



Red Hat Openshift Overview

NetApp Solutions

NetApp
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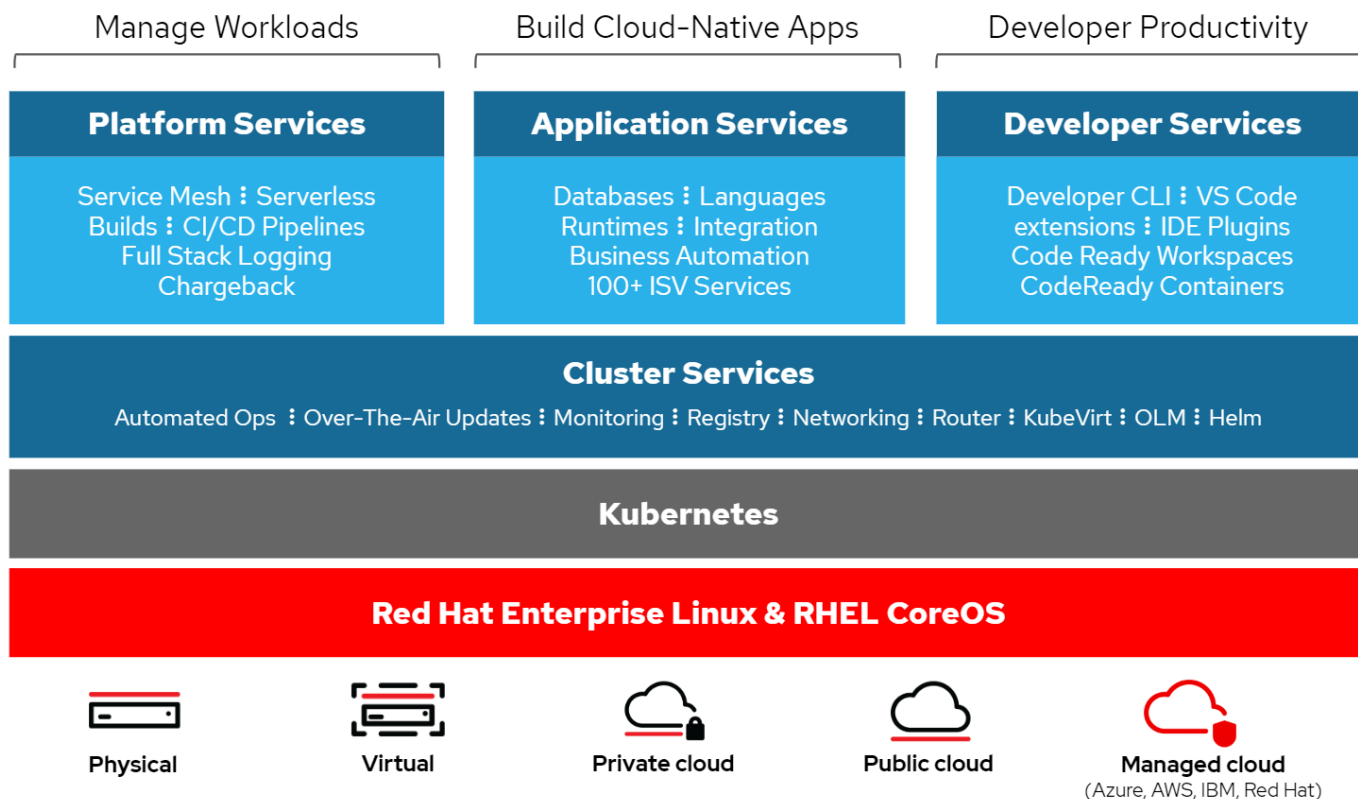
OpenShift Overview: Red Hat OpenShift with NetApp

The Red Hat OpenShift Container Platform unites development and IT operations on a single platform to build, deploy, and manage applications consistently across on-premises and hybrid cloud infrastructures. Red Hat OpenShift is built on open-source innovation and industry standards, including Kubernetes and Red Hat Enterprise Linux CoreOS, the world's leading enterprise Linux distribution designed for container-based workloads. OpenShift is part of the Cloud Native Computing Foundation (CNCF) Certified Kubernetes program, providing portability and interoperability of container workloads.

Red Hat OpenShift provides the following capabilities:

- **Self-service provisioning.** Developers can quickly and easily create applications on demand from the tools that they use most, while operations retain full control over the entire environment.
- **Persistent storage.** By providing support for persistent storage, OpenShift Container Platform allows you to run both stateful applications and cloud-native stateless applications.
- **Continuous integration and continuous development (CI/CD).** This source-code platform manages build and deployment images at scale.
- **Open-source standards.** These standards incorporate the Open Container Initiative (OCI) and Kubernetes for container orchestration, in addition to other open-source technologies. You are not restricted to the technology or to the business roadmap of a specific vendor.
- **CI/CD pipelines.** OpenShift provides out-of-the-box support for CI/CD pipelines so that development teams can automate every step of the application delivery process and make sure it's executed on every change that is made to the code or configuration of the application.
- **Role-Based Access Control (RBAC).** This feature provides team and user tracking to help organize a large developer group.
- **Automated build and deploy.** OpenShift gives developers the option to build their containerized applications or have the platform build the containers from the application source code or even the binaries. The platform then automates deployment of these applications across the infrastructure based on the characteristic that was defined for the applications. For example, how quantity of resources that should be allocated and where on the infrastructure they should be deployed in order for them to be compliant with third-party licenses.
- **Consistent environments.** OpenShift makes sure that the environment provisioned for developers and across the lifecycle of the application is consistent from the operating system, to libraries, runtime version (for example, Java runtime), and even the application runtime in use (for example, tomcat) in order to remove the risks originated from inconsistent environments.
- **Configuration management.** Configuration and sensitive data management is built in to the platform to make sure that a consistent and environment agnostic application configuration is provided to the application no matter which technologies are used to build the application or which environment it is deployed.
- **Application logs and metrics.** Rapid feedback is an important aspect of application development. OpenShift integrated monitoring and log management provides immediate metrics back to developers in order for them to study how the application is behaving across changes and be able to fix issues as early as possible in the application lifecycle.
- **Security and container catalog.** OpenShift offers multitenancy and protects the user from harmful code execution by using established security with Security-Enhanced Linux (SELinux), CGroups, and Secure Computing Mode (seccomp) to isolate and protect containers, encryption through TLS certificates for the various subsystems, and providing access to Red Hat certified containers (access.redhat.com/containers)

