Proxmox VE Storage

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The Proxmox VE storage model is very flexible. Virtual machine images can either be stored on one or several local storages, or on shared storage like NFS or iSCSI (NAS, SAN). There are no limits, and you may configure as many storage pools as you like. You can use all storage technologies available for Debian Linux.

One major benefit of storing VMs on shared storage is the ability to live-migrate running machines without any downtime, as all nodes in the cluster have direct access to VM disk images. There is no need to copy VM image data, so live migration is very fast in that case.

The storage library (package `libpve-storage-perl`) uses a flexible plugin system to provide a common interface to all storage types. This can be easily adopted to include further storage types in the future.

Storage Types

There are basically two different classes of storage types:

File level storage
: File level based storage technologies allow access to a fully featured (POSIX) file system. They are in general more flexible than any Block level storage (see below), and allow you to store content of any type. ZFS is probably the most advanced system, and it has full support for snapshots and clones.

Block level storage
: Allows to store large *raw* images. It is usually not possible to store other files (ISO, backups, ..) on such storage types. Most modern block level storage implementations support snapshots and clones. RADOS and GlusterFS are distributed systems, replicating storage data to different nodes.

Table 1. Available storage types

Description	PVE type	Level	Shared	Snapshots	Stable
ZFS (local)	`zfspool`	file	no	yes	yes
Directory	`dir`	file	no	no[1]	yes
BTRFS	`btrfs`	file	no	yes	technology preview
NFS	`nfs`	file	yes	no[1]	yes

Description	PVE type	Level	Shared	Snapshots	Stable
CIFS	`cifs`	file	yes	no[1]	yes
Proxmox Backup	`pbs`	both	yes	n/a	yes
GlusterFS	`glusterfs`	file	yes	no[1]	yes
CephFS	`cephfs`	file	yes	yes	yes
LVM	`lvm`	block	no[2]	no	yes
LVM-thin	`lvmthin`	block	no	yes	yes
iSCSI/kernel	`iscsi`	block	yes	no	yes
iSCSI/libiscsi	`iscsidirect`	block	yes	no	yes
Ceph/RBD	`rbd`	block	yes	yes	yes
ZFS over iSCSI	`zfs`	block	yes	yes	yes

[1]: On file based storages, snapshots are possible with the *qcow2* format.

[2]: It is possible to use LVM on top of an iSCSI or FC-based storage. That way you get a `shared` LVM storage.

Thin Provisioning

A number of storages, and the QEMU image format `qcow2`, support *thin provisioning*. With thin provisioning activated, only the blocks that the guest system actually use will be written to the storage.

Say for instance you create a VM with a 32GB hard disk, and after installing the guest system OS, the root file system of the VM contains 3 GB of data. In that case only 3GB are written to the storage, even if the guest VM sees a 32GB hard drive. In this way thin provisioning allows you to create disk images which are larger than the currently available storage blocks. You can create large disk images for your VMs, and when the need arises, add more disks to your storage without resizing the VMs' file systems.

All storage types which have the “Snapshots” feature also support thin provisioning.

- If a storage runs full, all guests using volumes on that storage receive IO errors. This can cause file system inconsistencies and may corrupt your data. So it is advisable to avoid over-provisioning of your storage resources, or carefully observe free space to avoid such conditions.

Storage Configuration

All Proxmox VE related storage configuration is stored within a single text file at `/etc/pve/storage.cfg`. As this file is within `/etc/pve/`, it gets automatically distributed to all cluster nodes. So all nodes share the same storage configuration.

Sharing storage configuration makes perfect sense for shared storage, because the same “shared” storage is accessible from all nodes. But it is also useful for local storage types. In this case such local storage is available on all nodes, but it is physically different and can have totally different content.

Storage Pools

Each storage pool has a `<type>`, and is uniquely identified by its `<STORAGE_ID>`. A pool configuration looks like this:

```
<type>: <STORAGE_ID>
        <property> <value>
        <property> <value>
        <property>
        ...
```

The `<type>: <STORAGE_ID>` line starts the pool definition, which is then followed by a list of properties. Most properties require a value. Some have reasonable defaults, in which case you can omit the value.

To be more specific, take a look at the default storage configuration after installation. It contains one special local storage pool named `local`, which refers to the directory `/var/lib/vz` and is always available. The Proxmox VE installer creates additional storage entries depending on the storage type chosen at installation time.

Default storage configuration (`/etc/pve/storage.cfg`)

```
dir: local
        path /var/lib/vz
        content iso,vztmpl,backup

# default image store on LVM based
installation
lvmthin: local-lvm
        thinpool data
        vgname pve
        content rootdir,images

# default image store on ZFS based
installation
zfspool: local-zfs
        pool rpool/data
        sparse
        content images,rootdir
```

Common Storage Properties

A few storage properties are common among different storage types.

nodes
: List of cluster node names where this storage is usable/accessible. One can use this property to restrict storage access to a limited set of nodes.

content
: A storage can support several content types, for example virtual disk images, cdrom iso images, container templates or container root directories. Not all storage types support all content types. One can set this property to select what this storage is used for.

images
: QEMU/KVM VM images.

rootdir
: Allow to store container data.

vztmpl
: Container templates.

backup
: Backup files (`vzdump`).

iso
: ISO images

snippets
: Snippet files, for example guest hook scripts

shared
: Mark storage as shared.

disable
: You can use this flag to disable the storage completely.

maxfiles
: Deprecated, please use `prune-backups` instead. Maximum number of backup files per VM. Use `0` for unlimited.

prune-backups
: Retention options for backups. For details, see Backup Retention.

format
: Default image format (`raw|qcow2|vmdk`)

preallocation
: Preallocation mode (`off|metadata|falloc|full`) for `raw` and `qcow2` images on file-based storages. The default is `metadata`, which is treated like `off` for `raw` images. When using network storages in combination with large `qcow2` images, using `off` can help to avoid timeouts.

