Virtuozzo Infrastructure Platform 2.5

Installation Guide

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Virtuozzo International GmbH

Vordergasse 59

8200 Schaffhausen

Switzerland

Tel: + 41 52 632 0411

Fax: + 41 52 672 2010

https://virtuozzo.com

Contents

CHAPTER 1

Deployment Overview

To deploy Virtuozzo Infrastructure Platform for evaluation purposes or in production, you will need to do the following:

1. Plan the infrastructure.
2. Install and configure Virtuozzo Infrastructure Platform on required servers.
3. Create the storage cluster.
4. Create a compute cluster and/or set up data export services.

CHAPTER 2

Planning Infrastructure

To plan the infrastructure, you will need to decide on the hardware configuration of each server, plan networks, decide on the redundancy method (and mode) to use, and decide which data will be kept on which storage tier.

Information in this chapter is meant to help you complete all of these tasks.

2.1 Storage Architecture Overview

The fundamental component of Virtuozzo Infrastructure Platform is a storage cluster: a group of physical servers interconnected by network. Each server in a cluster is assigned one or more roles and typically runs services that correspond to these roles:

- storage role: chunk service or CS
- metadata role: metadata service or MDS
- supplementary roles:
    - SSD cache,
    - system

Any server in the cluster can be assigned a combination of storage, metadata, and network roles. For example, a single server can be an S3 access point, an iSCSI access point, and a storage node at once.

Each cluster also requires that a web-based admin panel be installed on one (and only one) of the nodes. The panel enables administrators to manage the cluster.

2.1.1 Storage Role

Storage nodes run chunk services, store all the data in the form of fixed-size chunks, and provide access to these chunks. All data chunks are replicated and the replicas are kept on different storage nodes to achieve high availability of data. If one of the storage nodes fails, remaining healthy storage nodes continue providing the data chunks that were stored on the failed node.

Only a server with disks of certain capacity can be assigned the storage role.

2.1.2 Metadata Role

Metadata nodes run metadata services, store cluster metadata, and control how user files are split into chunks and where these chunks are located. Metadata nodes also ensure that chunks have the required amount of replicas and log all important events that happen in the cluster.

To provide system reliability, Virtuozzo Infrastructure Platform uses the Paxos consensus algorithm. It guarantees fault-tolerance if the majority of nodes running metadata services are healthy.

To ensure high availability of metadata in a production environment, at least three nodes in a cluster must be running metadata services. In this case, if one metadata service fails, the remaining two will still be controlling the cluster. However, it is recommended to have at least five metadata services to ensure that the cluster can survive simultaneous failure of two nodes without data loss.

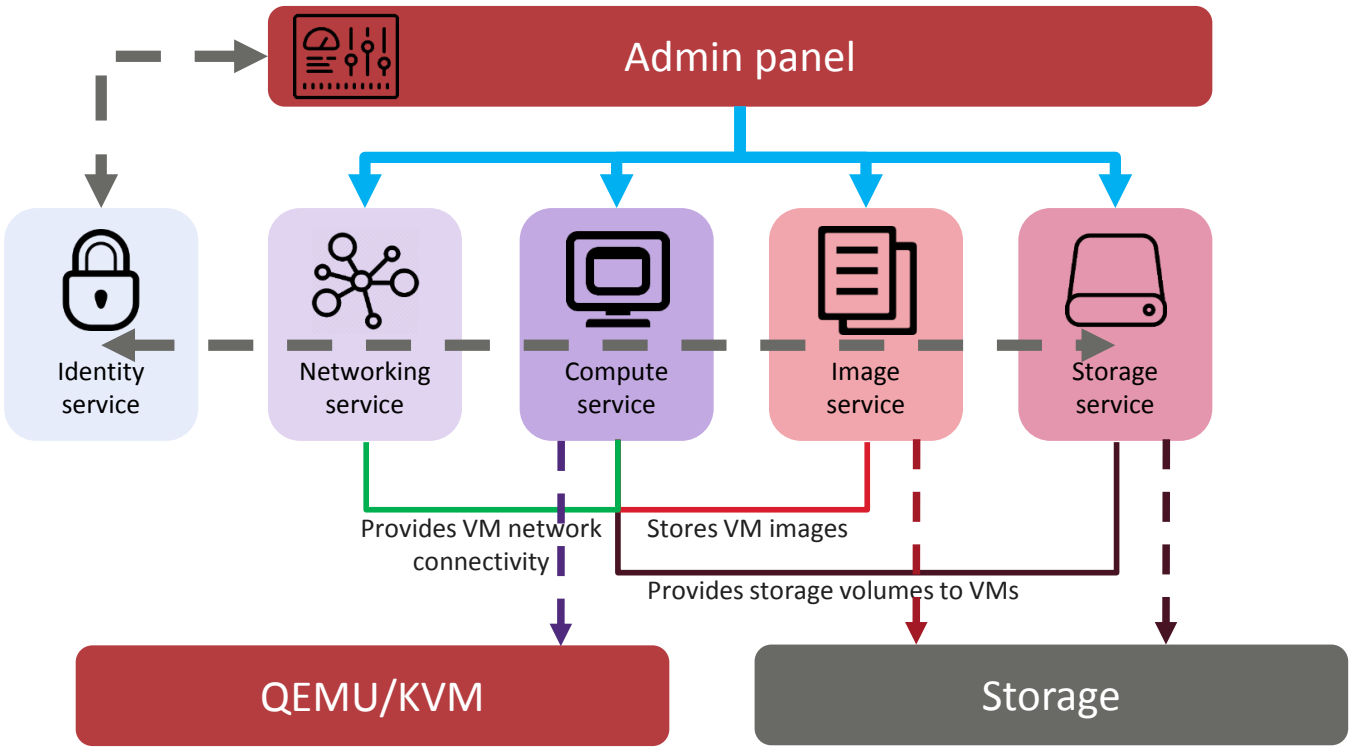
2.1.3 Supplementary Roles

SSD cache Boosts chunk read/write performance by creating write caches on selected solid-state drives (SSDs). It is recommended to also use such SSDs for metadata, see *Metadata Role* (page 3). The use of write journals may speed up write operations in the cluster by two and more times.

System One disk per node that is reserved for the operating system and unavailable for data storage.

2.2 Compute Architecture Overview

The following diagram shows the major compute components of Virtuozzo Infrastructure Platform.



- The storage service provides virtual disks to virtual machines. This service relies on the base storage cluster for data redundancy.
- The image service enables users to upload, store, and use images of supported guest operating systems and virtual disks. This service relies on the base storage cluster for data redundancy.
- The identity service provides authentication and authorization capabilities for Virtuozzo Infrastructure Platform.
- The compute service enables users to create, run, and manage virtual machines. This service relies on the custom QEMU/KVM hypervisor.
- The networking service provides private and public network capabilities for virtual machines.
- The admin panel service provides a convenient web user interface for managing the entire infrastructure.

2.3 Planning Node Hardware Configurations

Virtuozzo Infrastructure Platform works on top of commodity hardware, so you can create a cluster from regular servers, disks, and network cards. Still, to achieve the optimal performance, a number of

requirements must be met and a number of recommendations should be followed.

2.3.1 Hardware Limits

The following table lists the current hardware limits for Virtuozzo Infrastructure Platform servers:

Table 2.1: Server hardware limits

Hardware	Theoretical	Certified
RAM	64 TB	1 TB
CPU	5120 logical CPUs	384 logical CPUs

A logical CPU is a core (thread) in a multicore (multithreading) processor.

2.3.2 Hardware Requirements

Deployed Virtuozzo Infrastructure Platform consists of a single management node and a number of storage and compute nodes. The following subsections list requirements to node hardware depending on usage scenario.

2.3.2.1 Requirements for Management Node with Storage and Compute

The following table lists the minimal and recommended hardware requirements for a management node that also runs the storage and compute services.

If you plan to enable high availability for the management node (recommended), all servers that you will add to the HA cluster must meet the requirements listed this table.

Table 2.2: Hardware for management node with storage and compute

Type	Minimal	Recommended
CPU	64-bit x86 Intel processors with “unrestricted guest” and VT-x with Extended Page Tables (EPT) enabled in BIOS 16 logical CPUs in total*	64-bit x86 Intel processors with “unrestricted guest” and VT-x with Extended Page Tables (EPT) enabled in BIOS 32+ logical CPUs in total*
RAM	32 GB**	64+ GB**

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Table 2.2 – continued from previous page

Type	Minimal	Recommended
Storage	1 disk: system + metadata, 100+ GB SATA HDD 1 disk: storage, SATA HDD, size as required	2+ disks: system + metadata + cache, 100+ GB recommended enterprise-grade SSDs in a RAID1 volume, with power loss protection and 75 MB/s sequential write performance per serviced HDD (e.g., 750+ MB/s total for a 10-disk node) 4+ disks: HDD or SSD, 1 DWPD endurance minimum, 10 DWPD recommended
Network	1 GbE for storage traffic 1 GbE (VLAN tagged) for other traffic	2 x 10 GbE (bonded) for storage traffic 2 x 1 GbE or 2 x 10 GbE (bonded, VLAN tagged) for other traffic

* A logical CPU is a core (thread) in a multicore (multithreading) processor.

** Each CS, e.g., storage disk, requires 1 GB of RAM (0.5 GB anonymous memory + 0.5 GB page cache). The total page cache limit is 12 GB. In addition, each MDS requires 0.2 GB of RAM + 0.1 GB per 100TB of physical storage space.

2.3.2.2 Requirements for Storage and Compute

The following table lists the minimal and recommended hardware requirements for a node that runs the storage and compute services.

Table 2.3: Hardware for storage and compute

Type	Minimal	Recommended
CPU	64-bit x86 processor(s) with Intel VT hardware virtualization extensions enabled 8 logical CPUs*	64-bit x86 processor(s) with Intel VT hardware virtualization extensions enabled 32+ logical CPUs*
RAM	8 GB**	64+ GB**

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Table 2.3 – continued from previous page

Type	Minimal	Recommended
Storage	1 disk: system, 100 GB SATA HDD 1 disk: metadata, 100 GB SATA HDD (only on the first three nodes in the cluster) 1 disk: storage, SATA HDD, size as required	2+ disks: system, 100+ GB SATA HDDs in a RAID1 volume 1+ disk: metadata + cache, 100+ GB enterprise-grade SSD with power loss protection and 75 MB/s sequential write performance per serviced HD (e.g., 750+ MB/s total for a 10-disk node) 4+ disks: HDD or SSD, 1 DWPD endurance minimum, 10 DWPD recommended
Network	1 GbE for storage traffic 1 GbE (VLAN tagged) for other traffic	2 x 10 GbE (bonded) for storage traffic 2 x 1 GbE or 2 x 10 GbE (bonded) for other traffic

* A logical CPU is a core (thread) in a multicore (multithreading) processor.

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2.3.3 Hardware Recommendations

The following recommendations explain the benefits added by specific hardware in the hardware requirements table and are meant to help you configure the cluster hardware in an optimal way:

2.3.3.1 Storage Cluster Composition Recommendations

Designing an efficient storage cluster means finding a compromise between performance and cost that suits your purposes. When planning, keep in mind that a cluster with many nodes and few disks per node offers higher performance while a cluster with the minimal number of nodes (3) and a lot of disks per node is cheaper. See the following table for more details.

Table 2.4: Cluster composition recommendations

Design considerations	Minimum nodes (3), many disks per node	Many nodes, few disks per node
Optimization	Lower cost.	Higher performance.
Free disk space to reserve	More space to reserve for cluster rebuilding as fewer healthy nodes will have to store the data from a failed node.	Less space to reserve for cluster rebuilding as more healthy nodes will have to store the data from a failed node.
Redundancy	Fewer erasure coding choices.	More erasure coding choices.
Cluster balance and rebuilding performance	Worse balance and slower rebuilding.	Better balance and faster rebuilding.
Network capacity	More network bandwidth required to maintain cluster performance during rebuilding.	Less network bandwidth required to maintain cluster performance during rebuilding.
Favorable data type	Cold data (e.g., backups).	Hot data (e.g., virtual environments).
Sample server configuration	Supermicro SSG-6047R-E1R36L (Intel Xeon E5-2620 v1/v2 CPU, 32GB RAM, 36 x 12TB HDDs, a 500GB system disk).	Supermicro SYS-2028TP-HC0R-SIOM (4 x Intel E5-2620 v4 CPUs, 4 x 16GB RAM, 24 x 1.9TB Samsung SM863a SSDs).