that are scanned and graded with a specific emphasis on security to provide certified, trusted, and secure application containers to end users.



Deployment methods for Red Hat OpenShift

Starting with Red Hat OpenShift 4, the deployment methods for OpenShift include manual deployments using User Provisioned Infrastructure (UPI) for highly customized deployments, or fully automated deployments using IPI (Installer Provisioned Infrastructure).

The IPI installation method is the preferred method in most cases because it allows for rapid deployment of OCP clusters for dev, test, and production environments.











IPI installation of Red Hat OpenShift

The Installer Provisioned Infrastructure (IPI) deployment of OpenShift involves these high-level steps:

1. Visit the Red Hat OpenShift [website](#) and login with your SSO credentials.
2. Select the environment that you'd like to deploy Red Hat OpenShift into.

Install OpenShift Container Platform 4

Select an infrastructure provider

| | | | |
|---|--|--|--|
|  Run on Amazon Web Services |  Run on Microsoft Azure |  Run on Google Cloud Platform |  Run on VMware vSphere |
|  Run on Red Hat OpenStack |  Run on Red Hat Virtualization |  Run on Bare Metal |  Run on IBM Z |
|  Run on Power |  Run on Laptop <small>Powered by Red Hat CodeReady Containers</small> | | |


3. On the next screen download the installer, the unique pull secret, the CLI tools for management.

Downloads

OpenShift installer
Download and extract the install program for your operating system and place the file in the directory where you will store the installation configuration files. Note: The OpenShift install program is only available for Linux and macOS at this time.

Linux

Pull secret
Download or copy your pull secret. The install program will prompt you for your pull secret during installation.

 [Copy pull secret](#)

Command-line interface
Download the OpenShift command-line tools and add them to your PATH.

Linux

When the installer is complete you will see the console URL and credentials for accessing your new cluster. A `kubeconfig` file will also be generated for you to use with the `oc` CLI tools you downloaded.

4. Follow the [installation instructions](#) provided by Red Hat to deploy to your environment of choice.

NetApp validated OpenShift deployments

NetApp has tested and validated the deployment of Red Hat OpenShift in it's labs using the IPI (Installer Provisioned Infrastructure) deployment method in each of the following data center environments:

- [OpenShift on Bare Metal](#)
- [OpenShift on Red Hat OpenStack Platform](#)
- [OpenShift on Red Hat Virtualization](#)
- [OpenShift on VMware vSphere](#)

OpenShift on Bare Metal: Red Hat OpenShift with NetApp

OpenShift on Bare Metal provides an automated deployment of OpenShift Container Platform on commodity servers.

Similar to virtual deployments of OpenShift, which are quite popular because they allow for ease of deployment, rapid provisioning, and scaling of OpenShift clusters, while also supplying the need to support virtualized workloads for applications that are not ready to be containerized. By deploying on bare metal, a customer does require the extra overhead in managing the host hypervisor environment, as well as the OpenShift environment. By deploying directly on bare metal servers, the customer can also reduce the physical overhead limitations of having to share resources between the host and OpenShift environment.

OpenShift on Bare Metal provides the following features:

- **IPI or Assisted Installer Deployment** With an OpenShift cluster deployed by Installer Provisioned Infrastructure (IPI) on bare metal servers, customers can deploy an highly versatile, easily scalable OpenShift environment directly on commodity servers, without the need to manage a hypervisor layer.
- **Compact Cluster Design** To minimize the hardware requirements, OpenShift on bare metal allows for users to deploy clusters of just 3 nodes, by enabling the OpenShift control plane nodes to also act as worker nodes and host containers.
- **OpenShift Virtualization** OpenShift can run virtual machines within containers by using OpenShift Virtualization. This container-native virtualization runs the KVM hypervisor inside of a container, and attaches persistent volumes for VM storage.
- **AI/ML-Optimized Infrastructure** Deploy applications like Kubeflow for Machine Learning applications by incorporating GPU-based worker nodes to your OpenShift environment and leverage OpenShift Advanced Scheduling.

Network design

The Red Hat OpenShift on NetApp solution uses two data switches to provide primary data connectivity at 25Gbps. It also uses two additional management switches that provide connectivity at 1Gbps for in-band management for the storage nodes and out-of-band management for IPMI functionality.

The OpenShift bare metal IPI deployment requires the customer to create a Provisioner node, a Red Hat Enterprise Linux 8 machine which will need to have network interfaces attached to separate networks.