- It is not advisable to use the same storage pool on different Proxmox VE clusters. Some storage operation need exclusive access to the storage, so proper locking is required. While this is implemented within a cluster, it does not work between different clusters.

Volumes

We use a special notation to address storage data. When you allocate data from a storage pool, it returns such a volume identifier. A volume is identified by the `<STORAGE_ID>`, followed by a storage type dependent volume name, separated by colon. A valid `<VOLUME_ID>` looks like:

```
local:230/example-image.raw

local:iso/debian-501-amd64-netinst.iso

local:vztmpl/debian-5.0-joomla_1.5.9-
1_i386.tar.gz

iscsi-storage:0.0.2.scsi-
14f504e46494c4500494b5042546d2d646744372d31616d6
1
```

To get the file system path for a `<VOLUME_ID>` use:

```
pvesm path <VOLUME_ID>
```

Volume Ownership

There exists an ownership relation for `image` type volumes. Each such volume is owned by a VM or Container. For example volume `local:230/example-image.raw` is owned by VM 230. Most storage backends encodes this ownership information into the volume name.

When you remove a VM or Container, the system also removes all associated volumes which are owned by that VM or Container.

Using the Command Line Interface

It is recommended to familiarize yourself with the concept behind storage pools and volume identifiers, but in real life, you are not forced to do any of those low level operations on the command line. Normally, allocation and removal of volumes is done by the VM and Container management tools.

Nevertheless, there is a command line tool called `pvesm` ("Proxmox VE Storage Manager"), which is able to perform common storage management tasks.

Examples

Add storage pools

```
pvesm add <TYPE> <STORAGE_ID> <OPTIONS>
pvesm add dir <STORAGE_ID> --path <PATH>
pvesm add nfs <STORAGE_ID> --path <PATH> --
server <SERVER> --export <EXPORT>
pvesm add lvm <STORAGE_ID> --vgname <VGNAME>
pvesm add iscsi <STORAGE_ID> --portal
<HOST[:PORT]> --target <TARGET>
```

Disable storage pools

```
pvesm set <STORAGE_ID> --disable 1
```

Enable storage pools

```
pvesm set <STORAGE_ID> --disable 0
```

Change/set storage options

```
pvesm set <STORAGE_ID> <OPTIONS>
pvesm set <STORAGE_ID> --shared 1
pvesm set local --format qcow2
pvesm set <STORAGE_ID> --content iso
```

Remove storage pools. This does not delete any data, and does not disconnect or unmount anything. It just removes the storage configuration.

```
pvesm remove <STORAGE_ID>
```

Allocate volumes

```
pvesm alloc <STORAGE_ID> <VMID> <name> <size> [-
-format <raw|qcow2>]
```

Allocate a 4G volume in local storage. The name is auto-generated if you pass an empty string as `<name>`

```
pvesm alloc local <VMID> '' 4G
```

Free volumes

```
pvesm free <VOLUME_ID>
```

This really destroys all volume data.

List storage status

```
pvesm status
```

List storage contents

```
pvesm list <STORAGE_ID> [--vmid <VMID>]
```

List volumes allocated by VMID

```
pvesm list <STORAGE_ID> --vmid <VMID>
```

List iso images

```
pvesm list <STORAGE_ID> --iso
```

List container templates

```
pvesm list <STORAGE_ID> --vztmpl
```

Show file system path for a volume

```
pvesm path <VOLUME_ID>
```

Exporting the volume `local:103/vm-103-disk-0.qcow2` to the file `target`. This is mostly used internally with `pvesm import`. The stream format qcow2+size is different to the qcow2 format. Consequently, the exported file cannot simply be attached to a VM. This also holds for the other formats.

```
pvesm export local:103/vm-103-disk-0.qcow2
qcow2+size target --with-snapshots 1
```

Directory Backend

Storage pool type: `dir`

Proxmox VE can use local directories or locally mounted shares for storage. A directory is a file level storage, so you can store any content type like virtual disk images, containers, templates, ISO images or backup files.

You can mount additional storages via standard linux `/etc/fstab`, and then define a directory storage for that mount point. This way you can use any file system supported by Linux.

This backend assumes that the underlying directory is POSIX compatible, but nothing else. This implies that you cannot create snapshots at the storage level. But there exists a workaround for VM images using the `qcow2` file format, because that format supports snapshots internally.

> Some storage types do not support `O_DIRECT`, so you can't use cache mode `none` with such storages. Simply use cache mode `writeback` instead.

We use a predefined directory layout to store different content types into different sub-directories. This layout is used by all file level storage backends.

Table 2. Directory layout

Content type	Subdir
VM images	`images/<VMID>/`
ISO images	`template/iso/`
Container templates	`template/cache/`
Backup files	`dump/`
Snippets	`snippets/`

Configuration

This backend supports all common storage properties, and adds two additional properties. The `path` property is used to specify the directory. This needs to be an absolute file system path.

The optional `content-dirs` property allows for the default layout to be changed. It consists of a comma-separated list of identifiers in the following format:

```
vtype=path
```

Where `vtype` is one of the allowed content types for the storage, and `path` is a path relative to the mountpoint of the storage.

