peer-disk:UpToDate
  volume:1 peer-disk:UpToDate
```

You can access the DRBD resources on the block devices /dev/drbd0 and /dev/drbd1.

## 4.3 Creating the File Systems

After activating the DRBD devices, create file systems on them:

### PROCEDURE 5: CREATING FILE SYSTEMS FOR DRBD

1. Create an ext4 file system on /dev/drbd0:

```
# mkfs.ext4 /dev/drbd0
```

2. Create an ext4 file system on /dev/drbd1:

```
# mkfs.ext4 /dev/drbd1
```

## 5 Creating Cluster Resources

The following procedures describe how to configure the resources required for a highly available NFS cluster.

### OVERVIEW OF CLUSTER RESOURCES

#### DRBD Primitive and Multi-state Resources

These resources are used to replicate data. The multi-state resource is switched to and from the primary and secondary roles as deemed necessary by the cluster resource manager.

#### File System Resources

These resources manage the file system that will be exported, and the file system that will track NFS client states.

#### NFS Kernel Server Resource

This resource manages the NFS server daemon.

#### NFS Exports

This resource is used to export the directory /srv/nfs/share to clients.

#### Virtual IP Address

The initial installation creates an administrative virtual IP address for Hawk2. Create another virtual IP address exclusively for NFS exports. This makes it easier to apply security restrictions later.

### EXAMPLE NFS SCENARIO

- The following configuration examples assume that 192.168.1.11 is the virtual IP address to use for an NFS server which serves clients in the 192.168.1.x/24 subnet.
- The service exports data served from /srv/nfs/share.
- Into this export directory, the cluster mounts an ext4 file system from the DRBD device /dev/drbd1. This DRBD device sits on top of an LVM logical volume named /dev/nfs/share.
- The DRBD device /dev/drbd0 is used to share the NFS client states from /var/lib/nfs. This DRBD device sits on top of an LVM logical volume named /dev/nfs/state.

## 5.1 Creating DRBD Primitive and Multi-state Resources

Create a cluster resource to manage the DRBD devices, and a multi-state resource to allow the DRBD resource to run on both nodes:

### PROCEDURE 6: CREATING A DRBD RESOURCE FOR NFS

1. Start the `crm` interactive shell:

```
# crm configure
```

2. Create a primitive for the DRBD configuration `nfs`:

```
crm(live)configure# primitive drbd-nfs ocf:linbit:drbd \  
  params drbd_resource="nfs" \  
  op monitor interval=15 role=Master \  
  op monitor interval=30 role=Slave
```

3. Create a multi-state resource for the `drbd-nfs` primitive:

```
crm(live)configure# ms ms-drbd-nfs drbd-nfs \  
  meta master-max="1" master-node-max="1" \  
  clone-max="2" clone-node-max="1" notify="true"
```

4. Commit this configuration:

```
crm(live)configure# commit
```

Pacemaker activates the DRBD resources on both nodes and promotes them to the primary role on one of the nodes. Check the state of the cluster with the `crm status` command, or run `drbdadm status`.

## 5.2 Creating File System Resources

Create cluster resources to manage the file systems for export and state tracking:

### PROCEDURE 7: CREATING FILE SYSTEM RESOURCES FOR NFS

1. Create a primitive for the NFS client states on `/dev/drbd0`:

```
crm(live)configure# primitive fs-nfs-state Filesystem \  
  params device=/dev/drbd0 directory=/var/lib/nfs fstype=ext4
```

2. Create a primitive for the file system to be exported on `/dev/drbd1`:

```
crm(live)configure# primitive fs-nfs-share Filesystem \  
    params device=/dev/drbd1 directory=/srv/nfs/share fstype=ext4
```

*Do not* commit this configuration until after you add the colocation and order constraints.

3. Add both of these resources to a resource group named `g-nfs`:

```
crm(live)configure# group g-nfs fs-nfs-state fs-nfs-share
```

Resources start in the order they are added to the group and stop in reverse order.

4. Add a colocation constraint to make sure that the resource group always starts on the node where the DRBD multi-state resource is in the primary role:

```
crm(live)configure# colocation col-nfs-on-drbd inf: g-nfs ms-drbd-nfs:Master
```

5. Add an order constraint to make sure the DRBD multi-state resource always starts before the resource group:

```
crm(live)configure# order o-drbd-before-nfs Mandatory: ms-drbd-nfs:promote g-  
nfs:start
```

6. Commit this configuration:

