



# **HPE REFERENCE ARCHITECTURE FOR RED HAT OPENSIFT ON HPE PROLIANT DL380 GEN10 AND HPE PROLIANT DL360 GEN10 SERVERS**

Rapid deployment on HPE ProLiant servers using Red Hat OpenShift  
Container Platform 4.6

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## EXECUTIVE SUMMARY

Enterprise organizations across all industries are embarking on a hybrid cloud journey. To support digital transformation, business innovation, and accelerated growth, organizations have certain key goals. Some of the predominant goals include speed, agility, simplicity, consistency, and cost-effectiveness.

However, current IT practices and various incompatible application deployment environment has created challenges for organizations to achieve these objectives. Some of the key challenges are as follows:

- Modernizing legacy apps to take advantage of the latest agile cloud-native innovations are difficult and time-consuming
- Managing workloads in multiple platforms are spanning across hybrid cloud environments is challenging
- Provisioning a new environment is a slow process and can significantly stifle innovation as teams have to wait for the environment to be available
- Vendor lock-in is a real concern and pertains to the use of any proprietary technology, on-premises, or public clouds
- Siloed infrastructure increases overhead costs including administrative overhead in addition to the price of additional infrastructure
- Quickly deploy disconnected and secured end-to-end container platform

To unleash business opportunities through digital transformation, enterprises must overcome these restrictions and adapt to the new concepts and solutions of the next generation IT practices. To accelerate container application delivery, Hewlett Packard Enterprise and Red Hat® are collaborating to optimize Red Hat OpenShift® Container Platform 4.6 on the HPE infrastructure which includes HPE ProLiant DL compute.

This Reference Architecture provides architectural guidance for deploying a Platform as a Service/Container as a Service (PaaS/CaaS) solution based on Red Hat OpenShift Container Platform 4.6 and HPE ProLiant DL servers. The compute and storage requirements can easily be scaled by adding more HPE ProLiant DL servers with no workload downtime.

This Reference Architecture describes how to deploy OCP 4.6 clusters on bare metal HPE ProLiant DL servers, including:

- Setting up HPE ProLiant DL380 Gen10 and HPE ProLiant DL360 Gen10 servers
- To Install and configure Red Hat OpenShift Container Platform
- To Install and configure Red Hat OpenShift Container Storage (internal storage mode or external storage mode)
- Validating the Red Hat OpenShift Container Platform installation
- Significant reduction in the deployment time and efforts through the automated deployment process

The solution demonstrates the cost-effective and yet reliable solution by leveraging the benefits of HPE ProLiant DL servers, HPE Storage system, and Red Hat OpenShift Container Platform 4.6.

**Target audience:** This document is intended for Chief Information Officers (CIOs), Chief Technology Officers (CTOs), data center managers, enterprise architects, and implementation personnel who wish to learn more about Red Hat OpenShift Container Platform 4 on HPE ProLiant DL servers. This document assumes that the target audience is familiar with HPE ProLiant DL servers, Red Hat OpenShift Container Platform 4, solutions, and core networking.

**Document purpose:** The purpose of this document describes the benefits and technical details of deploying Red Hat OpenShift Container Platform 4.6 on HPE ProLiant DL servers, the implementation details, and processes.

## INTRODUCTION

This Reference Architecture provides guidance for installing Red Hat OpenShift Container Platform 4.6 on HPE ProLiant DL380 Gen10 and HPE ProLiant DL360 Gen10 servers. The solution consists of six (6) HPE ProLiant DL servers; three (3) HPE ProLiant DL360 Gen10 servers used for the OCP master nodes, three (3) HPE ProLiant DL380 Gen10 servers are used for the worker nodes (out of which one node will be used as the OCP bootstrap node). Later on, the bootstrap node will be reconfigured as an additional compute node and storage node.

OpenShift Container Storage (OCS) will be installed on the six (6) worker nodes. Each OCS node is equipped with a single SSD drive to be used as the OCS storage device. Optionally, the customer can configure the OCS in external storage mode. For this purpose, six (6) more



HPE ProLiant DL380 Gen10 servers will be required to form a Red Hat Ceph storage cluster. HPE storage system can be used for the External storage mode.

## SOLUTION OVERVIEW

This section provides an overview of Red Hat OpenShift Container Platform 4.6 User Provisioned Infrastructure (UPI) on bare metal HPE ProLiant DL380 Gen10 and HPE ProLiant DL360 Gen10 servers.

Figure 1 shows the high-level architecture of the solution. The storage can be internal or external depending upon the storage requirement. For external mode, a six-node Red Hat Ceph cluster can be set up.

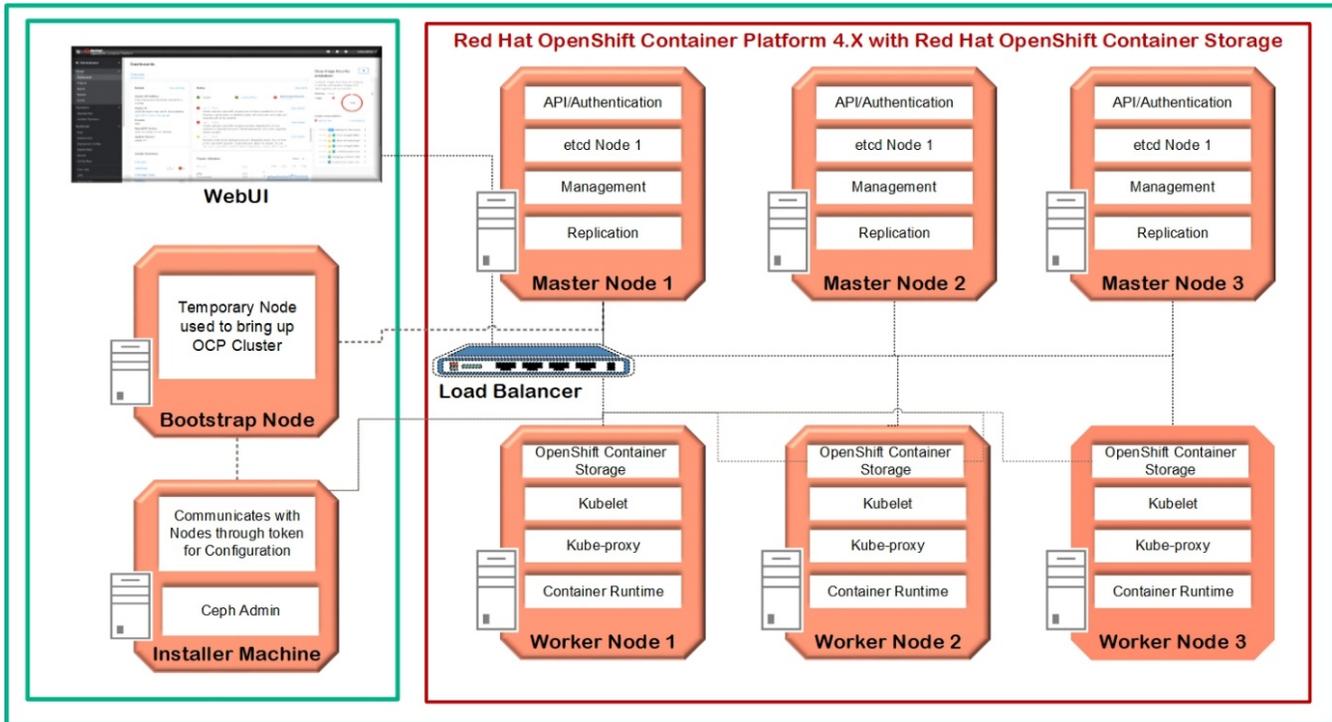


FIGURE 1. Red Hat OpenShift Container Platform 4.X

### NOTE

The number of physical nodes represented in the solution layout is only a basic building block. This is subject to change based on customer requirements.

## SOLUTION LAYOUT

This solution uses the OpenShift User Provisioned Infrastructure method of installation to install Red Hat Linux CoreOS on the HPE ProLiant DL servers and configure the OpenShift cluster

### Physical bare metal configuration

In a bare metal configuration, the master nodes are deployed in a highly available configuration running on three (3) HPE ProLiant DL360 Gen10 computes. Red Hat OpenShift worker nodes are deployed on the bare metal with three (3) HPE ProLiant DL380 Gen10 servers. The temporary bootstrap node is deployed on one of the worker nodes and later on configured as a worker node.

The solution described in this Reference Architecture uses the internal storage on HPE ProLiant DL360 and HPE ProLiant DL380 Gen10 servers. Optionally, three more HPE ProLiant DL380 Gen10 servers can be added as a cluster for the Red Hat Ceph cluster for Red Hat OpenShift Container Storage (OCS) external mode. The deployment environment (Installer machine, iPXE, DNS, DHCP, etc.) and a load balancer



in this solution were deployed on the virtual machines. The OpenShift-installer tool is run to generate ignition files that contain information about the hosts that will be provisioned. The Red Hat Linux CoreOS (RHCOS) for the nodes is then booted with the help of iPXE and the ignition files are passed with the OS image during installation. Optionally HPE Storage systems such as HPE Nimble or HPE 3PAR StoreServ can be leveraged to provide support for persistent container volume.

Figure 2 provides an overview of the Red Hat OpenShift Container Platform 4 solution layout in a bare metal setup configuration.

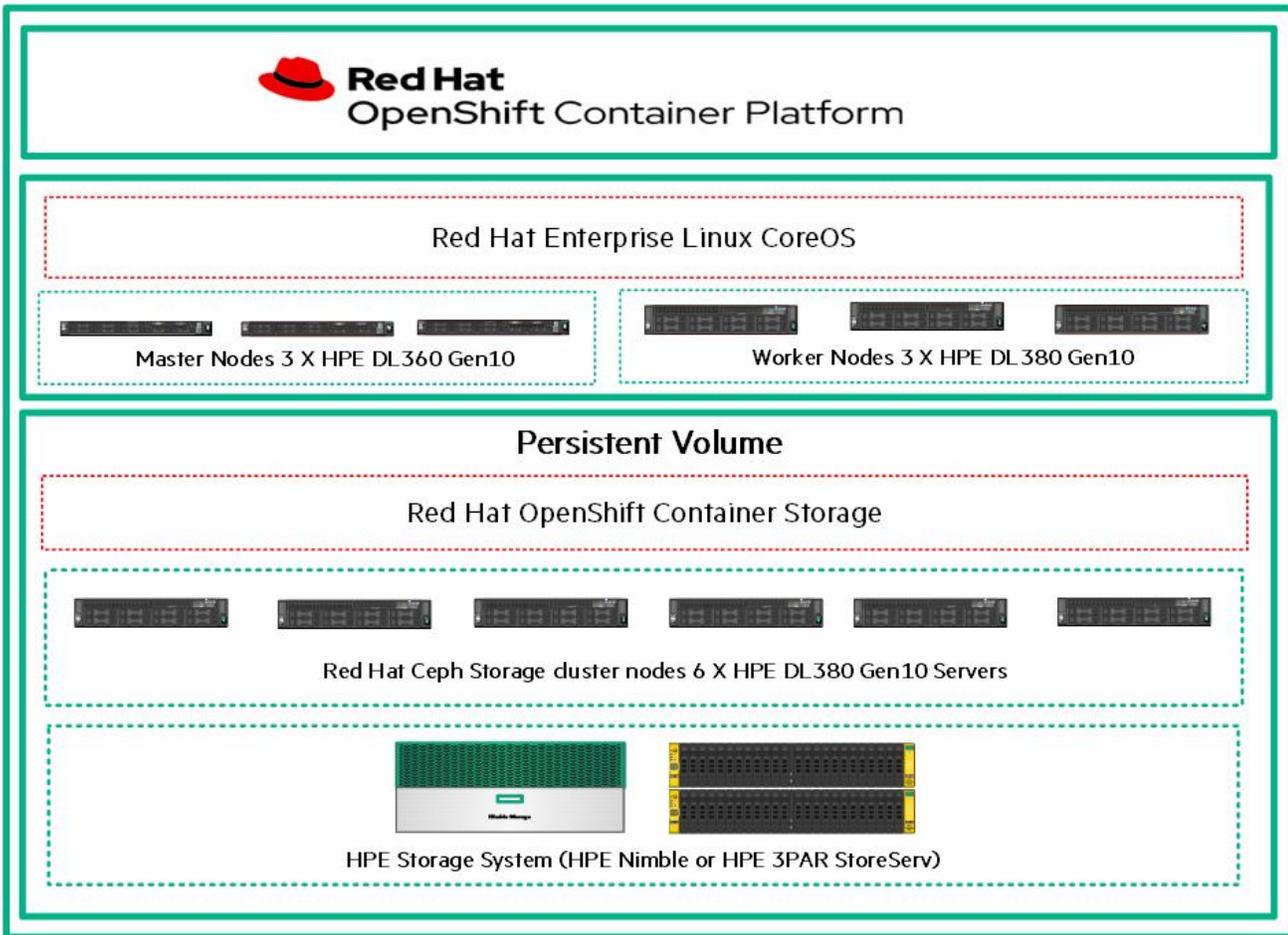


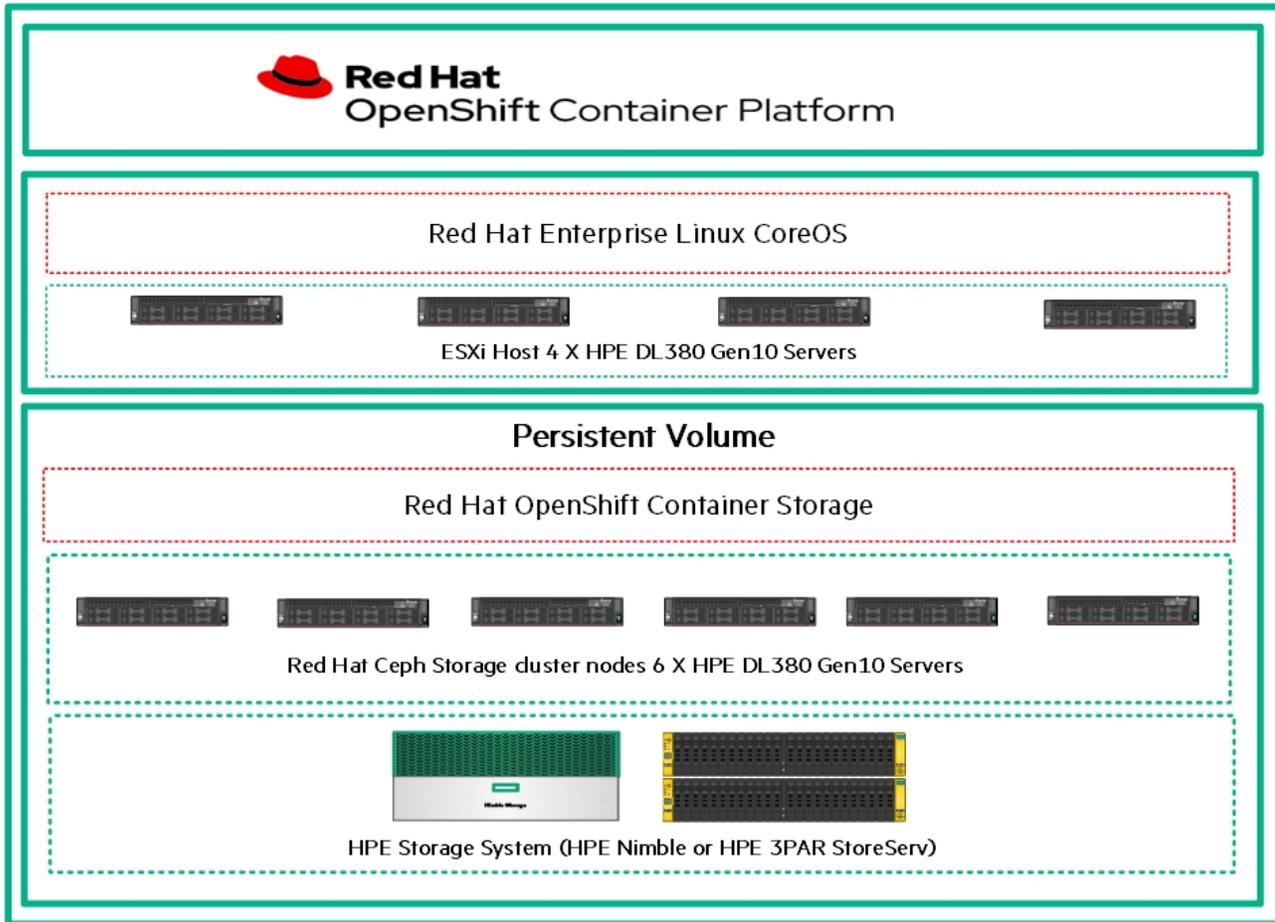
FIGURE 2. Solution Layout – Bare metal setup

**Virtualized configuration**

In a virtualized configuration, the OpenShift master nodes and worker nodes are deployed as VMware vSphere® virtual machines running on three (3) or more HPE ProLiant DL380 Gen10 servers run RHCOS version 4. The OpenShift install tool is run to generate ignition files that contain information about the hosts that will be provisioned. The CoreOS operating system for the nodes is then PXE booted and the ignition files are passed with the OS image during installation.