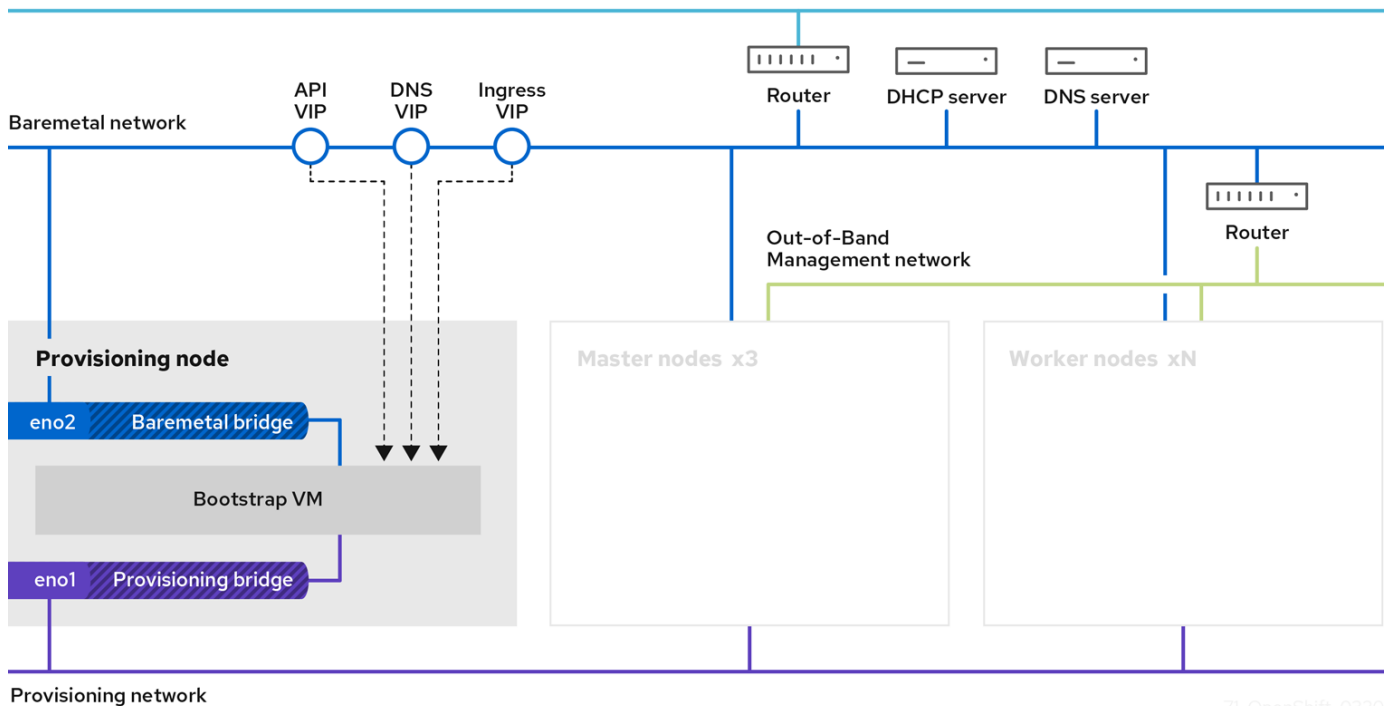
- **Provisioning Network:** This network is used to boot the bare metal nodes and install the necessary images and packages to deploy the OpenShift cluster.
- **Baremetal Network:** This network is used for public facing communication of the cluster once it is deployed.

The setup of the provisioner node will have the customer create bridge interfaces that allow the traffic to route properly on both the node itself, and for the Bootstrap VM which will be provisioned for deployment purposes.

Once the cluster is deployed the API and Ingress VIP addresses are migrated from the bootstrap node to the newly deployed cluster.