Take note of the following:

1. These considerations only apply if failure domain is host.
2. The speed of rebuilding in the replication mode does not depend on the number of nodes in the cluster.
3. Virtuozzo Infrastructure Platform supports hundreds of disks per node. If you plan to use more than 36 disks per node, contact sales engineers who will help you design a more efficient cluster.

2.3.3.2 General Hardware Recommendations

- At least three nodes are required for a production environment. This is to ensure that the cluster can survive failure of one node without data loss.
- One of the strongest features of Virtuozzo Infrastructure Platform is scalability. The bigger the cluster, the better Virtuozzo Infrastructure Platform performs. It is recommended to create production clusters from at least ten nodes for improved resiliency, performance, and fault tolerance in production

scenarios.

- Even though a cluster can be created on top of varied hardware, using nodes with similar hardware in each node will yield better cluster performance, capacity, and overall balance.
- Any cluster infrastructure must be tested extensively before it is deployed to production. Such common points of failure as SSD drives and network adapter bonds must always be thoroughly verified.
- It is not recommended for production to run Virtuozzo Infrastructure Platform on top of SAN/NAS hardware that has its own redundancy mechanisms. Doing so may negatively affect performance and data availability.
- To achieve best performance, keep at least 20% of cluster capacity free.
- During disaster recovery, Virtuozzo Infrastructure Platform may need additional disk space for replication. Make sure to reserve at least as much space as any single storage node has.
- It is recommended to have the same CPU models on each node to avoid VM live migration issues. For more details, see the *Administrator's Command Line Guide*.
- If you plan to use Backup Gateway to store backups in the cloud, make sure the local storage cluster has plenty of logical space for staging (keeping backups locally before sending them to the cloud). For example, if you perform backups daily, provide enough space for at least 1.5 days' worth of backups. For more details, see the *Administrator's Guide*.

2.3.3.3 Storage Hardware Recommendations

- It is possible to use disks of different size in the same cluster. However, keep in mind that, given the same IOPS, smaller disks will offer higher performance per terabyte of data compared to bigger disks. It is recommended to group disks with the same IOPS per terabyte in the same tier.
- Using the recommended SSD models may help you avoid loss of data. Not all SSD drives can withstand enterprise workloads and may break down in the first months of operation, resulting in TCO spikes.
    - SSD memory cells can withstand a limited number of rewrites. An SSD drive should be viewed as a consumable that you will need to replace after a certain time. Consumer-grade SSD drives can withstand a very low number of rewrites (so low, in fact, that these numbers are not shown in their technical specifications). SSD drives intended for storage clusters must offer at least 1 DWPD endurance (10 DWPD is recommended). The higher the endurance, the less often SSDs will need to be replaced, improving TCO.

  - Many consumer-grade SSD drives can ignore disk flushes and falsely report to operating systems that data was written while it in fact was not. Examples of such drives include OCZ Vertex 3, Intel 520, Intel X25-E, and Intel X-25-M G2. These drives are known to be unsafe in terms of data commits, they should not be used with databases, and they may easily corrupt the file system in case of a power failure. For these reasons, use to enterprise-grade SSD drives that obey the flush rules (for more information, see http://www.postgresql.org/docs/current/static/wal-reliability.html). Enterprise-grade SSD drives that operate correctly usually have the power loss protection property in their technical specification. Some of the market names for this technology are Enhanced Power Loss Data Protection (Intel), Cache Power Protection (Samsung), Power-Failure Support (Kingston), Complete Power Fail Protection (OCZ).
  - Consumer-grade SSD drives usually have unstable performance and are not suited to withstand sustainable enterprise workloads. For this reason, pay attention to sustainable load tests when choosing SSDs. We recommend the following enterprise-grade SSD drives which are the best in terms of performance, endurance, and investments: Intel S3710, Intel P3700, Huawei ES3000 V2, Samsung SM1635, and Sandisk Lightning.
- Using SSDs for write caching improves random I/O performance and is highly recommended for all workloads with heavy random access (e.g., iSCSI volumes).
- Using shingled magnetic recording (SMR) HDDs is strongly not recommended–even for backup scenarios. Such disks have unpredictable latency that may lead to unexpected temporary service outages and sudden performance degradations.
- Running metadata services on SSDs improves cluster performance. To also minimize CAPEX, the same SSDs can be used for write caching.
- If capacity is the main goal and you need to store non-frequently accessed data, choose SATA disks over SAS ones. If performance is the main goal, choose SAS disks over SATA ones.
- The more disks per node the lower the CAPEX. As an example, a cluster created from ten nodes with two disks in each will be less expensive than a cluster created from twenty nodes with one disk in each.
- Using SATA HDDs with one SSD for caching is more cost effective than using only SAS HDDs without such an SSD.
- Create hardware or software RAID1 volumes for system disks using RAID or HBA controllers, respectively, to ensure its high performance and availability.
- Use HBA controllers as they are less expensive and easier to manage than RAID controllers.

- Disable all RAID controller caches for SSD drives. Modern SSDs have good performance that can be reduced by a RAID controller's write and read cache. It is recommend to disable caching for SSD drives and leave it enabled only for HDD drives.
- If you use RAID controllers, do not create RAID volumes from HDDs intended for storage. Each storage HDD needs to be recognized by Virtuozzo Infrastructure Platform as a separate device.
- If you use RAID controllers with caching, equip them with backup battery units (BBUs) to protect against cache loss during power outages.
- Disk block size (e.g., 512b or 4K) is not important and has no effect on performance.

2.3.3.4 Network Hardware Recommendations

- Use separate networks (and, ideally albeit optionally, separate network adapters) for internal and public traffic. Doing so will prevent public traffic from affecting cluster I/O performance and also prevent possible denial-of-service attacks from the outside.
- Network latency dramatically reduces cluster performance. Use quality network equipment with low latency links. Do not use consumer-grade network switches.
- Do not use desktop network adapters like Intel EXPI9301CTBLK or Realtek 8129 as they are not designed for heavy load and may not support full-duplex links. Also use non-blocking Ethernet switches.
- To avoid intrusions, Virtuozzo Infrastructure Platform should be on a dedicated internal network inaccessible from outside.
- Use one 1 Gbit/s link per each two HDDs on the node (rounded up). For one or two HDDs on a node, two bonded network interfaces are still recommended for high network availability. The reason for this recommendation is that 1 Gbit/s Ethernet networks can deliver 110-120 MB/s of throughput, which is close to sequential I/O performance of a single disk. Since several disks on a server can deliver higher throughput than a single 1 Gbit/s Ethernet link, networking may become a bottleneck.
- For maximum sequential I/O performance, use one 1Gbit/s link per each hard drive, or one 10Gbit/s link per node. Even though I/O operations are most often random in real-life scenarios, sequential I/O is important in backup scenarios.
- For maximum overall performance, use one 10 Gbit/s link per node (or two bonded for high network availability).
- It is not recommended to configure 1 Gbit/s network adapters to use non-default MTUs (e.g., 9000-byte

jumbo frames). Such settings require additional configuration of switches and often lead to human error. 10 Gbit/s network adapters, on the other hand, need to be configured to use jumbo frames to achieve full performance.

- Currently supported Fibre Channel host bus adapters (HBAs) are QLogic QLE2562-CK and QLogic ISP2532.

2.3.4 Hardware and Software Limitations

Hardware limitations:

- Each management node must have at least two disks (one system+metadata, one storage).
- Each compute or storage node must have at least three disks (one system, one metadata, one storage).
- Three servers are required to test all the features of the product.
- Each server must have at least 4GB of RAM and two logical cores.
- The system disk must have at least 100 GBs of space.
- Admin panel requires a Full HD monitor to be displayed correctly.

Software limitations:

- The maintenance mode is not supported. Use SSH to shut down or reboot a node.
- One node can be a part of only one cluster.
- Only one S3 cluster can be created on top of a storage cluster.
- Only predefined redundancy modes are available in the admin panel.
- Thin provisioning is always enabled for all data and cannot be configured otherwise.
- Admin panel has been tested to work at resolutions 1280x720 and higher in the following web browsers: latest Firefox, Chrome, Safari.

For network limitations, see *Network Limitations* (page 19).

2.3.5 Minimum Storage Configuration

The minimum configuration described in the table will let you evaluate the following features of the storage cluster:

Table 2.5: Minimum cluster configuration

Node #	1st disk role	2nd disk role	3rd+ disk roles	Access points
1	System	Metadata	Storage	iSCSI, S3 private, S3 public, NFS, ABGW
2	System	Metadata	Storage	iSCSI, S3 private, S3 public, NFS, ABGW
3	System	Metadata	Storage	iSCSI, S3 private, S3 public, NFS, ABGW
3 nodes in total		3 MDSs in total	3+ CSs in total	Access point services run on three nodes in total.

Note: SSD disks can be assigned **System**, **Metadata**, and **Cache** roles at the same time, freeing up more disks for the storage role.

Even though three nodes are recommended even for the minimal configuration, you can start evaluating Virtuozzo Infrastructure Platform with just one node and add more nodes later. At the very least, an storage cluster must have one metadata service and one chunk service running. A single-node installation will let you evaluate services such as iSCSI, ABGW, etc. However, such a configuration will have two key limitations:

1. Just one MDS will be a single point of failure. If it fails, the entire cluster will stop working.
2. Just one CS will be able to store just one chunk replica. If it fails, the data will be lost.

Important: If you deploy Virtuozzo Infrastructure Platform on a single node, you must take care of making its storage persistent and redundant to avoid data loss. If the node is physical, it must have multiple disks so you can replicate the data among them. If the node is a virtual machine, make sure that this VM is made highly available by the solution it runs on.

Note: Backup Gateway works with the local object storage in the staging mode. It means that the data to be replicated, migrated, or uploaded to a public cloud is first stored locally and only then sent to the destination. It is vital that the local object storage is persistent and redundant so the local data does not get lost. There are multiple ways to ensure the persistence and redundancy of the local storage. You can deploy your Backup Gateway on multiple nodes and select a good redundancy mode. If your gateway is deployed on a single node in Virtuozzo Infrastructure Platform, you can make its storage redundant by replicating it among multiple local disks. If your entire Virtuozzo Infrastructure Platform installation is deployed in a single virtual machine with the sole purpose of creating a gateway, make sure this VM is made highly available by the solution it runs on.

2.3.6 Recommended Storage Configuration

It is recommended to have at least five metadata services to ensure that the cluster can survive simultaneous failure of two nodes without data loss. The following configuration will help you create clusters for production environments:

Table 2.6: Recommended cluster configuration

Node #	1st disk role	2nd disk role	3rd+ disk roles	Access points
Nodes 1 to 5	System	SSD; metadata, cache	Storage	iSCSI, S3 private, S3 public, ABGW
Nodes 6+	System	SSD; cache	Storage	iSCSI, S3 private, ABGW
5+ nodes in total		5 MDSs in total	5+ CSs in total	All nodes run required access points.

Even though a production-ready cluster can be created from just five nodes with recommended hardware, it is still recommended to enter production with at least ten nodes if you are aiming to achieve significant performance advantages over direct-attached storage (DAS) or improved recovery times.

Following are a number of more specific configuration examples that can be used in production. Each configuration can be extended by adding chunk servers and nodes.

2.3.6.1 HDD Only

This basic configuration requires a dedicated disk for each metadata server.

Table 2.7: HDD only configuration

Nodes 1-5 (base)			Nodes 6+ (extension)		
Disk #	**Disk type**	**Disk roles**	**Disk #**	**Disk type**	**Disk roles**
1	HDD	System	1	HDD	System
2	HDD	MDS	2	HDD	CS
3	HDD	CS	3	HDD	CS
...	...	...	...	...	...
N	HDD	CS	N	HDD	CS

2.3.6.2 HDD + System SSD (No Cache)

This configuration is good for creating capacity-oriented clusters.

Table 2.8: HDD + system SSD (no cache) configuration

Nodes 1-5 (base)			Nodes 6+ (extension)		
Disk #	**Disk type**	**Disk roles**	**Disk #**	**Disk type**	**Disk roles**
1	SSD	System, MDS	1	SSD	System
2	HDD	CS	2	HDD	CS
3	HDD	CS	3	HDD	CS
...	...	...	...	...	...
N	HDD	CS	N	HDD	CS

2.3.6.3 HDD + SSD

This configuration is good for creating performance-oriented clusters.