Figure 3 provides an overview of the Red Hat OpenShift Container Platform 4 solution layout in a virtualized setup configuration.



**FIGURE 3.** Solution Layout – Virtualized setup

The choices available for Persistent Volume storage in the solution are as follows:

- Install Red Hat OpenShift Container Storage (Internal) as pods within OpenShift Container Platform cluster
- Install Red Hat OpenShift Container Storage (External) on OpenShift Container Platform cluster and connect to an external Red Hat Ceph Storage cluster
- Use the [HPE CSI Operator for Kubernetes](#) within OpenShift Container Platform cluster and connect to HPE Nimble or HPE 3PAR Storage Array

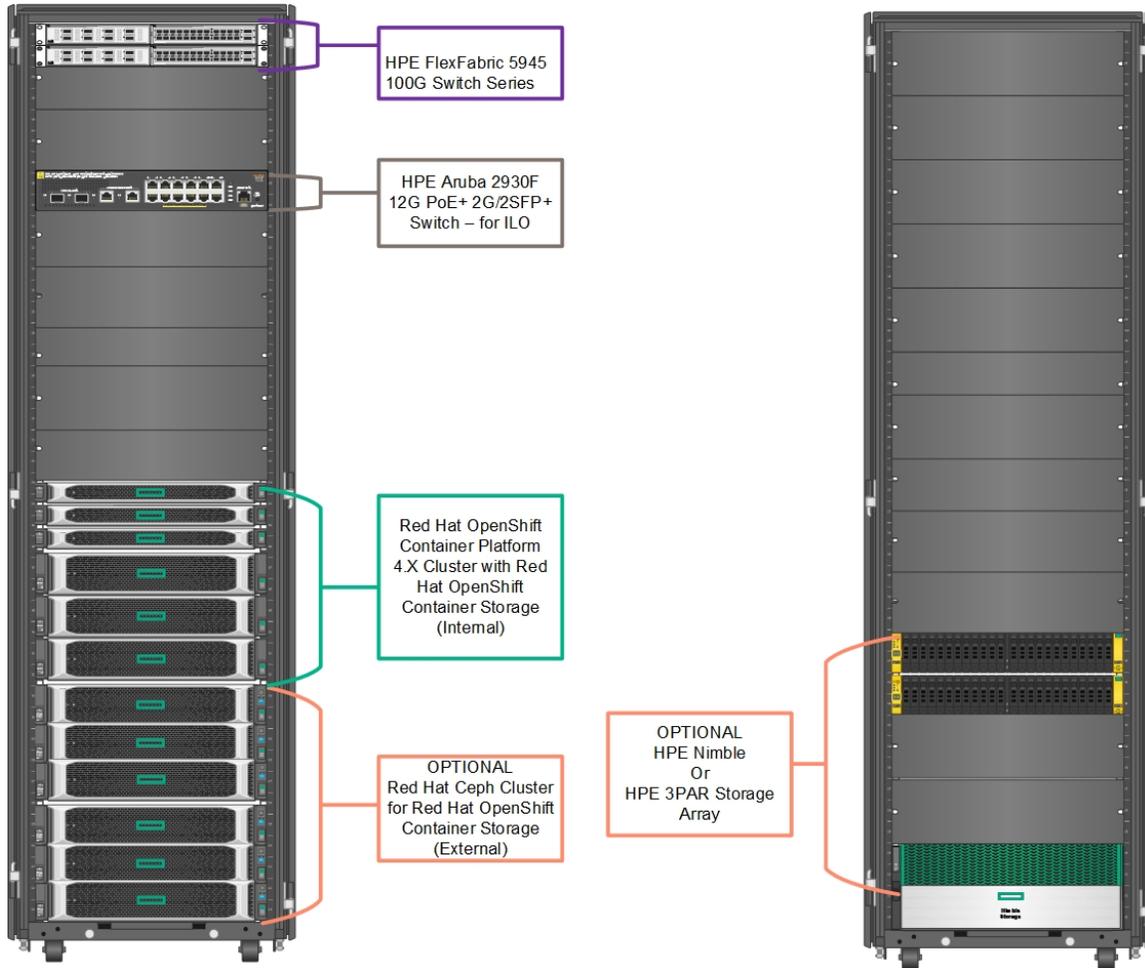
The solution assumes that the following infrastructure services and components are installed, configured, and function properly:

- LDAP or Active Directory (Optional)
- DHCP
- DNS
- NTP
- TFTP
- iPXE



- External Load Balancer

The rack diagram of the hardware components that form the solution is shown here in Figure 4, inside a rack. This figure illustrates the rack view of the HPE ProLiant DL servers deployed in this solution. Additional HPE ProLiant DL360 Gen10 and/or HPE ProLiant DL380 Gen10 servers can be added to the solution as needed. For OpenShift Container Storage external storage mode, which is optional, three (3) more HPE ProLiant DL380 Gen10 servers would be required to set up the Red Hat Ceph storage cluster. Optionally HPE Nimble or HPE 3PAR StoreServ storage can be used for External Persistent volumes using the [HPE CSI Operator for Kubernetes](#).



**FIGURE 4.** Front view of the HPE Rack and Solution Components featuring HPE ProLiant DL360 or HPE ProLiant DL380 servers, HPE Nimble Storage, and Network Switches

**NOTE**

The figure depicts the hardware layout in the test environment. However, this is subject to change based on the customer requirement. For providing Persistent storage for OpenShift Container Platform the customer can choose to either to deploy OCS (internal or external) or optionally persistent volumes storage can be provided either using HPE Nimble or HPE 3PAR StoreServ using HPE CSI driver for Kubernetes.



## SOLUTION COMPONENTS

This section provides the detail of the hardware and software components used in the solution being described.

### Hardware

Table 1 shows the minimum resource requirements for the deployment of OCP 4.6.

**TABLE 1.** Minimum hardware requirement for OCP 4.6 cluster

Node	Operating System	vCPU	Virtual RAM	Storage
Bootstrap node	RHCOS	4	16 GB	120 GB
Control plane or Master nodes	RHCOS	4	16 GB	120GB
Worker nodes	RHCOS	2	8 GB	120GB

The configuration deployed for this solution is described in greater detail in this section.

Table 2 lists the various hardware components used in the solution.

**TABLE 2.** Hardware components utilized in this solution

Component	Qty	Description
HPE ProLiant DL360 Gen10 server	3	OpenShift master and bootstrap/compute node
HPE ProLiant DL380 Gen10 server	3	OpenShift worker nodes
HPE ProLiant DL380 Gen10 server	3	Ceph storage cluster nodes – External storage mode (Optional)
HPE Nimble storage (AF40)	1	External iSCSI storage (Optional – Only for External storage mode)
HPE FlexFabric2-Slot Switch (Aruba 5945 switch)	1	A network switch for datacenter network
HPE Aruba 2930F switch	1	A network switch for iLO Management network
HPE ProLiant DL380 Gen10 server	1	Host the virtual machines for Installer Machine, HAProxy Load balancer (Expected to be available in the customer environment)

**TABLE 3.** Hardware requirement for OCS Storage (External approach)

Node	Operating System	vCPU	RAM	Quantity	Hard Disks	Platform
MON, OSD	RHEL7.7	4	16 GB	3	/dev/sda – os volume /dev/sdb – osd	HPE ProLiant DL380 Gen10
ADMIN	RHEL7.7	4	16 GB	1	/dev/sda – os volume	VM

### Server roles and hardware configuration

Table 4 lists the various server roles and their configuration used in this solution.

**TABLE 4.** Server roles and configuration

Node	Operating System	vCPU	RAM	Storage
Bootstrap node	RHCOS	4	16 GB	Hard Disk 1 : 300 GB
Control plane or Master nodes	RHCOS	8	64 GB	Hard Disk 1 : 300 GB
Worker nodes	RHCOS	16	64 GB	Hard Disk 1 : 300 GB Hard Disk 2 : 300 GB Hard Disk 3 : 2.4 TB
HAProxy (Load Balancer)	RHEL 7	4	16 GB	300 GB



**NOTE**

The HAProxy load balancer was deployed on a virtual machine.

The OpenShift Container Storage (OCS) operator installation will be using the Local Storage operator. OCS provides persistent storage for services including OpenShift, monitoring, logging, and registry, and other container-based applications that require persistent storage.

**HPE ProLiant DL380 Gen10 servers**

The HPE ProLiant DL380 Gen10 server delivers the latest in security, performance, and expandability, backed by a comprehensive warranty. The server is designed securely to reduce costs and complexity, featuring the First and the Second Generation Intel® Xeon® Processor Scalable Family with up to a 60% performance gain and a 27% increase over the previous processor generations.

The HPE ProLiant DL380 Gen10 server has an adaptable chassis, including new HPE modular drive bay configuration options with up to 30 Small Form Factor (SFF), up to 19 Large Form Factor (LFF), or up to 20 NVMe drive options along with support for up to three double-wide GPU options. Along with an embedded 4x1GbE, there is a choice of HPE FlexibleLOM or PCIe standup adapters, which offer a choice of networking bandwidth (1GbE to 40GbE) and fabric that adapt and grow to changing business needs. Also, the HPE ProLiant DL380 Gen10 server comes with a complete set of HPE Technology Services, delivering confidence, reducing risk, and helping customers realize agility and stability.

This section describes the HPE ProLiant DL380 Gen10 servers used in the creation of this solution. Table 5 describes the individual components. Each server was equipped with 192 GB RAM and dual Xeon 2.8GHz 16 Core CPUs. Individual server sizing should be based on customer needs and may not align with the configuration outlined in this document.

The HPE ProLiant DL380 Gen10 servers used in this solution provide a robust platform to run containerized applications. The three (3) HPE ProLiant DL380 Gen10 servers used in this solution are deployed as OpenShift compute nodes and OpenShift Container Storage nodes. One of the HPE ProLiant DL380 servers is initially used as the OpenShift bootstrap node. The bootstrap node provides resources used by the master nodes to create the control plane for the OpenShift cluster. The bootstrap node is a temporary role that is only used during the initial OpenShift cluster installation. After the OpenShift cluster bootstrap process is complete, the bootstrap node can be removed from the cluster and repurposed as an OpenShift compute node. In this Reference Architecture, the bootstrap node is used as one of the three OpenShift Container Storage nodes.

Figure 5 shows the HPE ProLiant DL380 Gen10 server.



**FIGURE 5.** HPE ProLiant DL380 Gen10 server

Table 5 lists the hardware configuration in each of the HPE ProLiant DL380 Gen10 servers used in this solution.

**TABLE 5.** Hardware configuration in each of the HPE ProLiant DL380 Gen10 Server

Component	Description
Processor	2 x Intel Xeon-Gold 6242 (2.8 GHz/16-core/150 W)
Memory	12 x HPE 16GB 2Rx8 PC4-2933V-R Smart Kit



Component	Description
Network	HPE IB FDR/EN 40/50Gb 547FLR 2QSFP Adapter
Array Controller	HPE Smart Array E208i-a SR Gen10 Controller
Disks	HPE 960GB SATA MU SFF SC DS SSD

### HPE iLO

HPE Integrated Lights Out (iLO) is embedded in HPE ProLiant platforms and provides server management that enables faster deployment, simplified lifecycle operations while maintaining end-to-end security thus increasing productivity.

### HPE ProLiant DL360 Gen10 server

The HPE ProLiant DL360 Gen10 server is a secure, performance driven dense server that can be confidently deployed for virtualization, database, or high-performance computing. The HPE ProLiant DL360 Gen10 server delivers security, agility, and flexibility without compromise.

This section describes the HPE ProLiant DL360 Gen10 servers used in the creation of this solution. Each server was equipped with 32GB RAM and dual Xeon 2.3 GHz 16 Core CPUs. Individual server sizing should be based on customer needs and may not align with the configuration outlined in this document.

The HPE ProLiant DL360 Gen10 servers in this Reference Architecture provide the OpenShift control plane and the OpenShift master nodes. The OpenShift master nodes are responsible for the OpenShift cluster health, scheduling, API access, and authentication. The etcd cluster runs on the OpenShift master nodes.

Table 6 lists the components installed in the HPE ProLiant DL360 Gen10 server.

**TABLE 6.** Configuration of each Master Nodes (HPE ProLiant DL360 server)

Component	Description
Processors	2 x Intel Xeon-Gold 5218 (2.3 GHz/16-core/125 W)
Memory	4 x HPE 8GB 1Rx8 PC4-2933V-R Smart Kit
Network	HPE IB FDR/EN 40/50Gb 547FLR 2QSFP Adapter
Array Controller	HPE Smart Array P408i-a SR Gen10 Controller
Disks	HDD1: 300GB HDD 2: 300GB HDD 3: HPE 2.4TB SATA MU SFF SC DS SSD

### HPE FlexFabric 5945 switch

HPE FlexFabric 5945 Switch Series is a family of high-density, ultra-low-latency, and ToR switches that is part of the HPE FlexFabric solution. Ideally suited for deployment at the aggregation or server access layer of large enterprise data centers, the HPE FlexFabric 5945 Switch Series is also powerful enough for deployment at the core layer of medium-sized enterprises. With the increase in virtualized applications and server-to-server traffic, customers require spine and ToR switches that can meet their throughput requirements. With the HPE FlexFabric 5945, data centers can now support up to 100 Gb per port, allowing high-performance server connectivity and the capabilities to handle virtual environments. This is available in the low-latency HPE FlexFabric 5945 Switch Series.



Figure 6 shows the HPE FlexFabric 5945 Switch.



**FIGURE 6.** HPE FlexFabric 5945 switch

### Aruba 2930F Switch

The Aruba 2930F Switch Series is designed for customers creating smart digital workplaces that are optimized for mobile users with an integrated wired and wireless approach. These convenient layer 3 network switches include built-in uplinks and PoE power and are simple to deploy and manage with advanced security and network management tools such as Aruba ClearPass Policy Manager, Aruba AirWave, and cloud-based Aruba Central. A powerful Aruba ProVision ASIC delivers performance, robust feature support, and value with programmability for the latest applications. Stacking with Virtual Switching Framework (VSF) provides simplicity and scalability. The 2930F Switch supports built-in 1GbE or 10GbE uplinks, PoE+, Access OSPF routing, Dynamic Segmentation, robust QoS, RIP routing, and IPv6 with no software licensing required.

Figure 7 shows the Aruba 2930F Switch.



**FIGURE 7.** Aruba 2930F switch

### HPE Nimble Storage

HPE Nimble Storage AF40 is used to provide persistent, block storage in this solution. The HPE Nimble Storage array for Docker data provides the storage volume, to host the repository, to store container images, and to provide persistent volume for applications. Using the HPE-CSI-driver for Kubernetes, HPE Nimble Storage can provide persistent volume for the Kubernetes cluster in this solution. With HPE Nimble Storage, DevOps, IT teams, and others can be assured that their environment exceeds enterprise-grade requirements for supporting backup or protection and disaster recovery of data.

### HPE 3PAR

HPE 3PAR storage provides the world's most intelligent storage for mission-critical apps that provides an on-demand experience for instant access to data and consumable as a service. The HPE 3PAR StoreServ flash-optimized data storage system modernizes the data center to handle unpredictable workloads effortlessly. Some of the other supported features include rapid and automated provisioning, multitenant design, hardware-accelerated deduplication, and compression. HPE 3PAR StoreServ 8440 Storage provides shared and dedicated storage for a variety



of purposes within this solution including housing virtual machines and persistent volume. Using the HPE-CSI-driver for Kubernetes, HPE 3PAR storage can provide persistent volume for the Kubernetes cluster in this solution.

## Software

### Red Hat OpenShift Container Platform

OpenShift Container Platform unites developers and IT operations on a single platform to build, deploy, and manage applications consistently across hybrid cloud and multi-cloud infrastructures. Red Hat OpenShift helps businesses achieve greater value by delivering modern and traditional applications with shorter development cycles and lower operating costs. Red Hat OpenShift is built on open source innovation and industry standards, including Kubernetes and Red Hat Enterprise Linux.

### Red Hat Enterprise Linux CoreOS

Red Hat OpenShift Container Platform uses Red Hat Enterprise Linux® CoreOS (RHCOS), a new container-oriented operating system that combines some of the best features and functions of the CoreOS and Red Hat Atomic Host operating systems. RHCOS is specifically designed for running containerized applications from OpenShift Container Platform and works with new tools to provide fast installation, operator-based management, and simplified upgrades. For OpenShift Container Platform 4.6 deployment on bare metal infrastructure, you must use RHCOS for all control plane machines, Bootstrap node, and worker nodes.

### Red Hat OpenShift Container Storage 4.6

Red Hat OpenShift Container Storage (OCS) is software-defined storage that is optimized for container environments. It runs as an operator on Red Hat OpenShift Container Platform 4 to provide highly integrated and simplified persistent storage management for containers. Red Hat OpenShift Container Storage supports a variety of storage types, including block storage for databases, shared file storage for continuous integration, messaging, and data aggregation, and object storage for archival, backup, and media storage.

Table 7 lists the major software used in this solution.

