



**PROXMOX**

# Scalable Infrastructures

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STARLINE COMPUTER GMBH | 03.06.2026 - 10:30 UHR | ONLINE

# About Me

## About Me

- Aaron Lauterer
- Over 20 years in IT
- Linux focus (10+ years)
- At Proxmox for 6+ years
  - Development
  - Ceph
  - Support
  - Trainings



# Introduction

# About Proxmox



## Open Source at Heart

Delivering powerful enterprise solutions.



## 100% Privately Owned

Driven by innovation and community needs, not investor demands.



## 20th Anniversary 2005 - 2025

20+ years of open-source innovation, serving enterprises worldwide.

# About Proxmox



**Omnipresent**  
7 continents & in space

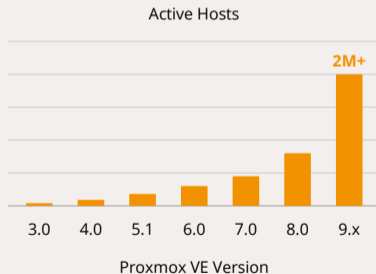


Enterprises of all sizes and industries



**3,000 Partners**  
Local expertise and support

Over  
**2 Million**



# Proxmox Support & Services



## Professional Enterprise Support

Flexible subscriptions for mission-critical environments.



## Subscription Plans

Access to the stable Enterprise Repository, timely updates, and security fixes.



## Technical Expertise

Help from the Proxmox team.



## Training Courses

Gain knowledge quickly.

# Products

- **Proxmox Virtual Environment**  
Hypervisor  
(KVM / Qemu and LXC guests)
- **Proxmox Backup Server**  
Backup for hosts and guests
- **Proxmox Offline Mirror**  
Offline repository for air-gapped hosts
- **Proxmox Datacenter Manager**  
Manage multiple clusters from a single dashboard
- **Proxmox Mail Gateway**  
Email security

# Open Source

# Benefits of Open Source

- **No vendor lock-in**  
Everything is openly available
- **No licensing costs**  
You only pay for support
- **Transparency**  
Development happens publicly
- **Flexibility**  
Adaptable to your use case
- **Contributions**  
Possible to contribute as an external entity
- **Cutting-Edge**  
Building on established cutting-edge tech

# Benefits of Open Source

## Developer Documentation:

[https://pve.proxmox.com/wiki/Developer\\_Documentation](https://pve.proxmox.com/wiki/Developer_Documentation)



## Mailing Lists:

<https://lists.proxmox.com>



## GIT Repositories:

<https://git.proxmox.com>



## Archive:

<https://lore.proxmox.com>



# Administration

# Administrative Tools

**Web UI** Web based interface, uses the API.

**API** Public, build your own tooling?

**CLI Tools** Commandline tools for everything available.

# Administrative Tools

3<sup>rd</sup> Party tools:

- Ansible
- Terraform / OpenTofu
- ...

# Scalable Infrastructures

# Proxmox VE

# Small Setups

# Single Node



## Use cases

- Branch offices
- Shop locations
- ...

## Single disk

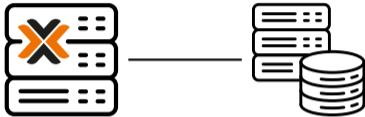
- ZFS
- LVM thin

No redundancy!

## Multiple disks (RAID)

- HW RAID → LVM thin
- SW RAID → ZFS

# Single Node – External Storage



- NFS/CIFS
- iSCSI/FC/SAS/...
  - Multipathing
  - LVM
- Ceph (external, non-HCI)

Multipath Setup Guide  
<https://pve.proxmox.com/wiki/Multipath>



# Clusters

# Cluster Basics

## Shared storage

- NFS/CIFS
- LUNs (iSCSI/FC/SAS)
- Ceph
- 3<sup>rd</sup> party

Local storage per node possible...  
...but HA?

