

TRAINING PROXMOX VIRTUAL ENVIRONMENT

WELCOME

Proxmox Server Solutions GmbH reserves the right to make changes to this document and to the products described herein without notice. Before installing and using the software, please review the latest version of the Proxmox VE reference documentation, which is available at https://pve.proxmox.com/pve-docs.

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September 2025 | v9.0

Training Schedule 5-days



Agenda — Deployment and Management

- Understanding the architecture of Proxmox VE
- Setting up Proxmox VE: system requirements, installation, updates, and network configuration.
- Management interfaces (web GUI, CLI)
- Networks (bridging and bonding, VLANs, software-defined networking)
- Storage options in Proxmox VE
- Virtual guest management: Exploring the options for VMs and Linux OS containers (LXC)

Agenda — Deployment and Management

- Migration to Proxmox VE from other hypervisors (V2V) or physical hosts (P2V)
- Backup and restore strategies: guest backups, Proxmox Backup Server, retention management, and restore possibilities.
- Authentication and permissions
- Integrated Firewall
- Troubleshooting common issues

Agenda — Clustering and Shared Storage

- Architecture and components of a Proxmox VE cluster
- Proxmox Cluster File System (pmxcfs) and Corosync
- Cluster networking and redundancy, software-defined networking (SDN), and VLANs
- Shared storage options
- Deploying Ceph: hyper-converged infrastructure (HCI), Ceph RBD, Ceph FS

Agenda — Clustering and Shared Storage

- Migration of guests between nodes
- ZFS for asynchronous guest disk replication
- High availability (HA) for VMs and containers
- Failure scenarios with exercises for HA and Ceph
- Considerations for a minimal 2 node setup with an external tiebreaker (QDevice).
- Automating tasks with REST API or CLI
- Troubleshooting common issues

INTRODUCTION

About Proxmox Server Solutions

About Proxmox

- Delivering open-source enterprise solutions to simplify server management.
- Based in Vienna (Austria).
- Established in 2005.
- Privately owned, free from venture capital influence.



About Proxmox — Business Model

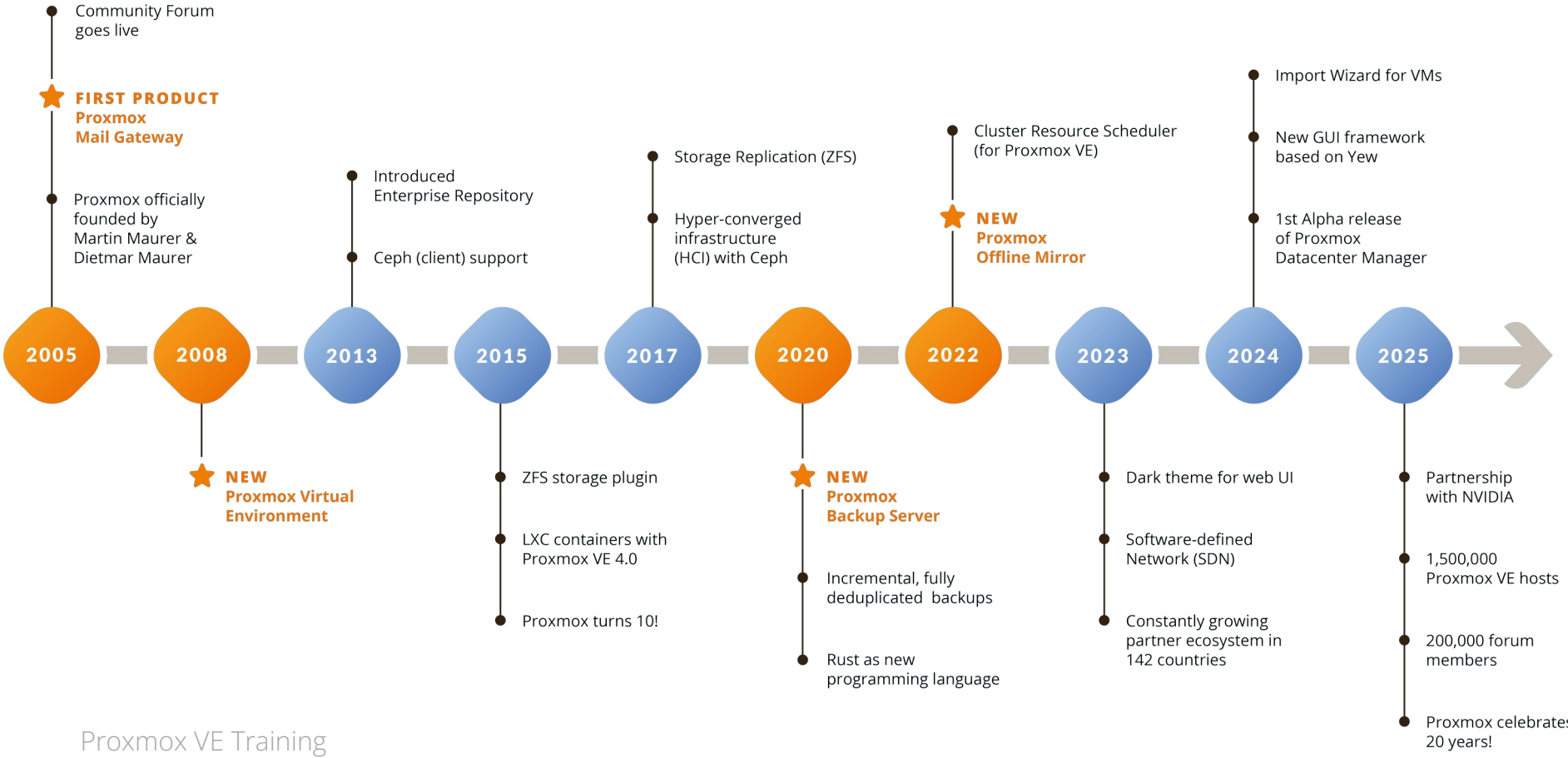
Software

- Open Source
- License: AGPLv3
- All features included

Services

- Subscriptions
  - Enterprise Repository
  - Support Tickets
- Training courses
- Global partner ecosystem