Configuration Example (`/etc/pve/storage.cfg`)

```
dir: backup
        path /mnt/backup
        content backup
        prune-backups keep-last=7
        max-protected-backups 3
        content-dirs backup=custom/backup/dir
```

The above configuration defines a storage pool called `backup`. That pool can be used to store up to 7 regular backups (`keep-last=7`) and 3 protected backups per VM. The real path for the backup files is `/mnt/backup/custom/backup/dir/...`.

File naming conventions

This backend uses a well defined naming scheme for VM images:

```
vm-<VMID>-<NAME>.<FORMAT>
```

`<VMID>`
: This specifies the owner VM.

`<NAME>`
: This can be an arbitrary name (`ascii`) without white space. The backend uses `disk-[N]` as default, where `[N]` is replaced by an integer to make the name unique.

`<FORMAT>`
: Specifies the image format (`raw|qcow2|vmdk`).

When you create a VM template, all VM images are renamed to indicate that they are now read-only, and can be used as a base image for clones:

```
base-<VMID>-<NAME>.<FORMAT>
```

> Such base images are used to generate cloned images. So it is important that those files are read-only, and never get modified. The backend changes the access mode to `0444`, and sets the immutable flag (`chattr +i`) if the storage supports that.

Storage Features

As mentioned above, most file systems do not support snapshots out of the box. To workaround that problem, this backend is able to use `qcow2` internal snapshot capabilities.

Same applies to clones. The backend uses the `qcow2` base image feature to create clones.

Table 3. Storage features for backend `dir`

Content types	Image formats	Shared	Snapshots	Clones

`images`
`rootdir`
`vztmpl`
`iso`
`backup`
`snippets`
	`raw`
	`qcow2`
	`vmdk`
	`subvol`
		no	qcow2	qcow2

Examples

Please use the following command to allocate a 4GB image on storage `local`:

```
# pvesm alloc local 100 vm-100-disk10.raw 4G
Formatting '/var/lib/vz/images/100/vm-100-
disk10.raw', fmt=raw size=4294967296
successfully created 'local:100/vm-100-
disk10.raw'
```

> The image name must conform to above naming conventions.

The real file system path is shown with:

```
# pvesm path local:100/vm-100-disk10.raw
/var/lib/vz/images/100/vm-100-disk10.raw
```

And you can remove the image with:

```
# pvesm free local:100/vm-100-disk10.raw
```

NFS Backend

Storage pool type: `nfs`

The NFS backend is based on the directory backend, so it shares most properties. The directory layout and the file naming conventions are the same. The main advantage is that you can directly configure the NFS server properties, so the backend can mount the share automatically. There is no need to modify `/etc/fstab`. The backend can also test if the server is online, and provides a method to query the server for exported shares.

Configuration

The backend supports all common storage properties, except the shared flag, which is always set. Additionally, the following properties are used to configure the NFS server:

server
: Server IP or DNS name. To avoid DNS lookup delays, it is usually preferable to use an IP address instead of a DNS name - unless you have a very reliable DNS server, or list the server in the local `/etc/hosts` file.

export
: NFS export path (as listed by `pvesm nfsscan`).

You can also set NFS mount options:

path
: The local mount point (defaults to `/mnt/pve/<STORAGE_ID>/`).

content-dirs
: Overrides for the default directory layout. Optional.

options
: NFS mount options (see `man nfs`).

Configuration Example (`/etc/pve/storage.cfg`)

```
nfs: iso-templates
        path /mnt/pve/iso-templates
        server 10.0.0.10
        export /space/iso-templates
        options vers=3,soft
        content iso,vztmpl
```

> After an NFS request times out, NFS request are retried indefinitely by default. This can lead to unexpected hangs on the client side. For read-only content, it is worth to consider the NFS `soft` option, which limits the number of retries to three.

Storage Features

NFS does not support snapshots, but the backend uses `qcow2` features to implement snapshots and cloning.

Table 4. Storage features for backend `nfs`

Content types	Image formats	Shared	Snapshots	Clones

`images`
`rootdir`
`vztmpl`
`iso`
`backup`
`snippets`
	`raw`
	`qcow2`
	`vmdk`
		yes	qcow2	qcow2

Examples

You can get a list of exported NFS shares with:

```
# pvesm nfsscan <server>
```

CIFS Backend

Storage pool type: `cifs`

The CIFS backend extends the directory backend, so that no manual setup of a CIFS mount is needed. Such a storage can be added directly through the Proxmox VE API or the WebUI, with all our backend advantages, like server heartbeat check or comfortable selection of exported shares.

Configuration

The backend supports all common storage properties, except the shared flag, which is always set. Additionally, the following CIFS special properties are available:

server
: Server IP or DNS name. Required.

> To avoid DNS lookup delays, it is usually preferable to use an IP address instead of a DNS name - unless you have a very reliable DNS server, or list the server in the local `/etc/hosts` file.

share
: CIFS share to use (get available ones with `pvesm scan cifs <address>` or the WebUI). Required.

username
: The username for the CIFS storage. Optional, defaults to 'guest'.

password
: The user password. Optional. It will be saved in a file only readable by root (`/etc/pve/priv/storage/<STORAGE-ID>.pw`).

domain
: Sets the user domain (workgroup) for this storage. Optional.

smbversion
: SMB protocol Version. Optional, default is `3`. SMB1 is not supported due to security issues.

path
: The local mount point. Optional, defaults to `/mnt/pve/<STORAGE_ID>/`.

content-dirs
: Overrides for the default directory layout. Optional.

subdir
: The subdirectory of the share to mount. Optional, defaults to the root directory of the share.