Multipath Setup Guide

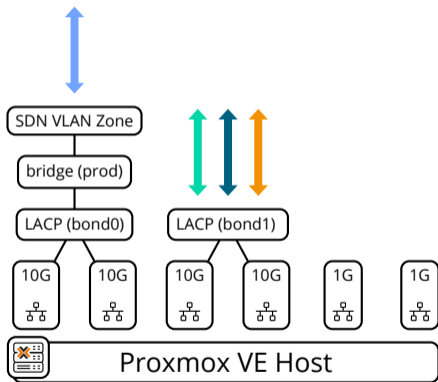
<https://pve.proxmox.com/wiki/Multipath>



# Cluster Basics

- Quorum-based (majority)
- Corosync protocol
- Split physical networks by use

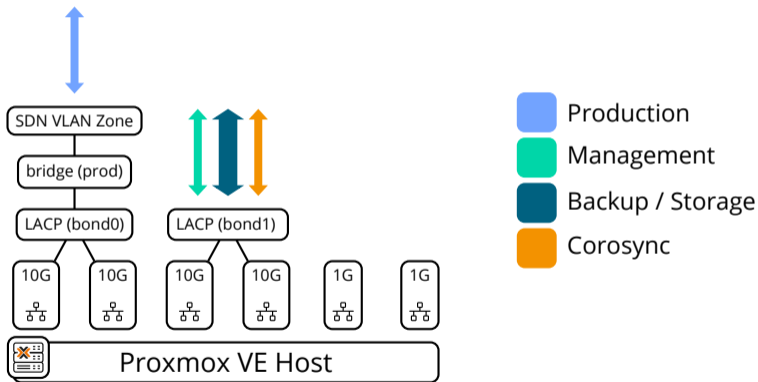
# Network



- Production
- Management
- Backup / Storage
- Corosync

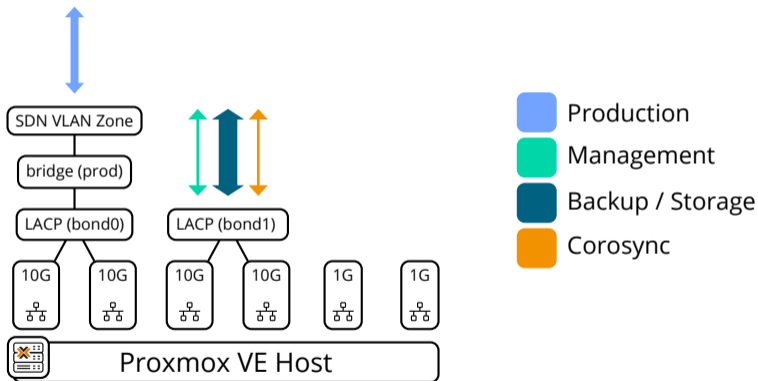
# Network

Backup or Storage consumes available bandwidth



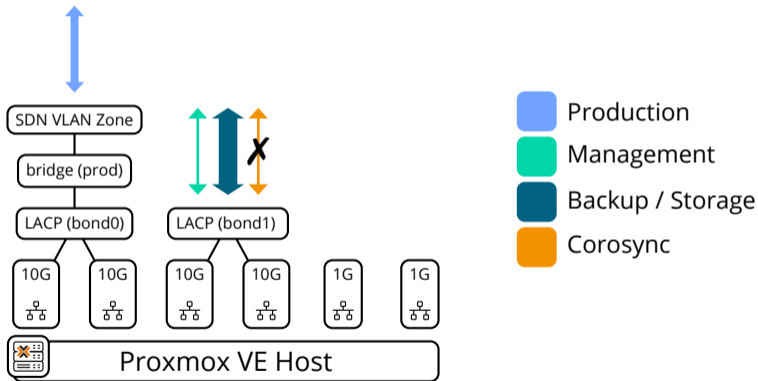
# Network

Other services starve (bandwidth & latency)