About Proxmox — History



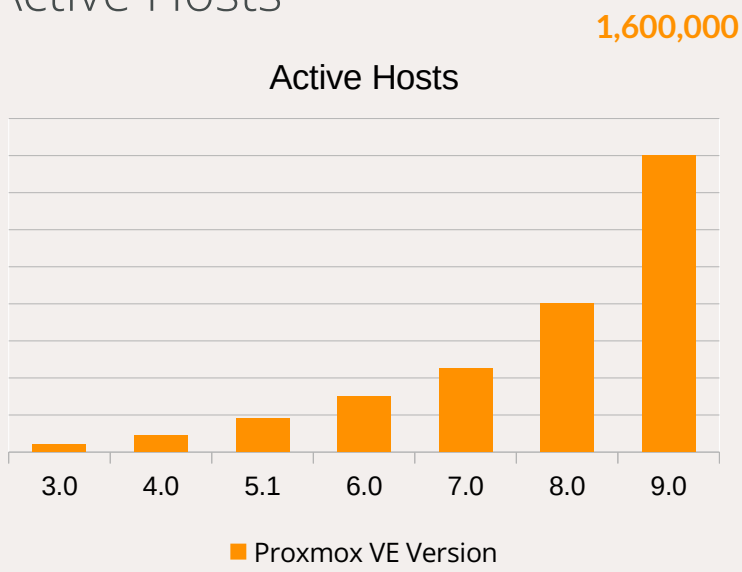
About Proxmox — Some Facts

142
Countries

225,000
Forum members

Enterprises of all sizes and industries

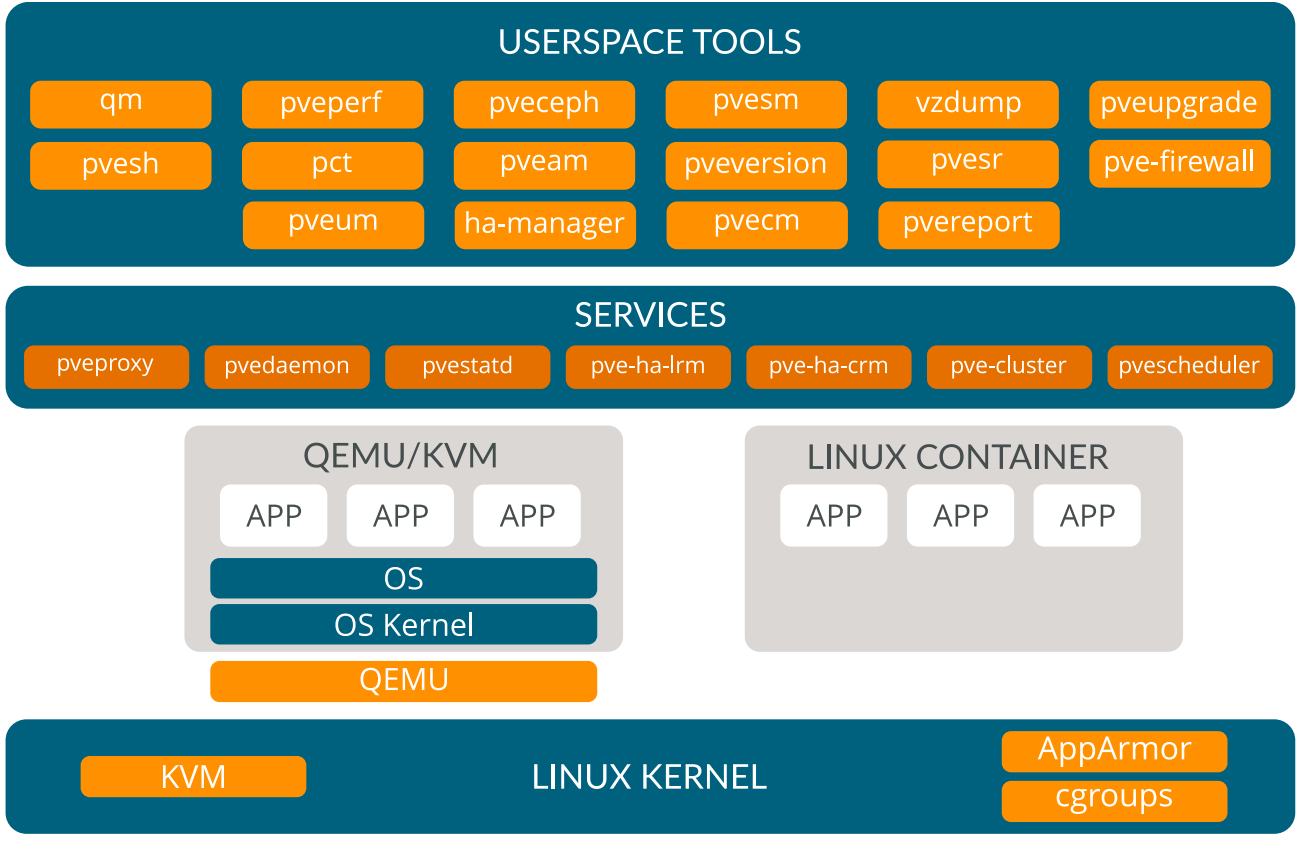
1,600,000
Active Hosts



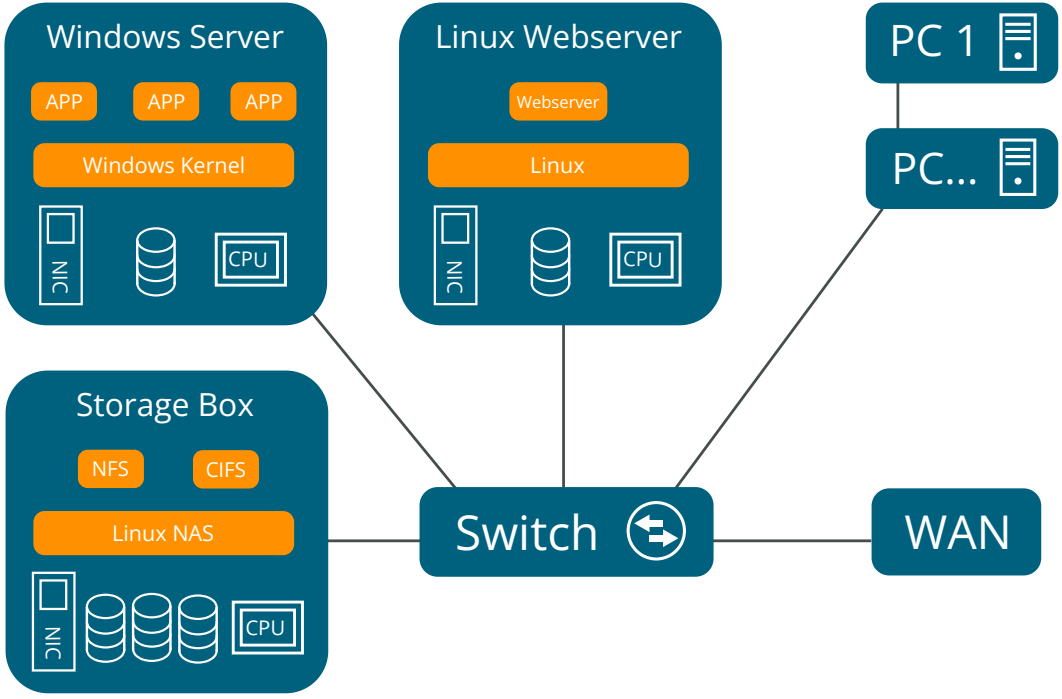
TRAINING COURSE

Proxmox Virtual Environment

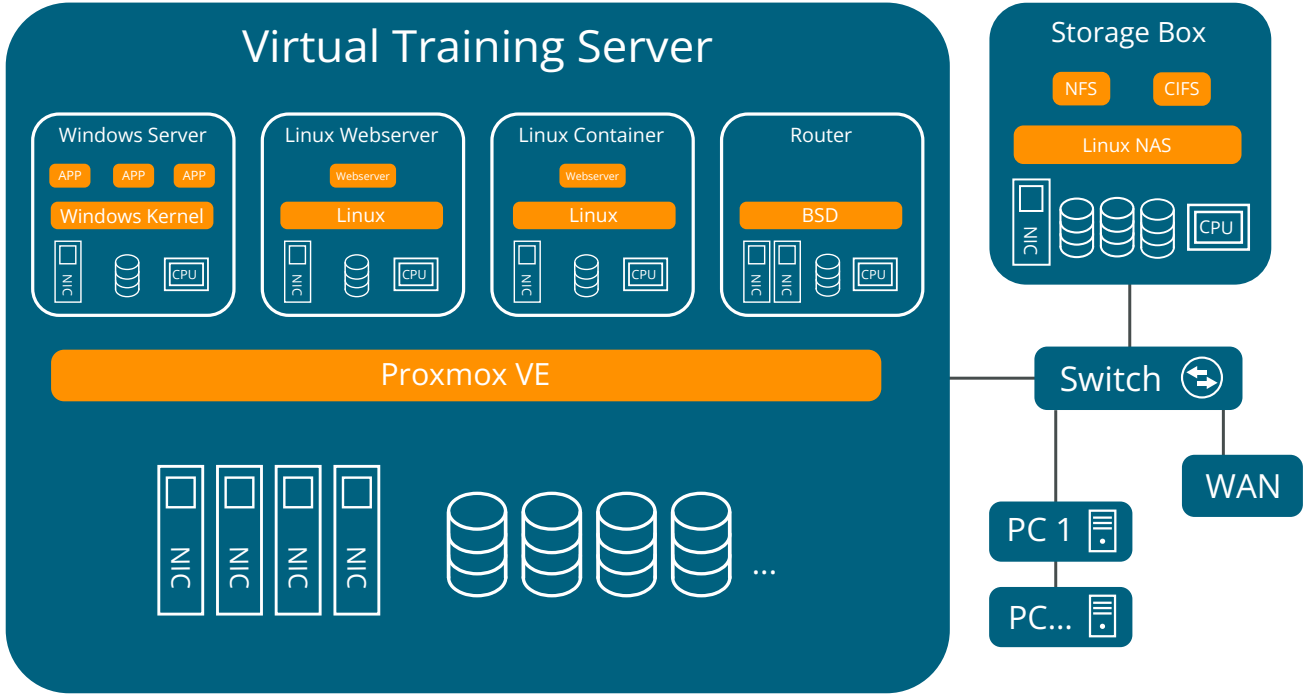
Proxmox VE Management Tools



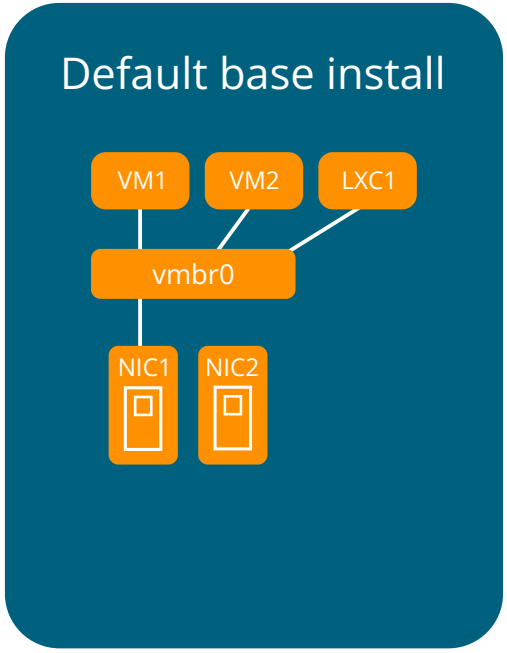
Training Scenario

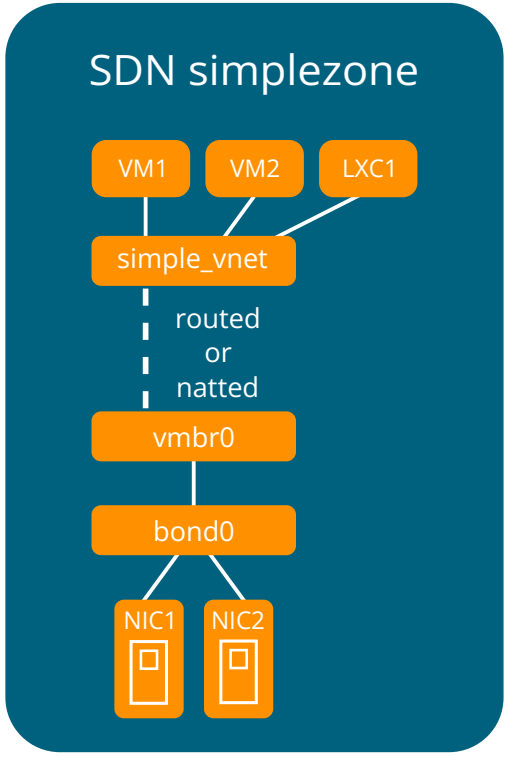


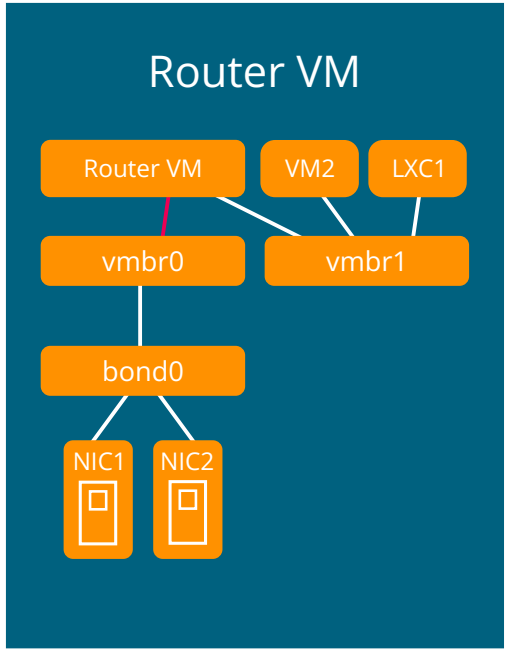
Training Scenario



Guests in Virtual Network behind Router







Available Storage in Proxmox VE

Description	Plugin type	Level	Shared	Snapshots	Stable
ZFS (local)	`zfspool`	both[1]	no	yes	yes
Directory	`dir`	file	no	yes[2]	yes
BTRFS	`btrfs`	file	no	yes	TP[5]
NFS	`nfs`	file	yes	yes[2]	yes
CIFS	`cifs`	file	yes	yes[2]	yes
Proxmox Backup	`pbs`	both	yes	n/a	yes
CephFS	`cephfs`	file	yes	yes	yes
LVM	`lvm`	block	no[3]	yes[4]	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]: Disk images for VMs are stored in ZFS volume (zvol) datasets, which provide block device functionality.

[2]: On file based storages, snapshots are possible with the *qcow2* format, either using the internal snapshot function, or snapshots as volume chains[4].

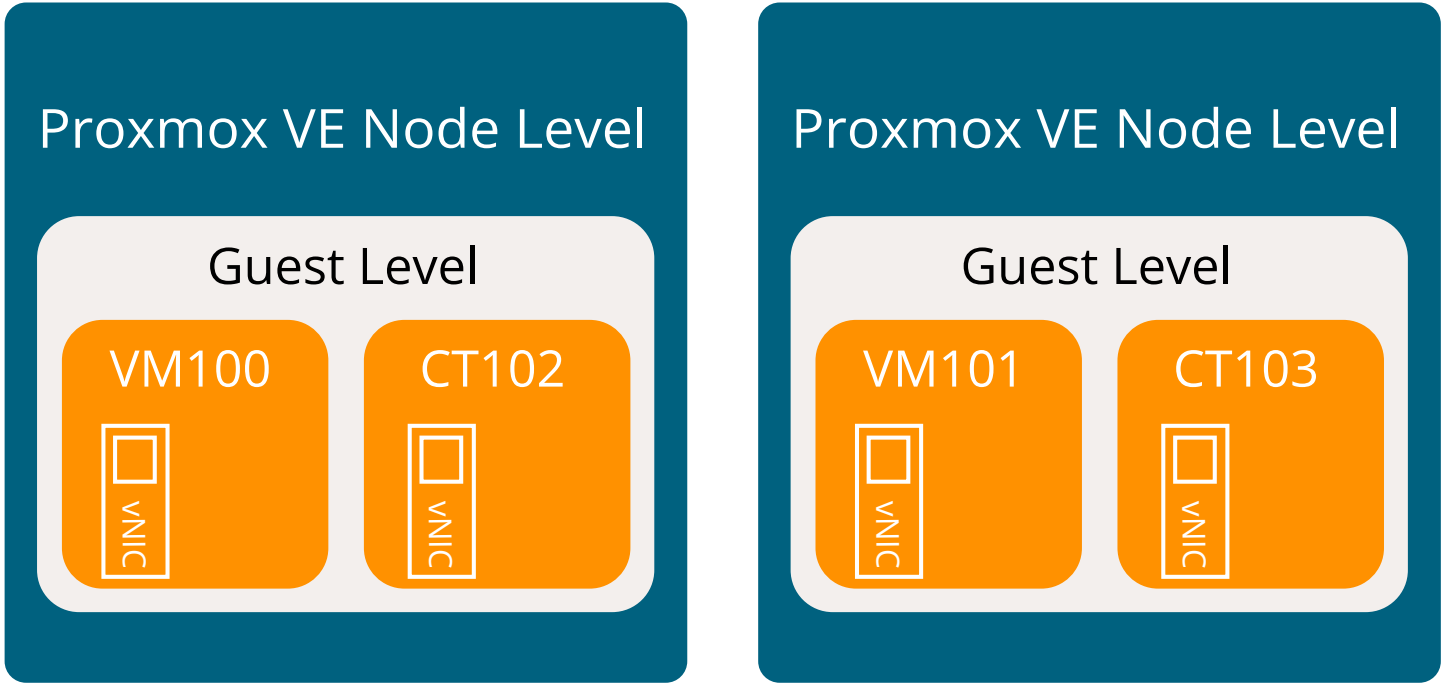
[3]: It is possible to use LVM on top of an iSCSI or FC-based storage. That way you get a `shared` LVM storage

[4]: Since Proxmox VE 9, snapshots as a volume chain have been available for VMs. These snapshots use separate volumes for the snapshot data and layer them. For more details, see the description for `snapshot-as-volume-chain` in the LVM configuration section.