Table 2.9: HDD + SSD configuration

Nodes 1-5 (base)			Nodes 6+ (extension)		
Disk #	**Disk type**	**Disk roles**	**Disk #**	**Disk type**	**Disk roles**
1	HDD	System	1	HDD	System
2	SSD	MDS, cache	2	SSD	Cache
3	HDD	CS	3	HDD	CS
...	...	...	...	...	...
N	HDD	CS	N	HDD	CS

2.3.6.4 SSD Only

This configuration does not require SSDs for cache.

When choosing hardware for this configuration, have in mind the following:

- Each Virtuozzo Infrastructure Platform client will be able to obtain up to about 40K sustainable IOPS (read + write) from the cluster.
- If you use the erasure coding redundancy scheme, each erasure coding file, e.g., a single VM HDD disk, will get up to 2K sustainable IOPS. That is, a user working inside a VM will have up to 2K sustainable IOPS per virtual HDD at their disposal. Multiple VMs on a node can utilize more IOPS, up to the client's limit.
- In this configuration, network latency defines more than half of overall performance, so make sure that the network latency is minimal. One recommendation is to have one 10Gbps switch between any two nodes in the cluster.

Table 2.10: SSD only configuration

Nodes 1-5 (base)			Nodes 6+ (extension)		
Disk #	**Disk type**	**Disk roles**	**Disk #**	**Disk type**	**Disk roles**
1	SSD	System, MDS	1	SSD	System
2	SSD	CS	2	SSD	CS
3	SSD	CS	3	SSD	CS
...	...	...	...	...	...
N	SSD	CS	N	SSD	CS

2.3.6.5 HDD + SSD (No Cache), 2 Tiers

In this configuration example, tier 1 is for HDDs without cache and tier 2 is for SSDs. Tier 1 can store cold data (e.g., backups), tier 2 can store hot data (e.g., high-performance virtual machines).

Table 2.11: HDD + SSD (no cache) 2-tier configuration

Nodes 1-5 (base)				**Nodes 6+ (extension)**			
Disk #	**Disk type**	**Disk roles**	**Tier**	**Disk #**	**Disk type**	**Disk roles**	**Tier**
1	SSD	System, MDS		1	SSD	System	
2	SSD	CS	2	2	SSD	CS	2
3	HDD	CS	1	3	HDD	CS	1
...	...	...	...	...	...	...	...
N	HDD/SSD	CS	1/2	N	HDD/SSD	CS	1/2

2.3.6.6 HDD + SSD, 3 Tiers

In this configuration example, tier 1 is for HDDs without cache, tier 2 is for HDDs with cache, and tier 3 is for SSDs. Tier 1 can store cold data (e.g., backups), tier 2 can store regular virtual machines, and tier 3 can store high-performance virtual machines.

Table 2.12: HDD + SSD 3-tier configuration

Nodes 1-5 (base)				**Nodes 6+ (extension)**			
Disk #	**Disk type**	**Disk roles**	**Tier**	**Disk #**	**Disk type**	**Disk roles**	**Tier**
1	HDD/SSD	System		1	HDD/SSD	System	
2	SSD	MDS, T2 cache		2	SSD	T2 cache	
3	HDD	CS	1	3	HDD	CS	1
4	HDD	CS	2	4	HDD	CS	2
5	SSD	CS	3	5	SSD	CS	3
...	...	...	...	...	...	...	...
N	HDD/SSD	CS	1/2/3	N	HDD/SSD	CS	1/2/3

2.3.7 Raw Disk Space Considerations

When planning the infrastructure, keep in mind the following to avoid confusion:

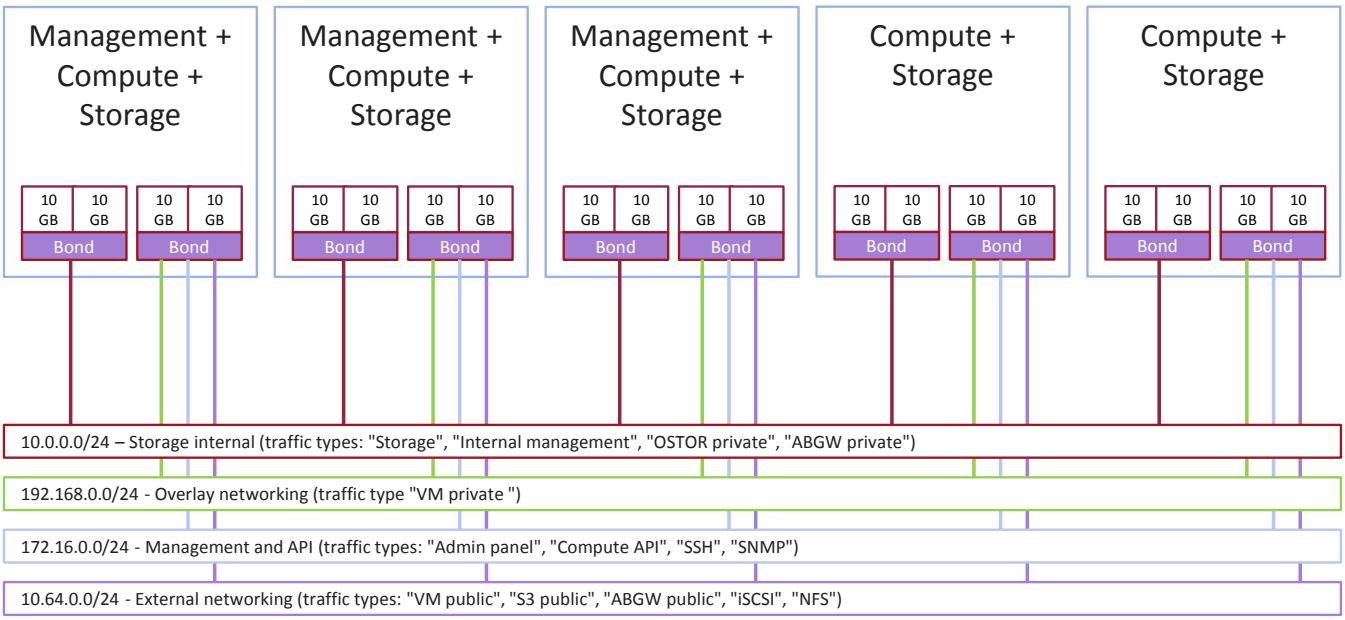
- The capacity of HDD and SSD is measured and specified with decimal, not binary prefixes, so “TB” in disk specifications usually means “terabyte”. The operating system, however, displays drive capacity using binary prefixes meaning that “TB” is “tebibyte” which is a noticeably larger number. As a result, disks may show capacity smaller than the one marketed by the vendor. For example, a disk with 6TB in specifications may be shown to have 5.45 TB of actual disk space in Virtuozzo Infrastructure Platform.
- 5% of disk space is reserved for emergency needs.

Therefore, if you add a 6TB disk to a cluster, the available physical space should increase by about 5.2 TB.

2.4 Planning Network

The recommended network configuration for Virtuozzo Infrastructure Platform is as follows:

- One bonded connection for internal storage traffic;
- One bonded connection for service traffic divided into these VLANs:
  - Overlay networking (VM private networks),
  - Management and API (admin panel, SSH, SNMP, compute API),
  - External networking (VM public networks, public export of iSCSI, NFS, S3, and ABGW data).



2.4.1 General Network Requirements

- Internal storage traffic must be separated from other traffic types.

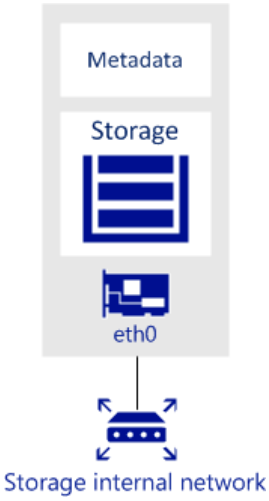
2.4.2 Network Limitations

- Nodes are added to clusters by their IP addresses, not FQDNs. Changing the IP address of a node in the cluster will remove that node from the cluster. If you plan to use DHCP in a cluster, make sure that IP addresses are bound to the MAC addresses of nodes' network interfaces.
- Each node must have Internet access so updates can be installed.
- MTU is set to 1500 by default.
- Network time synchronization (NTP) is required for correct statistics. It is enabled by default using the `chronyd` service. If you want to use `ntpdate` or `ntpd`, stop and disable `chronyd` first.
- The **Internal management** traffic type is assigned automatically during installation and cannot be changed in the admin panel later.
- Even though the management node can be accessed from a web browser by the hostname, you still need to specify its IP address, not the hostname, during installation.

2.4.3 Per-Node Network Requirements

Network requirements for each cluster node depend on services that will run on this node:

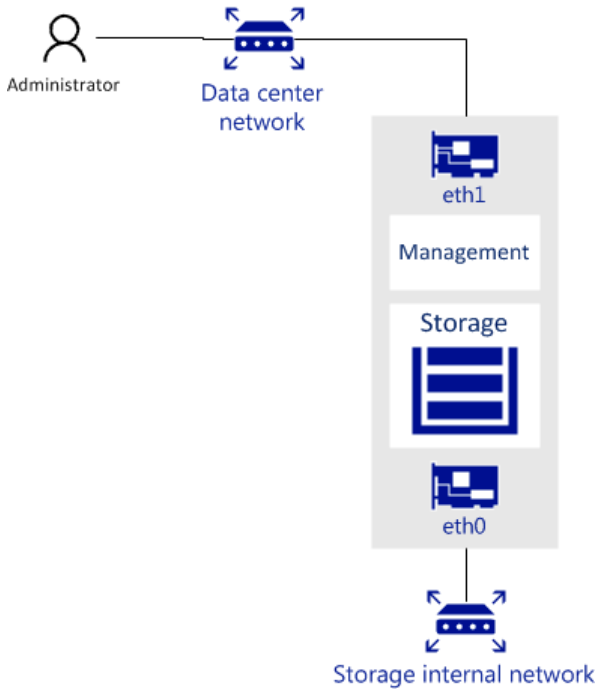
- Each node in the cluster must have access to the internal network and have the port 8888 open to listen for incoming connections from the internal network.
- All network interfaces on a node must be connected to different subnets. A network interface can be a VLAN-tagged logical interface, an untagged bond, or an Ethernet link.
- Each storage and metadata node must have at least one network interface for the internal network traffic. The IP addresses assigned to this interface must be either static or, if DHCP is used, mapped to the adapter's MAC address. The figure below shows a sample network configuration for a storage and metadata node.



- The management node must have a network interface for internal network traffic and a network interface for the public network traffic (e.g., to the datacenter or a public network) so the admin panel can be accessed via a web browser.

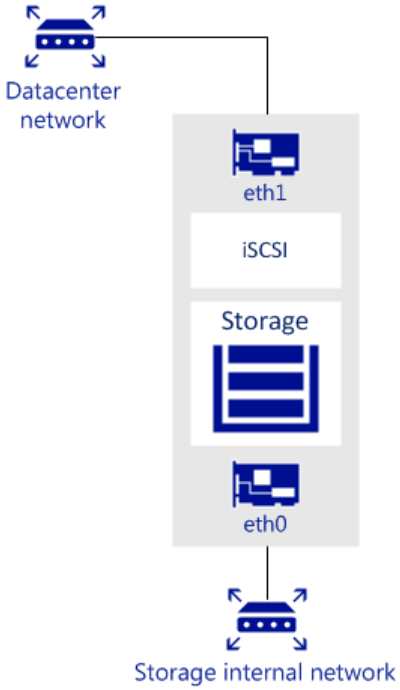
  The management node must have the port 8888 open by default to allow access to the admin panel from the public network and to the cluster node from the internal network.

  The figure below shows a sample network configuration for a storage and management node.



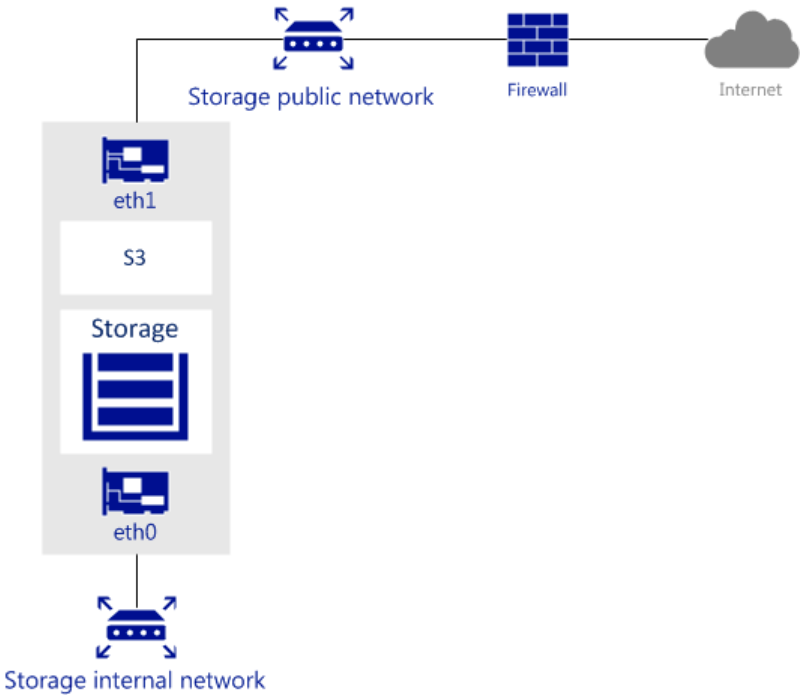
- A node that runs one or more storage access point services must have a network interface for the internal network traffic and a network interface for the public network traffic.