**TABLE 7.** Software used in this solution

Component	versions
Red Hat CoreOS	4.6
Red Hat OpenShift Container Platform	4.6
Red Hat OpenShift Container Storage	4.6

## CAPACITY AND SIZING

Sizing for a Red Hat OpenShift Container Platform 4 environment varies depending on the requirements of the organization and the type of deployment. The installer should read and understand Red Hat's recommendations around scalability and performance before installation. This ensures the need for their environment is addressed. Red Hat publishes documentation around scalability and performance for each OpenShift Container Platform release. For more information on the documentation for OpenShift Container Platform 4, see [https://docs.openshift.com/container-platform/4.6/scalability\\_and\\_performance/recommended-host-practices.html](https://docs.openshift.com/container-platform/4.6/scalability_and_performance/recommended-host-practices.html).

### Analysis and recommendations

This solution described in this document provides the guidance for deploying the OCP 4.6 cluster with three master nodes and three worker nodes using bare metal HPE ProLiant DL360 and HPE ProLiant DL380 Gen10 servers. However, based on the customer requirements on the workloads or setting up an external cluster, etc. the architecture and the sizing can change.

The solution described in this paper uses the internal storage on HPE ProLiant DL360 and HPE ProLiant DL380 Gen10 servers. Optionally, six more HPE ProLiant DL380 Gen10 servers can be added to the cluster for Red Hat Ceph cluster for Red Hat container external storage. HPE StoreServ or HPE Nimble storage can be used for external storage. Deploying the OCP cluster on bare metal eliminates the overhead associated with hypervisors and thus optimizes performance. Additionally, the use of automation scripts saves significant efforts, resulting in quicker deployment.



## BEST PRACTICES AND CONFIGURATION GUIDANCE FOR THE SOLUTION

This section discusses the high-level cabling, networking, and storage layout of the solution hardware and software.

### Network overview

All the Master and Worker nodes in the OCP cluster shall have the same network as that of the Machine Config Server during boot to fetch ignition files. All the nodes in the cluster need to be assigned an IP address by the DHCP server.

The OCP 4.6 cluster also need to have internet access to perform the following tasks:

- Access the Red Hat OpenShift Cluster Manager page to download the installation program and perform subscription management. If the cluster has internet access and you do not disable Telemetry, that service automatically entitles your cluster
- Access Quay.io to obtain the packages that are required to install your cluster
- Obtain the packages that are required to perform cluster updates

Table 8 lists the various networks used for this solution. All the cluster nodes and iPXE servers are connected on the same twentytnet network. Twentytnet satisfies the network requirements for the deployment of OCP 4.6.

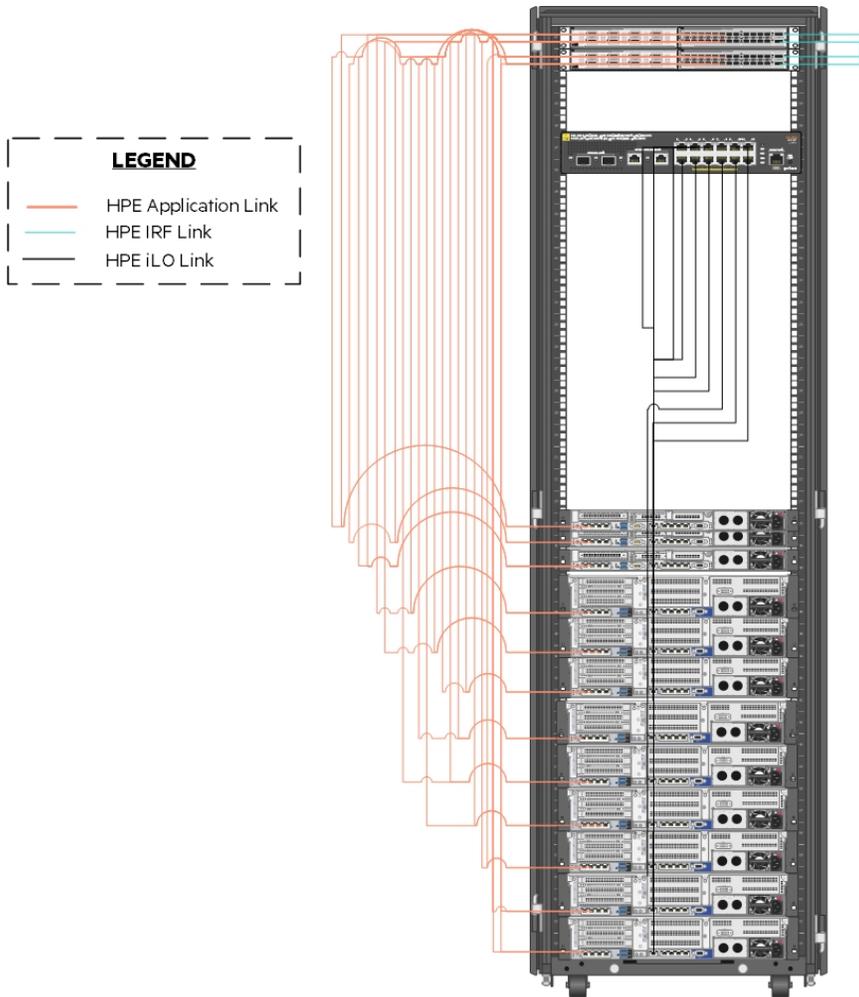
**TABLE 8.** Networks defined for the OCP 4.6

Network Name	Type	VLAN Number	Purpose
Network Name	Type	VLAN Number	Purpose
Management	Ethernet	1193	Solution management
Data_Center	Ethernet	2193	Application access, authentication, and other user networks
iPXE_Boot	Ethernet	2193	Boot for compute
iSCSI_VLAN_A	Ethernet	3193	iSCSI_VLAN_A
iSCSI_VLAN_B	Ethernet	3194	iSCSI_VLAN_B



### Solution cabling

Figure 8 below shows the rack wiring between the compute servers and network switches used in this solution. The various links include iLO management links for servers, IRF links between the network switches, and the internal network links.



**FIGURE 8.** Rack wiring between the Servers and the network switches

### Storage

In the internal storage mode, the storage for the OS and internal persistent volume is provided by the local storage disks (SSD/HDD) on the HPE ProLiant DL360 and/or HPE ProLiant 380 Gen10 servers. Whereas in the external storage mode, the OS storage provided by and the container storage is provided by the HPE storage system such as HPE Nimble or HPE 3PAR or by Red Hat OpenShift Container Platform that uses the local disks.

Table 9 lists all volumes used within the solution for the storage systems and highlights what storage provides the capacity and performance for each function.

**TABLE 9.** Details of the volume

Source	Volume/Disk Function	Hosts	Shared/Dedicated
Local storage on the Servers	OpenShift Container Volume	OpenShift worker nodes	Dedicated
	Operating System	All Nodes	Dedicated



Source	Volume/Disk Function	Hosts	Shared/Dedicated
HPE Nimble or HPE 3PAR (External storage)	iSCSI Persistent Volume	OpenShift worker nodes	Dedicated
HPE ProLiant DL380 Gen10 (External storage OCS)	Ceph Persistent Volume	OpenShift worker nodes	Dedicated

Figure 9 shows the Logical storage layout.

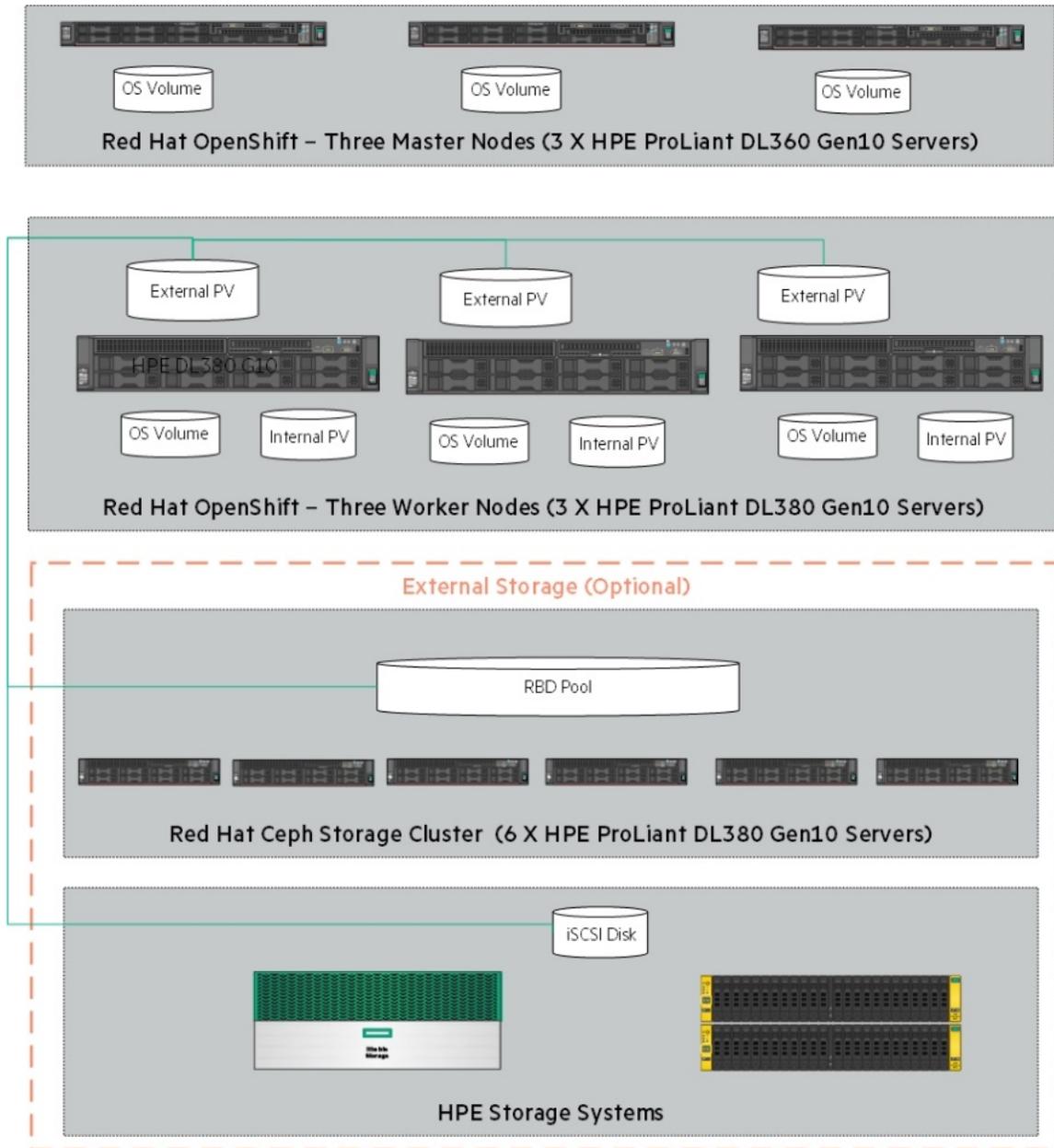


FIGURE 9. Logical storage layout in Solution



## DEPLOYMENT OVERVIEW

This section explains in detail the deployment of OCP 4.6 using both the internal storage mode and external storage mode. In the internal storage mode, the local storage for OS and internal Persistent volume is provided by the local disks on the HPE ProLiant DL360 Gen10 and/or HPE ProLiant DL380 Gen10 servers.

In the external storage mode, a Ceph cluster is set up using six HPE ProLiant DL380 Gen10 servers and integrated with the OCS. The external persistent storage could also be provided by HPE external storage such as HPE Nimble connected through the iSCSI network to the OCP cluster.

### Deploying the OCP 4.6 cluster using the User Provisioned Infrastructure (UPI)

The OpenShift Container Platform UPI deployment is a multi-step process. In this solution, most of the tasks are automated using the Hewlett Packard Enterprise developed automation scripts, whereas few steps need manual intervention to complete the deployment.

The installer machine in the deployment environment uses the openshift-installer program to create RHCOS ignition configuration files. These ignition files include bootstrap ignition file, master ignition file, worker ignition file. The ignition files are used to configure RHCOS on each of the master and worker nodes in the OpenShift cluster. For detailed installation and configuration information, refer to the deployment guide at <https://hewlettpackard.github.io/hpe-solutions-openshift/4.6-dl/>. For the Red Hat OpenShift document, see [https://access.redhat.com/documentation/en-us/openshift\\_container\\_platform/4.6/html/installing\\_on\\_bare\\_metal/installing-on-bare-metal](https://access.redhat.com/documentation/en-us/openshift_container_platform/4.6/html/installing_on_bare_metal/installing-on-bare-metal).

Figure 10 explains the OCP4.6 deployment process.

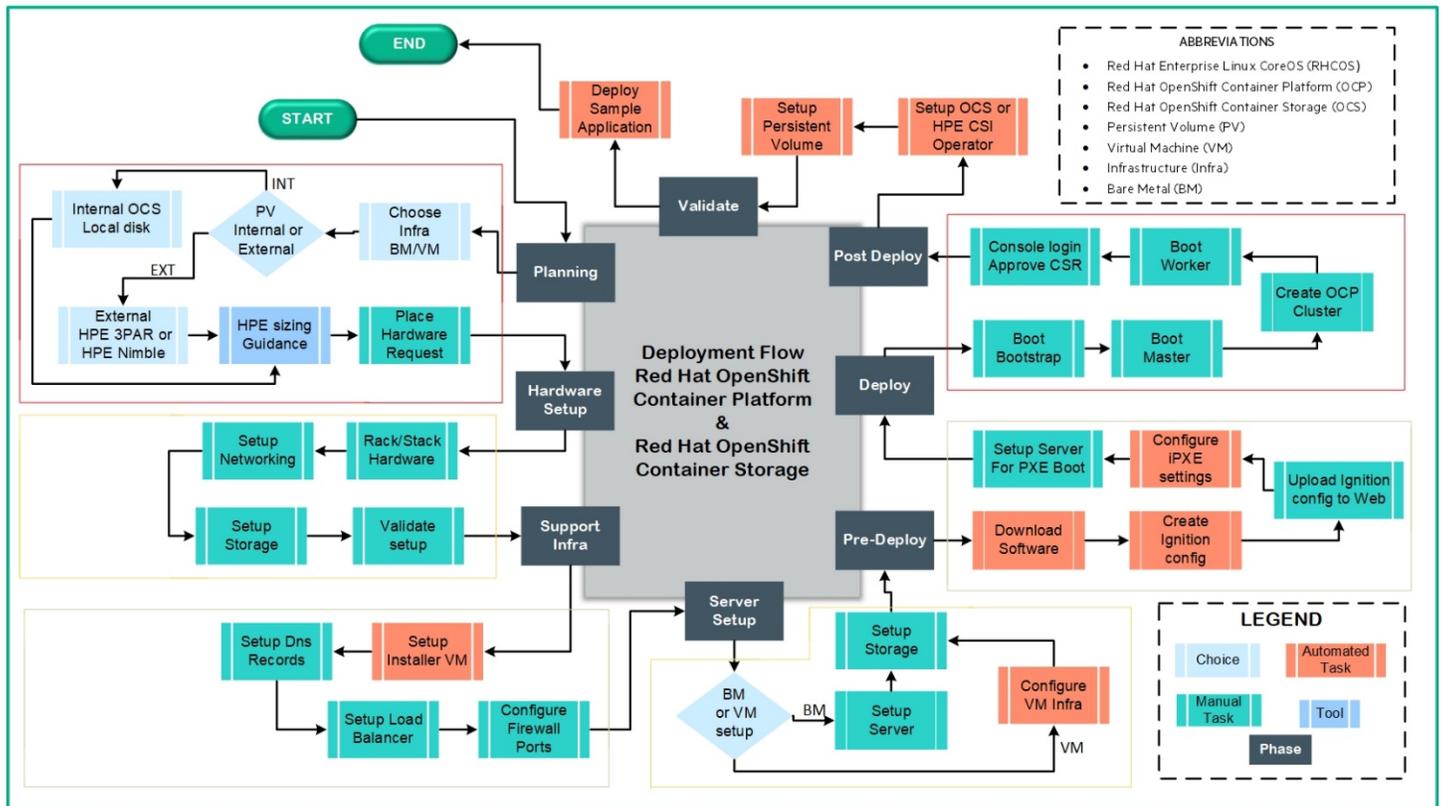


FIGURE 10. Deployment process flow diagram for OCP 4.6 cluster using the User Provisioned Infrastructure

### NOTE

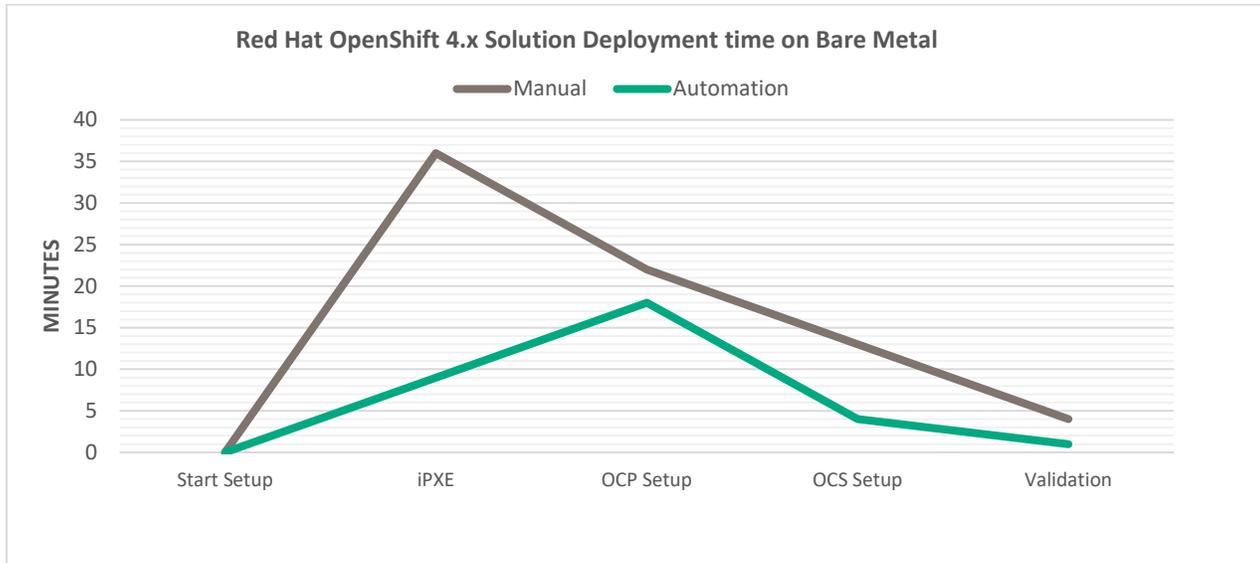
The load balancer described in this document is HAProxy.