[5] Technology preview with best-effort support.

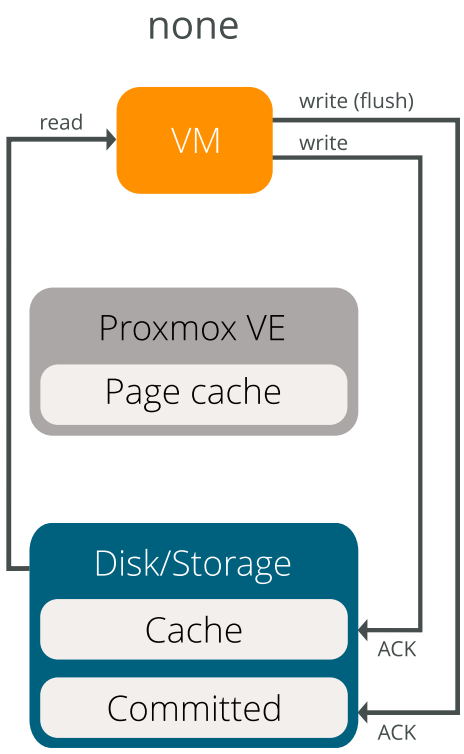
Read more in the DOCS →

Firewall Datacenter Level



Read more in the DOCS →

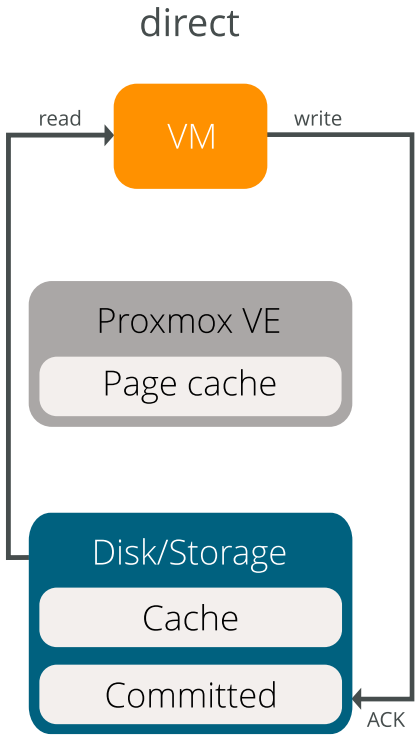
Cache Modes



- host page cache is not used
- guest disk cache is set to writeback

More Details →

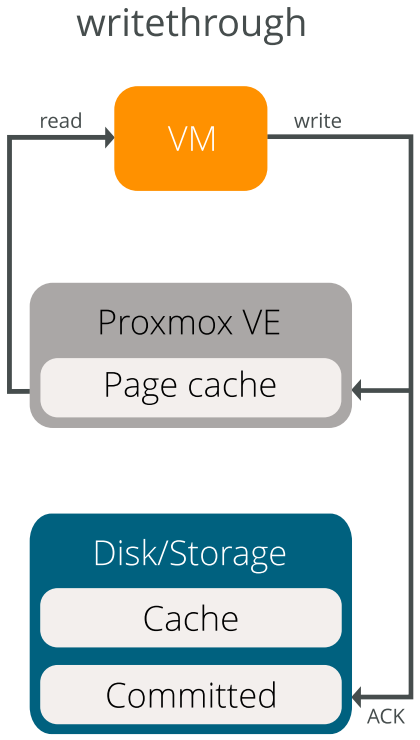
Cache Modes



- host page cache is not used
- guest disk cache mode is writethrough
- fsync is made for each write

More Details →

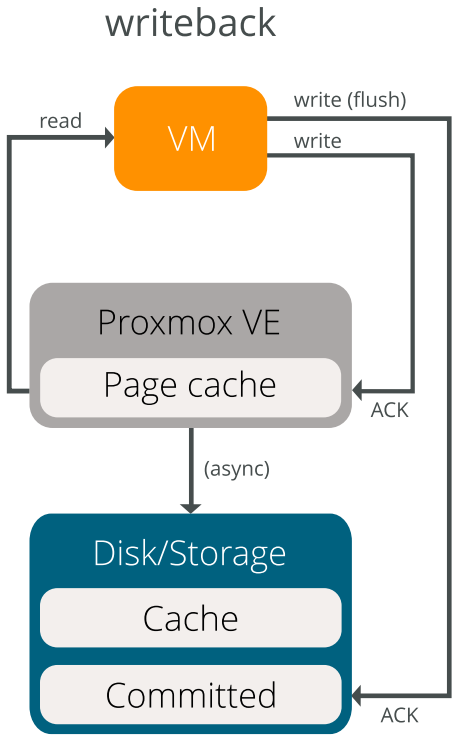
Cache Modes



- host page cache is used as read cache
- guest disk cache mode is writethrough
- fsync for each write, more secure, can't lose data on power-loss, slower

More Details →

Cache Modes



- host page cache is used as read & write cache
- guest disk cache mode is writeback
- Warning: you can lose data in case of a power failure

More Details →

Backups

Mode	VM	Container
stop	Shutdown, start immediately	Stop during whole backup
suspend	Provided for compatibility, better use snapshot	Rsync to tmp while running, suspend container and rsync again
snapshot	Use virtualization to take a consistent backup	Use storage snapshot functionality, fallback to suspend mode