  The figure below shows a sample network configuration for a node with an iSCSI access point. iSCSI access points use the TCP port 3260 for incoming connections from the public network.



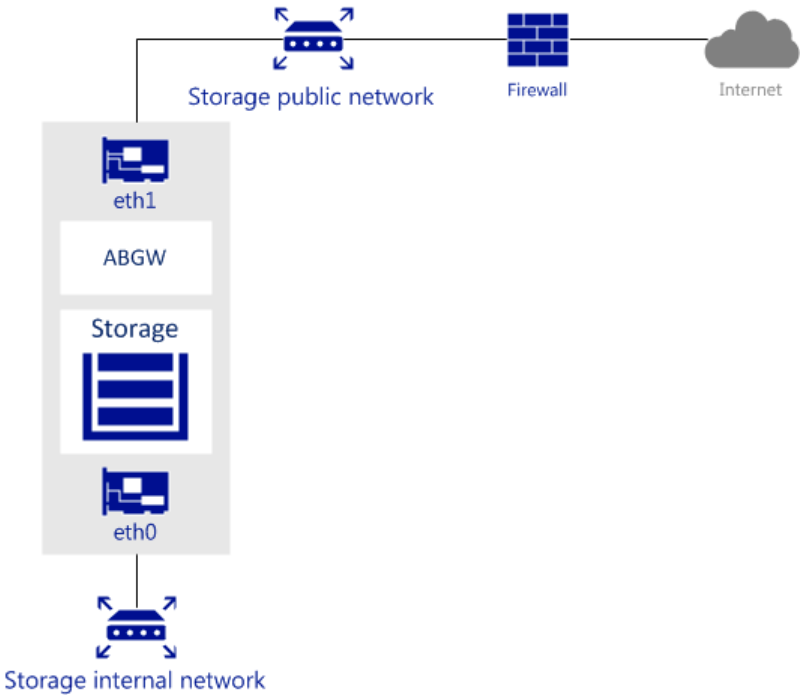
  The next figure shows a sample network configuration for a node with an S3 storage access point. S3

access points use ports 443 (HTTPS) and 80 (HTTP) to listen for incoming connections from the public network.



In the scenario pictured above, the internal network is used for both the storage and S3 cluster traffic.

The next figure shows a sample network configuration for a node with a Backup Gateway storage access point. Backup Gateway access points use port 44445 for incoming connections from both internal and public networks and ports 443 and 8443 for outgoing connections to the public network.



- A node that runs compute services must have a network interface for the internal network traffic and a network interface for the public network traffic.

2.4.4 Network Recommendations for Clients

The following table lists the maximum network performance a client can get with the specified network interface. The recommendation for clients is to use 10Gbps network hardware between any two cluster nodes and minimize network latencies, especially if SSD disks are used.

Table 2.13: Maximum client network performance

Storage network interface	Node max. I/O	VM max. I/O (replication)	VM max. I/O (erasure coding)
1 Gbps	100 MB/s	100 MB/s	70 MB/s
2 x 1 Gbps	~175 MB/s	100 MB/s	~130 MB/s
3 x 1 Gbps	~250 MB/s	100 MB/s	~180 MB/s
10 Gbps	1 GB/s	1 GB/s	700 MB/s
2 x 10 Gbps	1.75 GB/s	1 GB/s	1.3 GB/s

2.5 Understanding Data Redundancy

Virtuozzo Infrastructure Platform protects every piece of data by making it redundant. It means that copies of each piece of data are stored across different storage nodes to ensure that the data is available even if some of the storage nodes are inaccessible.

Virtuozzo Infrastructure Platform automatically maintains the required number of copies within the cluster and ensures that all the copies are up-to-date. If a storage node becomes inaccessible, the copies from it are replaced by new ones that are distributed among healthy storage nodes. If a storage node becomes accessible again after downtime, the copies on it which are out-of-date are updated.

The redundancy is achieved by one of two methods: replication or erasure coding (explained in more detail in the next section). The chosen method affects the size of one piece of data and the number of its copies that will be maintained in the cluster. In general, replication offers better performance while erasure coding leaves more storage space available for data (see table).

Virtuozzo Infrastructure Platform supports a number of modes for each redundancy method. The following table illustrates data overhead of various redundancy modes. The first three lines are replication and the rest are erasure coding.

Table 2.14: Redundancy mode comparison

Redundancy mode	**Min. number of nodes required**	**How many nodes can fail without data loss**	**Storage overhead, %**	**Raw space needed to store 100GB of data**
1 replica (no redundancy)	1	0	0	100GB
2 replicas	2	1	100	200GB
3 replicas	3	2	200	300GB
Encoding 1+0 (no redundancy)	1	0	0	100GB
Encoding 1+2	3	2	200	300GB
Encoding 3+2	5	2	67	167GB
Encoding 5+2	7	2	40	140GB
Encoding 7+2	9	2	29	129GB
Encoding 17+3	20	3	18	118GB

Note: The 1+0 and 1+2 encoding modes are meant for small clusters that have insufficient nodes for other erasure coding modes but will grow in the future. As redundancy type cannot be changed once chosen (from replication to erasure coding or vice versa), this mode allows one to choose erasure coding even if their cluster is smaller than recommended. Once the cluster has grown, more beneficial redundancy modes can be chosen.

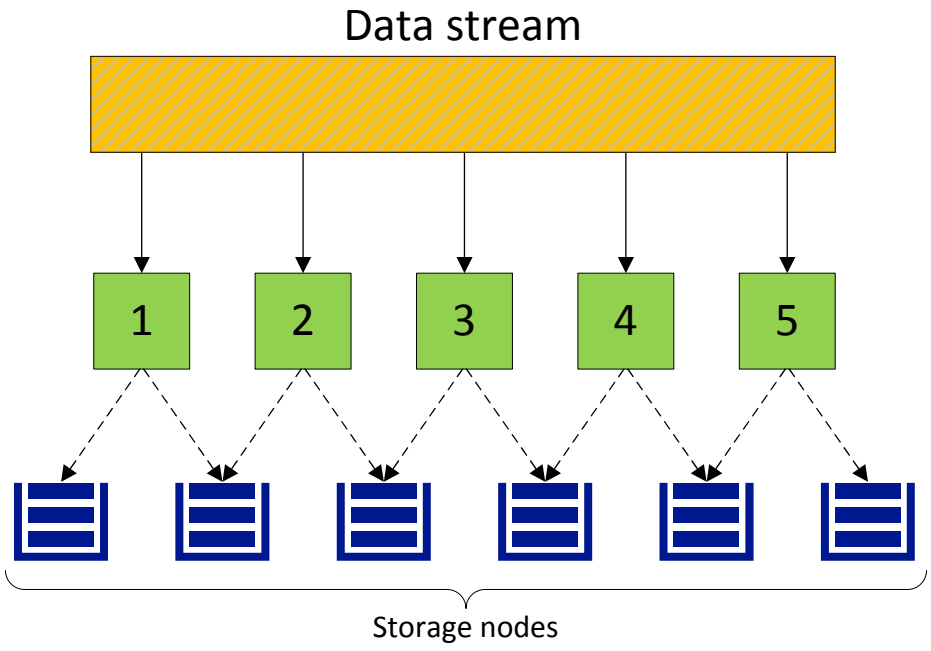
You choose a data redundancy mode when configuring storage services and creating storage volumes for virtual machines. No matter what redundancy mode you choose, it is highly recommended is to be protected against a simultaneous failure of two nodes as that happens often in real-life scenarios.

All redundancy modes allow write operations when one storage node is inaccessible. If two storage nodes are inaccessible, write operations may be frozen until the cluster heals itself.

2.5.1 Redundancy by Replication

With replication, Virtuozzo Infrastructure Platform breaks the incoming data stream into 256MB chunks. Each chunk is replicated and replicas are stored on different storage nodes, so that each node has only one replica of a given chunk.

The following diagram illustrates the 2 replicas redundancy mode.



Replication in Virtuozzo Infrastructure Platform is similar to the RAID rebuild process but has two key

differences:

- Replication in Virtuozzo Infrastructure Platform is much faster than that of a typical online RAID 1/5/10 rebuild. The reason is that Virtuozzo Infrastructure Platform replicates chunks in parallel, to multiple storage nodes.
- The more storage nodes are in a cluster, the faster the cluster will recover from a disk or node failure.

High replication performance minimizes the periods of reduced redundancy for the cluster. Replication performance is affected by:

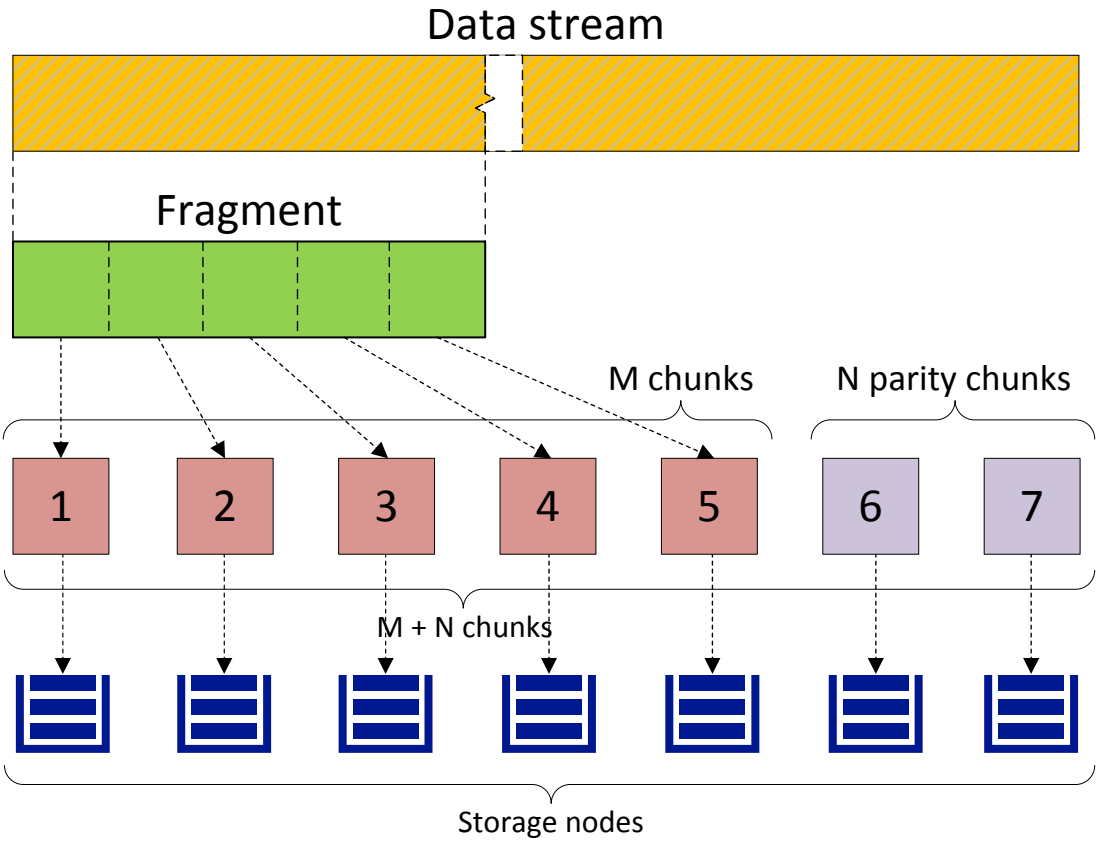
- The number of available storage nodes. As replication runs in parallel, the more available replication sources and destinations there are, the faster it is.
- Performance of storage node disks.
- Network performance. All replicas are transferred between storage nodes over network. For example, 1 Gbps throughput can be a bottleneck (see *Per-Node Network Requirements* (page 20)).
- Distribution of data in the cluster. Some storage nodes may have much more data to replicate than other and may become overloaded during replication.
- I/O activity in the cluster during replication.