**HPE Solution Differentiator with User Provisioned Infrastructure**

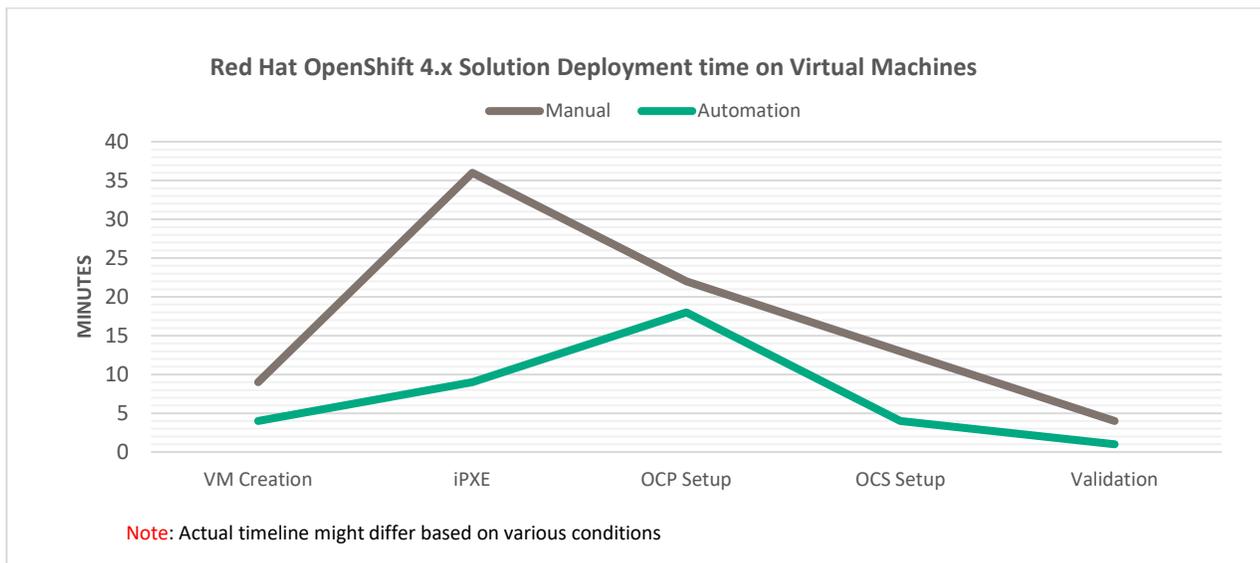
HPE Reference Configuration for Red Hat OpenShift Container Platform 4.6 on HPE DL Servers and HPE Storage systems solution leverages automation scripts to reduce the effort involved in setting up a manual a User Provision Infrastructure based Red Hat OpenShift Container Platform 4 solution. The automation script help saves time and also foster accuracy by decreasing the number of steps involved in setting up the solution. This in turn improves business productivity and promotes an “Idea Economy”, where success is defined by the ability to turn ideas into value faster than the competition.

The graph shown in Figure 11 depicts the graphical time difference in forming a manual vs automated deployment of Red Hat OpenShift Container Platform on bare metal servers using scripts mentioned in this document.



**FIGURE 11.** Red Hat OpenShift 4.x Solution Deployment Manual and Automation timelines on bare metal

The graph shown in Figure 12 depicts the graphical time difference in forming a manual vs automated deployment of Red Hat OpenShift Container Platform on Virtual Machines using scripts mentioned in this document.



**FIGURE 12.** Red Hat OpenShift 4.x Solution Deployment Manual and Automation timelines on Virtual Machines



The graph shown in Figure 13 depicts graphically the steps involved in setting up a manual vs automated deployment of Red Hat OpenShift Container Platform on bare metal using scripts mentioned in this document.

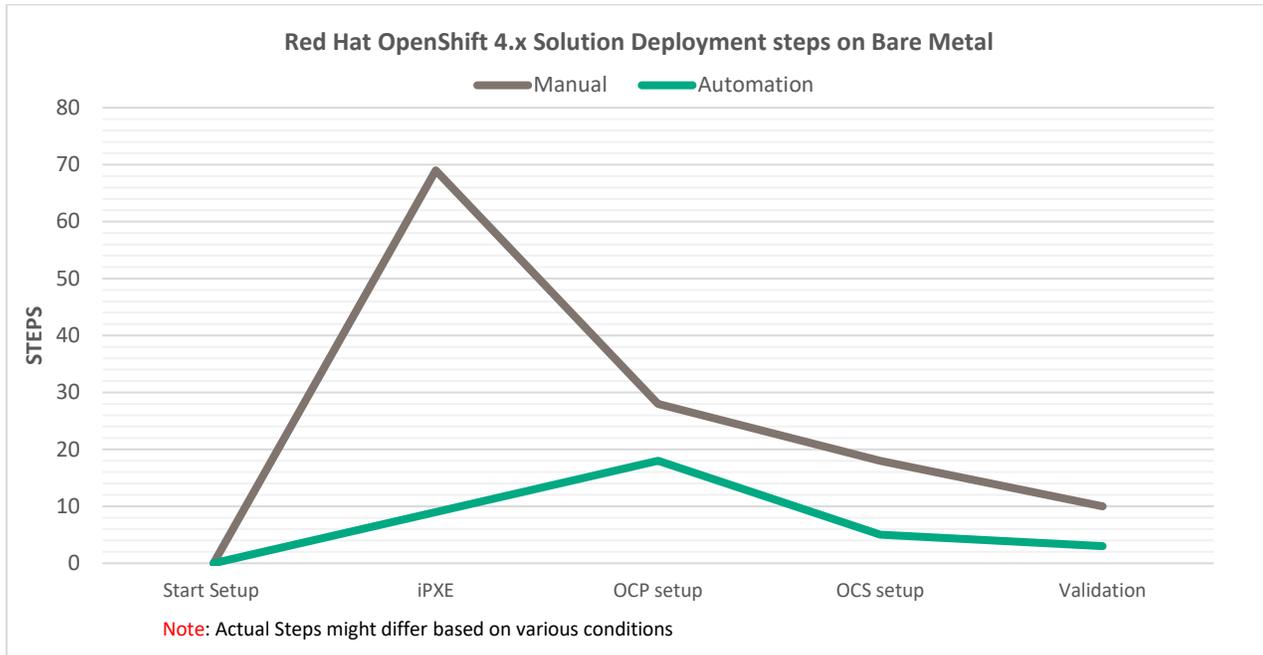


FIGURE 13. Red Hat OpenShift 4.x Solution Deployment Manual and Automation steps on bare metal

The graph shown in Figure 14 depicts graphically the steps involved in setting up a manual vs automated deployment of Red Hat OpenShift Container Platform on Virtual Machines using scripts mentioned in this document.

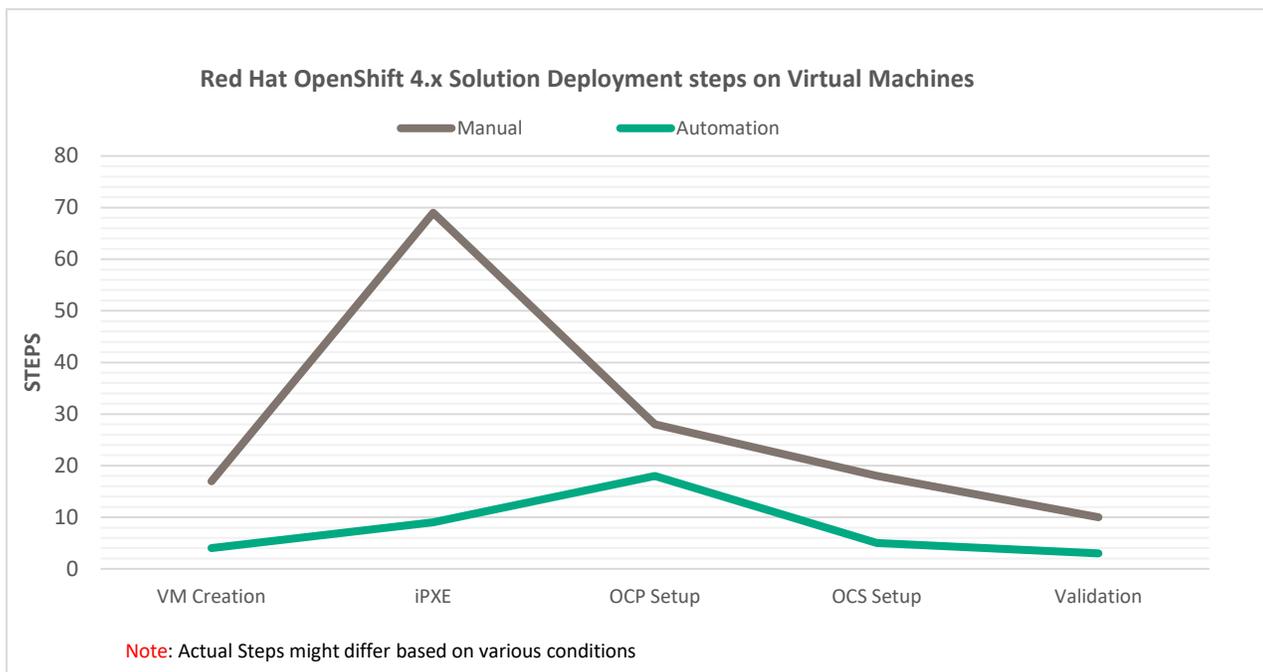


FIGURE 14. Red Hat OpenShift 4.x Solution Deployment Manual and Automation steps on Virtual Machines



The graphs are shown in this section quantify the time saved and the steps reduced in our lab setup. The graph serves as a reference and the time or the steps involved might differ depending on various environmental factors such as Infrastructure complexity, user proficiency with OpenShift, etc. The key is using the automation scripts along with this reference document and deployment guide will ensure improved business productivity.

### Deploying the OCP 4.6 cluster using UPI in a restricted network

A restricted or disconnected network deployment sometimes also referred to as the air-gapped network is a network deployment that has security implemented on one or more network segments within a data center to ensure there is restricted or no network access, to and from unsecured or less secured networks, such as the public Internet or a general local area network. Red Hat OpenShift Container Platform 4.6 can be deployed in such a restricted network on User Provisioned Infrastructure (UPI) only. To set up a restricted network installation, the key is having a registry that mirrors the contents of the OpenShift Container Platform registry on the internet and contains the installation media files required. This registry on a mirror host can be set up on a host that has access to the restricted network. The required files for setting up the mirror registry could be made available using methods such as file copy/transfer that meet the environment restrictions can be followed. Red Hat OpenShift Clusters in restricted networks have the following additional limitations and restrictions:

- The Cluster version status includes an unable to retrieve available updates error
- By default, you cannot use the contents of the Developer Catalog because you cannot access the required ImageStreamTags

Figure 15 shows a high-level solution overview of deploying Red Hat OpenShift 4.6 in a restricted network.

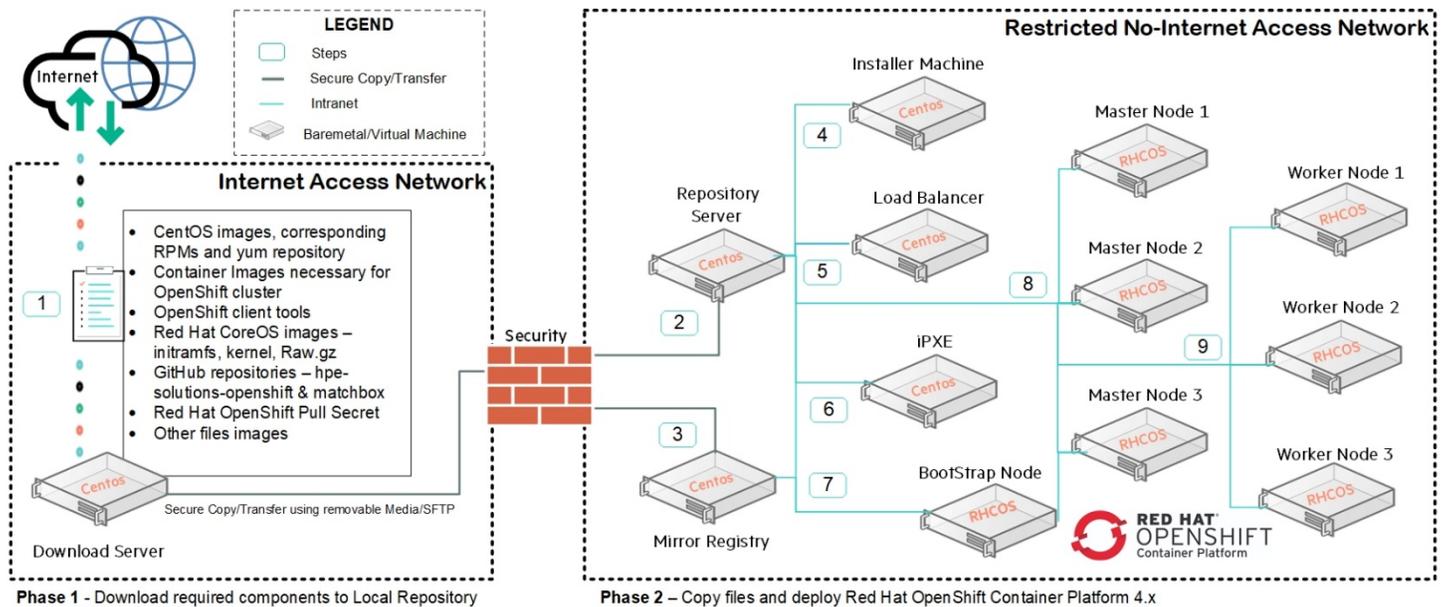


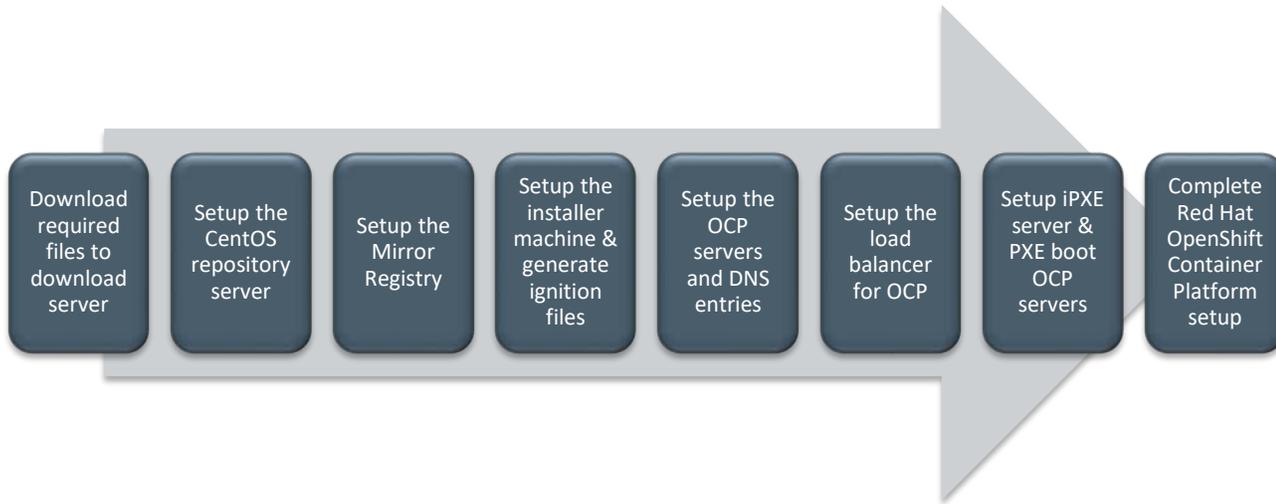
FIGURE 15. Red Hat OpenShift Container Platform deployment in a restricted network – Logical layout

The high-level deployment process is divided into two phases:

- Phase 1 – Download required components to a local repository that has access to the internet
- Phase 2 - Copying/transferring files to a repository server in the restricted network, setting up the registry, and then deploying the OCP



Figure 16 shows a high-level flow for deploying Red Hat OpenShift Container Platform 4.6 in a restricted network.