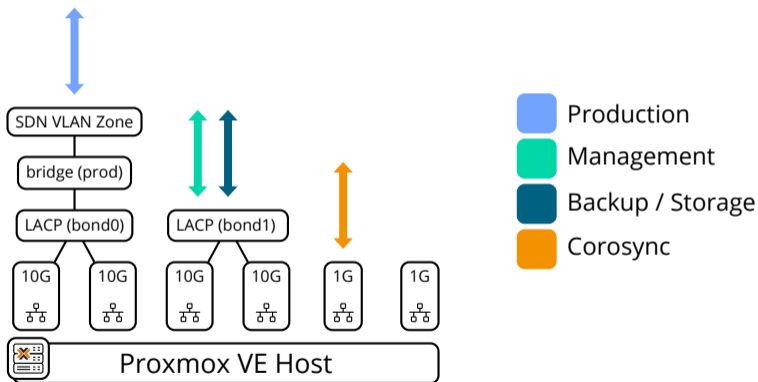
# Network

Corosync deems link as unusable/down



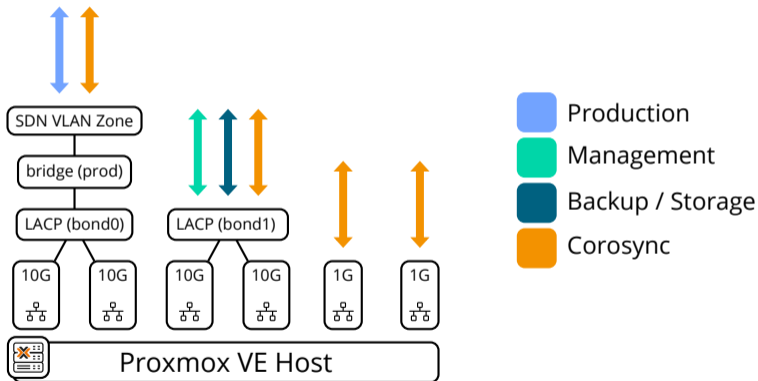
# Network

Better: dedicated network

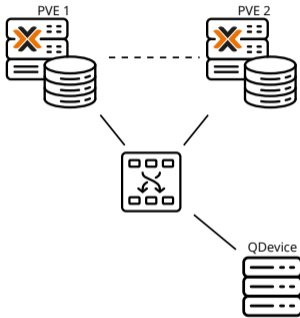


# Network

## Additional fallback networks



# Two-Node Cluster



## Use cases

- High availability
- Small environments

## Direct connection

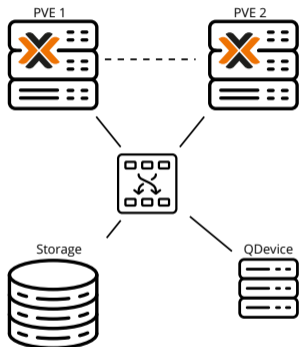
- Corosync/Cluster
- Live migration
- Replication (local ZFS storage)

3<sup>rd</sup> vote!  
External storage with  
QDevice



[https://pve.proxmox.com/pve-docs/pve-admin-guide.html#\\_corosync\\_external\\_vote\\_support](https://pve.proxmox.com/pve-docs/pve-admin-guide.html#_corosync_external_vote_support)

# Two-Node Cluster



## Use cases

- High availability
- Small environments

## Direct connection

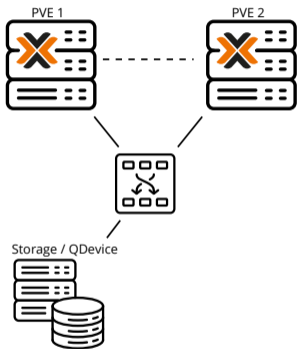
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# Two-Node Cluster



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- High availability
- Small environments



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## Direct connection

- Corosync/Cluster
- Live migration
- Replication (local ZFS storage)

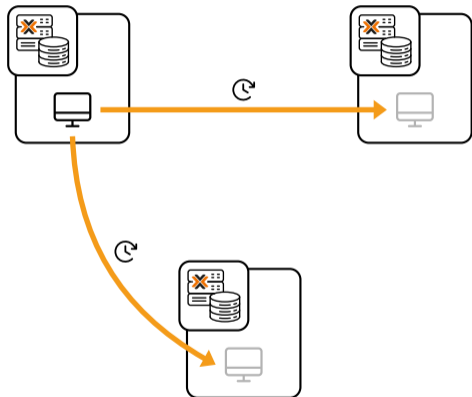
3<sup>rd</sup> vote!  
External storage with  
QDevice

# Guest Replication



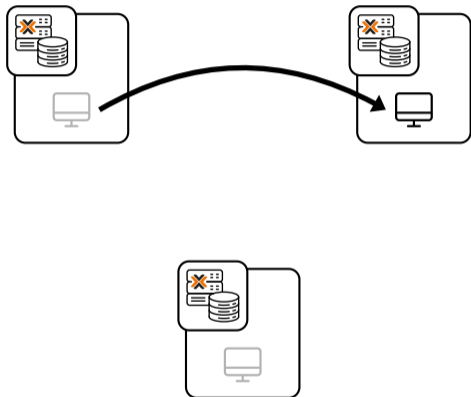
- ZFS
- Same pool name on all nodes
- Shortest interval: 1 minute
- "HCI Light"
- Multiple replication jobs