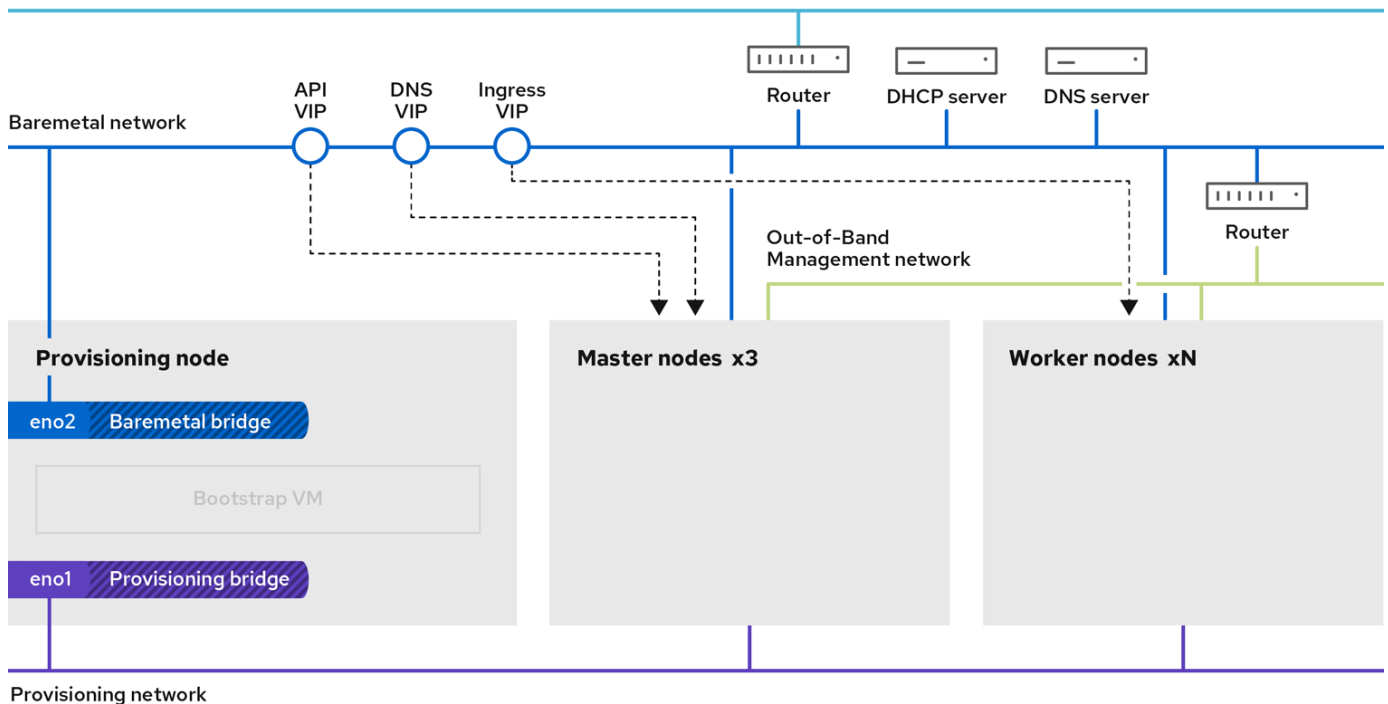
The images below display the environment both during IPI deployment, and once the deployment is complete.

Internet access



7L_OpenShift_0320

Internet access



VLAN requirements

The Red Hat OpenShift with NetApp solution is designed to logically separate network traffic for different purposes by using virtual local area networks (VLANs).

| VLANs | Purpose | VLAN ID |
|--------------------------------|---|---------|
| Out-of-band Management Network | Management for bare metal nodes and IPMI | 16 |
| Bare Metal Network | Network for OpenShift services once cluster is available | 181 |
| Provisioning Network | Network for PXE boot and installation of bare metal nodes via IPI | 3485 |



While each of these networks were virtually separated by VLANs, each physical port needed to be set up in "access mode" with the primary VLAN assigned, as there is no way to pass a VLAN tag during a PXE boot sequence.

Network infrastructure support resources

The following infrastructure should be in place prior to the deployment of the OpenShift Container Platform:

- At least one DNS server which provides a full host-name resolution that is accessible from the in-band management network and the VM network.
- At least one NTP server that is accessible from the in-band management network and the VM network.
- (Optional) Outbound internet connectivity for both the in-band management network and the VM network.

[Next: NetApp Storage Overview.](#)

OpenShift on Red Hat OpenStack Platform: Red Hat OpenShift with NetApp

Red Hat OpenStack Platform delivers an integrated foundation to create, deploy, and scale a secure and reliable private OpenStack cloud.

OSP is an infrastructure-as-a-service (IaaS) cloud implemented by a collection of control services that manage compute, storage, and networking resources. The environment is managed using a web-based interface that allows administrators and users to control, provision, and automate OpenStack resources. Additionally, the OpenStack infrastructure is facilitated through an extensive command line interface and API enabling full automation capabilities for administrators and end-users.