Configuration Example (`/etc/pve/storage.cfg`)

```
cifs: backup
        path /mnt/pve/backup
        server 10.0.0.11
        share VMData
        content backup
        username anna
        smbversion 3
        subdir /data
```

Storage Features

CIFS does not support snapshots on a storage level. But you may use `qcow2` backing files if you still want to have snapshots and cloning features available.

Table 5. Storage features for backend `cifs`

Content types	Image formats	Shared	Snapshots	Clones

`images`
`rootdir`
`vztmpl`
`iso`
`backup`
`snippets`
	`raw`
	`qcow2`
	`vmdk`
		yes	qcow2	qcow2

Examples

You can get a list of exported CIFS shares with:

```
# pvesm scan cifs <server> [--username
<username>] [--password]
```

Then you could add this share as a storage to the whole Proxmox VE cluster with:

```
# pvesm add cifs <storagename> --server
<server> --share <share> [--username
<username>] [--password]
```

Proxmox Backup Server

Storage pool type: `pbs`

This backend allows direct integration of a Proxmox Backup Server into Proxmox VE like any other storage. A Proxmox Backup storage can be added directly through the Proxmox VE API, CLI or the web interface.

Configuration

The backend supports all common storage properties, except the shared flag, which is always set. Additionally, the following special properties to Proxmox Backup Server are available:

server
: Server IP or DNS name. Required.

username
: The username for the Proxmox Backup Server storage. Required.

> Do not forget to add the realm to the username. For example, `root@pam` or `archiver@pbs`.

password
: The user password. The value will be saved in a file under `/etc/pve/priv/storage/<STORAGE-ID>.pw` with access restricted to the root user. Required.

datastore
: The ID of the Proxmox Backup Server datastore to use. Required.

fingerprint
: The fingerprint of the Proxmox Backup Server API TLS certificate. You can get it in the Servers Dashboard or using the `proxmox-backup-manager cert info` command. Required for self-signed certificates or any other one where the host does not trusts the servers CA.

encryption-key
: A key to encrypt the backup data from the client side. Currently only non-password protected (no key derive function (kdf)) are supported. Will be saved in a file under `/etc/pve/priv/storage/<STORAGE-ID>.enc` with access restricted to the root user. Use the magic value `autogen` to automatically generate a new one using `proxmox-backup-client key create --kdf none <path>`. Optional.

master-pubkey
: A public RSA key used to encrypt the backup encryption key as part of the backup task. The encrypted copy will be appended to the backup and stored on the Proxmox Backup Server instance for recovery purposes. Optional, requires `encryption-key`.

Configuration Example (`/etc/pve/storage.cfg`)

```
pbs: backup
        datastore main
        server enya.proxmox.com
        content backup
        fingerprint
09:54:ef:..snip..:88:af:47:fe:4c:3b:cf:8b:26:8
8:0b:4e:3c:b2
        prune-backups keep-all=1
        username archiver@pbs
```

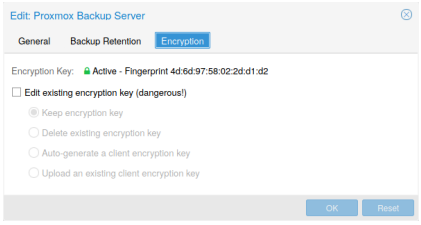
Storage Features

Proxmox Backup Server only supports backups, they can be block-level or file-level based. Proxmox VE uses block-level for virtual machines and file-level for container.

Table 6. Storage features for backend `pbs`

Content types	Image formats	Shared	Snapshots	Clones
`backup`	n/a	yes	n/a	n/a

Encryption



Optionally, you can configure client-side encryption with AES-256 in GCM mode. Encryption can be configured either via the web interface, or on the CLI with the `encryption-key` option (see above). The key will be saved in the file `/etc/pve/priv/storage/<STORAGE-ID>.enc`, which is only accessible by the root user.

> Without their key, backups will be inaccessible. Thus, you should keep keys ordered and in a place that is separate from the contents being backed up. It can happen, for example, that you back up an entire system, using a key on that system. If the system then becomes inaccessible for any reason and needs to be restored, this will not be possible as the encryption key will be lost along with the broken system.

It is recommended that you keep your key safe, but easily accessible, in order for quick disaster recovery. For this reason, the best place to store it is in your password manager, where it is immediately recoverable. As a backup to this, you should also save the key to a USB drive and store that in a secure place. This way, it is detached from any system, but is still easy to recover from, in case of emergency. Finally, in preparation for the worst case scenario, you should also consider keeping a paper copy of your key locked away in a safe place. The `paperkey` subcommand can be used to create a QR encoded version of your key. The following command sends the output of the `paperkey` command to a text file, for easy printing.

```
# proxmox-backup-client key paperkey
/etc/pve/priv/storage/<STORAGE-ID>.enc --
output-format text > qrkey.txt
```

Additionally, it is possible to use a single RSA master key pair for key recovery purposes: configure all clients doing encrypted backups to use a single public master key, and all subsequent encrypted backups will contain a RSA-encrypted copy of the used AES encryption key. The corresponding private master key allows recovering the AES key and decrypting the backup even if the client system is no longer available.

> The same safe-keeping rules apply to the master key pair as to the regular encryption keys. Without a copy of the private key recovery is not possible! The `paperkey` command supports generating paper copies of private master keys for storage in a safe, physical location.