**FIGURE 16.** Red Hat OpenShift Container Platform deployment in a restricted network – High-level setup flow

For more information, see the [Deployment Guide](#).

### Red Hat OpenShift Container Storage

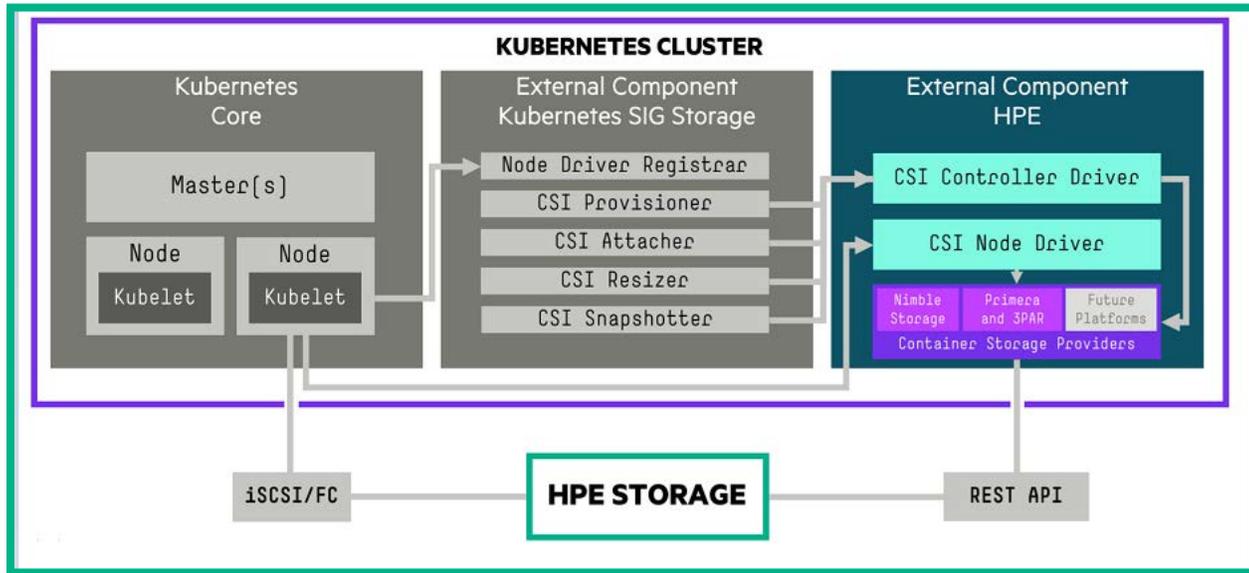
Red Hat OpenShift Container Storage is deployed as an operator with a minimal cluster of six (6) worker nodes. Spread the nodes across three different availability zones to ensure availability. Red Hat OpenShift Container Storage can be set up as the default storage class in the Red Hat OpenShift Container Platform. The OpenShift Container Storage in our test environment was configured on the virtualized set up. The details of OCS configuration and procedure on storage sizing is described in the Deployment guide at <https://hewlettpackard.github.io/hpe-solutions-openshift/46-dl/>.

### HPE Container Storage Interface

The HPE Container Storage Interface (CSI) Driver is a multi-vendor and multi-backend driver where each implementation has a Container Storage Provider (CSP). The HPE CSI Driver allows any vendor or project to develop its own Container Storage Provider by using the CSP specification. This makes it very easy for third parties to integrate their storage solution into Kubernetes as all the intricacies are taken care of by the HPE CSI Driver. The CSI specification includes constructs to manage snapshots as native Kubernetes objects and create new Persistent Volume Claim (PVC) by referencing those objects. Other capabilities include PVC expansion, inline ephemeral volumes, and the ability to present raw block storage to pods.



Figure 17 shows the HPE CSI Driver for Kubernetes architecture.



**FIGURE 17.** HPE CSI driver for Kubernetes architecture

For more information, see [https://scod.hpdev.io/csi\\_driver/index.html](https://scod.hpdev.io/csi_driver/index.html).

### Physical worker node labeling in OpenShift

In this document so far, we have discussed setting up the OCP cluster and then setting up the persistent volume. This is followed by discovering the node properties and advertising them through node labels that can be used to control workload placement in an OpenShift cluster. OpenShift does not label nodes by default with any hardware configuration information. If IT wants to use hardware configuration to optimize scheduling, the capabilities of the underlying platform must be manually uncovered and labeled by administrators to use the hardware configuration in scheduling decisions. An OpenShift cluster can have many nodes. Each node in turn can run multiple pods which, at scale, means that this process is both tedious and error-prone. With OpenShift running on the HPE server platform, organizations can automate the discovery of hardware properties and use that information to schedule workloads that benefit from the different capabilities that the underlying hardware provides. Using HPE iLO and its REST or Redfish® API-based discovery capabilities (Proliantutils), the following properties can be discovered about the nodes:

- Presence of GPUs
- Underlying RAID configurations
- Presence of disk by type
- Persistent-memory availability
- Status of CPU virtualization features
- SR-IOV capabilities
- CPU architecture
- CPU core count
- Platform information including model, iLO, and BIOS versions
- Memory capacity
- UEFI security settings



- Health status of compute, storage, and network components

After these properties are discovered for the physical worker nodes, node labeling can be applied to facilitate grouping nodes based on the underlying features of those hosts. Labels do not provide uniqueness. In general, it is expected that many objects will carry the same label(s). Using a label selector, the administrator can identify a set of objects with similar properties. This labeling can be used as either a hard or soft constraint for scheduling application pods on the desired node based on application requirements. For example, if the compute module in the HPE DL Server Infrastructure must support Intel TXT, which is specifically designed to harden the platform from the emerging threats of hypervisor attacks, malicious rootkit installations, or other software-based attacks. Administrators can use this information to restrict confidential data or sensitive workload to nodes that are better controlled and have their configurations more thoroughly evaluated using the Intel TXT-enabled platform. For more information about node labeling configuration, see the HPE solutions for Red Hat OpenShift GitHub at <https://hewlettpackard.github.io/hpe-solutions-openshift/46-dl/>.

### Securing and monitoring OpenShift with Sysdig SaaS

To address the security challenges that exist in containerized environments, this solution leverages the Sysdig SaaS Platform to secure and monitor the Red Hat OpenShift Container Platform, an enterprise-ready Kubernetes platform that is installed and configured on HPE Compute Infrastructure. After the configuration is deployed, access to the Red Hat OpenShift cluster is granted to the Sysdig SaaS Platform. The Sysdig SaaS Platform is a cloud-based service where the security and monitoring services will be available to the user based on the choice of subscription. For security and monitoring of Red Hat OpenShift Containers, it is required to install the Sysdig Agent on the OpenShift cluster. This means Sysdig Agents that are light-weight entities will be installed within each node in the OpenShift cluster. These agents run as a daemon to enable Sysdig Monitor and Sysdig Secure functionality. Sysdig Monitor provides deep, process-level visibility into a dynamic, distributed production environment. Sysdig Secure provides image scanning, run-time protection, and forensics to identify vulnerabilities, block threats, enforce compliance, and audit activity across an OpenShift cluster.

The key benefits are:

- Faster incident resolution using Sysdig Monitor for OpenShift cluster
- Simplified compliance for the entire solution
- Service-based access control for container security and monitoring
- Less time spent on managing platforms, containers, and vulnerabilities

The implementation of Sysdig in this solution uses the Software as a Service (SaaS) deployment method. The playbooks deploy Sysdig Agent software to capture the data from every node in the OpenShift deployment and the captured data is relayed back to the Sysdig SaaS Cloud portal. The deployment provides access to a 90- day try-and-buy, fully-featured version of the Sysdig software. For more information about Sysdig Agent deployment in the OpenShift setup, see the HPE solutions for Red Hat OpenShift GitHub at <https://hewlettpackard.github.io/hpe-solutions-openshift/46-dl/>.

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#### NOTE

The Sysdig functionality is not turned on by default in this solution. For more information on how to enable Sysdig, see the Sysdig configuration section listed in HPE solutions for Red Hat OpenShift Container Platform GitHub at <https://hewlettpackard.github.io/hpe-solutions-openshift/46-dl/>.

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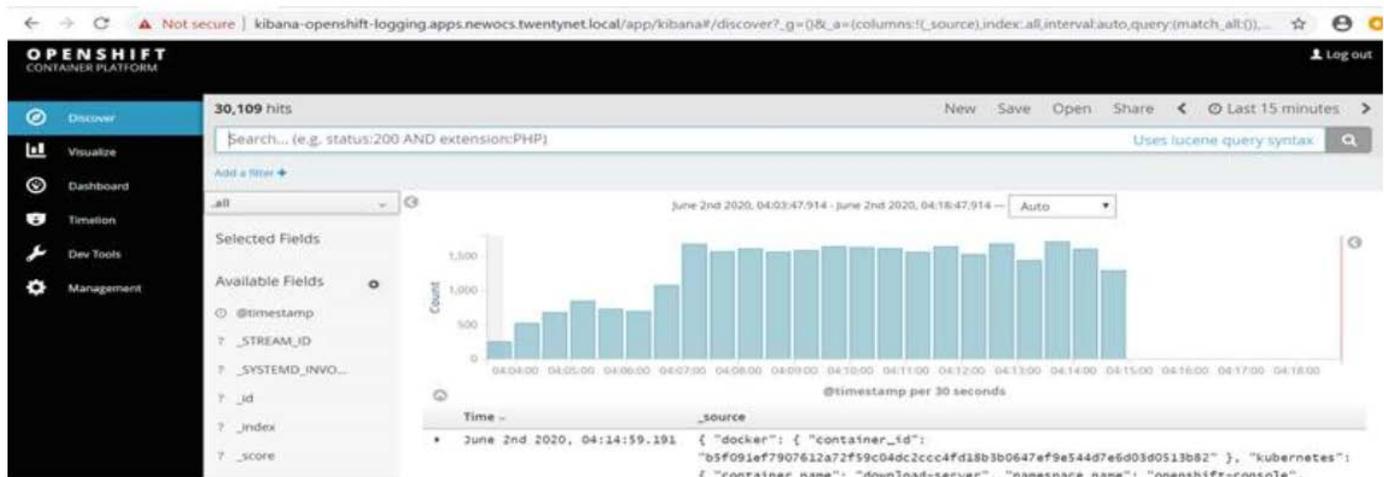
### Post-validation deployment

After the successful deployment of Red Hat OpenShift Container Platform 4 on the identified nodes and access to the OpenShift console is successful, the following are deployed from the operator hub for monitoring the logs of the applications deployed on the cluster.

- Install EFK operators in OCP
- Install the Elasticsearch and Cluster Logging operators (Fluentd and Kibana)
- Install Cluster Logging operator
- Create cluster logging Instance
- Launch Kibana



Figure 18 shows the Kibana Dashboard.



**FIGURE 18.** View of Kibana Dashboard

The details of installation and configuration of EFK operators, cluster operators, Kibana, etc. are described in the Deployment guide at <https://hewlettpackard.github.io/hpe-solutions-openshift/46-dl/>.

## NOTE

Kibana is a browser-based console to query, discover, and visualize your logs through histograms, line graphs, pie charts, heat maps, built-in geospatial support, and other visualizations.

## RED HAT ADVANCED CLUSTER MANAGEMENT FOR KUBERNETES

Red Hat Advanced Cluster Management for Kubernetes provides end-to-end management visibility and control to manage the Kubernetes environment. It allows the administrator to take control of application modernization program with management capabilities for cluster creation, application lifecycle, and provide security and compliance for all of them across data centers and hybrid cloud environments. Clusters and applications are all visible and managed from a single console, with built-in security policies. The administrator can perform day to day operations from anywhere that Red Hat OpenShift runs, and manage any Kubernetes cluster. The following are components for Red Hat Advanced Cluster Management for Kubernetes:

- **Hub cluster** - The hub cluster is the common term that is used to define the central controller that runs in a Red Hat Advanced Cluster Management for the Kubernetes cluster. The hub cluster provides access to the management console. The hub cluster aggregates information from multiple clusters by using an asynchronous work request model.
- **Managed cluster** - The managed cluster is the term that is used to define additional clusters with the Klusterlet, which is the agent that initiates a connection to the Red Hat Advanced Cluster Management for the Kubernetes hub cluster.
- **Cluster lifecycle** - The process of creating, importing, and managing clusters across public and private clouds from the hub cluster console.
- **Application lifecycle** - The processes that are used to manage application resources on managed clusters.
- **Governance and risk** - The processes that are used to manage security and compliance from a central interface page.

Figure 19 shows an overview of the Red Hat Advanced Cluster Management.

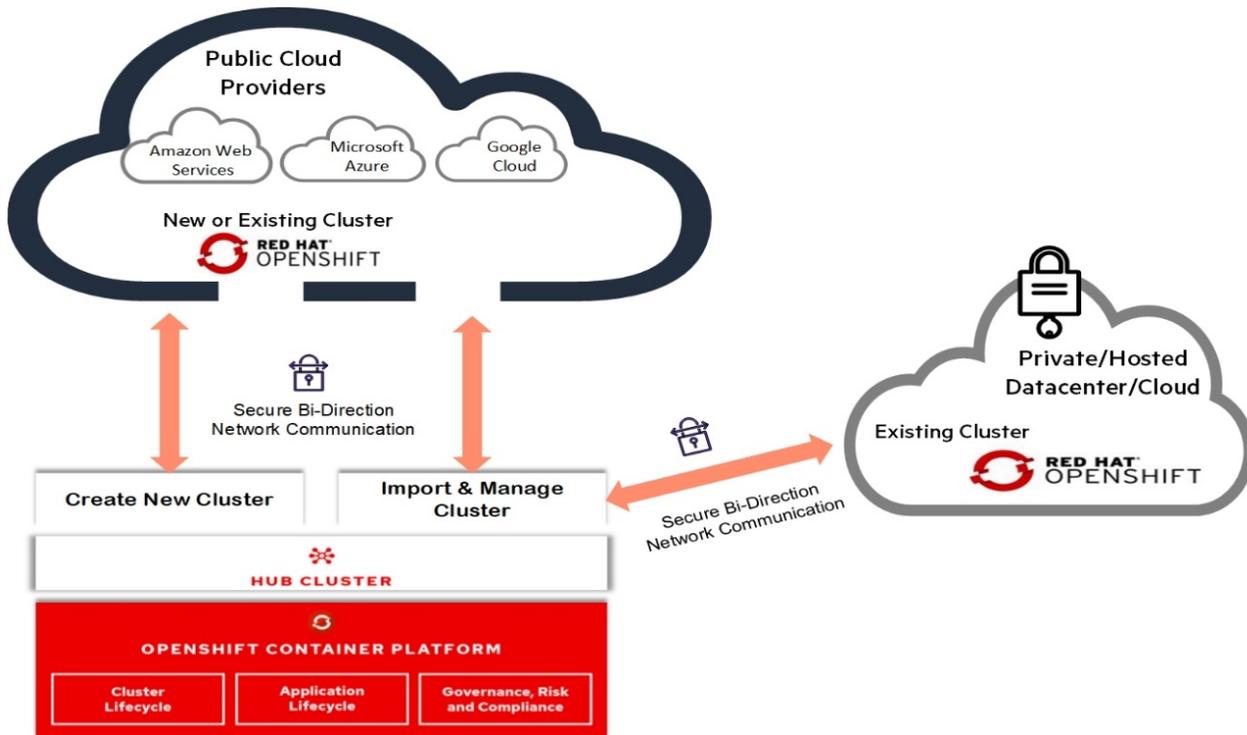


FIGURE 19. Red Hat Advanced Cluster Management Overview

**Installing Red Hat Advanced Cluster Management for Kubernetes**

High-level installation flow:

- Have a supported version of OpenShift Container Platform installed and configured
- Install the Operator for Red Hat Advanced Cluster Management for Kubernetes from the catalog
- Configure Red Hat Advanced Cluster Management for Kubernetes

For more information, see the deployment guide at <https://hewlettpackard.github.io/hpe-solutions-openshift/46-dl/>.