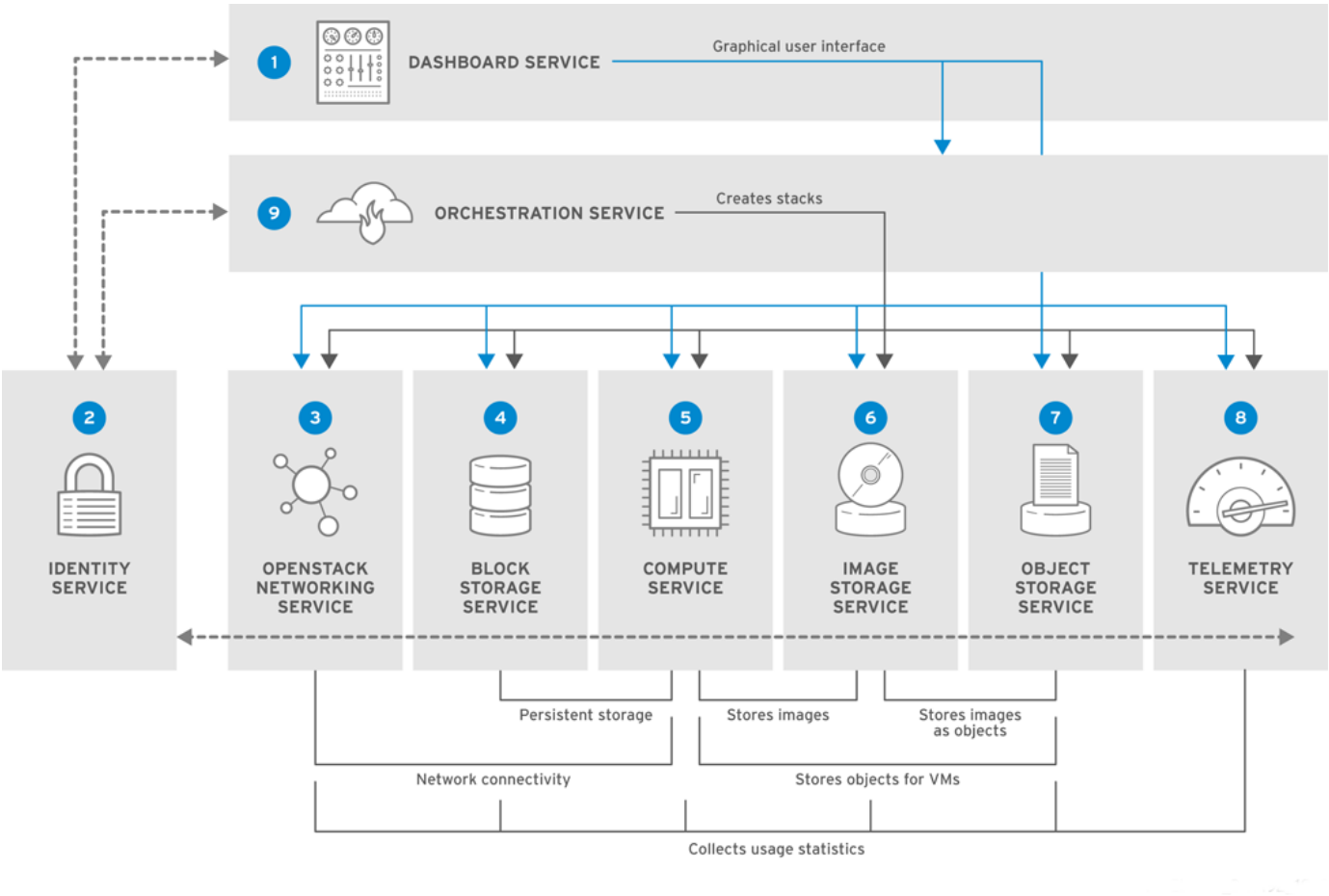
The OpenStack project is a rapidly developed community project, and provides updated releases every six months. Initially Red Hat OpenStack Platform kept pace with this release cycle by publishing a new release along with every upstream release, and providing long term support for every third release. Recently with the OSP 16.0 release (based on OpenStack Train) Red Hat has chosen not to keep pace with release numbers, but instead backport new features into sub-releases. The most recent release is Red Hat OpenStack Platform 16.1, which includes backported advanced features from the Ussuri and Victoria releases upstream.

For more information about OSP see the [Red Hat OpenStack Platform website](#).

OpenStack services

OpenStack Platform services are deployed as containers, which isolates services from one another and enables easy upgrades. The OpenStack Platform uses a set of containers built and managed with Kolla. The

deployment of services is performed by pulling container images from the Red Hat Custom Portal. These service containers are managed using the Podman command, and are deployed, configured, and maintained with Red Hat OpenStack Director.



| Service | Project Name | Description |
|----------------------|--------------|---|
| Dashboard | Horizon | Web browser-based dashboard that you use to manage OpenStack services. |
| Identity | Keystone | Centralized service for authentication and authorization of OpenStack services and for managing users, projects, and roles. |
| OpenStack Networking | Neutron | Provides connectivity between the interfaces of OpenStack services. |
| Block Storage | Cinder | Manages persistent block storage volumes for virtual machines (VMs). |
| Compute | Nova | Manages and provisions VMs running on compute nodes. |
| Image | Glance | Registry service used to store resources such as VM images and volume snapshots. |

| | | |
|----------------|------------|--|
| Object Storage | Swift | Allows users to storage and retrieve files and arbitrary data. |
| Telemetry | Ceilometer | Provides measurements of use of cloud resources. |
| Orchestration | Heat | Template-based orchestration engine that supports automatic creation of resource stacks. |

Network design

The Red Hat OpenShift with NetApp solution uses two data switches to provide primary data connectivity at 25Gbps. It also uses two additional management switches that provide connectivity at 1Gbps for in-band management for the storage nodes and out-of-band management for IPMI functionality.

IPMI functionality is required by Red Hat OpenStack Director to deploy Red Hat OpenStack Platform using the Ironic baremetal provision service.

VLAN requirements

Red Hat OpenShift with NetApp is designed to logically separate network traffic for different purposes by using virtual local area networks (VLANs). This configuration can be scaled to meet customer demands or to provide further isolation for specific network services. The following table lists the VLANs that are required to implement the solution while validating the solution at NetApp.

| VLANs | Purpose | VLAN ID |
|--------------------------------|--|---------|
| Out-of-band Management Network | Network used for management of physical nodes and IPMI service for Ironic. | 16 |
| Storage Infrastructure | Network used for controller nodes to map volumes directly to support infrastructure services like Swift. | 201 |
| Storage Cinder | Network used to map and attach block volumes directly to virtual instances deployed in the environment. | 202 |
| Internal API | Network used for communication between the OpenStack services using API communication, RPC messages, and database communication. | 301 |

| VLANs | Purpose | VLAN ID |
|----------------------------|---|---------|
| Tenant | Neutron provides each tenant with their own networks via tunneling through VXLAN. Network traffic is isolated within each tenant network. Each tenant network has an IP subnet associated with it, and network namespaces mean that multiple tenant networks can use the same address range without causing conflicts | 302 |
| Storage Management | OpenStack Object Storage (Swift) uses this network to synchronize data objects between participating replica nodes. The proxy service acts as the intermediary interface between user requests and the underlying storage layer. The proxy receives incoming requests and locates the necessary replica to retrieve the requested data. | 303 |
| PXE | The OpenStack Director provides PXE boot as a part of the Ironic bare metal provisioning service to orchestrate the installation of the OSP Overcloud. | 3484 |
| External | Publicly available network which hosts the OpenStack Dashboard (Horizon) for graphical management, and allows for public API calls to manage OpenStack services. | 3485 |
| In-band management network | Provides access for system administration functions such as SSH access, DNS traffic, and Network Time Protocol (NTP) traffic. This network also acts as a gateway for non-controller nodes. | 3486 |