Because the encryption is managed on the client side, you can use the same datastore on the server for unencrypted backups and encrypted backups, even if they are encrypted with different keys. However, deduplication between backups with different keys is not possible, so it is often better to create separate datastores.

> Do not use encryption if there is no benefit from it, for example, when you are running the server locally in a trusted network. It is always easier to recover from unencrypted backups.

Example: Add Storage over CLI

Then you could add this share as a storage to the whole Proxmox VE cluster with:

```
# pvesm add pbs <id> --server <server> --
datastore <datastore> --username <username> --
fingerprint 00:B4:... --password
```

GlusterFS Backend

Storage pool type: `glusterfs`

GlusterFS is a scalable network file system. The system uses a modular design, runs on commodity hardware, and can provide a highly available enterprise storage at low costs. Such system is capable of scaling to several petabytes, and can handle thousands of clients.

> After a node/brick crash, GlusterFS does a full `rsync` to make sure data is consistent. This can take a very long time with large files, so this backend is not suitable to store large VM images.

Configuration

The backend supports all common storage properties, and adds the following GlusterFS specific options:

`server`
: GlusterFS volfile server IP or DNS name.

`server2`
: Backup volfile server IP or DNS name.

`volume`
: GlusterFS Volume.

`transport`
: GlusterFS transport: `tcp`, `unix` or `rdma`

Configuration Example (`/etc/pve/storage.cfg`)

```
glusterfs: Gluster
        server 10.2.3.4
        server2 10.2.3.5
        volume glustervol
        content images,iso
```

File naming conventions

The directory layout and the file naming conventions are inherited from the `dir` backend.

Storage Features

The storage provides a file level interface, but no native snapshot/clone implementation.

Table 7. Storage features for backend `glusterfs`

Content types	Image formats	Shared	Snapshots	Clones

`images`
`vztmpl`
`iso`
`backup`
`snippets`
	`raw`
	`qcow2`
	`vmdk`
		yes	qcow2	qcow2

Local ZFS Pool Backend

Storage pool type: `zfspool`

This backend allows you to access local ZFS pools (or ZFS file systems inside such pools).

Configuration

The backend supports the common storage properties `content`, `nodes`, `disable`, and the following ZFS specific properties:

pool
: Select the ZFS pool/filesystem. All allocations are done within that pool.

blocksize
: Set ZFS blocksize parameter.

sparse
: Use ZFS thin-provisioning. A sparse volume is a volume whose reservation is not equal to the volume size.

mountpoint
: The mount point of the ZFS pool/filesystem. Changing this does not affect the `mountpoint` property of the dataset seen by `zfs`. Defaults to `/<pool>`.

Configuration Example (`/etc/pve/storage.cfg`)

```
zfspool: vmdata
        pool tank/vmdata
        content rootdir,images
        sparse
```

File naming conventions

The backend uses the following naming scheme for VM images:

```
vm-<VMID>-<NAME>       // normal VM images
base-<VMID>-<NAME>     // template VM image
(read-only)
```

```
subvol-<VMID>-<NAME>  // subvolumes (ZFS
filesystem for containers)
```

`<VMID>`
: This specifies the owner VM.

`<NAME>`
: This can be an arbitrary name (`ascii`) without white space. The backend uses `disk[N]` as default, where `[N]` is replaced by an integer to make the name unique.

Storage Features

ZFS is probably the most advanced storage type regarding snapshot and cloning. The backend uses ZFS datasets for both VM images (format `raw`) and container data (format `subvol`). ZFS properties are inherited from the parent dataset, so you can simply set defaults on the parent dataset.

Table 8. Storage features for backend `zfs`

Content types	Image formats	Shared	Snapshots	Clones
`images rootdir`	`raw subvol`	no	yes	yes

Examples

It is recommended to create an extra ZFS file system to store your VM images:

```
# zfs create tank/vmdata
```

To enable compression on that newly allocated file system:

```
# zfs set compression=on tank/vmdata
```

You can get a list of available ZFS filesystems with:

```
# pvesm zfsscan
```

LVM Backend

Storage pool type: `lvm`

LVM is a light software layer on top of hard disks and partitions. It can be used to split available disk space into smaller logical volumes. LVM is widely used on Linux and makes managing hard drives easier.

Another use case is to put LVM on top of a big iSCSI LUN. That way you can easily manage space on that iSCSI LUN, which would not be possible otherwise, because the iSCSI specification does not define a management interface for space allocation.

Configuration

The LVM backend supports the common storage properties `content`, `nodes`, `disable`, and the following LVM specific properties:

`vgname`

LVM volume group name. This must point to an existing volume group.

`base`
: Base volume. This volume is automatically activated before accessing the storage. This is mostly useful when the LVM volume group resides on a remote iSCSI server.

`saferemove`
: Zero-out data when removing LVs. When removing a volume, this makes sure that all data gets erased.

`saferemove_throughput`
: Wipe throughput (`cstream -t` parameter value).

Configuration Example (`/etc/pve/storage.cfg`)

```
lvm: myspace
        vgname myspace
        content rootdir,images
```

File naming conventions

The backend use basically the same naming conventions as the ZFS pool backend.

```
vm-<VMID>-<NAME>      // normal VM images
```

Storage Features

LVM is a typical block storage, but this backend does not support snapshots and clones. Unfortunately, normal LVM snapshots are quite inefficient, because they interfere with all writes on the entire volume group during snapshot time.

One big advantage is that you can use it on top of a shared storage, for example, an iSCSI LUN. The backend itself implements proper cluster-wide locking.