```
crm(live)configure# commit
```

Pacemaker mounts `/dev/drbd0` to `/var/lib/nfs`, and `/dev/drbd1` to `srv/nfs/share`. Confirm this with `mount`, or by looking at `/proc/mounts`.

## 5.3 Creating an NFS Kernel Server Resource

Create a cluster resource to manage the NFS server daemon:

### PROCEDURE 8: CREATING AN NFS KERNEL SERVER RESOURCE

1. Create a primitive to manage the NFS server daemon:

```
crm(live)configure# primitive nfsserver nfsserver \  
    params nfs_shared_infodir="/var/lib/nfs"
```



## Warning: Low lease time can cause loss of file state

NFS clients regularly renew their state with the NFS server. If the lease time is too low, system or network delays can cause the timer to expire before the renewal is complete. This can lead to I/O errors and loss of file state.

`NFSV4LEASETIME` is set on the NFS server in the file `/etc/sysconfig/nfs`. The default is 90 seconds. If lowering the lease time is necessary, we recommend a value of 60 or higher. We strongly discourage values lower than 30.

2. Append this resource to the existing `g-nfs` resource group:

```
crm(live)configure# modgroup g-nfs add nfserver
```

3. Commit this configuration:

```
crm(live)configure# commit
```

## 5.4 Creating an NFS Export Resource

Create a cluster resource to manage the NFS exports:

### PROCEDURE 9: CREATING AN NFS EXPORT RESOURCE

1. Create a primitive for the NFS exports:

```
crm(live)configure# primitive exportfs-nfs exportfs \  
  params directory="/srv/nfs/share" \  
  options="rw,mountpoint" clientspec="192.168.1.0/24" fsid=101 \  
  op monitor interval=30s timeout=90s
```

- ① The `fsid` must be unique for each NFS export resource.
- ② The value of `op monitor timeout` must be higher than the value of `stonith-timeout`. To find the `stonith-timeout` value, run `crm configure show` and look under the `property` section.



## Important: Do not set `wait_for_lease_time_on_stop=true`

Setting this option to `true` in a highly available NFS setup can cause unnecessary delays and loss of locks.

The default value for `wait_for_lease_time_on_stop` is `false`. There is no need to set it to `true` when `/var/lib/nfs` and `nfsserver` are configured as described in this guide.

2. Append this resource to the existing `g-nfs` resource group:

```
crm(live)configure# modgroup g-nfs add exportfs-nfs
```

3. Commit this configuration:

```
crm(live)configure# commit
```

4. Confirm that the NFS exports are set up properly:

```
# exportfs -v  
/srv/nfs/share IP_ADDRESS_OF_CLIENT(OPTIONS)
```

## 5.5 Creating a Virtual IP Address for NFS Exports

Create a cluster resource to manage the virtual IP address for the NFS exports:

### PROCEDURE 10: CREATING A VIRTUAL IP ADDRESS FOR NFS EXPORTS

1. Create a primitive for the virtual IP address:

```
crm(live)configure# primitive vip-nfs IPAddr2 params ip=192.168.1.11
```

2. Append this resource to the existing `g-nfs` resource group:

```
crm(live)configure# modgroup g-nfs add vip-nfs
```

3. Commit this configuration:

```
crm(live)configure# commit
```

4. Leave the `crm` interactive shell:

```
crm(live)configure# quit
```

5. Check the status of the cluster. The resources in the `g-nfs` group should appear in the following order:

```
# crm status
[...]
Full List of Resources
[...]
* Resource Group: g-nfs:
  * fs-nfs-state      (ocf:heartbeat:Filesystem): Started alice
  * fs-nfs-share      (ocf:heartbeat:Filesystem): Started alice
  * nfsserver         (ocf:heartbeat:nfsserver): Started alice
  * exportfs-nfs     (ocf:heartbeat:exportfs): Started alice
  * vip-nfs           (ocf:heartbeat:IPAddr2): Started alice
```

## 6 Using the NFS Service

This section outlines how to use the highly available NFS service from an NFS client.

To connect to the NFS service, make sure to use the *virtual IP address* to connect to the cluster rather than a physical IP configured on one of the cluster nodes' network interfaces. For compatibility reasons, use the *full* path of the NFS export on the server.

The command to mount the NFS export looks like this:

```
# mount 192.168.1.11:/srv/nfs/share /home/share
```

If you need to configure other mount options, such as a specific transport protocol (`proto`), maximum read and write request sizes (`rsize` and `wsizes`), or a specific NFS version (`vers`), use the `-o` option. For example:

```
# mount -o proto=tcp,rsize=32768,wsizes=32768,vers=3 \
192.168.1.11:/srv/nfs/share /home/share
```

For further NFS mount options, see the `nfs` man page.



### Note: Loopback mounts

Loopback mounts are only supported for NFS version 3, *not* NFS version 4. For more information, see <https://www.suse.com/support/kb/doc?id=000018709>.

## 7 Adding More NFS Shares to the Cluster

If you need to increase the available storage, you can add more NFS shares to the cluster.

In this example, a new DRBD device named `/dev/drbd2` sits on top of an LVM logical volume named `/dev/nfs/share2`.

### PROCEDURE 11: ADDING MORE NFS SHARES TO THE CLUSTER

1. Create an LVM logical volume for the new share:

```
# crm cluster run "lvcreate -n share2 -L 20G nfs"
```

2. Update the file `/etc/drbd.d/nfs.res` to add the new volume under the existing volumes:

```
volume 2 {
    device          /dev/drbd2;
    disk            /dev/nfs/share2;
    meta-disk       internal;
}
```

3. Copy the updated file to the other nodes:

```
# csync2 -xv
```

4. Initialize the metadata storage for the new volume:

```
# crm cluster run "drbdadm create-md nfs/2 --force"
```

5. Update the `nfs` configuration to create the new device:

```
# crm cluster run "drbdadm adjust nfs"
```

6. Skip the initial synchronization for the new device:

```
# drbdadm new-current-uuid --clear-bitmap nfs/2
```

7. The NFS cluster resources might have moved to another node since they were created. Check the DRBD status with `drbdadm status nfs`, and make a note of which node is in the `Primary` role.

8. On the node that is in the `Primary` role, create an `ext4` file system on `/dev/drbd2`:

```
# mkfs.ext4 /dev/drbd2
```

9. Start the `crm` interactive shell:

```
# crm configure
```

10. Create a primitive for the file system to be exported on `/dev/drbd2`:

```
crm(live)configure# primitive fs-nfs-share2 Filesystem \  
  params device="/dev/drbd2" directory="/srv/nfs/share2" fstype=ext4
```

11. Add the new file system resource to the `g-nfs` group *before* the `nfsserver` resource:

```
crm(live)configure# modgroup g-nfs add fs-nfs-share2 before nfsserver
```

12. Create a primitive for NFS exports from the new share:

```
crm(live)configure# primitive exportfs-nfs2 exportfs \  
  params directory="/srv/nfs/share2" \  
  options="rw,mountpoint" clientspec="192.168.1.0/24" fsid=102 \  
  op monitor interval=30s timeout=90s
```

13. Add the new NFS export resource to the `g-nfs` group *before* the `vip-nfs` resource:

```
crm(live)configure# modgroup g-nfs add exportfs-nfs2 before vip-nfs
```

14. Commit this configuration:

```
crm(live)configure# commit
```

15. Leave the `crm` interactive shell:

```
crm(live)configure# quit
```

16. Check the status of the cluster. The resources in the `g-nfs` group should appear in the following order:

```
# crm status  
[...]  
Full List of Resources  
[...]  
* Resource Group: g-nfs:  
  * fs-nfs-state (ocf:heartbeat:Filesystem): Started alice  
  * fs-nfs-share (ocf:heartbeat:Filesystem): Started alice  
  * fs-nfs-share2 (ocf:heartbeat:Filesystem): Started alice  
  * nfsserver (ocf:heartbeat:nfsserver): Started alice  
  * exportfs-nfs (ocf:heartbeat:exportfs): Started alice
```

```
* exportfs-nfs2 (ocf:heartbeat:exportfs): Started alice
* vip-nfs (ocf:heartbeat:IPAddr2): Started alice
```

17. Confirm that the NFS exports are set up properly:

```
# exportfs -v
/srv/nfs/share IP_ADDRESS_OF_CLIENT(OPTIONS)
/srv/nfs/share2 IP_ADDRESS_OF_CLIENT(OPTIONS)
```

## 8 For More Information

- For more details about the steps in this guide, see <https://www.suse.com/support/kb/doc/?id=000020396>.
- For more information about NFS and LVM, see [Storage Administration Guide for SUSE Linux Enterprise Server \(https://documentation.suse.com/sles/html/SLES-all/book-storage.html\)](https://documentation.suse.com/sles/html/SLES-all/book-storage.html).
- For more information about DRBD, see *Book "Administration Guide", Chapter 18 "DRBD"*.
- For more information about cluster resources, see *Book "Administration Guide", Chapter 5 "Configuration and Administration Basics", Section 5.3 "Cluster Resources"*.

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