Network infrastructure support resources

The following infrastructure should be in place prior to the deployment of the OpenShift Container Platform:

- At least one DNS server which provides a full host-name resolution.
- At least three NTP servers which can keep time synchronized for the servers in the solution.
- (Optional) Outbound internet connectivity for the OpenShift environment.

Best practices for production deployments

This section lists several best practices that an organization should take into consideration before deploying this solution into production.

Deploy OpenShift to an OSP private cloud with at least three compute nodes

The verified architecture described in this document presents the minimum hardware deployment suitable for HA operations by deploying three OSP controller nodes and two OSP compute nodes, and ensuring a fault tolerant configuration where both compute nodes can launch the virtual instances and deployed VMs can migrate between the two hypervisors.

Because Red Hat OpenShift initially deploys with three master nodes, it is ensured in a two-node configuration that at least two masters will occupy the same node, which can lead to a possible outage for OpenShift if that specific node becomes unavailable. Therefore, it is a Red Hat best practice that at least three OSP compute nodes be deployed as part of the solution so that the OpenShift masters can be distributed evenly, and the solution receives an added degree of fault tolerance.

Configure virtual machine/host affinity

Ensuring the distribution of the OpenShift masters across multiple hypervisor nodes can be achieved by enabling VM/host affinity.

Affinity is a way to define rules for a set of VMs and/or hosts that determine whether the VMs run together on the same host or hosts in the group or on different hosts. It is applied to VMs by creating affinity groups that consist of VMs and/or hosts with a set of identical parameters and conditions. Depending on whether the VMs in an affinity group run on the same host or hosts in the group or separately on different hosts, the parameters of the affinity group can define either positive affinity or negative affinity. In Red Hat OpenStack Platform, host affinity and anti-affinity rules can be created and enforced by creating Server Groups and configuring filters so that instances deployed by Nova in a server group deploy on different compute nodes.

A server group has a default maximum of 10 virtual instances that it can manage placement for. This can be modified by updating the default quotas for Nova.



There is a specific hard affinity/anti-affinity limit for OSP Server Groups, where if there not enough resources to deploy on separate nodes, or not enough resources to allow sharing of nodes, the VM will fail to boot.

To configure affinity groups, see [How do I configure Affinity and Anti-Affinity for OpenStack instances?](#).

Use a custom install file for OpenShift deployment

IPI makes the deployment of OpenShift clusters extremely easy through the interactive wizard discussed earlier in this document. However, it is possible that there are some default values that might need to be changed as a part of a cluster deployment.

In these instances, the wizard can be run and tasked without immediately deploying a cluster, but instead outputting a configuration file from which the cluster can be deployed later. This is very useful if any IPI defaults need to be changed, or if a user wants to deploy multiple identical clusters in their environment for other uses such as multitenancy. For more information about creating a customized install configuration for OpenShift, see [Red Hat OpenShift Installing a Cluster on OpenStack with Customizations](#).

[Next: NetApp Storage Overview.](#)

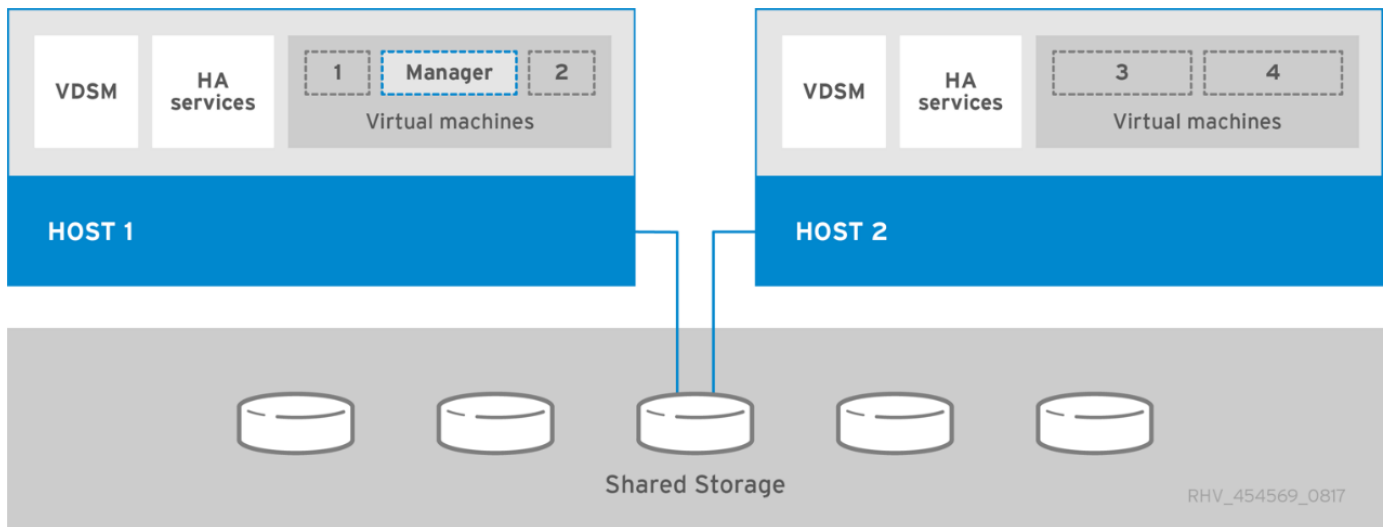
OpenShift on Red Hat Virtualization: Red Hat OpenShift with NetApp

RHV is an enterprise virtual data center platform that runs on Red Hat Enterprise Linux (RHEL) and uses the KVM hypervisor.