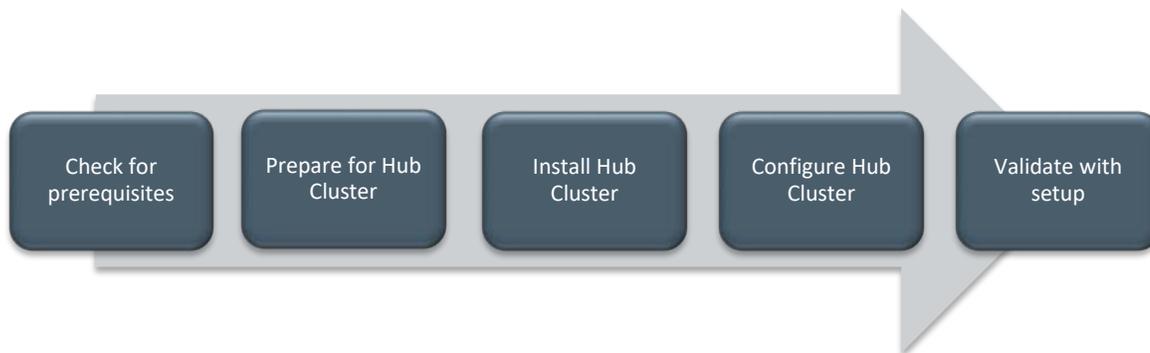


FIGURE 20. Red Hat Advanced Cluster Management Installation Overview



With Red Hat Advanced Cluster Management for Kubernetes:

- Work across a range of environments, including multiple data centers, private clouds, and public clouds that run Kubernetes clusters
- Easily create Kubernetes clusters and offer cluster lifecycle management in a single console
- Enforce policies at the target clusters using Kubernetes-supported custom resource definitions
- Deploy and maintain day-two operations of business applications distributed across your cluster landscape

## BUSINESS CONTINUITY WITH DISASTER RECOVERY STRATEGIES FOR RED HAT OPENSIFT CONTAINER PLATFORM 4.6

Stateful Applications require a more sophisticated disaster recovery (DR) strategy than stateless applications, as a state must be maintained along with traffic redirection. Disaster recovery strategies become less generic and more application-specific as application complexity increases. In this section, we shall see the various options available to provide Disaster recovery for an application running on Red Hat OpenShift Container Platform 4.6 deployment. Recovery Time Objective (RTO) is the organization’s tolerance for “App Downtime” and Recovery Point Objective (RPO) is the organization’s tolerance for “Data Loss” are two key metrics that must be considered to develop an appropriate disaster recovery plan that can maintain business continuity after an unexpected event.

Figure 21 shows the comparison of the Red Hat OpenShift Disaster recovery strategies using RTO and RPO objectives.

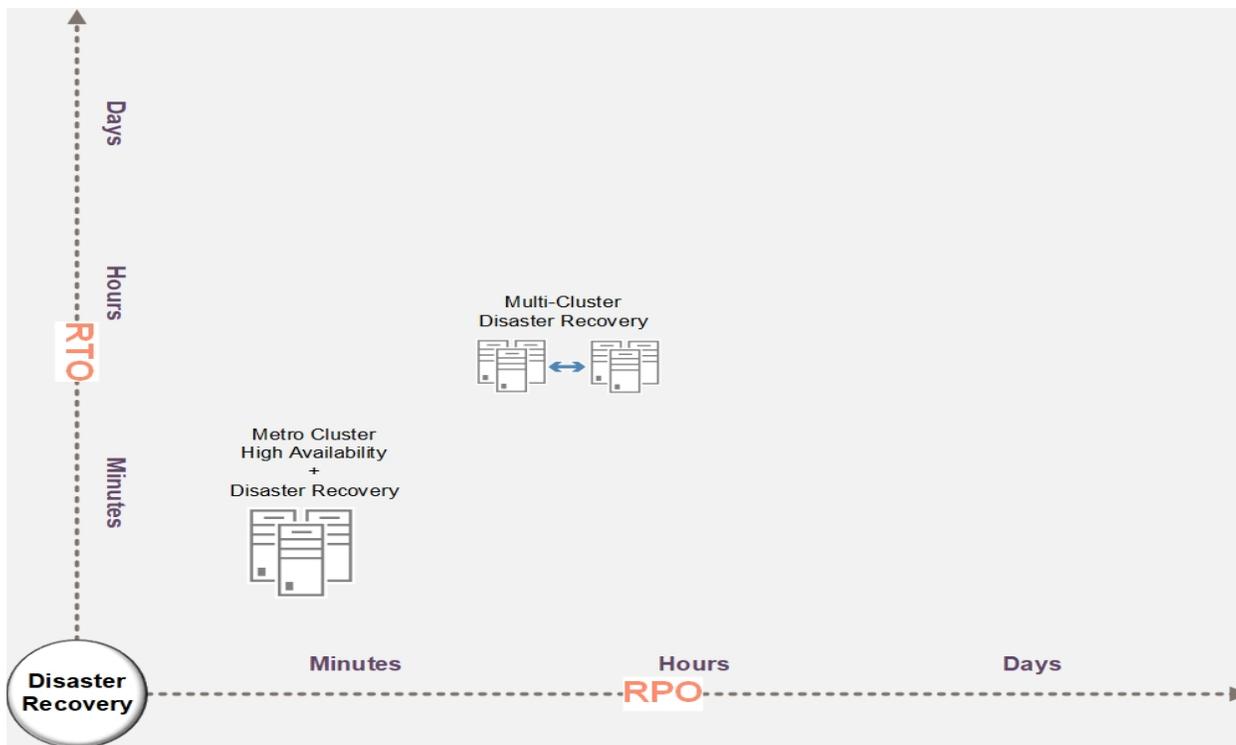


FIGURE 21. Red Hat OpenShift Disaster recovery strategies comparison using RTO and RPO objectives

### Metro Cluster High Availability and Disaster Recovery Strategy

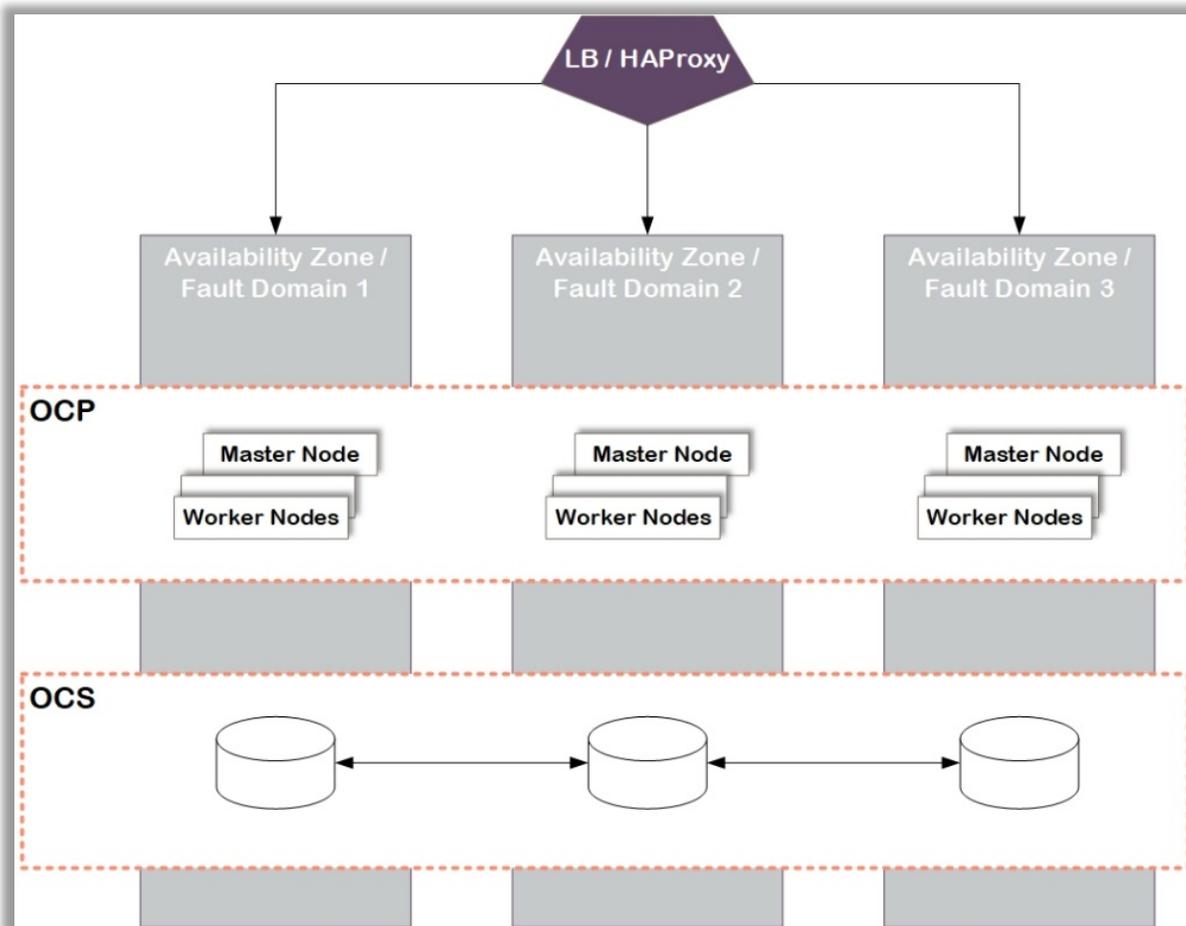
Also known as stretched or distributed clustering, is a high-availability configuration that allows one compute/storage cluster such as a single OpenShift cluster to be stretched across two or more physically separate sites or data centers is an active/active DR strategy. The recommendation is to use a minimum of three physically separate sites or data centers to meet generic application Service Level Requirements (SLA).



Following are the requirements for HA like Automatic Recovery along with No Data loss Data Mirroring:

- Synchronous HA-DR for localized data center failures
  - DR sites/Availability zones (AZs) connected by MAN or campus networks
  - AZs are mapped to a fault domain (HVAC, Power grids, etc.)
  - An odd number of AZ/Fault Domains are required for the cluster quorum
  - Network latency between zones does not typically exceed 5ms.
- OCP ensures Pods, nodes get scheduled across zones during deployment
- OCS ensures maintains consistent mirror copies across AZs => no data loss
- Stretched OCP cluster provides automatic and non-disruptive recovery for apps across AZs
- An application with a consensus protocol that allows it to determine which instances of the cluster are active and healthy

Figure 22 shows an overview Red Hat OpenShift Metro Cluster design.



**FIGURE 22.** Red Hat OpenShift Metro Cluster design overview

When one of the AZs is down, no action needs to occur as both OpenShift and the stateful workload will autonomously react to the situation. In particular, the stateful workload will sense the loss of one of the instances and will continue using the remaining instances. The same is true when



the affected AZ is recovered. When the stateful instance in the recovered AZ comes back online, before the instance is allowed to join the cluster, it will need to resync its state. Again, this is handled autonomously and is part of the clustering features of some stateful workloads.

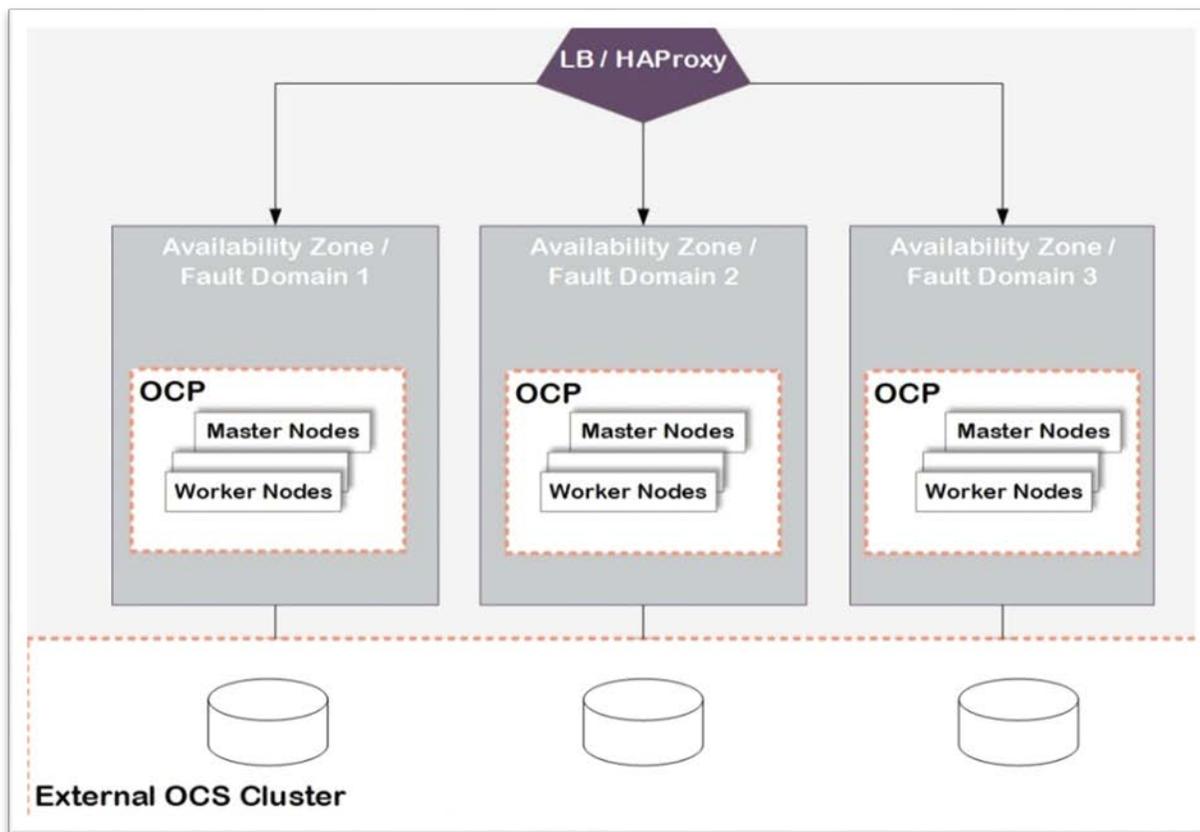
### Multi-Cluster Disaster Strategy

In this strategy, the multiple data centers (at least three) are potentially geographically distributed. In each data center, has its own independent OpenShift clusters. A global load balancer balances traffic between the data centers. The stateful workload is deployed across the OpenShift clusters. This approach is more suitable than the previous one for geographical, on-premise, and hybrid deployments. The compute and storage clusters are independent clusters and the storage cluster is accessed using an external storage access framework from within the OpenShift compute cluster. In this configuration, the members of the stateful workload cluster need to be able to communicate with each other across multiple clusters. Also, this entire strategy is dependent on the ability to replicate the state from the active site to another site. Each workload is different, so these various approaches should be chosen to meet SLA requirements according to cluster compute and storage configuration such as:

- Volume-level Replication
- Application-level Replication
- Proxy-level Replication

When one AZ is down, the global load balancer must be able to sense the unavailability of one of the data centers and redirect all traffic to the remaining active data centers. No action needs to occur on the stateful workload as it will self-reorganize to manage the loss of a cluster member.

Figure 23 shows the Red Hat OpenShift Multi-cluster disaster recovery approach.



**FIGURE 23.** Red Hat OpenShift Multi-cluster disaster recovery approach

For more information, see [Disaster Recovery Strategies for Applications Running on OpenShift](#).



## BUSINESS CONTINUITY WITH DATA PROTECTION (BACKUP) FOR RED HAT OPENSIFT CONTAINER PLATFORM 4.6

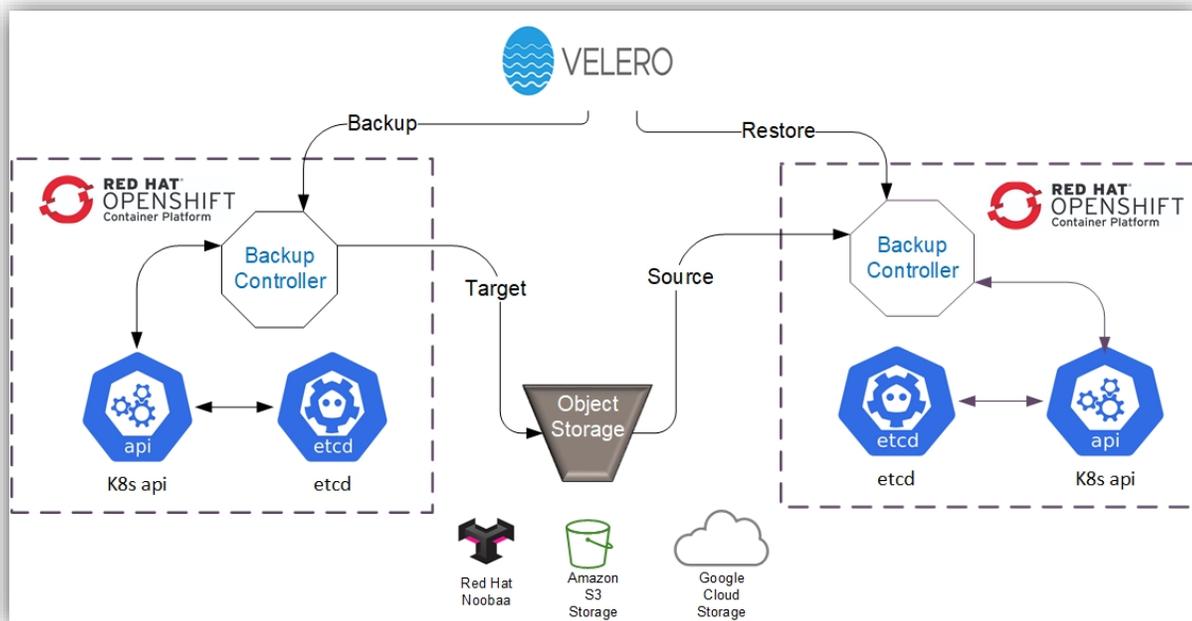
Backup and restore is a day 2 operational task of making periodic copies of configuration and application data to a separate or secondary device and then using those copies to recover the data and applications. This is done to mitigate the risk if the original data and applications are lost or damaged due to a power outage, cyberattack, human error, disaster, or some other unplanned event. Traditional backup solutions have existed a while in Enterprise Datacenter's ecosystem, these solutions need to evolve to address the needs of the new container infrastructure this where Velero adds value. Velero is an open-source tool to safely backup and restore, perform disaster recovery, and migrate Kubernetes cluster resources and persistent volumes.