> The newer LVM-thin backend allows snapshots and clones, but does not support shared storage.

Table 9. Storage features for backend `lvm`

Content types	Image formats	Shared	Snapshots	Clones
`images rootdir`	`raw`	possible	no	no

Examples

List available volume groups:

```
# pvesm lvmscan
```

LVM thin Backend

Storage pool type: `lvmthin`

LVM normally allocates blocks when you create a volume. LVM thin pools instead allocates blocks when they are written. This

behaviour is called thin-provisioning, because volumes can be much larger than physically available space.

You can use the normal LVM command line tools to manage and create LVM thin pools (see `man lvmthin` for details). Assuming you already have a LVM volume group called `pve`, the following commands create a new LVM thin pool (size 100G) called `data`:

```
lvcreate -L 100G -n data pve
lvconvert --type thin-pool pve/data
```

Configuration

The LVM thin backend supports the common storage properties `content`, `nodes`, `disable`, and the following LVM specific properties:

`vgname`
: LVM volume group name. This must point to an existing volume group.

`thinpool`
: The name of the LVM thin pool.

Configuration Example (`/etc/pve/storage.cfg`)

```
lvmthin: local-lvm
        thinpool data
        vgname pve
        content rootdir,images
```

File naming conventions

The backend use basically the same naming conventions as the ZFS pool backend.

```
vm-<VMID>-<NAME>       // normal VM images
```

Storage Features

LVM thin is a block storage, but fully supports snapshots and clones efficiently. New volumes are automatically initialized with zero.

It must be mentioned that LVM thin pools cannot be shared across multiple nodes, so you can only use them as local storage.

Table 10. Storage features for backend `lvmthin`

Content types	Image formats	Shared	Snapshots	Clones
`images rootdir`	`raw`	no	yes	yes

Examples

List available LVM thin pools on volume group `pve`:

```
# pvesm lvmthinscan pve
```

Open-iSCSI initiator

Storage pool type: `iscsi`

iSCSI is a widely employed technology used to connect to storage servers. Almost all storage vendors support iSCSI. There are also open source iSCSI target solutions available, e.g. OpenMediaVault, which is based on Debian.

To use this backend, you need to install the Open-iSCSI (`open-iscsi`) package. This is a standard Debian package, but it is not installed by default to save resources.

```
# apt-get install open-iscsi
```

Low-level iscsi management task can be done using the `iscsiadm` tool.

Configuration

The backend supports the common storage properties `content`, `nodes`, `disable`, and the following iSCSI specific properties:

portal
: iSCSI portal (IP or DNS name with optional port).

target
: iSCSI target.

Configuration Example (`/etc/pve/storage.cfg`)

```
iscsi: mynas
     portal 10.10.10.1
     target iqn.2006-
01.openfiler.com:tsn.dcb5aaaddd
     content none
```

> If you want to use LVM on top of iSCSI, it make sense to set `content none`. That way it is not possible to create VMs using iSCSI LUNs directly.

File naming conventions

The iSCSI protocol does not define an interface to allocate or delete data. Instead, that needs to be done on the target side and is vendor specific. The target simply exports them as numbered LUNs. So Proxmox VE iSCSI volume names just encodes some information about the LUN as seen by the linux kernel.

Storage Features

iSCSI is a block level type storage, and provides no management interface. So it is usually best to export one big LUN, and setup LVM on top of that LUN. You can then use the LVM plugin to manage the storage on that iSCSI LUN.

Table 11. Storage features for backend `iscsi`

Content types	Image formats	Shared	Snapshots	Clones
`images` `none`	`raw`	yes	no	no

Examples

Scan a remote iSCSI portal, and returns a list of possible targets:

```
pvesm scan iscsi <HOST[:PORT]>
```

User Mode iSCSI Backend

Storage pool type: `iscsidirect`

This backend provides basically the same functionality as the Open-iSCSI backed, but uses a user-level library to implement it. You need to install the `libiscsi-bin` package in order to use this backend.

It should be noted that there are no kernel drivers involved, so this can be viewed as performance optimization. But this comes with the drawback that you cannot use LVM on top of such iSCSI LUN. So you need to manage all space allocations at the storage server side.

Configuration

The user mode iSCSI backend uses the same configuration options as the Open-iSCSI backed.

Configuration Example (`/etc/pve/storage.cfg`)

```
iscsidirect: faststore
     portal 10.10.10.1
     target iqn.2006-
01.openfiler.com:tsn.dcb5aaaddd
```

Storage Features

This backend works with VMs only. Containers cannot use this driver.

Table 12. Storage features for backend `iscsidirect`

Content types	Image formats	Shared	Snapshots	Clones
`images`	`raw`	yes	no	no

Ceph RADOS Block Devices (RBD)

Storage pool type: `rbd`

Ceph is a distributed object store and file system designed to provide excellent performance, reliability and scalability. RADOS block devices implement a feature rich block level storage, and you get the following advantages:

- thin provisioning
- resizable volumes
- distributed and redundant (striped over multiple OSDs)
- full snapshot and clone capabilities

- self healing
- no single point of failure
- scalable to the exabyte level
- kernel and user space implementation available

> For smaller deployments, it is also possible to run Ceph services directly on your Proxmox VE nodes. Recent hardware has plenty of CPU power and RAM, so running storage services and VMs on same node is possible.