2.5.2 Redundancy by Erasure Coding

With erasure coding, Virtuozzo Infrastructure Platform breaks the incoming data stream into fragments of certain size, then splits each fragment into a certain number (M) of 1-megabyte pieces and creates a certain number (N) of parity pieces for redundancy. All pieces are distributed among M+N storage nodes, that is, one piece per node. On storage nodes, pieces are stored in regular chunks of 256MB but such chunks are not replicated as redundancy is already achieved. The cluster can survive failure of any N storage nodes without data loss.

The values of M and N are indicated in the names of erasure coding redundancy modes. For example, in the 5+2 mode, the incoming data is broken into 5MB fragments, each fragment is split into five 1MB pieces and two more 1MB parity pieces are added for redundancy. In addition, if N is 2, the data is encoded using the RAID6 scheme, and if N is greater than 2, erasure codes are used.

The diagram below illustrates the 5+2 mode.



2.5.3 No Redundancy

Warning: Danger of data loss!

Without redundancy, singular chunks are stored on storage nodes, one per node. If the node fails, the data may be lost. Having no redundancy is highly not recommended no matter the scenario, unless you only want to evaluate Virtuozzo Infrastructure Platform on a single server.

2.6 Understanding Failure Domains

A failure domain is a set of services which can fail in a correlated manner. To provide high availability of data, Virtuozzo Infrastructure Platform spreads data replicas evenly across failure domains, according to a replica placement policy.

The following policies are available:

- Host as a failure domain (default). If a single host running multiple CS services fails (e.g., due to a power outage or network disconnect), all CS services on it become unavailable at once. To protect against data loss under this policy, Virtuozzo Infrastructure Platform never places more than one data replica per host. This policy is highly recommended for clusters of three nodes and more.
- Disk, the smallest possible failure domain. Under this policy, Virtuozzo Infrastructure Platform never places more than one data replica per disk or CS. While protecting against disk failure, this option may still result in data loss if data replicas happen to be on different disks of the same host and it fails. This policy can be used with small clusters of up to three nodes (down to a single node).

2.7 Understanding Storage Tiers

In Virtuozzo Infrastructure Platform terminology, tiers are disk groups that allow you to organize storage workloads based on your criteria. For example, you can use tiers to separate workloads produced by different tenants. Or you can have a tier of fast SSDs for service or virtual environment workloads and a tier of high-capacity HDDs for backup storage.

When assigning disks to tiers (which you can do at any time), have in mind that faster storage drives should be assigned to higher tiers. For example, you can use tier 0 for backups and other cold data (CS without SSD cache), tier 1 for virtual environments—a lot of cold data but fast random writes (CS with SSD cache), tier 2 for hot data (CS on SSD), caches, specific disks, and such.

This recommendation is related to how Virtuozzo Infrastructure Platform works with storage space. If a storage tier runs out of free space, Virtuozzo Infrastructure Platform will attempt to temporarily use the space of the lower tiers down to the lowest. If the lowest tier also becomes full, Virtuozzo Infrastructure Platform will attempt to use a higher one. If you add more storage to the original tier later, the data, temporarily stored elsewhere, will be moved to the tier where it should have been stored originally. For example, if you try to write data to the tier 2 and it is full, Virtuozzo Infrastructure Platform will attempt to write that data to tier 1, then to tier 0. If you add more storage to tier 2 later, the aforementioned data, now stored on the tier 1 or 0, will be moved back to the tier 2 where it was meant to be stored originally.

Inter-tier data allocation as well as the transfer of data to the original tier occurs in the background. You can disable such migration and keep tiers strict as described in the *Administrator's Command Line Guide*.

Note: With the exception of out-of-space situations, automatic migration of data between tiers is not

supported.

2.8 Understanding Cluster Rebuilding

The storage cluster is self-healing. If a node or disk fails, a cluster will automatically try to restore the lost data, i.e. rebuild itself.

The rebuild process involves the following steps. Every CS sends a heartbeat message to an MDS every 5 seconds. If a heartbeat is not sent, the CS is considered *inactive* and the MDS informs all cluster components that they stop requesting operations on its data. If no heartbeats are received from a CS for 15 minutes, the MDS considers that CS *offline* and starts cluster rebuilding (if prerequisites below are met). In the process, the MDS finds CSs that do not have pieces (replicas) of the lost data and restores the data—one piece (replica) at a time—as follows:

- If replication is used, the existing replicas of a degraded chunk are locked (to make sure all replicas remain identical) and one is copied to the new CS. If at this time a client needs to read some data that has not been rebuilt yet, it reads any remaining replica of that data.
- If erasure coding is used, the new CS requests almost all the remaining data pieces to rebuild the missing ones. If at this time a client needs to read some data that has not been rebuilt yet, that data is rebuilt out of turn and then read.

Self-healing requires more network traffic and CPU resources if replication is used. On the other hand, rebuilding with erasure coding is slower.

For a cluster to be able to rebuild itself, it must have at least:

1. as many healthy nodes as required by the redundancy mode;
2. enough free space to accomodate as much data as any one node can store.

The first prerequisite can be explained on the following example. In a cluster that works in the 5+2 erasure coding mode and has seven nodes (i.e. the minumum), each piece of user data is distributed to 5+2 nodes for redundancy, i.e. each node is used. If one or two nodes fail, the user data will not be lost, but the cluster will become degraded and will not be able to rebuild itself until at least seven nodes are healthy again (that is, until you add the missing nodes). For comparison, in a cluster that works in the 5+2 erasure coding mode and has ten nodes, each piece of user data is distributed to the random 5+2 nodes out of ten to even out the load on CSs. If up to three nodes fail, such a cluster will still have enough nodes to rebuild itself.

The second prerequisite can be explained on the following example. In a cluster that has ten 10 TB nodes, at least 1 TB on each node should be kept free, so if a node fails, its 9 TB of data can be rebuilt on the remaining nine nodes. If, however, a cluster has ten 10 TB nodes and one 20 TB node, each smaller node should have at least 2 TB free in case the largest node fails (while the largest node should have 1 TB free).

Two recommendations that help smooth out rebuilding overhead:

- To simplify rebuilding, keep uniform disk counts and capacity sizes on all nodes.
- Rebuilding places additional load on the network and increases the latency of read and write operations. The more network bandwidth the cluster has, the faster rebuilding will be completed and bandwidth freed up.

CHAPTER 3

Installing Using GUI

After planning out the infrastructure, proceed to install the product on each server included in the plan.

The installation is similar for all servers. One exception is the first server where you must also install the admin panel (only one is allowed per cluster).

Important: On all nodes in the same cluster, time needs to be synchronized via NTP. Make sure the nodes can access the NTP server.

3.1 Obtaining Distribution Image

To obtain the distribution ISO image, visit the product page and submit a request for the trial version.

3.2 Preparing for Installation

Virtuozzo Infrastructure Platform can be installed from

- IPMI virtual drives,
- PXE servers (in this case, time synchronization via NTP is enabled by default),
- USB drives.

3.2.1 Preparing for Installation from USB Storage Drives

To install Virtuozzo Infrastructure Platform from a USB storage drive, you will need a 4 GB or higher-capacity USB drive and the Virtuozzo Infrastructure Platform distribution ISO image.

Make a bootable USB drive by transferring the distribution image to it with `dd`.

Important: Be careful to specify the correct drive to transfer the image to.

For example, on Linux:

```
# dd if=storage-image.iso of=/dev/sdb
```

And on Windows (with dd for Windows):

```
C:\>dd if=storage-image.iso of=\\?\Device\Harddisk1\Partition0
```

3.3 Starting Installation

The installation program requires a minimum screen resolution of 800x600. With 800x600, however, you may experience issues with the user interface. For example, some elements can be inaccessible. The recommended screen resolution is at least 1024x768.

To start the installation, do the following:

1. Configure the server to boot from the chosen media.
2. Boot the server and wait for the welcome screen.
3. On the welcome screen, do one of the following:
   - If you want to set installation options manually, choose **Install Virtuozzo Infrastructure Platform**.
   - If you want to install Virtuozzo Infrastructure Platform in the unattended mode, press **E** to edit the menu entry, append kickstart file location to the `linux` line, and press **Ctrl+X**. For example:

     ```
     linux /images/pxeboot/vmlinuz inst.stage2=hd:LABEL=<ISO_image> quiet ip=dhcp \
     logo.nologo=1 inst.ks=<URL>
     ```

     For instructions on how to create and use a kickstart file, see *Creating Kickstart File* (page 45) and

Using Kickstart File (page 51), respectively.

3.4 Configuring Network

Virtuozzo Infrastructure Platform requires one network interface per server for management. On the **Component Installation** screen, you will need to specify a network interface to which to assign the network with the **Internal management** traffic type. After installation, you will not be able to remove this traffic type from the preconfigured network in the admin panel.

On the **NETWORK & HOST NAME** screen, you need to have at least one network card configured. Usually network is configured automatically (via DHCP). If manual configuration is required, select a network card, click **Configure...**, and specify the necessary parameters.

It is recommended, however, to create two bonded connections as described in *Planning Network* (page 18) and create three VLAN interfaces on one of the bonds. One of the VLAN interfaces must be created in the installer and assigned to the admin panel network so that you can access the admin panel after the installation. The remaining VLAN interfaces can be more conveniently created and assigned to networks in the admin panel as described in the *Administrator's Guide*.

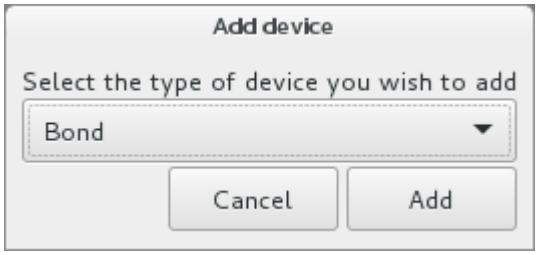
In addition, you can provide a unique hostname, either a fully qualified domain name (`<hostname>.<domainname>`) or a short name (`<hostname>`), in the **Host name** field. If do not, a unique hostname will be generated automatically by the installation program.

3.4.1 Creating Bonded Connections

Bonded connections offer increased throughput beyond the capabilities of a single network card as well as improved redundancy.

You can create network bonds on the **NETWORK & HOSTNAME** screen as described below.

1. To add a new bonded connection, click the plus button in the bottom, select **Bond** from the drop-down list, and click **Add**.

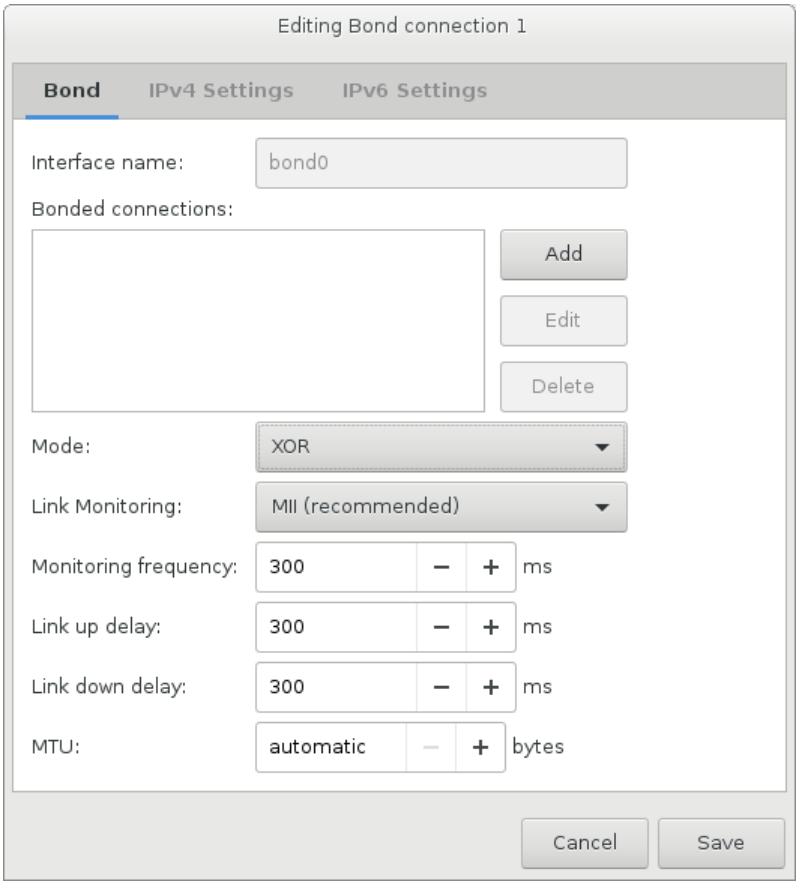


2. In the **Editing Bond connection...** window, set the following parameters for an Ethernet bonding interface:

   2.1. **Mode** to `XOR`.