For more information about RHV, see the [Red Hat Virtualization website](#).

RHV provides the following features:

- **Centralized management of VMs and hosts.** The RHV manager runs as a physical or virtual machine (VM) in the deployment and provides a web-based GUI for the management of the solution from a central interface.
- **Self-hosted engine.** To minimize the hardware requirements, RHV allows RHV Manager (RHV-M) to be deployed as a VM on the same hosts that run guest VMs.
- **High availability.** In event of host failures, to avoid disruption, RHV allows VMs to be configured for high availability. The highly available VMs are controlled at the cluster level using resiliency policies.
- **High scalability.** A single RHV cluster can have up to 200 hypervisor hosts enabling it to support requirements of massive VMs to hold resource-greedy, enterprise-class workloads.
- **Enhanced security.** Inherited from RHV, Secure Virtualization (sVirt) and Security Enhanced Linux (SELinux) technologies are employed by RHV for the purposes of elevated security and hardening for the hosts and VMs. The key advantage from these features is logical isolation of a VM and its associated resources.



Network design

The Red Hat OpenShift on NetApp solution uses two data switches to provide primary data connectivity at 25Gbps. It also uses two additional management switches that provide connectivity at 1Gbps for in-band management for the storage nodes and out-of-band management for IPMI functionality. OCP uses the Virtual Machine logical network on RHV for its cluster management. This section describes the arrangement and purpose of each virtual network segment used in the solution and outlines the pre-requisites for deployment of the solution.

VLAN requirements

Red Hat OpenShift on RHV is designed to logically separate network traffic for different purposes by using virtual local area networks (VLANs). This configuration can be scaled to meet customer demands or to provide further isolation for specific network services. The following table lists the VLANs that are required to implement the solution while validating the solution at NetApp.

| VLANs | Purpose | VLAN ID |
|--------------------------------|--|---------|
| Out-of-band Management Network | Management for physical nodes and IPMI | 16 |
| VM Network | Virtual Guest Network Access | 1172 |
| In-band Management Network | Management for RHV-H Nodes, RHV-Manager, ovirtmgmt network | 3343 |
| Storage Network | Storage network for NetApp Element iSCSI | 3344 |
| Migration Network | Network for virtual guest migration | 3345 |

Network infrastructure support resources

The following infrastructure should be in place prior to the deployment of the OpenShift Container Platform:

- At least one DNS server which provides a full host-name resolution that is accessible from the in-band management network and the VM network.
- At least one NTP server that is accessible from the in-band management network and the VM network.
- (Optional) Outbound internet connectivity for both the in-band management network and the VM network.

Best practices for production deployments

This section lists several best practices that an organization should take into consideration before deploying this solution into production.

Deploy OpenShift to an RHV cluster of at least three nodes

The verified architecture described in this document presents the minimum hardware deployment suitable for HA operations by deploying two RHV-H hypervisor nodes and ensuring a fault tolerant configuration where both hosts can manage the hosted-engine and deployed VMs can migrate between the two hypervisors.

Because Red Hat OpenShift initially deploys with three master nodes, it is ensured in a two-node configuration that at least two masters will occupy the same node, which can lead to a possible outage for OpenShift if that specific node becomes unavailable. Therefore, it is a Red Hat best practice that at least three RHV-H hypervisor nodes be deployed as part of the solution so that the OpenShift masters can be distributed evenly, and the solution receives an added degree of fault tolerance.

Configure virtual machine/host affinity

You can distribute the OpenShift masters across multiple hypervisor nodes by enabling VM/host affinity.

Affinity is a way to define rules for a set of VMs and/or hosts that determine whether the VMs run together on the same host or hosts in the group or on different hosts. It is applied to VMs by creating affinity groups that consist of VMs and/or hosts with a set of identical parameters and conditions. Depending on whether the VMs

in an affinity group run on the same host or hosts in the group or separately on different hosts, the parameters of the affinity group can define either positive affinity or negative affinity.

The conditions defined for the parameters can be either hard enforcement or soft enforcement. Hard enforcement ensures that the VMs in an affinity group always follows the positive/negative affinity strictly without any regards to external conditions. Soft enforcement, on the other hand, ensures that a higher preference is set out for the VMs in an affinity group to follow the positive/negative affinity whenever feasible. In a two or three hypervisor configuration as described in this document soft affinity is the recommended setting, in larger clusters hard affinity can be relied on to ensure OpenShift nodes are distributed.

To configure affinity groups, see the [Red Hat 6.11. Affinity Groups documentation](#).

Use a custom install file for OpenShift deployment

IPI makes the deployment of OpenShift clusters extremely easy through the interactive wizard discussed earlier in this document. However, it is possible that there are some default values that might need to be changed as a part of a cluster deployment.