Configuration

This backend supports the common storage properties `nodes`, `disable`, `content`, and the following `rbd` specific properties:

monhost
: List of monitor daemon IPs. Optional, only needed if Ceph is not running on the Proxmox VE cluster.

pool
: Ceph pool name.

username
: RBD user ID. Optional, only needed if Ceph is not running on the Proxmox VE cluster. Note that only the user ID should be used. The "client." type prefix must be left out.

krbd
: Enforce access to rados block devices through the krbd kernel module. Optional.

> Containers will use `krbd` independent of the option value.

Configuration Example for a external Ceph cluster (`/etc/pve/storage.cfg`)

```
rbd: ceph-external
        monhost 10.1.1.20 10.1.1.21 10.1.1.22
        pool ceph-external
        content images
        username admin
```

> You can use the `rbd` utility to do low-level management tasks.

Authentication

> If Ceph is installed locally on the Proxmox VE cluster, the following is done automatically when adding the storage.

If you use `cephx` authentication, which is enabled by default, you need to provide the keyring from the external Ceph cluster.

To configure the storage via the CLI, you first need to make the file containing the keyring available. One way is to copy the file from the external Ceph cluster directly to one of the Proxmox VE nodes. The following example will copy it to the `/root` directory of the node on which we run it:

```
# scp <external
cephserver>:/etc/ceph/ceph.client.admin.keyrin
g /root/rbd.keyring
```

Then use the `pvesm` CLI tool to configure the external RBD storage, use the `--keyring` parameter, which needs to be a path to the keyring file that you copied. For example:

```
# pvesm add rbd <name> --monhost "10.1.1.20
10.1.1.21 10.1.1.22" --content images --
keyring /root/rbd.keyring
```

When configuring an external RBD storage via the GUI, you can copy and paste the keyring into the appropriate field.

The keyring will be stored at

```
# /etc/pve/priv/ceph/<STORAGE_ID>.keyring
```

> Creating a keyring with only the needed capabilities is recommend when connecting to an external cluster. For further information on Ceph user management, see the Ceph docs.[1]

Ceph client configuration (optional)

Connecting to an external Ceph storage doesn't always allow setting client-specific options in the config DB on the external cluster. You can add a `ceph.conf` beside the Ceph keyring to change the Ceph client configuration for the storage.

The ceph.conf needs to have the same name as the storage.

```
# /etc/pve/priv/ceph/<STORAGE_ID>.conf
```

See the RBD configuration reference [2] for possible settings.

> Do not change these settings lightly. Proxmox VE is merging the <STORAGE_ID>.conf with the storage configuration.

Storage Features

The `rbd` backend is a block level storage, and implements full snapshot and clone functionality.

Table 13. Storage features for backend `rbd`

Content types	Image formats	Shared	Snapshots	Clones
`images rootdir`	`raw`	yes	yes	yes

Ceph Filesystem (CephFS)

Storage pool type: `cephfs`

CephFS implements a POSIX-compliant filesystem, using a Ceph storage cluster to store its data. As CephFS builds upon Ceph, it shares most of its properties. This includes redundancy, scalability, self-healing, and high availability.

> Proxmox VE can manage Ceph setups, which makes configuring a CephFS storage easier. As modern hardware offers a lot of processing power and RAM, running storage services and VMs on same node is possible without a significant performance impact.

To use the CephFS storage plugin, you must replace the stock Debian Ceph client, by adding our Ceph repository. Once added, run `apt update`, followed by `apt dist-upgrade`, in order to get the newest packages.

> Please ensure that there are no other Ceph repositories configured. Otherwise the installation will fail or there will be mixed package versions on the node, leading to unexpected behavior.

Configuration

This backend supports the common storage properties `nodes`, `disable`, `content`, as well as the following `cephfs` specific properties:

monhost
: List of monitor daemon addresses. Optional, only needed if Ceph is not running on the Proxmox VE cluster.

path
: The local mount point. Optional, defaults to `/mnt/pve/<STORAGE_ID>/`.

username
: Ceph user id. Optional, only needed if Ceph is not running on the Proxmox VE cluster, where it defaults to `admin`.

subdir
: CephFS subdirectory to mount. Optional, defaults to `/`.

fuse
: Access CephFS through FUSE, instead of the kernel client. Optional, defaults to `0`.

Configuration example for an external Ceph cluster (`/etc/pve/storage.cfg`)

```
cephfs: cephfs-external
        monhost 10.1.1.20 10.1.1.21 10.1.1.22
        path /mnt/pve/cephfs-external
        content backup
        username admin
```

> Don’t forget to set up the client’s secret key file, if cephx was not disabled.

Authentication

> If Ceph is installed locally on the Proxmox VE cluster, the following is done automatically when adding the storage.

If you use `cephx` authentication, which is enabled by default, you need to provide the secret from the external Ceph cluster.

To configure the storage via the CLI, you first need to make the file containing the secret available. One way is to copy the file from the external Ceph cluster directly to one of the Proxmox VE nodes. The following example will copy it to the `/root` directory of the node on which we run it:

```
# scp <external
cephserver>:/etc/ceph/cephfs.secret
/root/cephfs.secret
```

Then use the `pvesm` CLI tool to configure the external RBD storage, use the `--keyring` parameter, which needs to be a path to the secret file that you copied. For example:

```
# pvesm add cephfs <name> --monhost "10.1.1.20
10.1.1.21 10.1.1.22" --content backup --
keyring /root/cephfs.secret
```

When configuring an external RBD storage via the GUI, you can copy and paste the secret into the appropriate field.

The secret is only the key itself, as opposed to the `rbd` backend which also contains a `[client.userid]` section.