Velero provides the following feature to the Kubernetes bases container ecosystem:

- Data Protection - Offers key data protection features such as scheduled backups, retention schedules, and pre or post-backup hooks for custom actions
- Disaster Recovery - Reduces time to recovery in case of infrastructure loss, data corruption, and/or service outages
- Data Migration - Enables cluster portability by easily migrating Kubernetes resources from one cluster to another

In Red Hat OpenShift Container Platform 4.6, Velero uses a controller model where it monitors custom resources and takes actions.

Figure 24 shows the overview of Velero backup and restore with OCP 4.6.



**FIGURE 24.** Velero backup and restore with OCP 4.6

Velero development consists of a server that runs in the OpenShift Cluster and a command-line client that runs locally on the management machine.

### Prerequisites

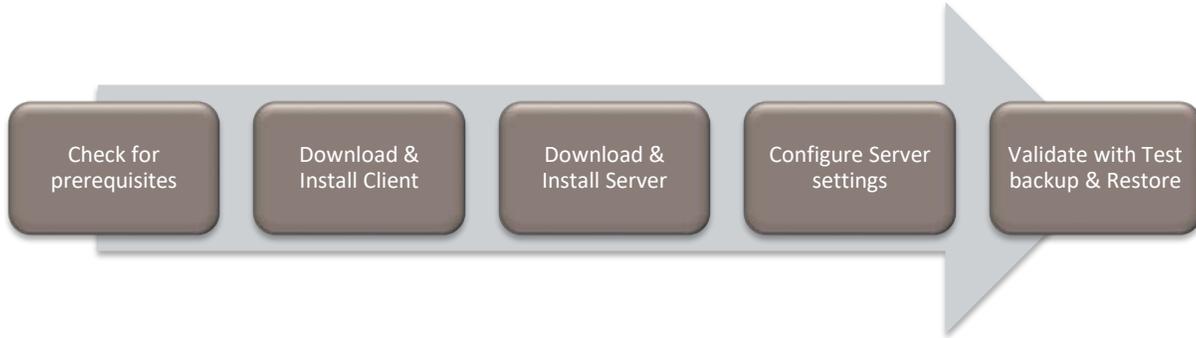
- OpenShift Container Platform cluster should be available with the administrator credentials
- When using NooBaa as a target we need external DNS of NooBaa and access Id and key



- When using public cloud-based object storage require the appropriate Velero plugin along with the access information and credentials

**Velero for OpenShift setup overview**

Figure 25 shows the overview of Velero for OpenShift setup.



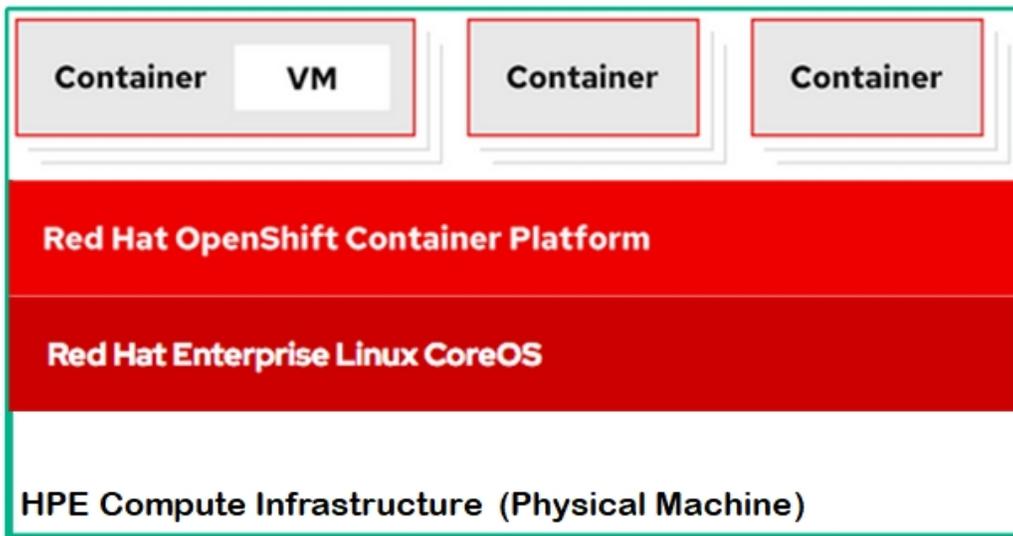
**FIGURE 25.** Velero for OpenShift setup overview

Velero makes it simple to back up the OpenShift configuration information and application data to a Cloud Object-based storage platform and restore it on demand. For more information, see the deployment guide at <https://hewlettpackard.github.io/hpe-solutions-openshift/46-dl/>.

**OPENSIFT VIRTUALIZATION**

The new paradigm shift in application development is moving to containers, and increasingly serverless as well, however, existing investment in applications that run as virtual machines in many organizations poses management challenges. Many of the existing virtual machines (VMs) provide vital services to new and existing containerized applications at times are not good candidates for containerization. OpenShift Virtualization also referred to as container-native virtualization lets developers bring virtual machines (VMs) into containerized workflows by running a virtual machine within a container where they can develop, manage, and deploy virtual machines side-by-side with containers and serverless all in one platform. This is a built-in feature of OpenShift Container Platform, OpenShift Virtualization combines two technologies of virtualization and containerization into a single management platform so organizations take advantage of the simplicity and speed of containers and Kubernetes while still benefiting from the applications and services that have been architected for virtual machines.

Figure 26 shows an overview of OpenShift virtualization.



**FIGURE 26.** OpenShift virtualization overview layout

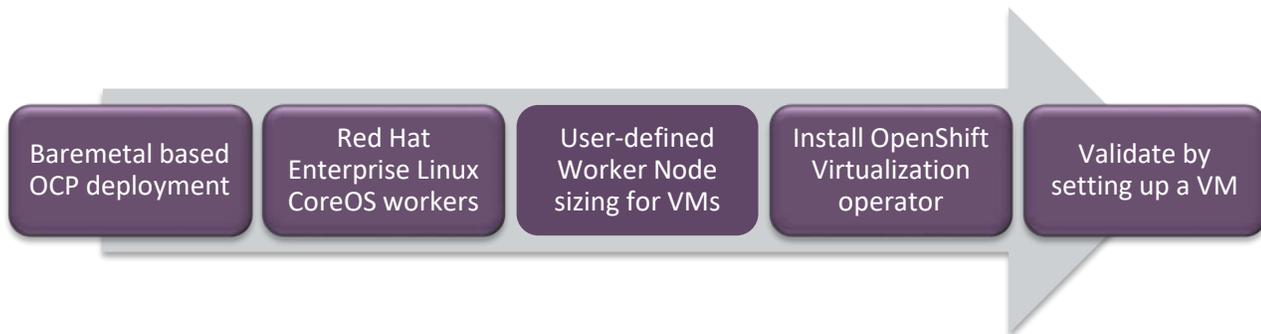


OpenShift virtualization adds new objects into your OpenShift Container Platform cluster via Kubernetes custom resources to enable virtualization tasks. These tasks include:

- Creating and managing Linux and Windows virtual machines
- Connecting to virtual machines through a variety of consoles and CLI tools
- Importing and cloning existing virtual machines
- Managing network interface controllers and storage disks attached to virtual machines
- Live migrating virtual machines between nodes
- An enhanced web console provides a graphical portal to manage these virtualized resources alongside the OpenShift Container Platform cluster containers and infrastructure
- OpenShift Virtualization is tested with OpenShift Container Storage (OCS) and designed to use with OCS features for the best experience
- OpenShift Virtualization allows the usage with either the OVN-Kubernetes or the OpenShiftSDN default Container Network Interface (CNI) network provider
- OpenShift Virtualization 2.4 is supported for use on OpenShift Container Platform 4.6 clusters

### Enabling OpenShift Virtualization

Figure 27 shows an overview of OpenShift virtualization.



**FIGURE 27.** OpenShift virtualization setup

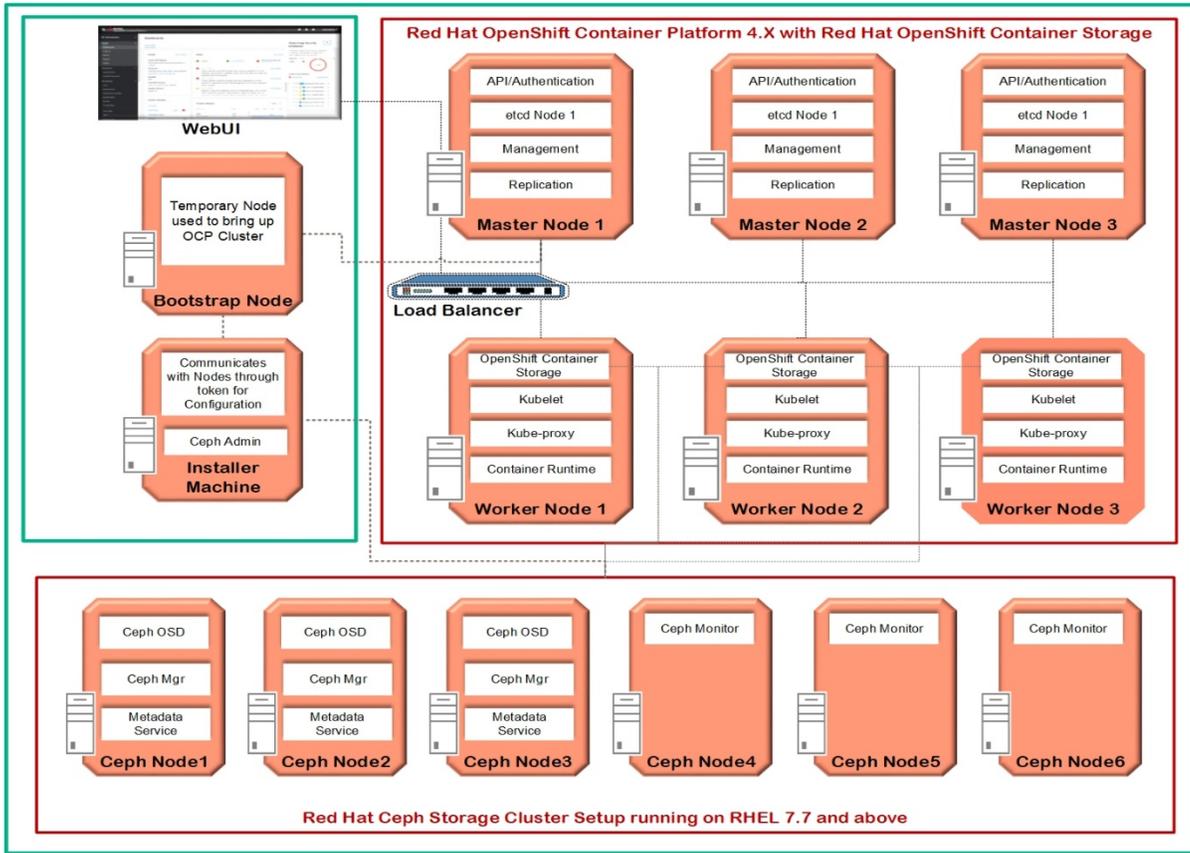
OpenShift Virtualization adds the ability to easily create and manage traditional virtual machines in OpenShift alongside standard container workloads. Its deep integration into the OpenShift UI makes the first step very easy and intuitive. For more information, see [OpenShift Virtualization](#) documentation.

### RED HAT OPENSIFT CONTAINER STORAGE – EXTERNAL MODE

Red Hat OpenShift Container Storage can use an externally hosted Red Hat Ceph Storage cluster as the storage provider. Red Hat Ceph Storage is designed for cloud infrastructure and web-scale object storage. Red Hat Ceph Storage is a scalable, open, software-defined storage platform that combines an enterprise-hardened version of the Ceph storage system with a Ceph management platform, deployment utilities, and supports services.



Figure 28 shows a high-level solution overview of Red Hat OpenShift Container Storage – External Mode.



**FIGURE 28.** Red Hat OpenShift Container Storage – External Mode Solution Layout

Setting up the Red Hat OpenShift Container Storage in external mode allows an enterprise to disintegrate the container setup platform from the container compute platform. The disintegration allows on-demand independent growth of storage and compute clusters. Before configuring the Red Hat OpenShift Container Storage in external mode the Red Hat Ceph Storage pool must be set up and configured appropriately. For this Reference Architecture, a six node Red Hat Ceph storage cluster running on Red Hat Enterprise Linux 7.7 was used. The high-level steps involved in setting up Red Hat OpenShift Container Storage in external is as follows:

- Setting up a prerequisite for Red Hat Ceph installation on three (3) bare metal servers
- Deploy and register Ceph Nodes
- Setup Ceph storage pool
- Configure OpenShift Container Storage in external mode
- Validate the creation of PV on Red Hat OpenShift Container Storage in external mode



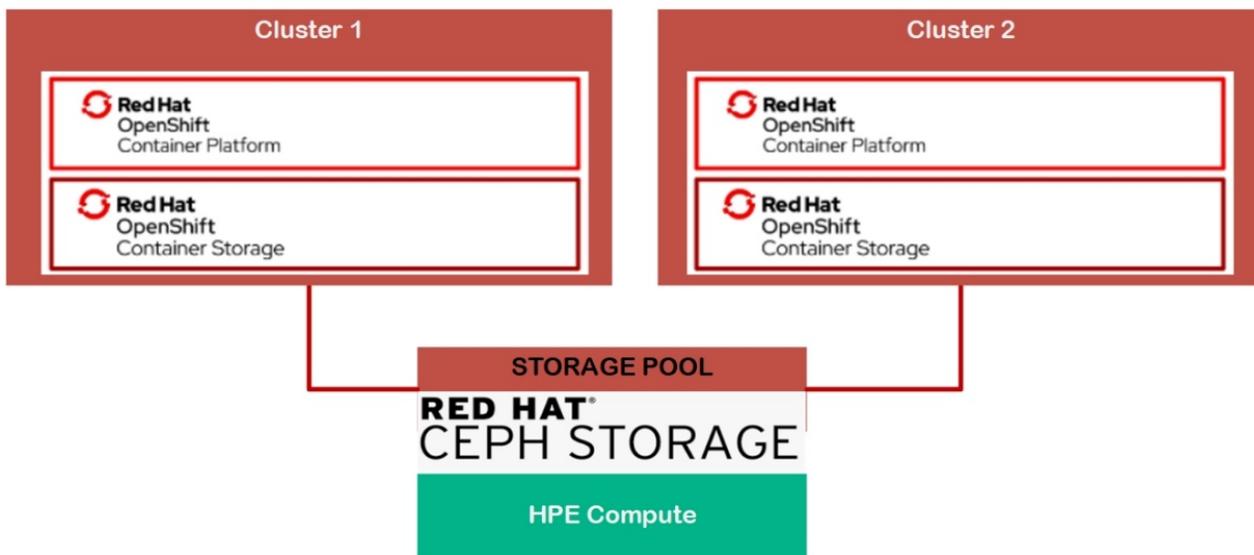
Figure 29 shows the high-level setup.



**FIGURE 29.** Red Hat OpenShift Container Storage – External mode solution setup flow

For more information, view the deployment guide at <https://hewlettpackard.github.io/hpe-solutions-openshift/46-dl/>.

A single Red Hat Ceph Storage could be used to provide persistent volume to multiple OpenShift Container Platform clusters.



**FIGURE 30.** Red Hat OpenShift Container Storage - Usage

## RED HAT OPENSIFT 4.X INSTALLER-PROVISIONED INSTALLATION FOR BAREMETAL

The OpenShift Container Platform installation program offers the flexibility of using the installation program to deploy a cluster on infrastructure that the installation program provisions and the cluster maintenance. With the installer-provisioned infrastructure clusters, OpenShift Container Platform manages all aspects of the cluster, including the operating system itself. Each machine boots with a configuration that references resources hosted in the cluster that it joins. This configuration allows the cluster to manage itself as updates are applied. When using the Red Hat OpenShift installer-provisioned installation, the installation program acts much as an installation wizard, requests input for values that it cannot determine on its own, and providing reasonable default values for the remaining parameters. In this section, we discuss Installer-provisioned installation for installing OpenShift Container Platform on bare metal nodes.