In these instances, the wizard can be run and tasked without immediately deploying a cluster, but instead outputting a configuration file from which the cluster can be deployed later. This is very useful if any IPI defaults need to be changed, or if a user wants to deploy multiple identical clusters in their environment for other uses such as multitenancy. For more information about creating a customized install configuration for OpenShift, see [Red Hat OpenShift Installing a Cluster on RHV with Customizations](#).

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OpenShift on VMware vSphere: Red Hat OpenShift with NetApp

VMware vSphere is a virtualization platform for centrally managing a large number of virtualized servers and networks running on the ESXi hypervisor.

For more information about VMware vSphere, see the [VMware vSphere website](#).

VMware vSphere provides the following features:

- **VMware vCenter Server** VMware vCenter Server provides unified management of all hosts and VMs from a single console and aggregates performance monitoring of clusters, hosts, and VMs.
- **VMware vSphere vMotion** VMware vCenter provides for the ability to hot migrate virtual machines between nodes in the cluster, upon user request in non-disruptive manner.
- **vSphere High Availability.** In event of host failures, to avoid disruption, VMware vSphere allows hosts to be clustered and configured for High Availability. VMs that are disrupted by host failure are rebooted shortly on other hosts in the cluster, restoring services.
- **Distributed Resource Scheduler (DRS)** A VMware vSphere cluster can be configured to load balance the resource needs of the VM's it is hosting. Virtual machines with resource contentions can be hot migrated to other nodes in the cluster to ensure that there are enough resources available.



Network design

The Red Hat OpenShift on NetApp solution uses two data switches to provide primary data connectivity at 25Gbps. It also uses two additional management switches that provide connectivity at 1Gbps for in-band management for the storage nodes and out-of-band management for IPMI functionality. OCP uses the Virtual Machine logical network on VMware vSphere for its cluster management. This section describes the arrangement and purpose of each virtual network segment used in the solution and outlines the pre-requisites for deployment of the solution.

VLAN requirements

Red Hat OpenShift on VMware vSphere is designed to logically separate network traffic for different purposes by using virtual local area networks (VLANs). This configuration can be scaled to meet customer demands or to provide further isolation for specific network services. The following table lists the VLANs that are required to implement the solution while validating the solution at NetApp.

| VLANs | Purpose | VLAN ID |
|--------------------------------|--|---------|
| Out-of-band Management Network | Management for physical nodes and IPMI | 16 |
| VM Network | Virtual Guest Network Access | 181 |
| Storage Network | Storage network for ONTAP NFS | 184 |
| Storage Network | Storage network for ONTAP iSCSI | 185 |

| VLANs | Purpose | VLAN ID |
|----------------------------|---|---------|
| In-band Management Network | Management for ESXi Nodes, VCenter Server, ONTAP Select | 3480 |
| Storage Network | Storage network for NetApp Element iSCSI | 3481 |
| Migration Network | Network for virtual guest migration | 3482 |

Network infrastructure support resources

The following infrastructure should be in place prior to the deployment of the OpenShift Container Platform:

- At least one DNS server which provides a full host-name resolution that is accessible from the in-band management network and the VM network.
- At least one NTP server that is accessible from the in-band management network and the VM network.
- (Optional) Outbound internet connectivity for both the in-band management network and the VM network.

Best practices for production deployments

This section lists several best practices that an organization should take into consideration before deploying this solution into production.

Deploy OpenShift to an ESXi cluster of at least three nodes

The verified architecture described in this document presents the minimum hardware deployment suitable for HA operations by deploying two ESXi hypervisor nodes and ensuring a fault tolerant configuration by enabling VMware vSphere HA and VMware vMotion, allowing deployed VMs to migrate between the two hypervisors and reboot should one host become unavailable.

Because Red Hat OpenShift initially deploys with three master nodes, it is ensured in a two-node configuration that at least two masters will occupy the same node, which can lead to a possible outage for OpenShift if that specific node becomes unavailable. Therefore, it is a Red Hat best practice that at least three ESXi hypervisor nodes be deployed as part of the solution so that the OpenShift masters can be distributed evenly, and the solution receives an added degree of fault tolerance.

Configure virtual machine and host affinity

Ensuring the distribution of the OpenShift masters across multiple hypervisor nodes can be achieved by enabling VM/host affinity.

Affinity or Anti-Affinity is a way to define rules for a set of VMs and/or hosts that determine whether the VMs run together on the same host or hosts in the group or on different hosts. It is applied to VMs by creating affinity groups that consist of VMs and/or hosts with a set of identical parameters and conditions. Depending on whether the VMs in an affinity group run on the same host or hosts in the group or separately on different hosts, the parameters of the affinity group can define either positive affinity or negative affinity.

To configure affinity groups, see the [vSphere 6.7 Documentation: Using DRS Affinity Rules](#).

Use a custom install file for OpenShift deployment

IPI makes the deployment of OpenShift clusters extremely easy through the interactive wizard discussed earlier in this document. However, it is possible that there are some default values that might need to be

changed as a part of a cluster deployment.

In these instances, the wizard can be run and tasked without immediately deploying a cluster, but instead outputting a configuration file from which the cluster can be deployed later. This is very useful if any IPI defaults need to be changed, or if a user wants to deploy multiple identical clusters in their environment for other uses such as multitenancy. For more information about creating a customized install configuration for OpenShift, see [Red Hat OpenShift Installing a Cluster on vSphere with Customizations](#).

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