Read more in the DOCS →

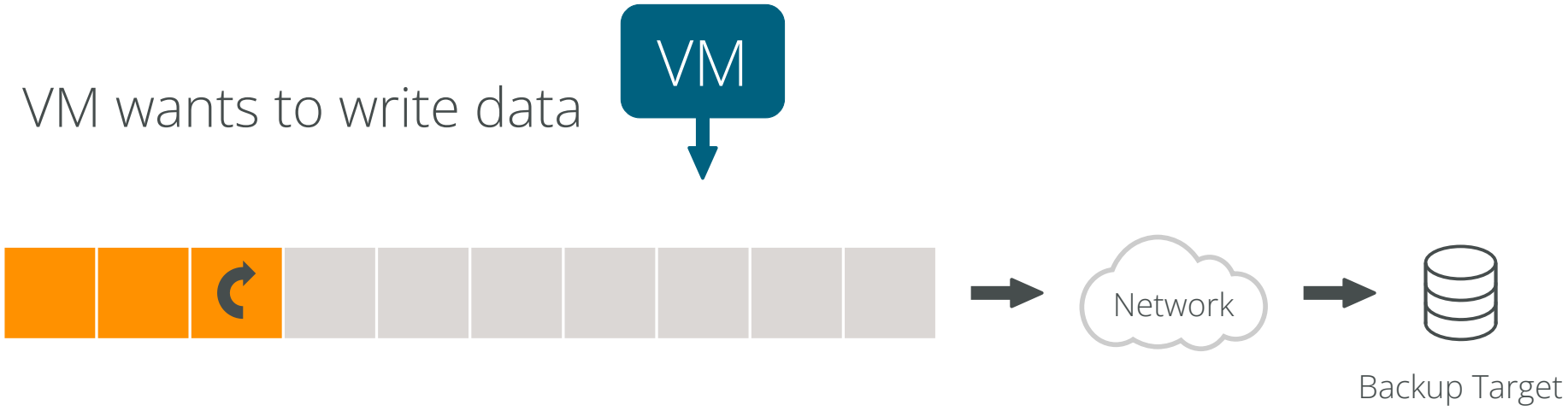
Proxmox VE

Begin at start



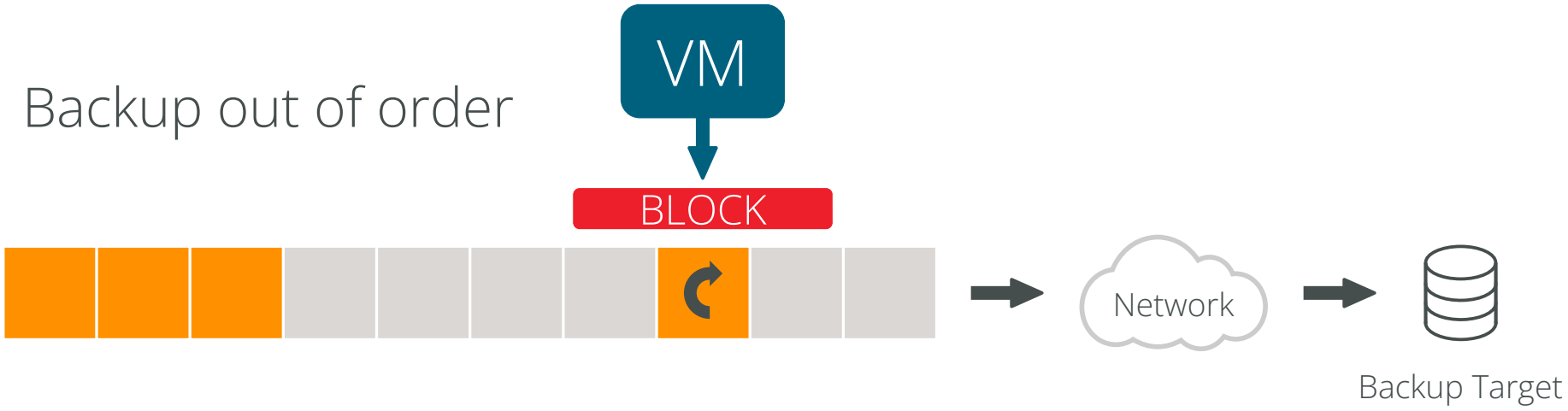
Proxmox VE

VM wants to write data



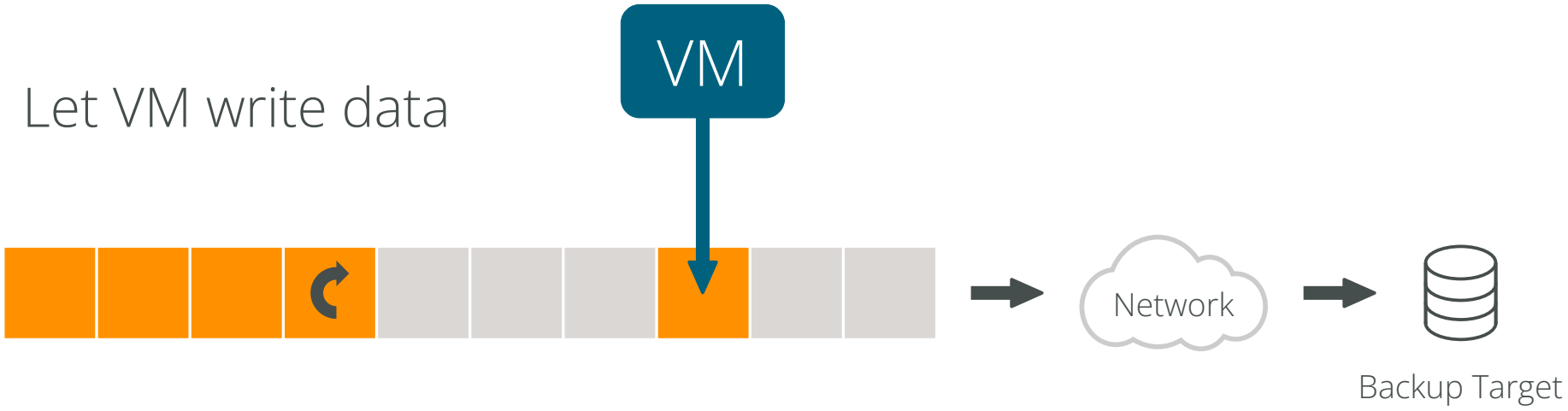
Proxmox VE

Backup out of order



Proxmox VE

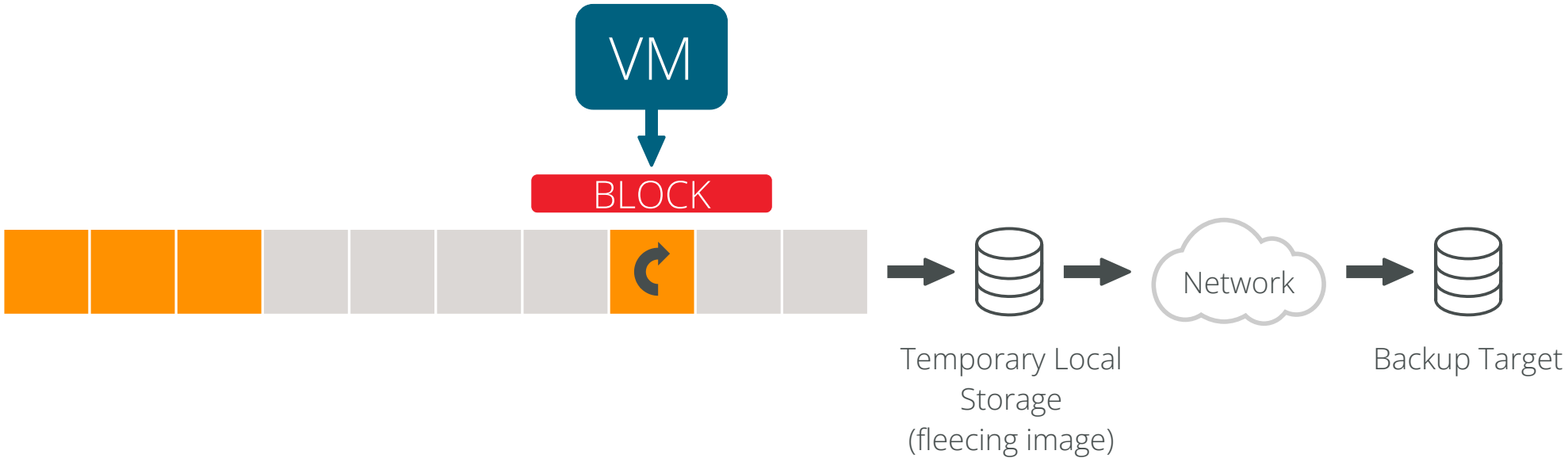
Let VM write data



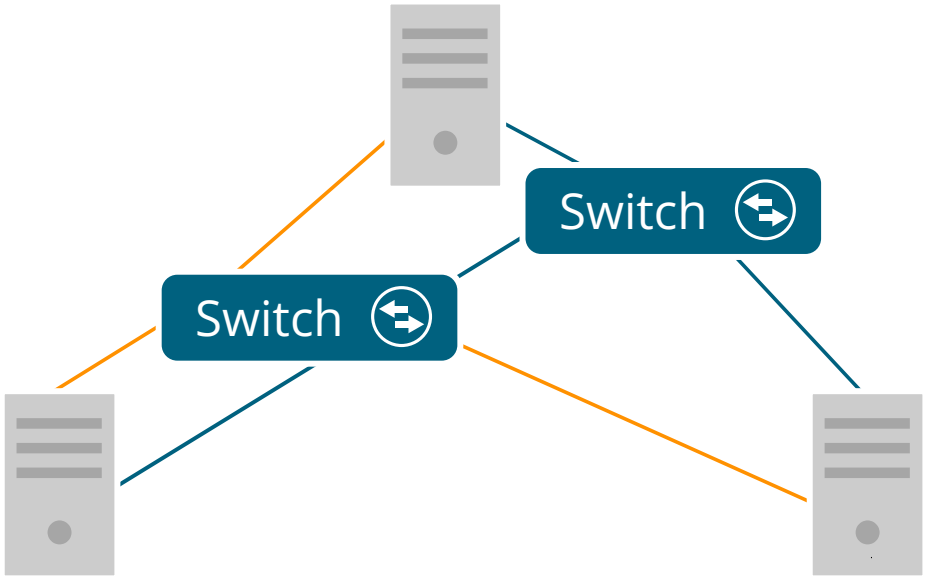
Continue backup



Proxmox VE

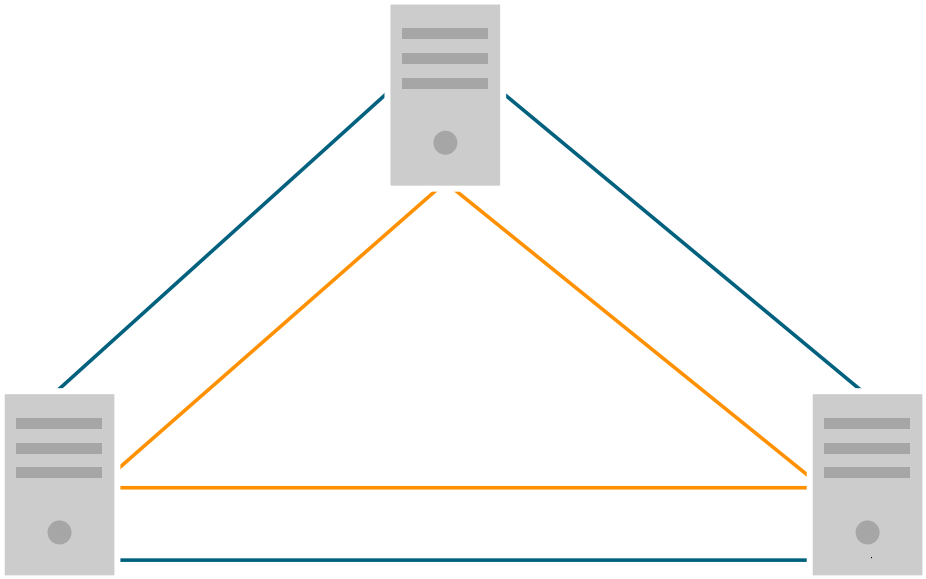

VM
BLOCK
Network
Temporary Local Storage (fleecing image)
Backup Target

Network — Star Topology



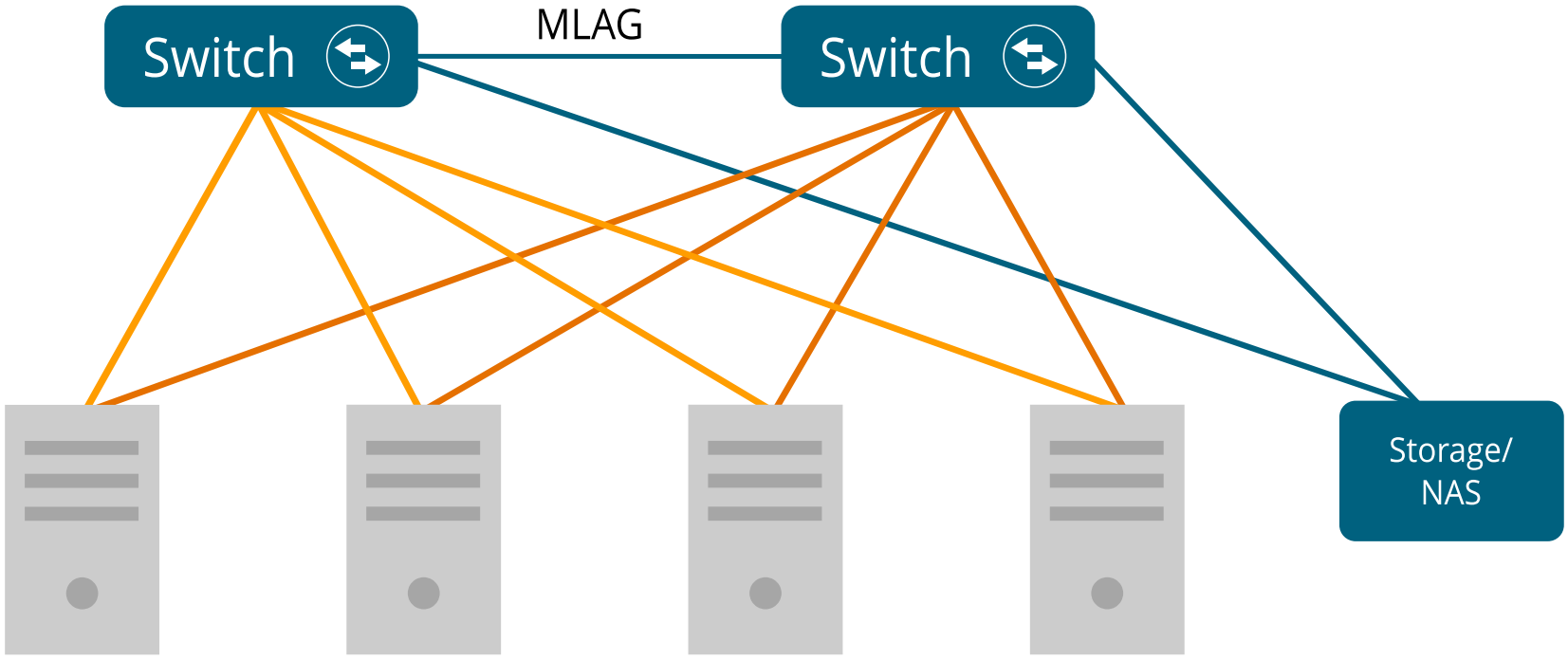
- Can scale well
- MLAG (multi device LAG) for redundancy