# Guest Replication



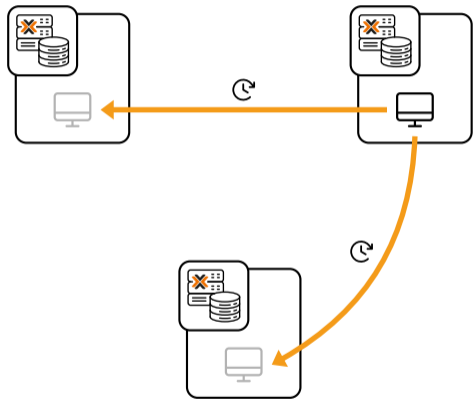
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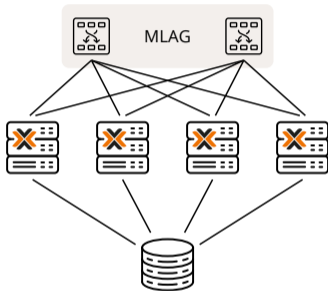
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# Guest Replication



- ZFS
- Same pool name on all nodes
- Shortest interval: 1 minute
- "HCI Light"
- Multiple replication jobs

# Cluster – External Storage



## Use cases

- 3+ nodes
- High Availability
- "Default"

## Shared Storage

- NFS / CIFS
- iSCSI / FC / SAS / ...  
Multipathing + LVM
- External Ceph cluster
- 3<sup>rd</sup> party storage plugins

# HCI Cluster



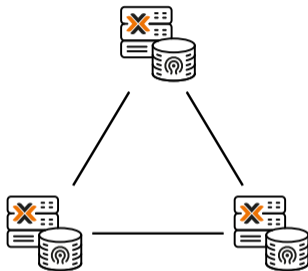
## Use cases

- 3+ nodes
- no centralized storage
- commodity server hardware
- easy scaling (horizontal & vertical)

## Proxmox VE + Ceph

- Hyperconverged
- Fast NICs, 25 Gbit/s or faster

# HCI Cluster – Full-Mesh



## Proxmox VE + Ceph

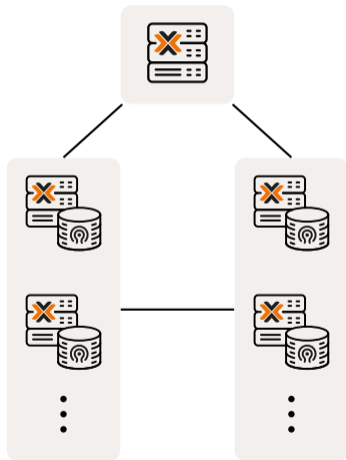
- No switches needed
- 3 to 5 nodes feasible

## Full-Mesh Guide

[https://pve.proxmox.com/wiki/Full\\_Mesh\\_Network\\_for\\_Ceph\\_Server](https://pve.proxmox.com/wiki/Full_Mesh_Network_for_Ceph_Server)



# Stretch Cluster



## Proxmox VE + Ceph Cluster

- Can tolerate the loss of one site
- Tie-breaker node in 3<sup>rd</sup> location
- Latency!

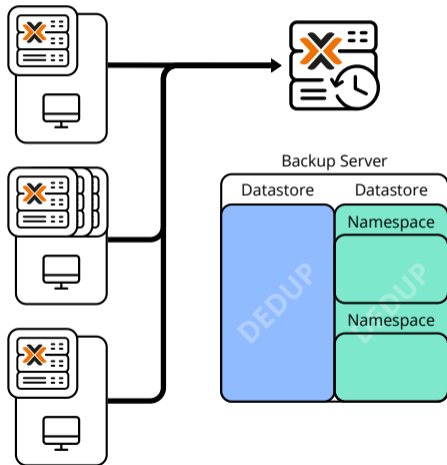
## Stretch-Cluster Guide

[https://pve.proxmox.com/wiki/Stretch\\_Cluster](https://pve.proxmox.com/wiki/Stretch_Cluster)