   2.2. **Link Monitoring** to `MII (recommended)`.

   2.3. **Monitoring frequency**, **Link up delay**, and **Link down delay** to 300.



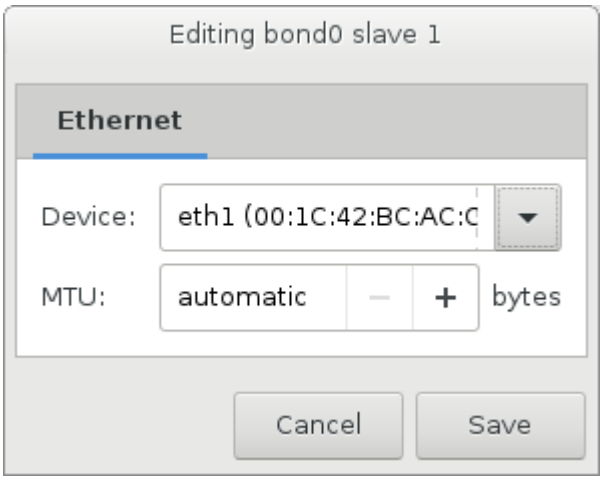
Note: It is also recommended to manually set `xmit_hash_policy` to `layer3+4` after the installation.

---

3. In the **Bonded connections** section on the **Bond** tab, click **Add**.

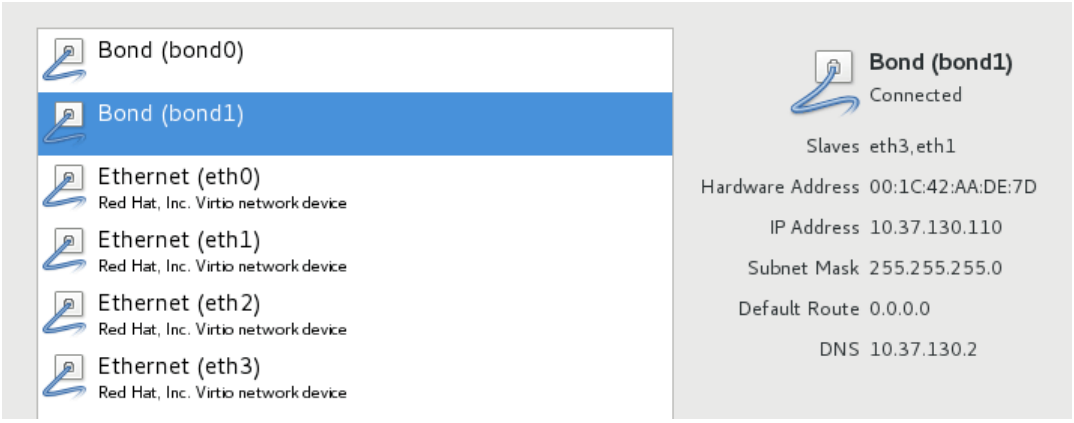
4. In the **Choose a Connection Type** window, select **Ethernet** from the in the drop-down list, and click **Create**.

5. In the **Editing bond slave...** window, select a network interface to bond from the **Device** drop-down list.



6. Configure MTU if required and click **Save**.
7. Repeat steps 3 to 7 for each network interface you need to add to the bonded connection.
8. Configure IPv4/IPv6 settings if required and click **Save**.

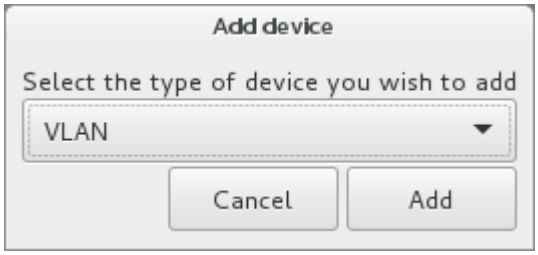
The connection will appear in the list on the **NETWORK & HOSTNAME** screen.



3.4.2 Creating VLAN Adapters

While installing Virtuozzo Infrastructure Platform, you can also create virtual local area network (VLAN) adapters on the basis of physical adapters or bonded connections on the **NETWORK & HOSTNAME** screen as described below.

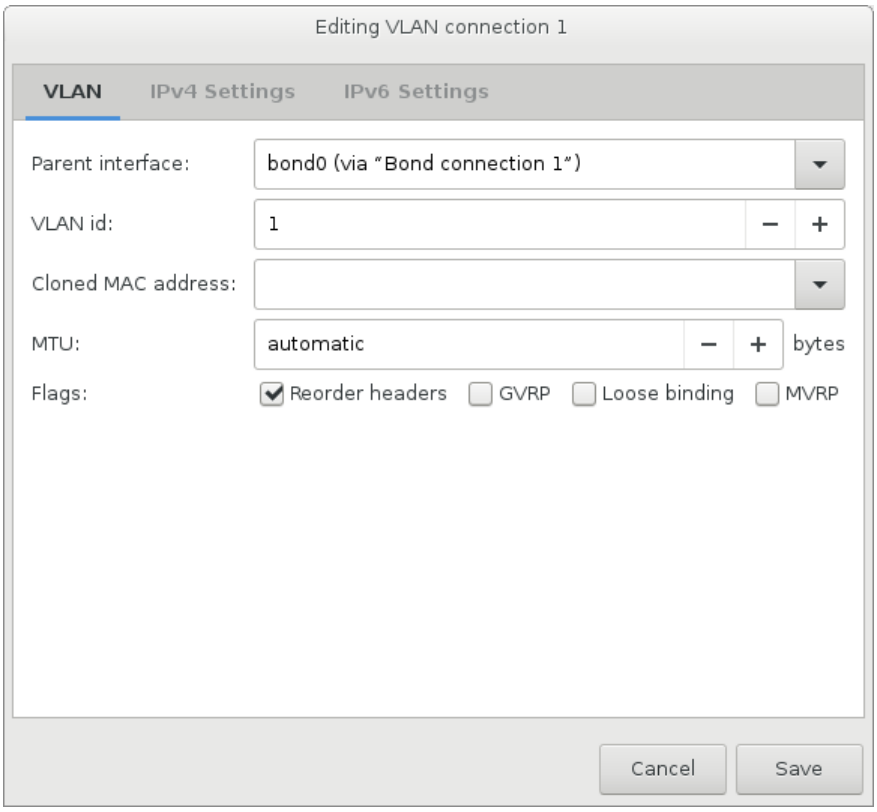
1. To add a new VLAN adapter, click the plus button in the bottom, select **VLAN** from the drop-down list, and click **Add**.



2. In the **Editing VLAN connection...** window:

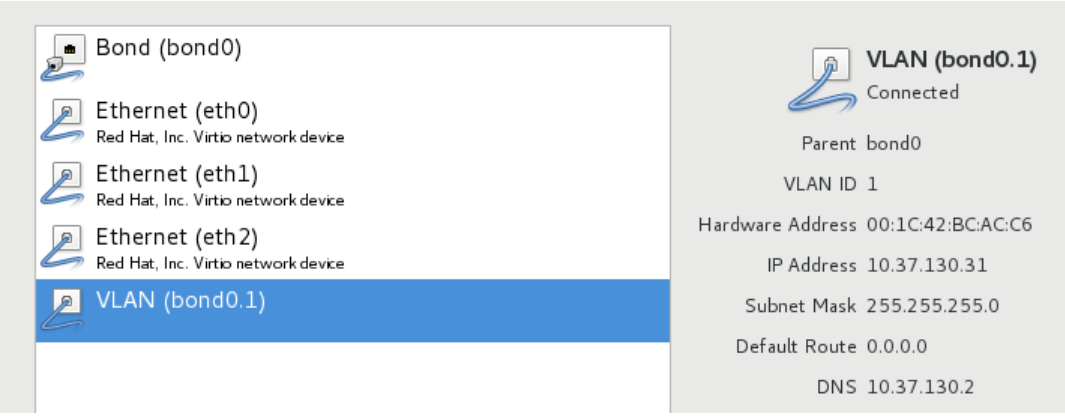
   2.1. Select a physical adapter or bonded connection the VLAN adapter will be based on from the **Parent interface** drop-down list.

   2.2. Specify a VLAN adapter identifier in the **VLAN ID** field. The value must be in the 1-4094 range.



3. Configure IPv4/IPv6 settings if required and click **Save**.

The VLAN adapter will appear in the list on the **NETWORK & HOSTNAME** screen.



3.5 Choosing Components to Install

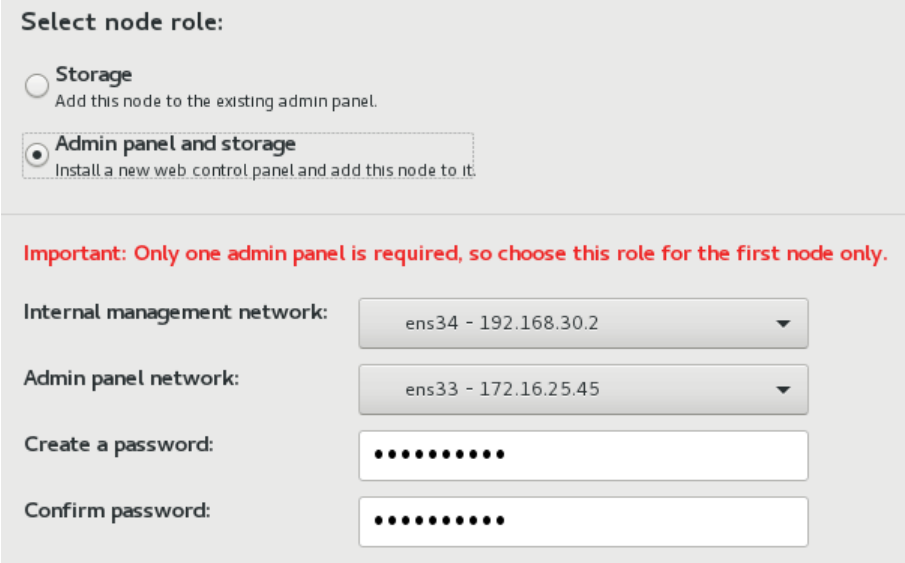
To deploy Virtuozzo Infrastructure Platform, you need to choose components to install on the **VIRTUOZZO INFRASTRUCTURE PLATFORM** screen. You need to deploy a single management+storage node first and then as many storage-only nodes as you want. The detailed instructions are provided in the following sections.

3.5.1 Deploying the Management Node

On the first server, you will need to install the admin panel alongside the storage component.

Do the following on the **VIRTUOZZO INFRASTRUCTURE PLATFORM** screen:

1. Choose **Admin panel and storage**.
2. In the **Internal management network** drop-down list, select a network interface for internal management and configuration purposes.
3. In the **Admin panel network** drop-down list, select a network interface that will provide access to the admin panel.
4. Create a password for the superadmin account of the admin panel and confirm it in the corresponding fields.



5. Click **Done** and proceed to *Selecting Destination Partition* (page 39).

3.5.2 Deploying Storage Nodes

On the second and other servers, you will need to install the **Storage** component only. Such servers will run services related to data storage and will be added to the infrastructure during installation.

For security reasons, you will need to provide a token that can only be obtained from the admin panel you have installed on the first server. A single token can be used to install the storage component on multiple servers in parallel.