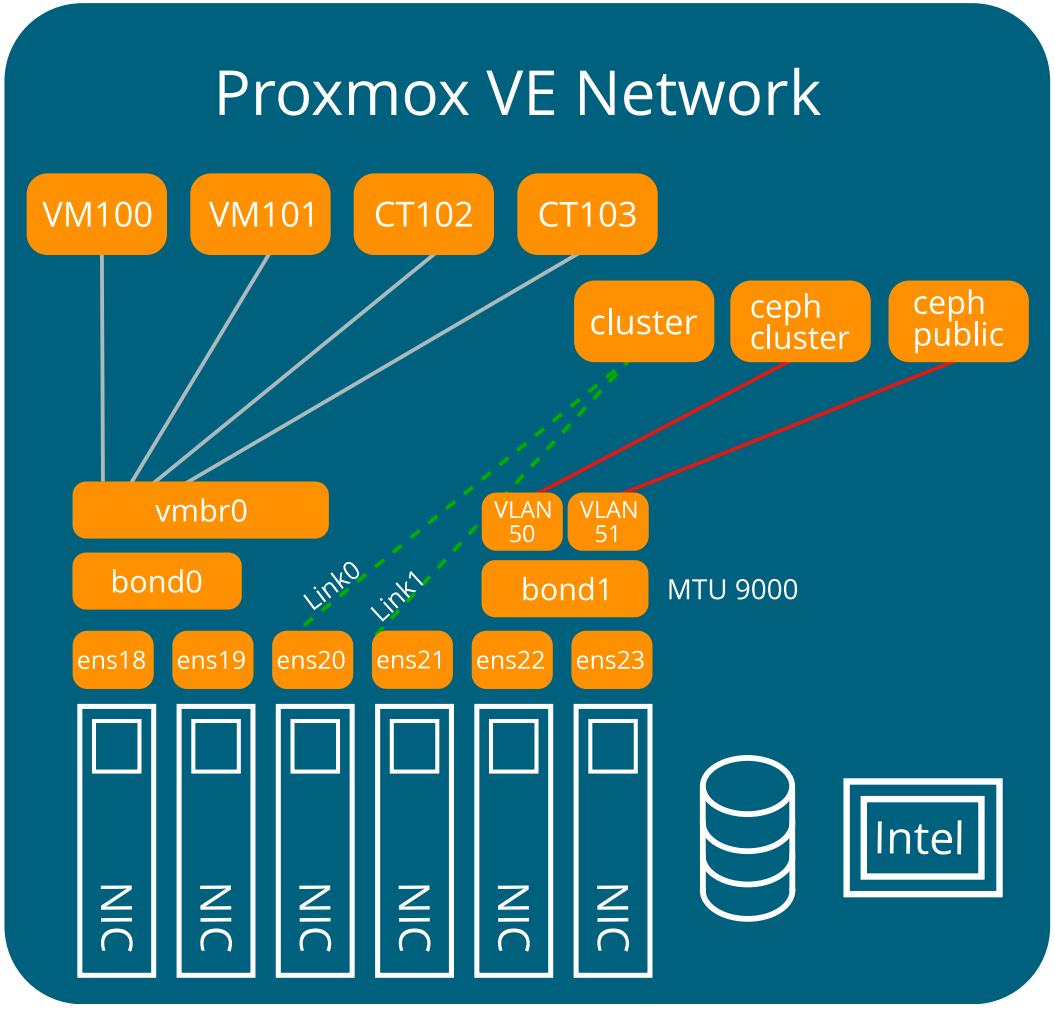
Network — Full Mesh



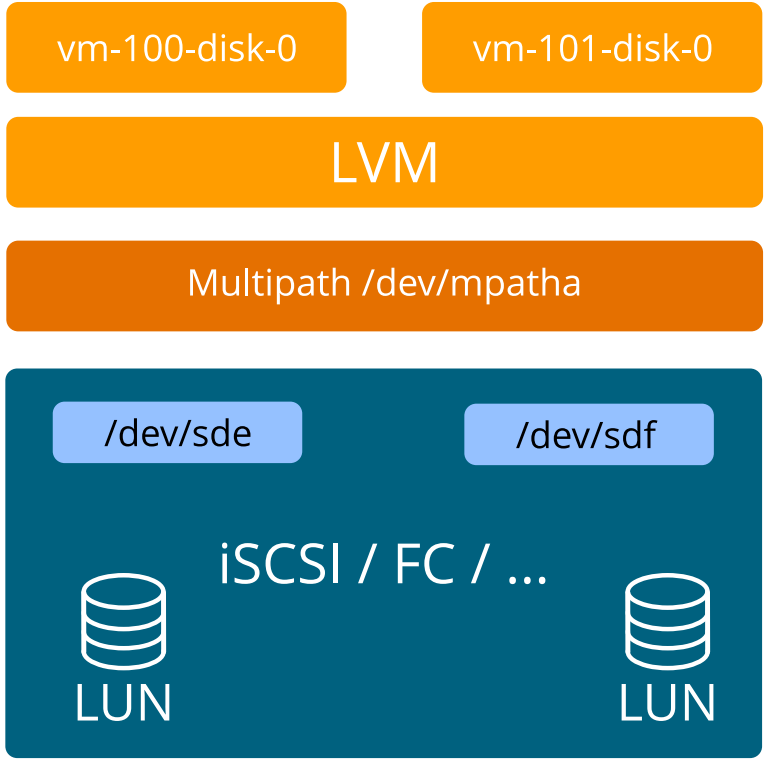
- No switches
- Can only scales so much...
  - Usually 3 to 5 nodes
- Useful in cluster internal networks (Ceph)

Full-Mesh Guide →


Switch
MLAG
Switch
Storage/
NAS

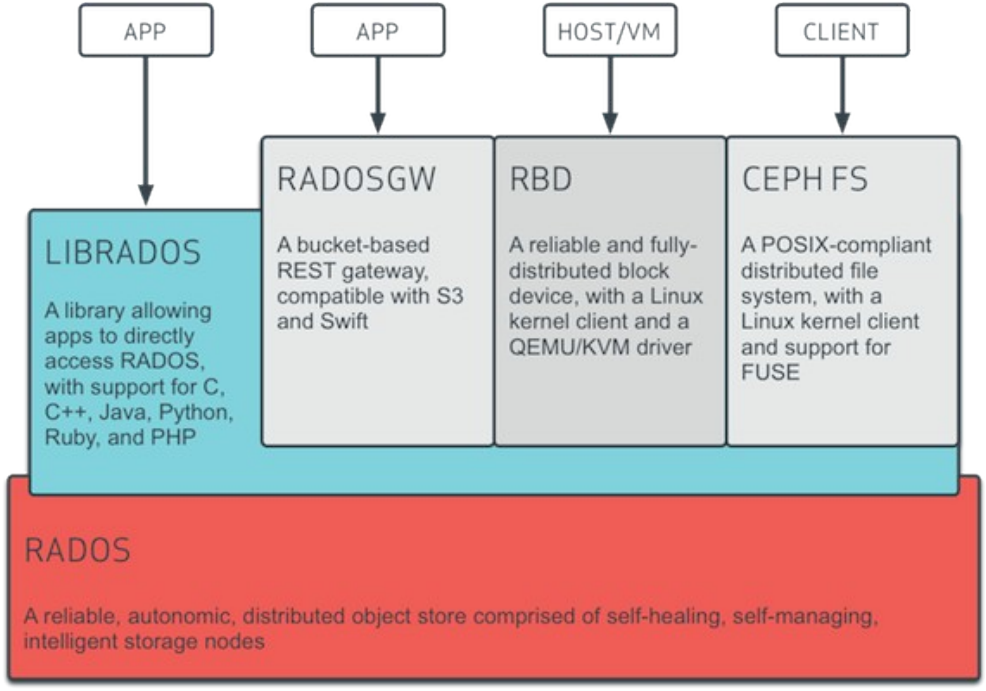

Proxmox VE Network
VM100
VM101
CT102
CT103
cluster
ceph cluster
ceph public
vmbr0
bond0
Link0
Link1
VLAN 50
VLAN 51
bond1
MTU 9000
ens18
ens19
ens20
ens21
ens22
ens23
NIC
NIC
NIC
NIC
NIC
NIC
Intel