# Proxmox Backup Server

# Backup Server + Virtual Environment (VE)



## Proxmox VE as client

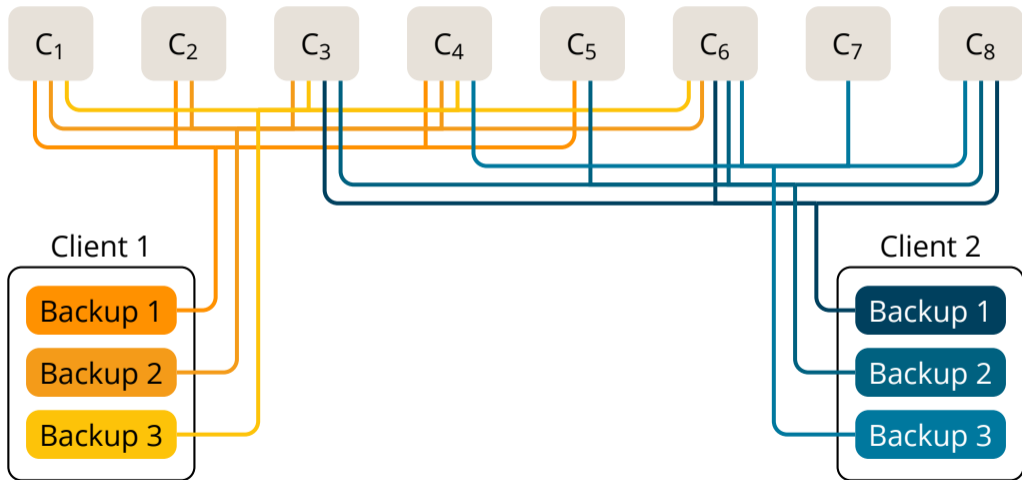
- Single node
- Cluster

Multiple Proxmox VE (clusters):  
Separate instances by

- Datastores
- Namespaces

Deduplication borders:  
Datastores and encryption keys

# Proxmox Backup Server - Deduplication

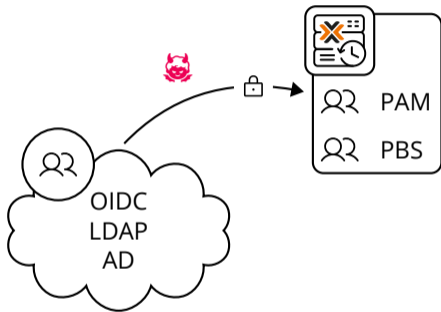


## 3-2-1 Rule

There should be at least 3 copies of the data, stored on 2 different types of storage media, and one copy should be kept offsite, in a remote location.

- 3 copies
- 2 types of storage
- 1 off-site/remote
- Ransomware / Hacking?

# Permissions & Users



## Local realms

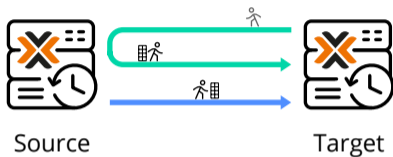
- PAM (Linux system user)
- PBS (API/web UI user)

## External realms

- OpenID Connect
- LDAP
- Active Directory

Only "Read/Audit" permissions?

# Remote Sync



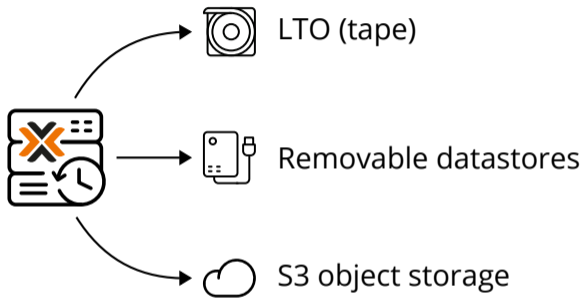
## Pull / Push

### Minimal Permissions

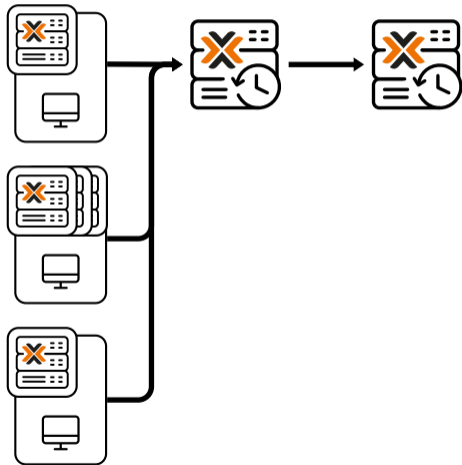
- **Pull**: DatastoreReader
- **Push**: DatastoreBackup

Prune always on target!