Installer-provisioned installation of OpenShift Container Platform requires:

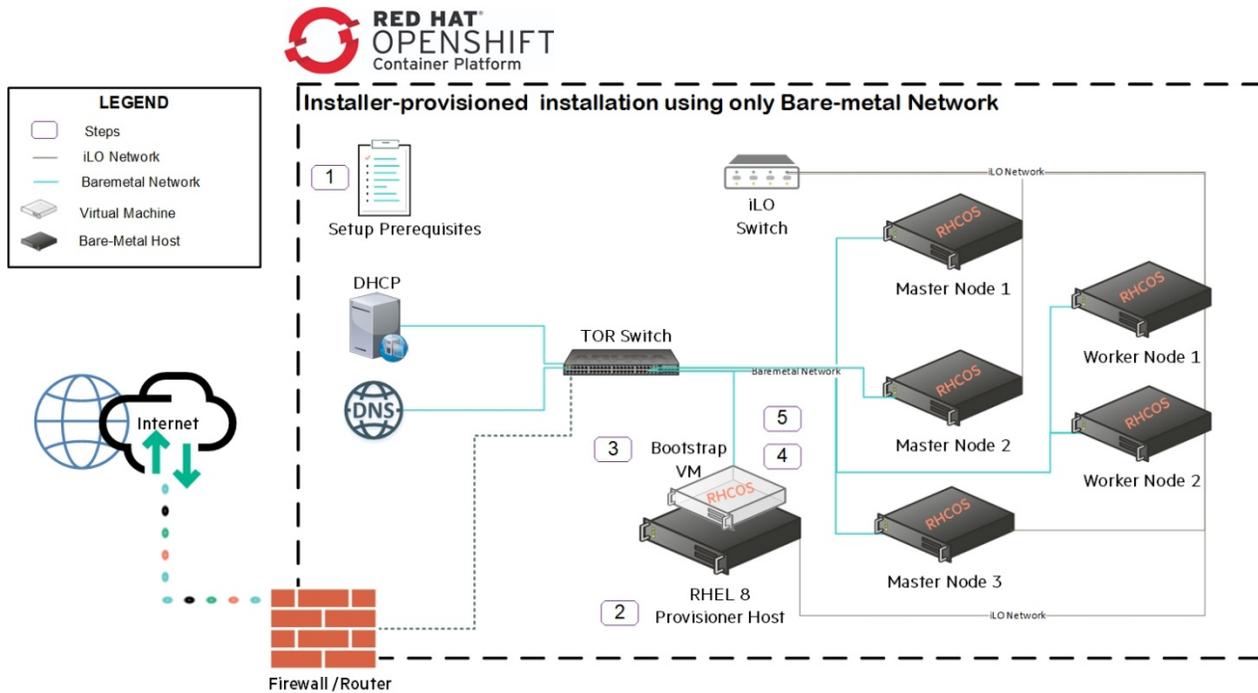
- One provisioner node with RHEL 8.1 installed
- Three Control Plane nodes



- At least two worker nodes
- Baseboard Management Controller (BMC) access to each node
- At least one network:
  - One required routable network

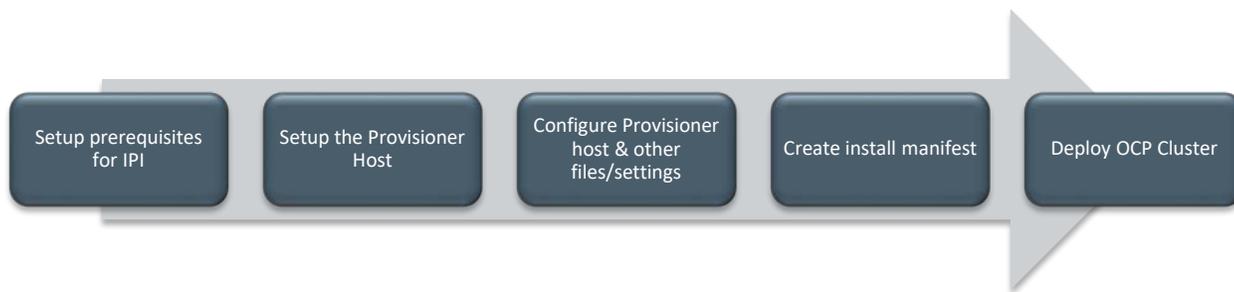
For more detailed information on Red Hat OpenShift Container Platform Installer-provisioned installation prerequisites, see [https://docs.openshift.com/container-platform/4.6/installing/installing\\_bare\\_metal\\_ipi/ipi-install-prerequisites.html](https://docs.openshift.com/container-platform/4.6/installing/installing_bare_metal_ipi/ipi-install-prerequisites.html).

Figure 31 shows the logical layout of Red Hat OpenShift Container Platform Installer-provisioned installation.



**FIGURE 31.** Red Hat OpenShift Container Platform Installer-provisioned installation – Logical layout

The high-level steps involved in setting up Red Hat OpenShift Container Platform Installer-provisioned infrastructure using three (3) master nodes, two (2) worker nodes, and using the bare metal network is as shown in Figure 32.



**FIGURE 32.** Red Hat OpenShift Container Platform Installer-provisioned installation – High-level setup flow

For more information, view the deployment guide at <https://hewlettpackard.github.io/hpe-solutions-openshift/4.6-dl/>.



## SUMMARY

The installation and configuration of the Red Hat OpenShift Container Platform Version 4.6 with OpenShift Container Storage version 4.5 on the bare-metal HPE ProLiant DL360 and HPE ProLiant DL380 server's solution provides customers with greater efficiency, higher utilization, and bare-metal performance by "collapsing the stack" and eliminating the need for virtualization. IT teams can manage multiple Kubernetes clusters with multitenant container isolation and data access, for any workload from edge to core to cloud. The benefits of containers beyond cloud-native microservices architected stateless applications can be extended by providing the ability to containerize monolithic stateful analytic applications with persistent data.

Benefits include:

- Deploying the management, etcd, and worker nodes on bare-metal eliminate the overhead associated with hypervisors and thus optimizes performance
- The deployment of OCP 4.6 on bare-metal HPE ProLiant DL servers using automation scripts saves significant efforts, resulting in quicker deployment
- The OCS storage can be configured in the internal or external storage mode based on the customer storage requirements

## APPENDIX A: BILL OF MATERIALS

The following BOMs contain electronic license to use (E-LTU) parts. Electronic software license delivery is now available in most countries. Hewlett Packard Enterprise recommends purchasing electronic products over physical products (when available) for faster delivery and for the convenience of not tracking and managing confidential paper licenses. For more information, please contact your reseller or a Hewlett Packard Enterprise representative.

### NOTE

Part numbers are at the time of publication/testing and subject to change. The bill of materials does not include complete support options or other rack and power requirements. If you have questions regarding ordering, please consult with your Hewlett Packard Enterprise Reseller or Hewlett Packard Enterprise Sales Representative for more details [hpe.com/us/en/services/consulting.html](https://www.hpe.com/us/en/services/consulting.html).

**TABLE A1.** Bill of materials

Part Number	Qty	Description
<b>Rack</b>		
P9K10A	1	HPE 42U 600mmx1200mm G2 Kitted Advanced Shock Rack with Side Panels and Baying
P9K10A 001	1	HPE Factory Express Base Racking Service
<b>Master Nodes</b>		
867959-B21	3	HPE ProLiant DL360 Gen10 8SFF Configure-to-order server
867959-B21 OD1	3	Factory Integrated
867959-B21 ABA	3	HPE DL360 Gen10 8SFF CTO server
P02592-L21	3	Intel Xeon-Gold 5218 (2.3GHz/16-core/125W) FIO Processor Kit for HPE ProLiant DL360 Gen10
P02592-B21	3	Intel Xeon-Gold 5218 (2.3GHz/16-core/125W) Processor Kit for HPE ProLiant DL360 Gen10
P02592-B21 OD1	3	Factory Integrated
P00918-B21	12	HPE 8GB (1x8GB) Single Rank x8 DDR4-2933 CAS-21-21-21 Registered Smart Memory Kit
P00918-B21 OD1	12	Factory Integrated
P18434-B21	6	HPE 960GB SATA 6G Mixed Use SFF (2.5in) SC 3yr Wty Multi-Vendor SSD
P18434-B21 OD1	6	Factory Integrated
P01366-B21	3	HPE 96W Smart Storage Lithium-ion Battery with 145mm Cable Kit
P01366-B21 OD1	3	Factory Integrated
804326-B21	3	HPE Smart Array E208i-a SR Gen10 (8 Internal Lanes/No Cache) 12G SAS Modular Controller
804326-B21 OD1	3	Factory Integrated
879482-B21	3	HPE InfiniBand FDR/Ethernet 40/50Gb 2-port 547FLR-QSFP Adapter
879482-B21 OD1	3	Factory Integrated



Part Number	Qty	Description
865414-B21	6	HPE 800W Flex Slot Platinum Hot Plug Low Halogen Power Supply Kit
865414-B21 OD1	6	Factory Integrated
BD505A	3	HPE iLO Advanced 1-server License with 3yr Support on iLO Licensed Features
BD505A OD1	3	Factory Integrated
734811-B21	3	HPE 1U Cable Management Arm for Rail Kit
734811-B21 OD1	3	Factory Integrated
867998-B21	3	HPE 1U Gen10 Bezel Kit
867998-B21 OD1	3	Factory Integrated
874543-B21	3	HPE 1U Gen10 SFF Easy Install Rail Kit
874543-B21 OD1	3	Factory Integrated
<b>Worker Nodes</b>		
868703-B21	3	HPE ProLiant DL380 Gen10 8SFF Configure-to-order server
868703-B21 OD1	3	Factory Integrated
868703-B21 ABA	3	HPE DL380 Gen10 8SFF CTO server
P02510-L21	3	Intel Xeon-Gold 6242 (2.8GHz/16-core/150W) FIO Processor Kit for HPE ProLiant DL380 Gen10
P02510-B21	3	Intel Xeon-Gold 6242 (2.8GHz/16-core/150W) Processor Kit for HPE ProLiant DL380 Gen10
P02510-B21 OD1	3	Factory Integrated
P00922-B21	36	HPE 16GB (1x16GB) Dual Rank x8 DDR4-2933 CAS-21-21-21 Registered Smart Memory Kit
P00922-B21 OD1	36	Factory Integrated
P18434-B21	9	HPE 960GB SATA 6G Mixed Use SFF (2.5in) SC 3yr Wty Multi-Vendor SSD
P18434-B21 OD1	9	Factory Integrated
826694-B21	3	HPE DL38X Gen10 x16/x16 Riser Kit
826694-B21 OD1	3	Factory Integrated
871674-B21	3	HPE DL38X Gen10 Slot 1/2 x16/x16 FIO Riser Kit
804326-B21	3	HPE Smart Array E208i-a SR Gen10 (8 Internal Lanes/No Cache) 12G SAS Modular Controller
804326-B21 OD1	3	Factory Integrated
879482-B21	3	HPE InfiniBand FDR/Ethernet 40/50Gb 2-port 547FLR-QSFP Adapter
879482-B21 OD1	3	Factory Integrated
867810-B21	3	HPE DL38X Gen10 High-Performance Temperature Fan Kit
867810-B21 OD1	3	Factory Integrated
830272-B21	3	HPE 1600W Flex Slot Platinum Hot Plug Low Halogen Power Supply Kit
830272-B21 OD1	6	Factory Integrated
BD505A	3	HPE iLO Advanced 1-server License with 3yr Support on iLO Licensed Features
BD505A OD1	3	Factory Integrated
733664-B21	3	HPE 2U Cable Management Arm for Easy Install Rail Kit
733664-B21 OD1	3	Factory Integrated
867809-B21	3	HPE Gen10 2U Bezel Kit
867809-B21 OD1	3	Factory Integrated
733660-B21	3	HPE 2U Small Form Factor Easy Install Rail Kit
733660-B21 OD1	3	Factory Integrated
<b>Ceph Nodes</b>		
868703-B21	6	HPE ProLiant DL380 Gen10 8SFF Configure-to-order server
868703-B21 OD1	6	Factory Integrated
868703-B21 ABA	6	HPE DL380 Gen10 8SFF CTO server
P02510-L21	6	Intel Xeon-Gold 6242 (2.8GHz/16-core/150W) FIO Processor Kit for HPE ProLiant DL380 Gen10
P02510-B21	6	Intel Xeon-Gold 6242 (2.8GHz/16-core/150W) Processor Kit for HPE ProLiant DL380 Gen10
P02510-B21 OD1	6	Factory Integrated
P00922-B21	72	HPE 16GB (1x16GB) Dual Rank x8 DDR4-2933 CAS-21-21-21 Registered Smart Memory Kit
P00922-B21 OD1	72	Factory Integrated
P18434-B21	24	HPE 960GB SATA 6G Mixed Use SFF (2.5in) SC 3yr Wty Multi-Vendor SSD
P18434-B21 OD1	24	Factory Integrated
826694-B21	6	HPE DL38X Gen10 x16/x16 Riser Kit



Part Number	Qty	Description
826694-B21 OD1	6	Factory Integrated
871674-B21	6	HPE DL38X Gen10 Slot 1/2 x16/x16 FIO Riser Kit
804326-B21	6	HPE Smart Array E208i-a SR Gen10 (8 Internal Lanes/No Cache) 12G SAS Modular Controller
804326-B21 OD1	6	Factory Integrated
879482-B21	6	HPE InfiniBand FDR/Ethernet 40/50Gb 2-port 547FLR-QSFP Adapter
879482-B21 OD1	6	Factory Integrated
867810-B21	6	HPE DL38X Gen10 High High-Performance Temperature Fan Kit
867810-B21 OD1	6	Factory Integrated
830272-B21	6	HPE 1600W Flex Slot Platinum Hot Plug Low Halogen Power Supply Kit
830272-B21 OD1	12	Factory Integrated
BD505A	6	HPE iLO Advanced 1-server License with 3yr Support on iLO Licensed Features
BD505A OD1	6	Factory Integrated
733664-B21	6	HPE 2U Cable Management Arm for Easy Install Rail Kit
733664-B21 OD1	6	Factory Integrated
867809-B21	6	HPE Gen10 2U Bezel Kit
867809-B21 OD1	6	Factory Integrated
733660-B21	6	HPE 2U Small Form Factor Easy Install Rail Kit
733660-B21 OD1	6	Factory Integrated
<b>Networking</b>		
JL260A	1	Aruba 2930F 48G 4SFP Switch
JL260A B2E	1	Aruba 2930F 48G 4SFP Switch United States 220 volt
JH397A	2	HPE FlexFabric 5940 2-slot Switch
JC680A	4	HPE 58x0AF 650W AC Power Supply
JC680A ABA	4	HPE 58x0AF 650W AC Power Supply U.S. - English Localization
JH180A	4	HPE 5930 24-port SFP+ and 2-port QSFP+ Module
Q2F25A OD1	1	Factory Integrated
H6J85A	1	HPE Rack Hardware Kit
H6J85A OD1	1	Factory Integrated
P9Q41A	2	HPE G2 Basic 4.9kVA/L6-30P 24A/208V Outlets (20) C13/Vertical NA/JP PDU
P9Q41A OD1	2	Factory Integrated
120672-B21	1	HPE Rack Ballast Kit
120672-B21 OD1	1	Factory Integrated
670759-B22	4	HPE 1M FDR Quad Small Form Factor Pluggable InfiniBand Copper Cable
J9583A	1	HPE X410 1U Universal 4-post Rackmount Kit
J9583A OD1	1	Factory Integrated
BW932A	1	HPE 600mm Rack Stabilizer Kit
BW932A B01	1	HPE 600mm Rack include with Complete System Stabilizer Kit
R1B12AAE	3	Red Hat OpenShift Container Platform 1-32 Cores 1yr Subscription 9x5 RH Support E-LTU
Q9Y41AAE	1	HPE Network Orchestrator E-LTU
JL307A	6	Aruba 100G QSFP28 to QSFP28 3m Direct Attach Copper Cable
H1K92A3	1	HPE 3Y Proactive Care 24x7 SVC
H1K92A5#R2M	6	HPE iLO Advanced 1-server License with 3yr Support on iLO Licensed Features HPE 5Y Proactive Care 24x7 SVC
H1K92A5#WAG	3	HPE ProLiant DL360 Gen10 8SFF support, PE 5Y Proactive Care 24x7 SVC
<b>Red Hat Enterprise Linux CoreOS (RHCOS) Server</b>		
J8J36AAE	6	Red Hat Enterprise Linux CoreOS (RHCOS) Server 2 Sockets 1 Guest 1 Year Subscription 24x7 Support
<b>Red Hat Enterprise Linux CoreOS (RHCOS) for Virtual data centers</b>		
G3J22AAE	11	Red Hat Enterprise Linux CoreOS (RHCOS) for Virtual Datacenters 2 Sockets 1 Year Subscription 24x7 Support



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**NOTE**

For OCS – External approach, six (6) more HPE ProLiant DL360 and/or HPE ProLiant DL380 Gen10 servers will be required. This is an optional requirement.

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### RESOURCES AND ADDITIONAL LINKS

HPE Reference Architectures, [hpe.com/info/ra](https://hpe.com/info/ra)

HPE Servers, [hpe.com/servers](https://hpe.com/servers)

HPE Storage, [hpe.com/storage](https://hpe.com/storage)

HPE Networking, [hpe.com/networking](https://hpe.com/networking)

HPE Technology Consulting Services, [hpe.com/us/en/services/consulting.html](https://hpe.com/us/en/services/consulting.html)

HPE ProLiant DL380 Gen10 server, <https://h20195.www2.hpe.com/v2/default.aspx?cc=us&lc=en&oid=1010026818>

HPE ProLiant DL360 Gen10 server, <http://www.hpe.com/servers/dl360-gen10>

Red Hat OpenShift Container Platform, [https://access.redhat.com/documentation/en-us/openshift\\_container\\_platform/4.6/](https://access.redhat.com/documentation/en-us/openshift_container_platform/4.6/)

Red Hat OpenShift Container Storage, [https://access.redhat.com/documentation/en-us/red\\_hat\\_openshift\\_container\\_storage/4.6/](https://access.redhat.com/documentation/en-us/red_hat_openshift_container_storage/4.6/)

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