Multipath



Multipath Guide →

Ceph Stack

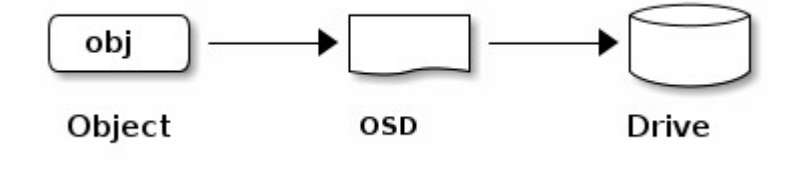


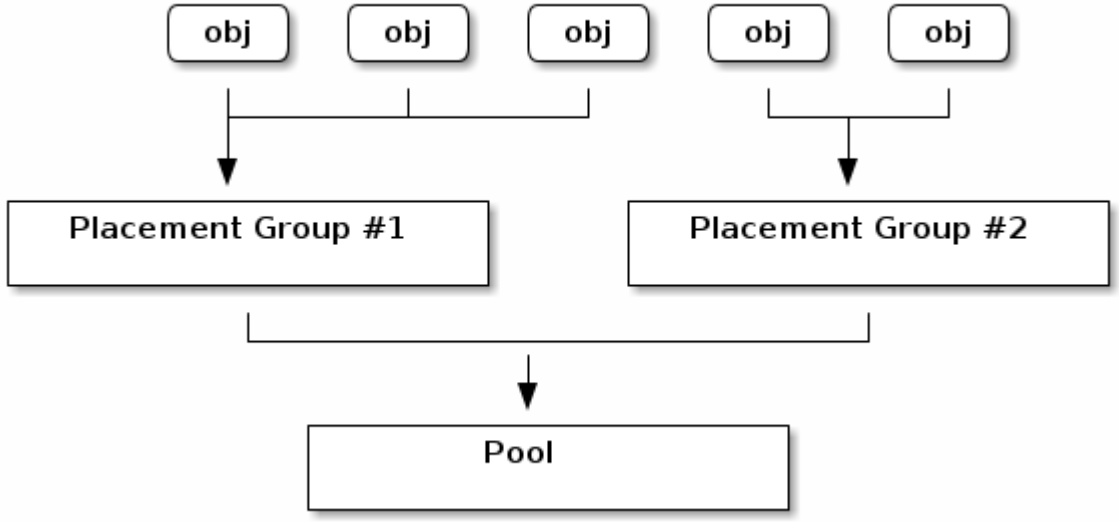
Source: docs.ceph.com

Ceph Services

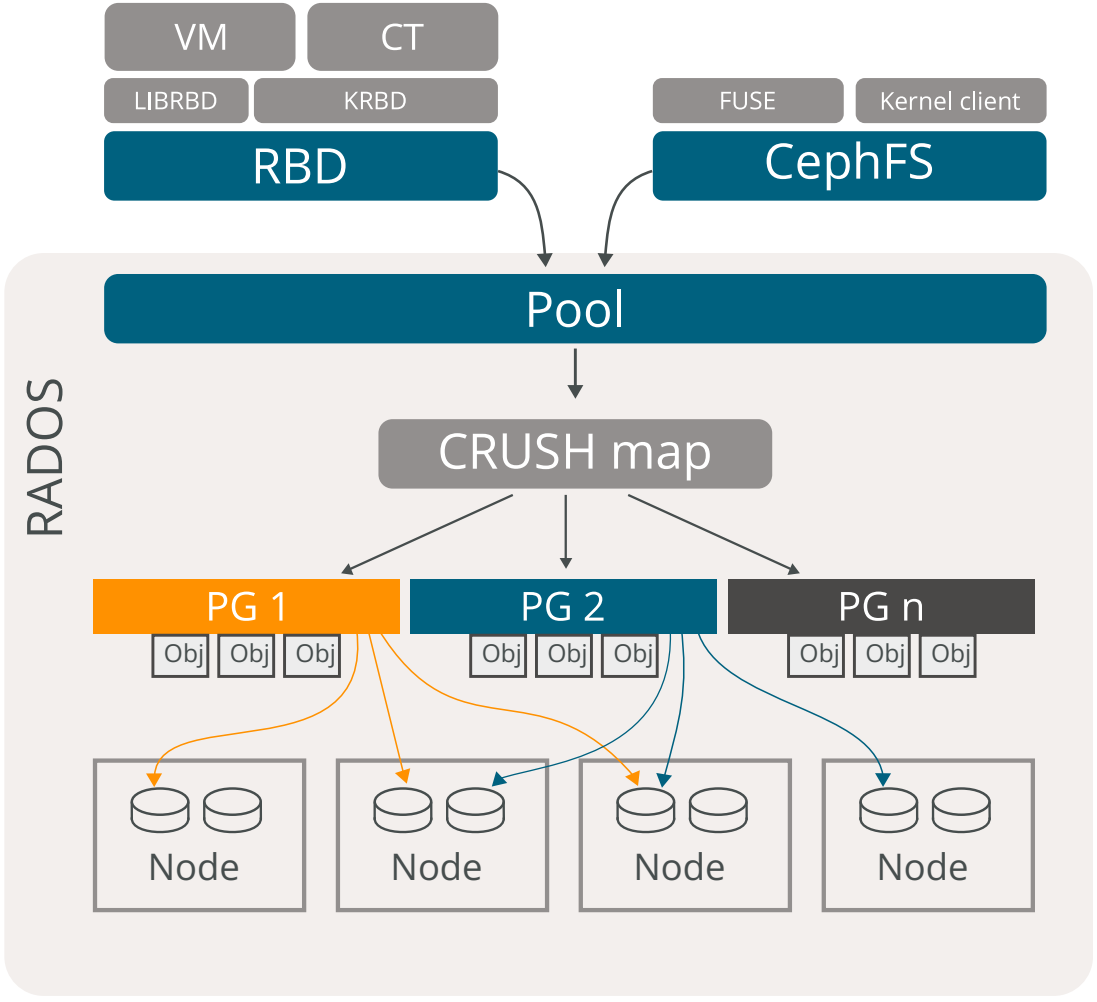
- **OSD** (Object Storage Daemon) checks its own state and the state of other OSDs and reports back to monitors.
- **MON** (Monitor) maintains a master copy of the cluster map. A cluster of Ceph monitors ensures high availability should a monitor daemon fail. Storage cluster clients retrieve a copy of the cluster map from the Ceph Monitor.
- **MGR** (Manager) acts as an endpoint for monitoring, orchestration, and plug-in modules.
- **MDS** (Metadata Server) manages file metadata when CephFS is used to provide file services.

Ceph Data Organization





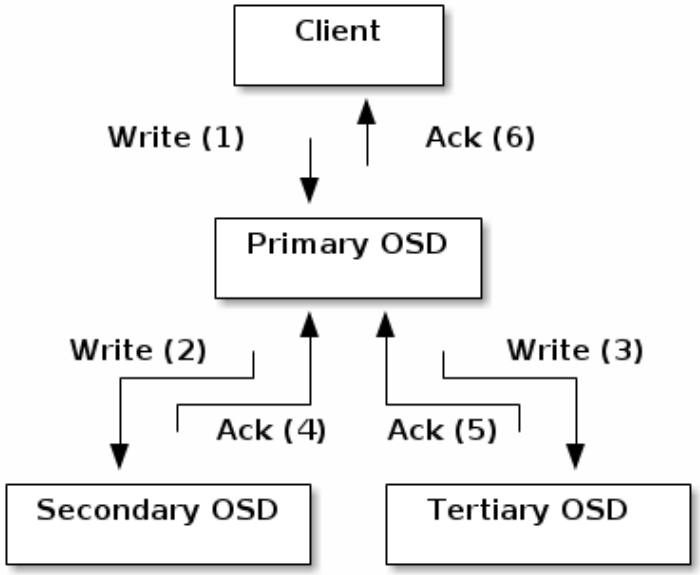
Source: docs.ceph.com


VM
CT
LIBRBD
KRBD
RBD
FUSE
Kernel client
CephFS
Pool
RADOS
CRUSH map
PG 1
PG 2
PG n
Obj
Obj
Obj
Obj
Obj
Obj
Obj
Obj
Obj
Node
Node
Node
Node

Ceph Pool Types

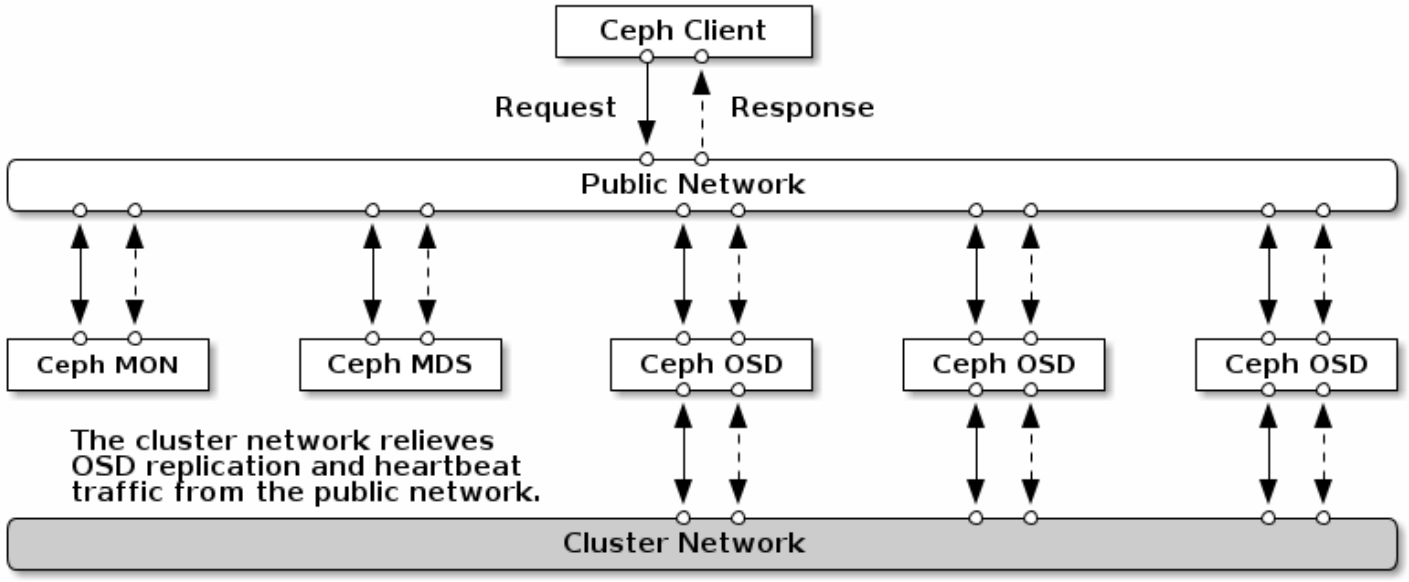
- Replicated
  - Stores copies / replicas on multiple hosts for redundancy
- Erasure Code (EC)
  - Splits data into *k* chunks and creates *m* coding chunks. Each chunk is stored on a separate node.

Ceph Write



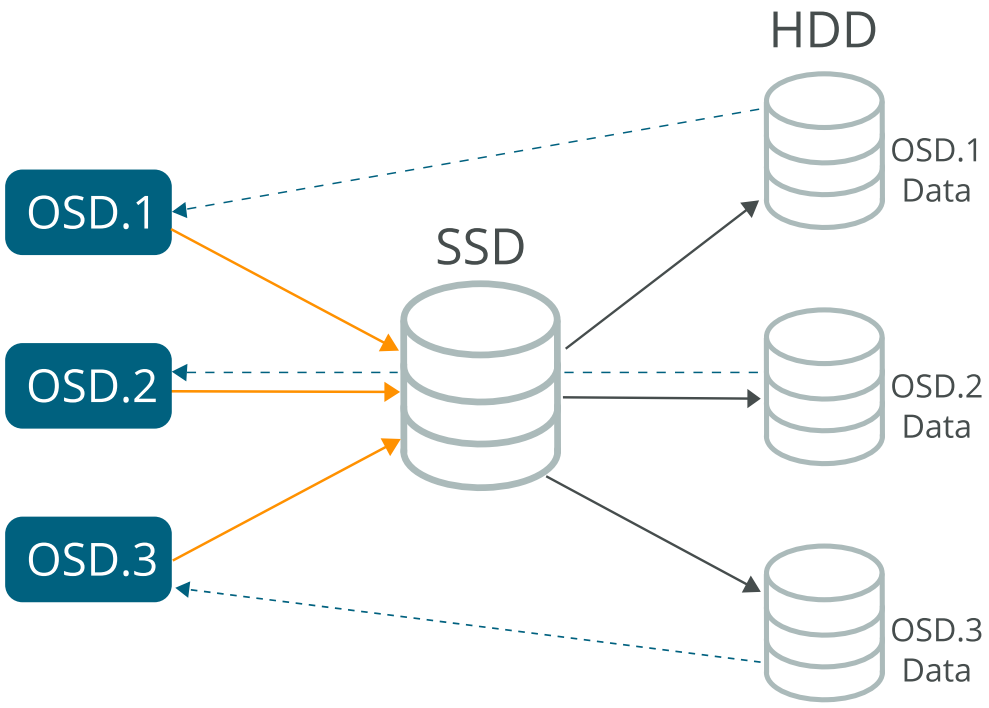
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Ceph Networks