The secret will be stored at

```
# /etc/pve/priv/ceph/<STORAGE_ID>.secret
```

A secret can be received from the Ceph cluster (as Ceph admin) by issuing the command below, where `userid` is the client ID that has been configured to access the cluster. For further information on Ceph user management, see the Ceph docs.[1]

```
# ceph auth get-key client.userid >
cephfs.secret
```

Storage Features

The `cephfs` backend is a POSIX-compliant filesystem, on top of a Ceph cluster.

Table 14. Storage features for backend `cephfs`

Content types	Image formats	Shared	Snapshots	Clones
`vztmpl` `iso` `backup` `snippets`	`none`	yes	yes[1]	no

[1] While no known bugs exist, snapshots are not yet guaranteed to be stable, as they lack sufficient testing.

BTRFS Backend

Storage pool type: `btrfs`

On the surface, this storage type is very similar to the directory storage type, so see the directory backend section for a general overview.

The main difference is that with this storage type `raw` formatted disks will be placed in a subvolume, in order to allow taking snapshots and supporting offline storage migration with snapshots being preserved.

> BTRFS will honor the `O_DIRECT` flag when opening files, meaning VMs should not use cache mode `none`, otherwise there will be checksum errors.

Configuration

This backend is configured similarly to the directory storage. Note that when adding a directory as a BTRFS storage, which is not itself also the mount point, it is highly recommended to specify the actual mount point via the `is_mountpoint` option.

For example, if a BTRFS file system is mounted at `/mnt/data2` and its `pve-storage/` subdirectory (which may be a snapshot, which is recommended) should be added as a storage pool called `data2`, you can use the following entry:

```
btrfs: data2
        path /mnt/data2/pve-storage
        content rootdir,images
        is_mountpoint /mnt/data2
```

Snapshots

When taking a snapshot of a subvolume or `raw` file, the snapshot will be created as a read-only subvolume with the same path followed by an `@` and the snapshot's name.

ZFS over ISCSI Backend

Storage pool type: `zfs`

This backend accesses a remote machine having a ZFS pool as storage and an iSCSI target implementation via `ssh`. For each guest disk it creates a ZVOL and, exports it as iSCSI LUN. This LUN is used by Proxmox VE for the guest disk.

The following iSCSI target implementations are supported:

- LIO (Linux)
- IET (Linux)
- ISTGT (FreeBSD)
- Comstar (Solaris)

> This plugin needs a ZFS capable remote storage appliance, you cannot use it to create a ZFS Pool on a regular Storage Appliance/SAN

Configuration

In order to use the ZFS over iSCSI plugin you need to configure the remote machine (target) to accept `ssh` connections from the Proxmox VE node. Proxmox VE connects to the target for creating the ZVOLs and exporting them via iSCSI. Authentication is done through a ssh-key (without password protection) stored in `/etc/pve/priv/zfs/<target_ip>_id_rsa`

The following steps create a ssh-key and distribute it to the storage machine with IP 192.0.2.1:

```
mkdir /etc/pve/priv/zfs
ssh-keygen -f
/etc/pve/priv/zfs/192.0.2.1_id_rsa
ssh-copy-id -i
/etc/pve/priv/zfs/192.0.2.1_id_rsa.pub
root@192.0.2.1
ssh -i /etc/pve/priv/zfs/192.0.2.1_id_rsa
root@192.0.2.1
```

The backend supports the common storage properties `content`, `nodes`, `disable`, and the following ZFS over ISCSI specific properties:

pool
: The ZFS pool/filesystem on the iSCSI target. All allocations are done within that pool.

portal
: iSCSI portal (IP or DNS name with optional port).

target
: iSCSI target.

iscsiprovider
: The iSCSI target implementation used on the remote machine

comstar_tg
: target group for comstar views.

comstar_hg
: host group for comstar views.

lio_tpg
: target portal group for Linux LIO targets

nowritecache
: disable write caching on the target

blocksize
: Set ZFS blocksize parameter.

sparse
: Use ZFS thin-provisioning. A sparse volume is a volume whose reservation is not equal to the volume size.

Configuration Examples (`/etc/pve/storage.cfg`)

```
zfs: lio
   blocksize 4k
   iscsiprovider LIO
   pool tank
```

```
    portal 192.0.2.111
    target iqn.2003-01.org.linux-
iscsi.lio.x8664:sn.xxxxxxxxxxxx
    content images
    lio_tpg tpg1
    sparse 1

zfs: solaris
    blocksize 4k
    target iqn.2010-08.org.illumos:02:xxxxxxxx-
xxxx-xxxx-xxxx-xxxxxxxxxxxx:tank1
    pool tank
    iscsiprovider comstar
    portal 192.0.2.112
    content images

zfs: freebsd
    blocksize 4k
    target iqn.2007-09.jp.ne.peach.istgt:tank1
    pool tank
    iscsiprovider istgt
    portal 192.0.2.113
    content images

zfs: iet
    blocksize 4k
    target iqn.2001-04.com.example:tank1
    pool tank
    iscsiprovider iet
    portal 192.0.2.114
    content images
```

Storage Features

The ZFS over iSCSI plugin provides a shared storage, which is capable of snapshots. You need to make sure that the ZFS appliance does not become a single point of failure in your deployment.

Table 15. Storage features for backend `iscsi`

Content types	Image formats	Shared	Snapshots	Clones
`images`	`raw`	yes	yes	no

1. Ceph User Management

2. RBD configuration reference https://docs.ceph.com/en/quincy/rbd/rbd-config-ref/

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