To obtain a token:

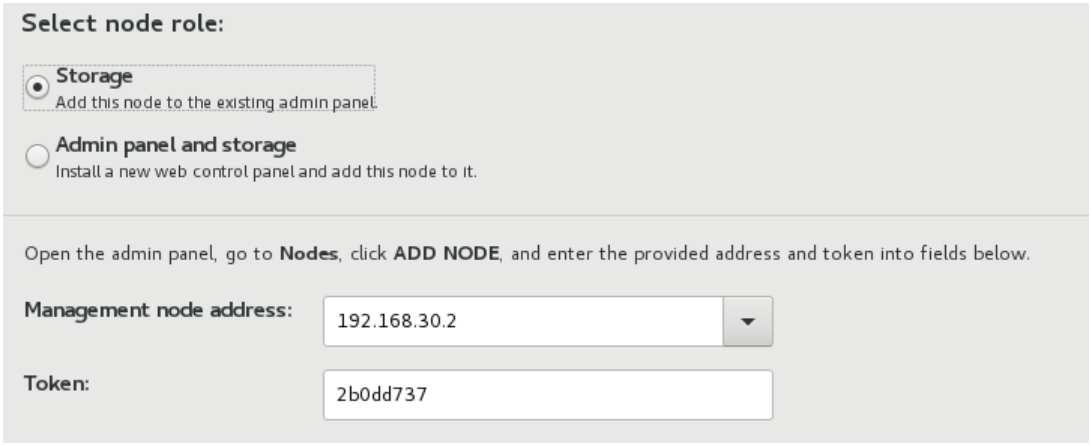
1. Log in to the admin panel: on a computer with access to the admin panel network, open a web browser and visit the management node IP address on port 8888, e.g., https://<management_node_IP_address>:8888. Use the default user name shown on the login screen and the password created during installation.

   If prompted, add the security certificate to browser's exceptions.

2. In the admin panel, you will see the **NODES** screen where the only node will be shown in the **UNASSIGNED** list. Click **ADD NODE** and a screen with instructions on adding storage nodes will appear. On it, a token will be shown (you can generate a new one if needed; generating a new token invalidates the old one).

Having obtained the token, do the following on the **Virtuozzo Infrastructure Platform** screen:

1. Choose **Storage**.
2. In the **Management node address** field, specify the IP address of the management node.
3. In the **Token** field, specify the acquired token.



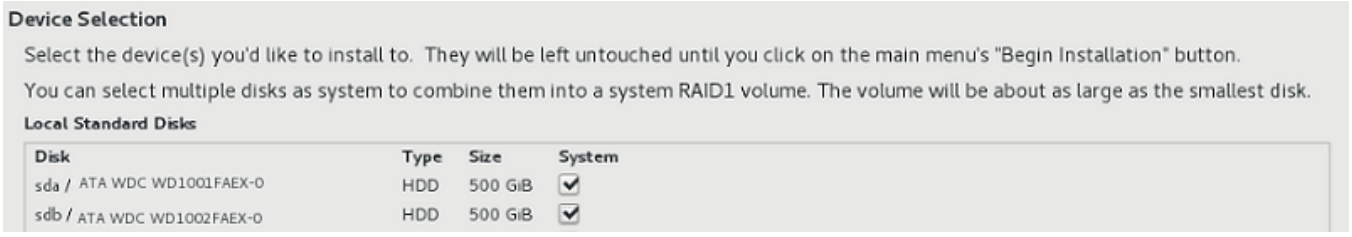
4. Click **Done** and proceed to *Selecting Destination Partition* (page 39).

The node will appear on the **NODES** screen in the **UNASSIGNED** list right after the successful token validation. However, you can join it to the storage cluster only after the installation is complete.

3.6 Selecting Destination Partition

You need to choose a disk for the operating system. This disk will have the supplementary role **System**, although it can still be used for data storage. To choose a system disk, open the **INSTALLATION DESTINATION** screen and select a device in the **Device Selection** section.

You can create software RAID1 for the system disk to ensure its high performance and availability. To do this, select at least two disks as **System**:



It is recommended to create RAID1 from disks of the same size as the volume equals the size of the smallest disk.

3.7 Finishing Installation

Set the remaining options:

- Open the **DATE & TIME** screen and make sure that **Network Time** is enabled so that time on each node is synchronized.
- Open the **EULA** screen and accept the end-user license agreement.
- Open the **ROOT PASSWORD** screen and create a password for node's root account.

Having configured everything necessary on the **INSTALLATION SUMMARY** screen, click **Begin Installation**.

Once the installation is complete, the node will reboot automatically and you will see a welcome prompt with the address of the admin panel.

Your next steps depend on which server you installed Virtuozzo Infrastructure Platform:

- If you installed the management and storage components on the first server, proceed to install the storage component on the second and other servers.
- If you installed the storage component on a server and need to install it on more servers, repeat the installation steps. When on the **Virtuozzo Infrastructure Platform** screen, follow the instructions in *Deploying Storage Nodes* (page 38).
- If you installed the storage component on the last server, log in to the admin panel at https://<management_node_IP_address>:8888, using the default user name shown on the login screen and the password created during installation, and check that all the storage nodes are present in the **UNASSIGNED** list on the **NODES** screen.

With the admin panel ready and with all the nodes present in the **UNASSIGNED** list, you can start managing your infrastructure as described in the *Administrator's Guide*.

CHAPTER 4

Installing Using PXE

This chapter explains how to install Virtuozzo Infrastructure Platform over network using a preboot execution environment (PXE) server.

You will need to do the following:

1. Get the distribution image as described in *Obtaining Distribution Image* (page 31).
2. Set up the TFTP, DHCP, and HTTP (or FTP) servers.
3. Boot the node where you will install Virtuozzo Infrastructure Platform from network and launch the Virtuozzo Infrastructure Platform installer.
4. Set installation options manually or supply them automatically by means of a kickstart file and complete installation.

4.1 Preparing Environment

This section explains how to set up the environment for installation over network.

4.1.1 Installing PXE Components

You will need these components to set up a PXE environment:

- TFTP server. This is a machine that allows your servers to boot and install Virtuozzo Infrastructure Platform over the network. Any machine that can run Linux and is accessble over network can be a TFTP server.
- DHCP server. This is a standard DHCP machine serving TCP/IP settings to computers on your network.

- HTTP server. This is a machine serving Virtuozzo Infrastructure Platform installation files over network.

  You can also share Virtuozzo Infrastructure Platform distribution over network via FTP (e.g., with `vsftpd`) or NFS.

The easiest way is to set up all of these on the same physical machine:

```
# yum install tftp-server syslinux httpd dhcp
```

You can also use servers that already exist in your infrastructure. For example, skip `httpd` and `dhcp` if you already have the HTTP and DHCP servers.

4.1.2 Configuring TFTP Server

This section describes how to configure the TFTP server for BIOS-based systems. For information on how to configure it for installing Virtuozzo Infrastructure Platform on EFI-based systems, see the Red Hat Enterprise Linux Installation Guide.

Do the following:

1. On the server, open the `/etc/xinetd.d/tftp` file, and edit it as follows:

   ```
   service tftp
   {
   disable         = no
   socket_type     = dgram
   protocol        = udp
   wait            = yes
   user            = root
   server          = /usr/sbin/in.tftpd
   server_args     = -v -s /tftpboot
   per_source      = 11
   cps             = 100 2
   flags           = IPv4
   }
   ```

   Once you are done, save the file.

2. Create the `/tftpboot` directory and copy the following files to it: `vmlinuz`, `initrd.img`, `menu.c32`, `pxelinux.0`.

   These files are necessary to start installation. You can find the first two in the `/images/pxeboot` directory of the Virtuozzo Infrastructure Platform distribution. The last two files are located in the `syslinux` directory (usually `/usr/share/syslinux` or `/usr/lib/syslinux`).

3. Create the `/tftpboot/pxelinux.cfg` directory and make the `default` file in it.

```
# mkdir /tftpboot/pxelinux.cfg
# touch /tftpboot/pxelinux.cfg/default
```

4. Add the following lines to `default`:

```
default menu.c32
prompt 0
timeout 100
ontimeout INSTALL
menu title Boot Menu
label INSTALL
        menu label Install
        kernel vmlinuz
        append initrd=initrd.img ip=dhcp
```

   For detailed information on parameters you can specify in this file, see the documentation for `syslinux`.

5. Restart the `xinetd` service:

```
# /etc/init.d/xinetd restart
```

6. If necessary, configure firewall to allow access to the TFTP server (on port 69 by default).

   When running the TFTP server, you might get the "Permission denied" error. In this case, you may try to fix the problem by running the following command: `# restorecon -Rv /tftboot/`.

4.1.3 Setting Up DHCP Server

To set up a DHCP server for installing Virtuozzo Infrastructure Platform over network, add the following strings to the `dhcpd.conf` file, which is usually located in the `/etc` or `/etc/dhcp` directory:

```
next-server <PXE_server_IP_address>;
filename "/pxelinux.0";
```

To configure a DHCP server for installation on EFI-based systems, specify `filename "/bootx64.efi"` instead of `filename "/pxelinux.0"` in the `dhcpd.conf` file, where `/bootx64.efi` is the directory to which you copied the EFI boot images when setting up the TFTP server.

4.1.4 Setting Up HTTP Server

Now that you have set up the TFTP and DHCP servers, you need to make the Virtuozzo Infrastructure Platform distribution files available for installation over the network. To do this:

1. Set up an HTTP server (or configure one you already have).

2. Copy the contents of your Virtuozzo Infrastructure Platform installation DVD to some directory on the HTTP server (e.g., `/var/www/html/distrib`).

3. On the PXE server, open the `/tftpboot/pxelinux.cfg/default` file for editing, and specify the path to the Virtuozzo Infrastructure Platform installation files on the HTTP server.

   For EFI-based systems, the file you need to edit has the name of `/tftpboot/pxelinux.cfg/efidefault` or `/tftpboot/pxelinux.cfg/<PXE_server_IP_address>`.

   Assuming that you have the installation files in the `/var/www/html/distrib` directory on the HTTP server with the IP address of 198.123.123.198 and the `DocumentRoot` directory is set to `/var/www/html`, you can add the following option to the `append` line of the `default` file to make the Virtuozzo Infrastructure Platform files accessible over HTTP:

   ```
   inst.repo=http://198.123.123.198/distrib
   ```

   So your default file should look similar to the following:

   ```
   default menu.c32
   prompt 0
   timeout 100
   ontimeout INSTALL
   menu title Boot Menu
   label INSTALL
           menu label Install
           kernel vmlinuz
           append initrd=initrd.img ip=dhcp inst.repo=http://198.123.123.198/distrib
   ```

4.2 Installing Over the Network

Now that you have prepared all the servers, you can install Virtuozzo Infrastructure Platform over the network:

1. Boot the Virtuozzo Infrastructure Platform server from the network. You should see the **Boot Menu** that you have created.

2. In the boot menu, choose **Install Virtuozzo Infrastructure Platform**.

3. On the main installer screen, set installation options as described in *Installing Using GUI* (page 31) and click **Begin Installation**.

If you want to install Virtuozzo Infrastructure Platform in the unattended mode, you will need to do the following:

1. Create a kickstart file as described in *Creating Kickstart File* (page 45).
2. Add the kickstart file location to the boot menu as explained in *Using Kickstart File* (page 51).
3. Boot the node from network and choose **Install Virtuozzo Infrastructure Platform** in the boot menu.

   Installation should proceed automatically.

4.3 Creating Kickstart File

If you plan to perform an unattended installation of Virtuozzo Infrastructure Platform, you can use a kickstart file. It will automatically supply to the Virtuozzo Infrastructure Platform installer the options you would normally choose by hand. Virtuozzo Infrastructure Platform uses the same kickstart file syntax as Red Hat Enterprise Linux.

The following sections describe options and scripts you will need to include in your kickstart file, provide an example you can start from, and explain how to use the kickstart file you have created.

4.3.1 Kickstart Options

Even though your kickstart file may include any of the standard options used in kickstart files for installing Linux operating systems, it is recommended to use the following options with as few changes as possible. Possible variations may include configuration of network adapters: activation, bonding, and VLAN setup.

Listed below are the mandatory options that you must include in a kickstart file.

`auth --enableshadow --passalgo=sha512`	Specifies authentication options for the Virtuozzo Infrastructure Platform physical server.
`autopart --type=lvm`	Automatically partitions the system disk, which is `sda`. This option must follow `clearpart --all`. Other disks will be partitioned automatically during cluster creation.
`bootloader`	Specifies how the boot loader should be installed.
`clearpart --all`	Removes all partitions from all recognized disks.

> **Warning:** This option will destroy data on all disks that the installer can reach!

`keyboard <layout>`	Sets the system keyboard type.
`lang <lang>`	Sets the language to use during installation and the default language to use on the installed system.
`logvol`	Creates a logical volume for a Logical Volume Management (LVM) group.
`network <options>`	Configures network devices and creates bonds and VLANs.
`raid`	Creates a software RAID volume.
`part`	Creates a partition on the server.
`rootpw --iscrypted <passwd>`	Sets the root password for the server. The value is your password's hash obtained with the algorithm specified in the `--passalgo` parameter. For example, to create a SHA-512 hash of your password, run `python -c 'import crypt; print(crypt.crypt("yourpassword"))'`.
`selinux --disabled`	Disables SElinux, because it prevents virtualization from working correctly.
`services --enabled="chronyd"`	Enables time synchronization via NTP.
`timezone <timezone>`	Sets the system time zone. For a list of time zones, run `timedatectl list-timezones`.
`volgroup`	Creates a Logical Volume Management (LVM) group.
`zerombr`	Initializes disks with invalid partition tables.