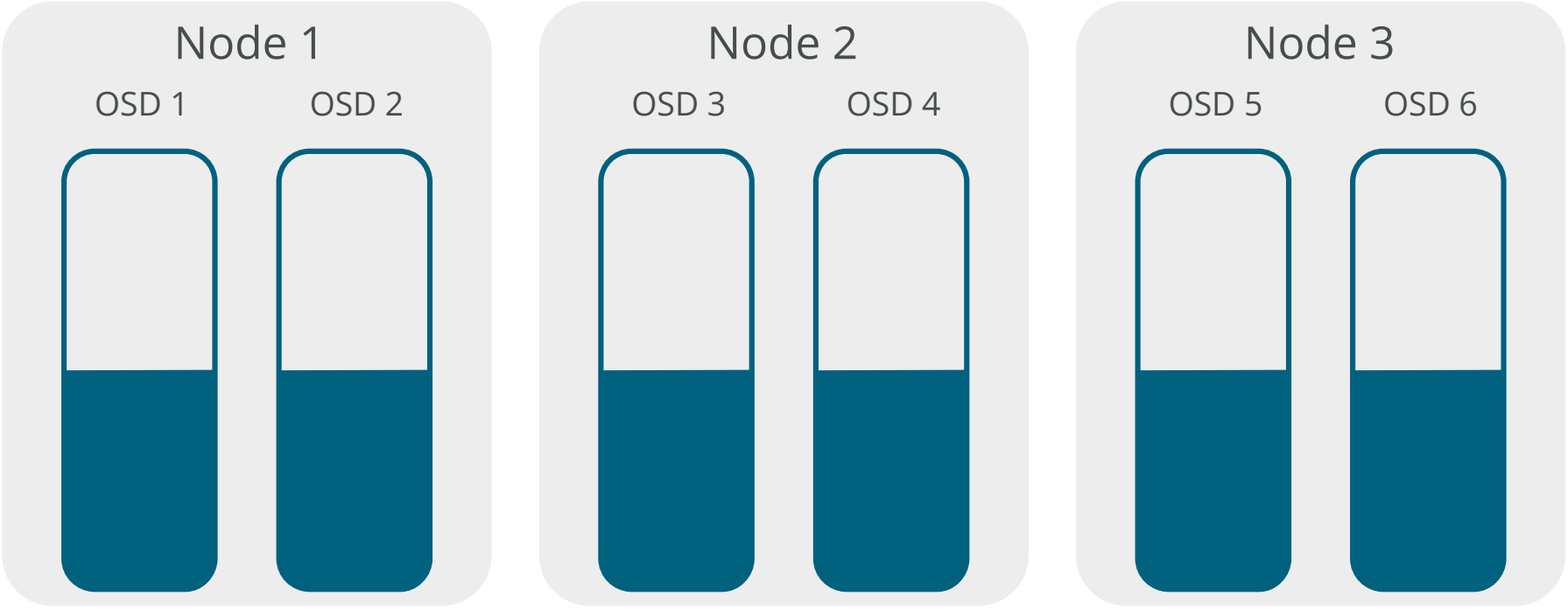


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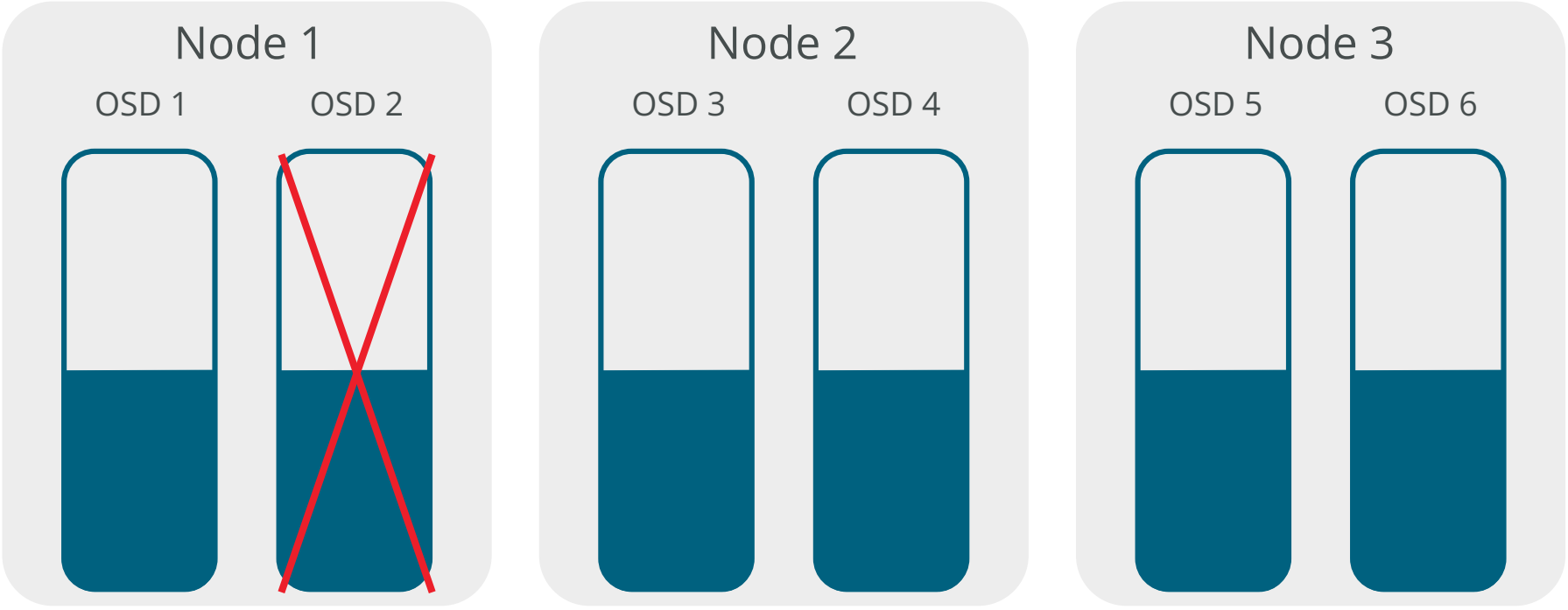
Ceph WAL/DB/Block on SSD