# External Media



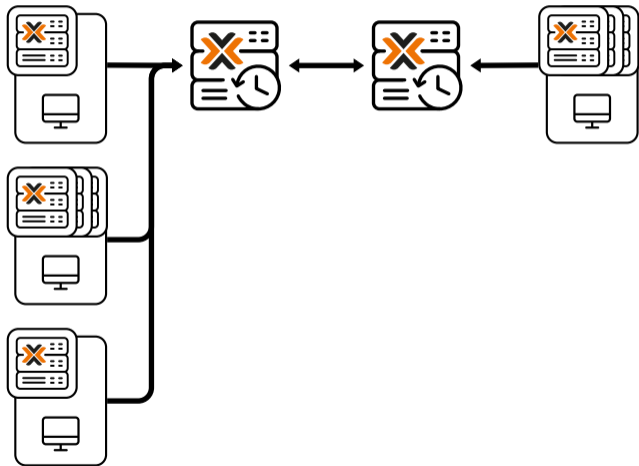
# Backup Server – Scenarios



## One Way

- branch office to HQ
- offsite to a  
"Backup Server as a Service"

# Backup Server – Scenarios



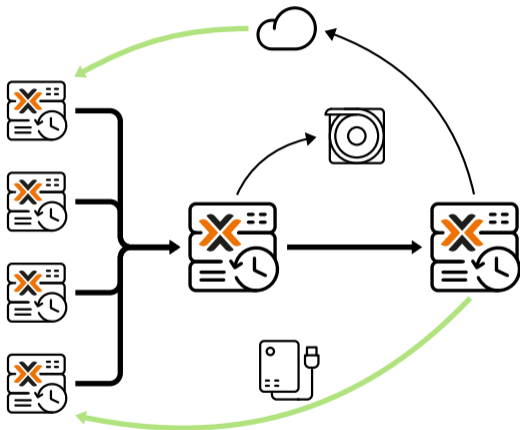
## Two Way

- Multiple locations
- Cross-location sync
- Disaster recovery

## Best practices

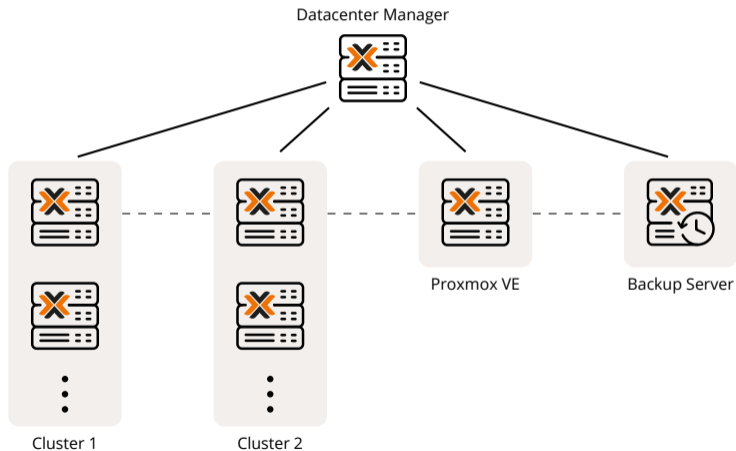
- Namespaces

# Backup Server – Scenarios



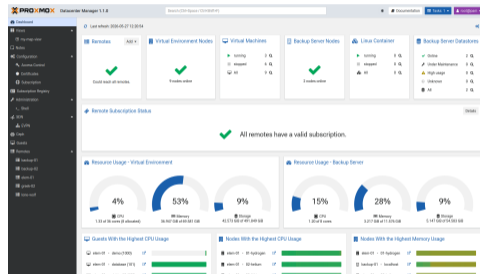
# Proxmox Datacenter Manager

# Proxmox Datacenter Manager



# Proxmox Datacenter Manager

- Centralized Overview
- Multi Cluster Management
- Cross Cluster (live) Migration
- Answer Server
- Subscription Key Management
- Ceph Cluster Monitoring
- Update Management
- SDN: EVPN, ...
- ...



# Questions?

Thank you!



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