> **Warning:** This option will destroy data on all disks that the installer can reach!

4.3.2 Kickstart Scripts

After setting the options, add scripts to the kickstart file that will install the mandatory package group and Storage components.

4.3.2.1 Installing Packages

In the body of the `%packages` script, specify the package group `hci` to be installed on the server:

```
%packages
@^hci
%end
```

4.3.2.2 Installing Admin Panel and Storage

Only one admin panel is required, install it on the first node only. To deploy all other nodes, you will need to obtain a token from a working admin panel. For more information, see the *Choosing Components to Install* (page 37).

To install the admin panel and storage components on the node without exposing the superadmin password and storage token in the kickstart file, do the following:

1. Add the `%addon com_vstorage` script to the kickstart file:

   ```
   %addon com_vstorage --management --bare
   %end
   ```

2. Once the installation is complete, execute the following command on the node to configure the admin panel component:

   ```
   echo <superadmin_password> | /usr/libexec/vstorage-ui-backend/bin/configure-backend.sh \
   -i <private_iface> -x <public_iface>
   ```

   where

   - `<superadmin_password>` is the password of the superadmin account of admin panel,
   - `<private_iface>` is the name of the private network interface (the one you would choose for the management network during attended installation),
   - `<public_iface>` is the name of the public network interface (the one you would choose for the admin panel network during attended installation).

3. Start the admin panel service:

```
# systemctl start vstorage-ui-backend
```

4. If you also installed the storage component on the node, execute the following command:

```
# /usr/libexec/vstorage-ui-agent/bin/register-storage-node.sh -m <management_IP_address>
```

To install the components without running scripts afterwards at the expense of exposing the password and token, specify the interfaces for the public (external) and private (internal) networks and the password for the superadmin account of the admin panel in the kickstart file. For example:

```
%addon com_vstorage --management --internal-iface=<private_iface> \
--external-iface=<public_iface> --password=<password>
%end
```

4.3.2.3 Installing Storage Component Only

The storage component alone, without the admin panel, is installed by default and does not require any scripts in the kickstart file unless you want to specify the token.

If you do not want to expose the token in the kickstart file, run the following command on the node after the installation to register the node in the admin panel:

```
# /usr/libexec/vstorage-ui-agent/bin/register-storage-node.sh -m <MN_IP_address> -t <token>
```

where

- `<token>` is the token that can be obtained in the admin panel,
- `<MN_IP_address>` is the IP address of the private network interface on the node with the admin panel.

To install the storage component without running scripts afterwards at the expense of exposing the token, specify the token and the IP address of the node with the admin panel in the kickstart file. For example:

```
%addon com_vstorage --storage --token=<token> --mgmt-node-addr=<MN_IP_address>
%end
```

4.3.3 Kickstart File Example

Below is an example of kickstart file that you can use to install and configure Virtuozzo Infrastructure Platform in the unattended mode. You can use this file as the basis for creating your own kickstart files.

Important: This kickstart file instructs the installer to erase and automatically partition every disk that it recognizes. Make sure to disconnect any disks with useful data prior to installation.

```
# Use the SHA-512 encryption for user passwords and enable shadow passwords.
auth --enableshadow --passalgo=sha512
# Use the US English keyboard.
keyboard --vckeymap=us --xlayouts='us'
# Use English as the installer language and the default system language.
lang en_US.UTF-8
# Specify the encrypted root password for the node.
rootpw --iscrypted xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
# Disable SELinux.
selinux --disabled
# Enable time synchronization via NTP.
services --enabled="chronyd"
# Set the system time zone.
timezone America/New_York

# Specify a hostname for the node.
network --hostname=<hostname>

# Configure network interfaces via DHCP.
network --device=<iface1> --activate
network --device=<iface2> --activate
# Alternatively, assign static addresses to network interfaces.
#network --device=<iface1> --activate --bootproto=static --ip=<IP_addr> \
#--netmask=<mask> --gateway=<gw> --nameserver=<ns1>[,<ns2>,...]
#network --device=<iface2> --activate --bootproto=static --ip=<IP_addr> \
#--netmask=<mask> --gateway=<gw> --nameserver=<ns1>[,<ns2>,...]

# If needed, uncomment and specify network interfaces to create a bond.
#network --device=bond0 --bondslaves=<iface1>,<iface2> \
#--bondopts=mode=balance-xor,miimon=100,xmit_hash_policy=layer3+4

# Erase all partitions from all recognized disks.
# WARNING: Destroys data on all disks that the installer can reach!
clearpart --all --initlabel
zerombr
# Automatically partition the system disk, which is 'sda'.
autopart --type=lvm

# Install the required packages on the node.
%packages
@^hci
%end

# Uncomment to install the admin panel and storage components.
# Specify an internal interface for the management network and
# an external interface for the admin panel network.
```

```
#%addon com_vstorage --management --internal-iface=eth0 \
#--external-iface=eth1 --password=xxxxxxxxx
#%end

# Uncomment to install the storage component. To register the node,
# specify the token as well as the IP address of the admin panel.
#%addon com_vstorage --storage --token=xxxxxxxxx --mgmt-node-addr=10.37.130.1
#%end
```

4.3.3.1 Creating the System Partition on Software RAID1

To create a system partition on a software RAID1 volume, you will need to do the following instead of using `autopart`:

1. Partition the disks.
2. Create a RAID1 volume.
3. Create swap and root LVM volumes.

It is recommended to create RAID1 from disks of the same size as the volume equals the size of the smallest disk.

The following example for a BIOS-based server partitions the disks `sda` and `sdb`, assembles the software RAID1 array, and creates expandable swap and root LVM volumes:

```
# Create partitions on sda.
part biosboot  --size=1     --ondisk=sda --fstype=biosboot
part raid.sda1 --size=256   --ondisk=sda --fstype=ext4
part raid.sda2 --size=39936 --ondisk=sda --grow
# Create partitions on sdb.
part biosboot   --size=1     --ondisk=sdb --fstype=biosboot
part raid.sdb1  --size=256   --ondisk=sdb --fstype=ext4
part raid.sdb2  --size=39936 --ondisk=sdb --grow
# Create software RAID1 from sda and sdb.
raid /boot --level=RAID1 --device=md0 --fstype=ext4 raid.sda1 raid.sdb1
raid pv.01 --level=RAID1 --device=md1 --fstype=ext4 raid.sda2 raid.sdb2
# Make LVM volumes for swap and root partitions.
volgroup vgsys pv.01
logvol swap --fstype=swap --name=swap --vgname=vgsys --recommended
logvol /    --fstype=ext4 --name=root --vgname=vgsys --size=10240 --grow
# Set the RAID device md0 as the first drive in the BIOS boot order.
bootloader --location=mbr --boot-drive=sda --driveorder=md0
bootloader --location=mbr --boot-drive=sdb --driveorder=md0
```

For installation on EFI-based servers, specify the `/boot/efi` partition instead of `biosboot`.

```
part /boot/efi --size=200 --ondisk={sda|sdb} --fstype=efi
```

4.4 Using Kickstart File

To install Virtuozzo Infrastructure Platform using a kickstart file, you first need to make the kickstart file accessible over the network. To do this:

1. Copy the kickstart file to the same directory on the HTTP server where the Virtuozzo Infrastructure Platform installation files are stored (e.g., to `/var/www/html/astor`).
2. Add the following string to the `/tftpboot/pxelinux.cfg/default` file on the PXE server:

   ```
   inst.ks=<HTTP_server_address>/<path_to_kickstart_file>
   ```

   For EFI-based systems, the file you need to edit has the name of `/tftpboot/pxelinux.cfg/efidefault` or `/tftpboot/pxelinux.cfg/<PXE_server_IP_address>`.

   Assuming that the HTTP server has the IP address of 198.123.123.198, the `DocumentRoot` directory is set to `/var/www/html`, and the full path to your kickstart file on this server is `/var/www/html/astor/ks.cfg`, your `default` file may look like the following:

   ```
   default menu.c32
   prompt 0
   timeout 100
   ontimeout ASTOR
   menu title Boot Menu
   label ASTOR
           menu label Install
           kernel vmlinuz
           append initrd=initrd.img ip=dhcp inst.repo=http://198.123.123.198/astor \
   inst.ks=http://198.123.123.198/astor/ks.cfg
   ```

CHAPTER 5

Additional Installation Modes

This chapter describes additional installation modes that may be of help depending on your needs.

5.1 Installing in Text Mode

To install Virtuozzo Infrastructure Platform in the text mode, boot to the welcome screen and do the following:

1. Select the main installation option and press **E** to start editing it.
2. Add `text` at the end of the line starting with `linux /images/pxeboot/vmlinuz`. For example:

   ```
   linux /images/pxeboot/vmlinuz inst.stage2=hd:LABEL=<ISO_image> quiet ip=dhcp logo.nologo=1 tex
   ```

3. Press **Ctrl+X** to start booting the chosen installation option.
4. When presented with a choice of starting VNC or proceeding to the text mode, press **2**.
5. In the installation menu that is shown, at least do the following: set or confirm the installation source (press **3**), the installation destination (press **6**), and the root password (press **9**), select software to install (press **4**), and accept the EULA (press **5**).
6. Press **b** to begin installation.
7. When installation ends, press **Enter** to reboot.

5.2 Installing via VNC

To install Virtuozzo Infrastructure Platform via VNC, boot to the welcome screen and do the following:

1. Select the main installation option and press **E** to start editing it.
2. Add `text` at the end of the line starting with `linux /images/pxeboot/vmlinuz`. For example:

   ```
   linux /images/pxeboot/vmlinuz inst.stage2=hd:LABEL=<ISO_image> quiet ip=dhcp logo.nologo=1 tex
   ```

3. Press **Ctrl+X** to start booting the chosen installation option.
4. When presented with a choice of starting VNC or proceeding to the text mode, press **1**.
5. Enter a VNC password when offered.
6. In the output that follows, look up the hostname or IP address and VNC port to connect to, e.g., `192.168.0.10:1`.
7. Connect to the address in a VNC client. You will see the usual **Installation Summary** screen.

The installation process itself is the same as in the default graphics mode (see *Installing Using GUI* (page 31)).

CHAPTER 6

Troubleshooting Installation

This chapter describes ways to troubleshoot installation of Virtuozzo Infrastructure Platform.

6.1 Installing in Basic Graphics Mode

If the installer cannot load the correct driver for your graphics card, you can try to install Virtuozzo Infrastructure Platform in the basic graphics mode. To select this mode, on the welcome screen, choose **Troubleshooting–>**, then **Install in basic graphics mode**.

In this mode, however, you may experience issues with the user interface. For example, some of its elements may not fit the screen.

The installation process itself is the same as in the default graphics mode (see *Installing Using GUI* (page 31)).

6.2 Booting into Rescue Mode

If you experience problems with your system, you can boot into the rescue mode to troubleshoot these problems. Once you are in the rescue mode, your Virtuozzo Infrastructure Platform installation is mounted under `/mnt/sysimage`. You can go to this directory and make the necessary changes to your system.

To enter the rescue mode, do the following:

1. Boot your system from the Virtuozzo Infrastructure Platform distribution image.
2. On the welcome screen, click **Troubleshooting–>**, then **Rescue system**.
3. Once Virtuozzo Infrastructure Platform boots into the emergency mode, press **Ctrl+D** to load the

rescue environment.

4. In the rescue environment, you can choose one of the following options:

   - Continue (press **1**): mount the Virtuozzo Infrastructure Platform installation in read and write mode under `/mnt/sysimage`.
   - Read-only mount (press **2**): mount the Virtuozzo Infrastructure Platform installation in read-only mode under `/mnt/sysimage`.
   - Skip to shell (press **3**): load shell, if your file system cannot be mounted; for example, when it is corrupted.
   - Quit (Reboot) (press **4**): reboot the server.

5. Unless you press **4**, a shell prompt will appear. In it, run `chroot /mnt/sysimage` to make the Virtuozzo Infrastructure Platform installation the root environment. Now you can run commands and try to fix the problems you are experiencing.

6. After you fix the problem, run `exit` to exit the chrooted environment, then `reboot` to restart the system.