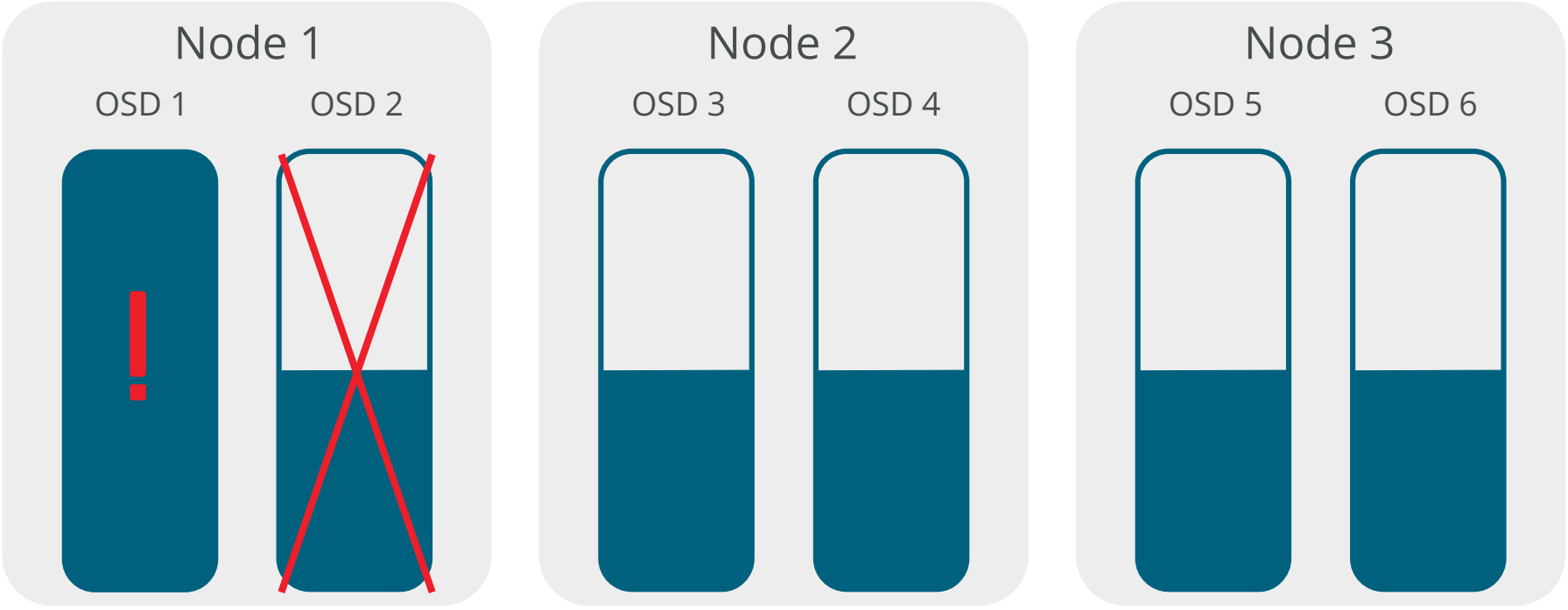
OSDs in a Three–Node Ceph Cluster



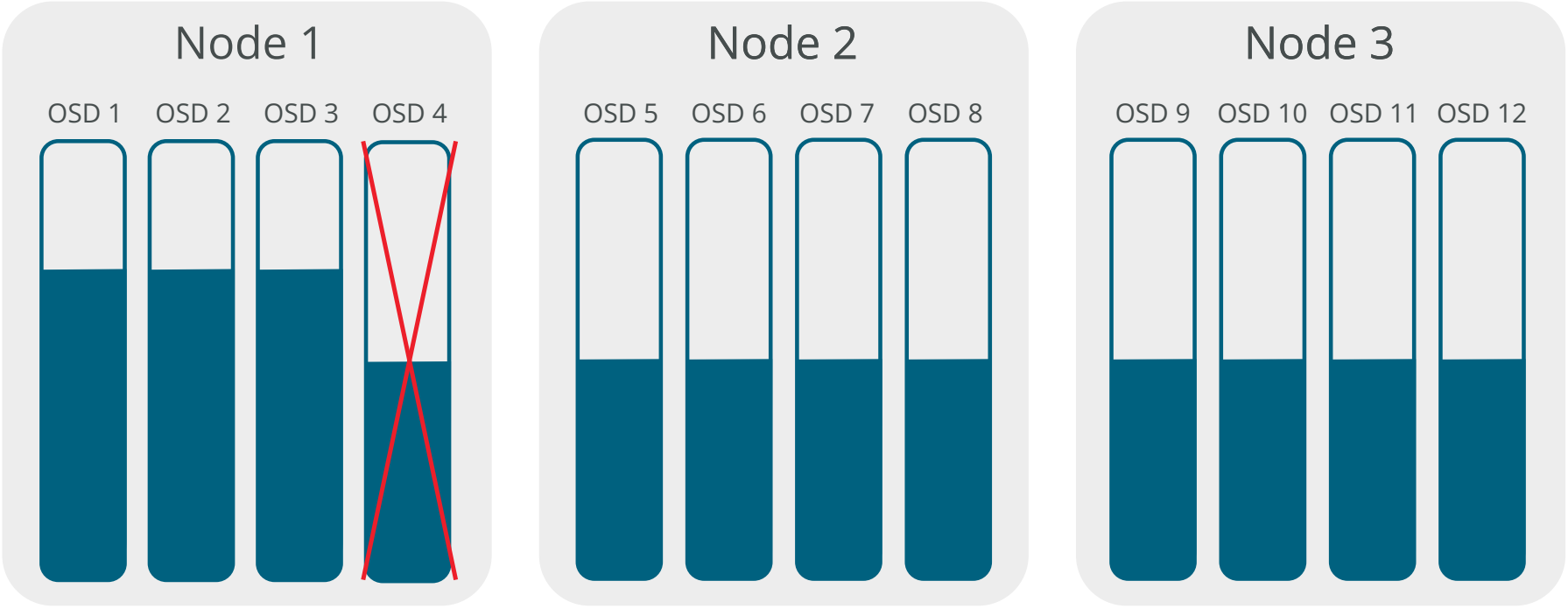
OSDs in a Three–Node Ceph Cluster



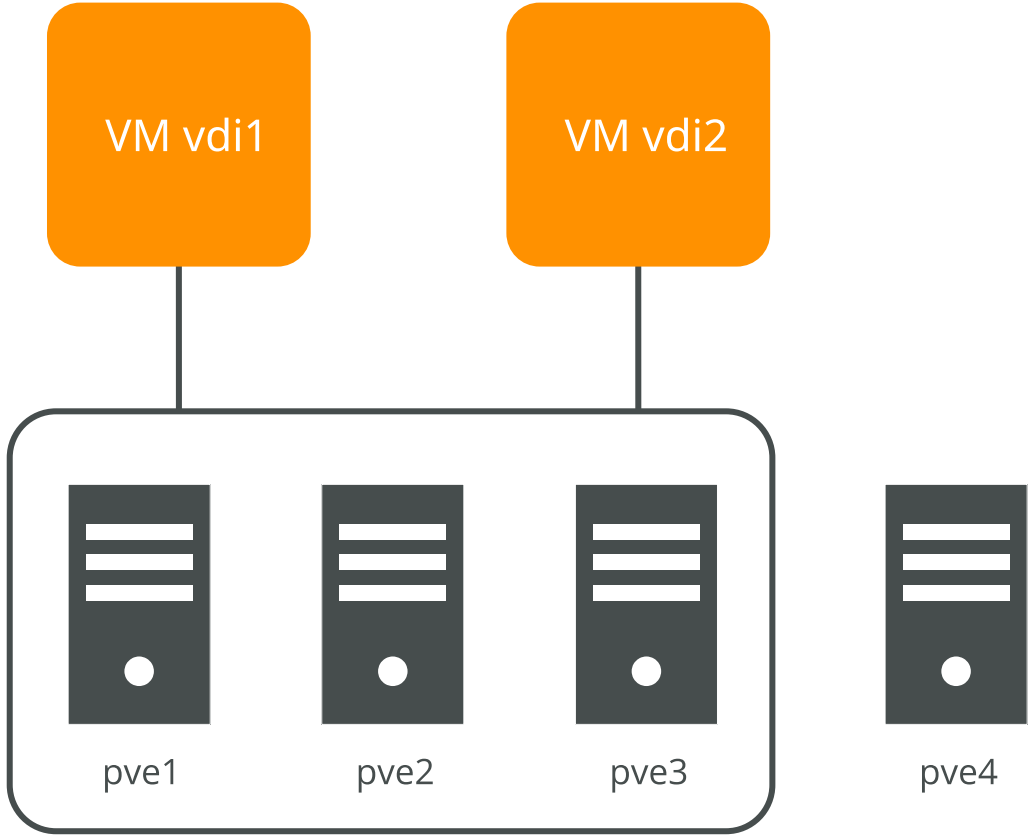
OSDs in a Three–Node Ceph Cluster



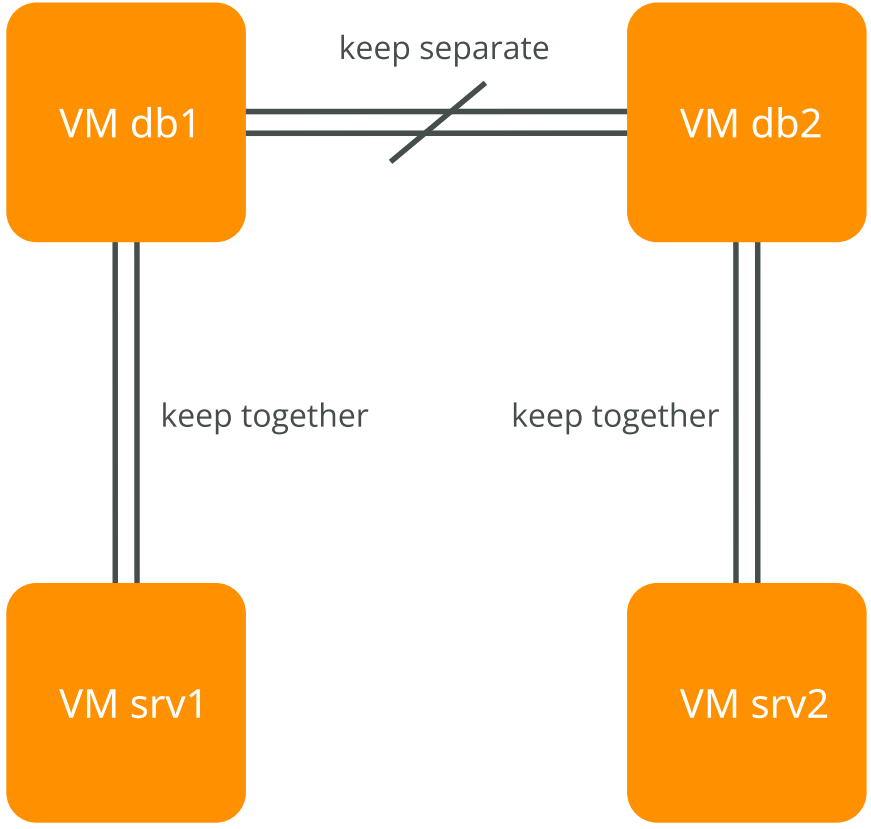
OSDs in a Three–Node Ceph Cluster



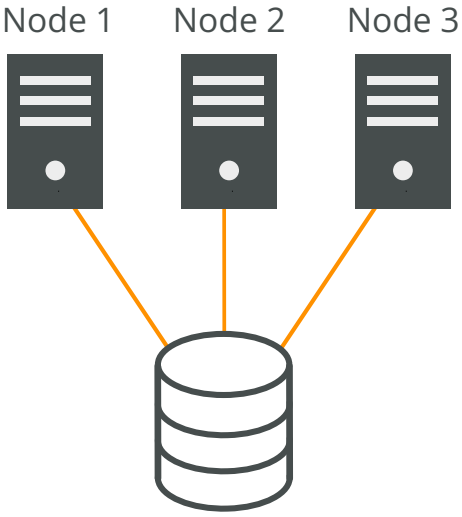
HA Node Affinity Rules



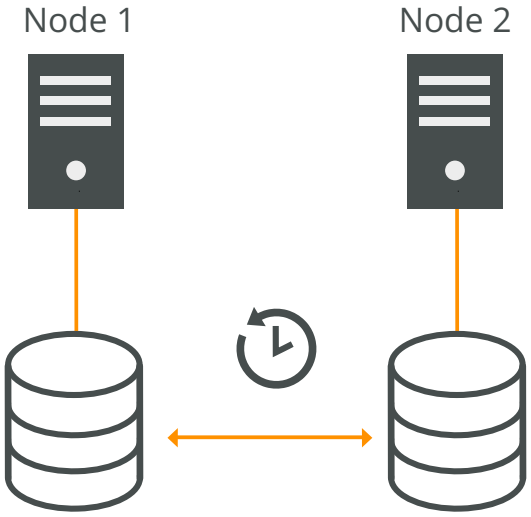
HA Resource Affinity Rules



HA – Shared vs. Replicated Storage

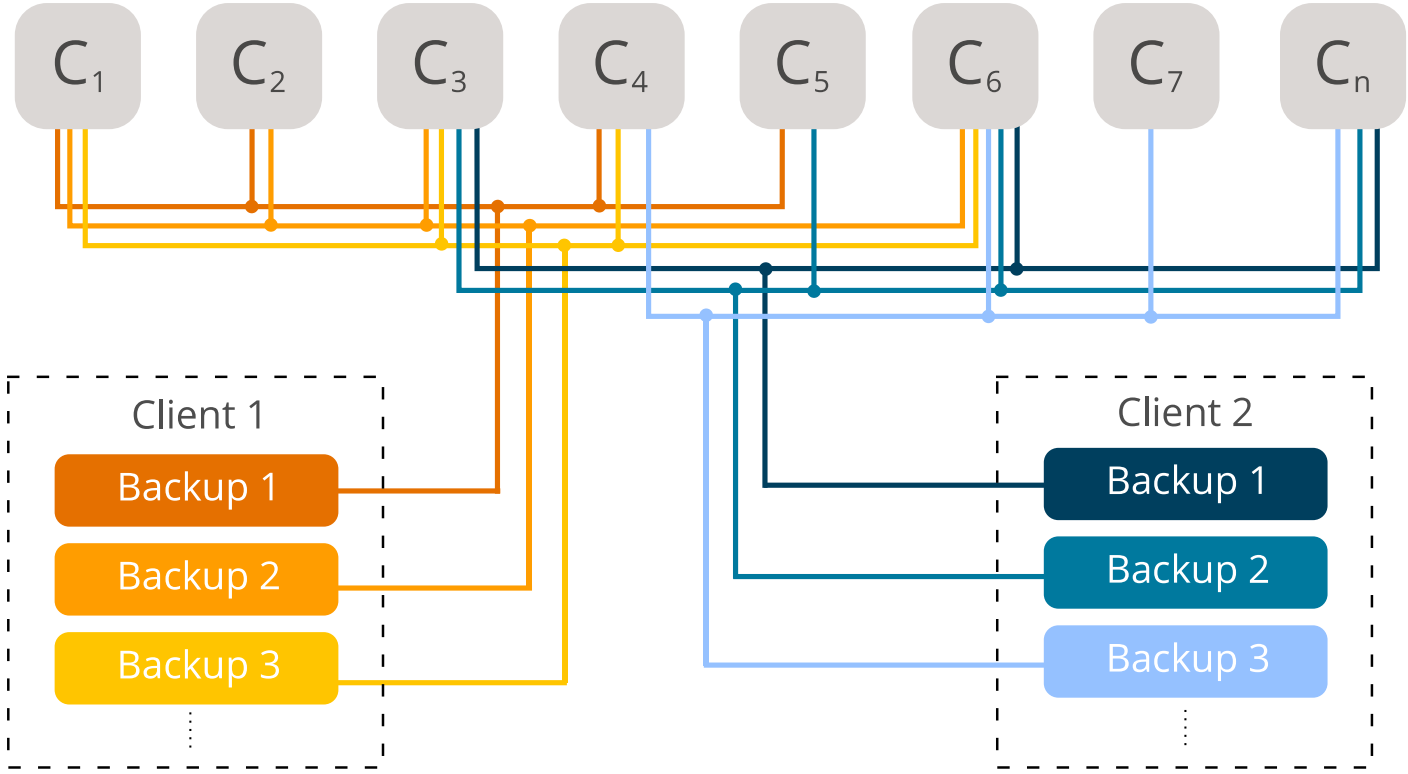


All nodes see same shared storage



Nodes see local storage with potentially older data

Proxmox Backup Server Chunks Deduplication



ROADMAP

Upcoming Features

Roadmap

- Proxmox VE 9.1 is planned for Q3/Q4 2025: https://pve.proxmox.com/wiki/Roadmap
- Follow our mailing lists for latest information https://lists.proxmox.com

PROXMOX SUPPORT & SERVICE

Enterprise Support

- Annual subscription: provides access to the stable Enterprise repositories
- Technical help: fast and direct support from the Proxmox support team
- Access to the Proxmox Customer Portal https://my.proxmox.com
- Remote access via SSH/HTTPS

Package Repositories

Proxmox solutions use APT as package management tool as well as the following three repositories:

Enterprise Repository

- Default
- For all subscribers
- The most stable packages
- For production use

No-Subscription Repository

- No subscription is needed
- For non-production use and testing

Test Repository

- Latest packages and new features
- For developers and testing

“TRAINING PLUS” Promotion

Get 20% discount on your Proxmox VE subscriptions!

(Valid if you buy within 2 months after the training. For new subscriptions only. See Training FAQs for more details.)

Contact your local reseller or purchase via
the Proxmox Online Shop at https://shop.proxmox.com

Get involved

- Community
  - https://www.proxmox.com/en/about/open-source/community
- Development
  - https://www.proxmox.com/en/about/open-source/developers

ANY QUESTIONS?

We're looking forward to help!

Please contact us at: https://www.proxmox.com/en/about/contact



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