Reference Architecture

HPE REFERENCE CONFIGURATION FOR RED HAT OPENSHIFT CONTAINER PLATFORM 4 ON HPE SYNERGY

CONTENTS

EXECUTIVE SUMMARY

In today's digital world, organizations are under increasing pressure to deliver applications faster while reducing costs. As these applications grow more complex, this puts stress on IT infrastructure, IT teams, and processes. To remain competitive, organizations must adapt quickly, and developers need to be more effective, efficient, and agile. Container technology provides the right application platform to help organizations become more responsive and iterate across multiple IT environments and develop, deploy, and manage applications faster. Implementing a containerized environment across existing infrastructure is a complex undertaking that can require weeks or months to mobilize particularly for enterprises. To help accelerate container application delivery, Hewlett Packard Enterprise and Red Hat® are collaborating to optimize Red Hat OpenShift® Container Platform 4 on HPE platforms, including HPE Synergy, the industry's first composable infrastructure.

Red Hat OpenShift Container Platform 4 on HPE Synergy provides an end-to-end fully integrated container solution that can be configured within hours after being assembled. This eliminates the complexities associated with implementing a container platform across an enterprise data center. This also provides the automation of hardware and software configuration to quickly provision and deploy a containerized environment at scale. Red Hat OpenShift Container Platform 4 provides organizations a reliable platform for deploying and scaling container-based applications. HPE Synergy provides the flexible infrastructure required to run the container platform to dynamically provision and scale applications, whether they run on virtual machines or containers, or hosted on-premises, in the cloud, or as part of a hybrid cloud solution.

This Reference Configuration provides architectural guidance for deploying, scaling, and managing the Red Hat OpenShift environment with local persistent volume on HPE Synergy Composable Infrastructure and storage.

The Reference Configuration describes how to:

- Leverage HPE Synergy strength in composability along with the capabilities of Red Hat OpenShift Container Platform 4 to provide a simplified deployment experience
- Efficient lay out of a Red Hat OpenShift Container Platform 4 configuration using bare metal hosts running RHEL Core OS
- Configure local persistent storage for containers using HPE Synergy storage

The solution demonstrates the following benefits of utilizing HPE Synergy for Red Hat OpenShift Container Platform 4:

- Deploy the core management functions and the worker nodes on bare metal to optimize performance
- Use an enterprise grade composable storage solution such as HPE Synergy D3940 Storage for local persistent storage for containers to enable speed, portability, and agility for traditional enterprise applications and data
- HPE Composable Infrastructure solution provides a layered view of security controls. The objective of this layered security view is to ensure that customers become aware of the depth of security risk that an infrastructure can have and also to make them aware of the depth of defense that is built in to the HPE Synergy Composable Infrastructure design.
- A business-driven container application that provides basic data protection provided by HPE Synergy D3940 Storage

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 Synergy Composable Infrastructure. This document assumes that the target audience is familiar with HPE Synergy, Red Hat OpenShift Container Platform 4, container-based 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 on HPE Synergy Composable Infrastructure, the implementation details, and processes. For more information on implementation details and processes, see Deployment guide at https://github.com/HewlettPackard/hpe-solutions-openshift/tree/master/synergy.

INTRODUCTION

This Reference Configuration describes the deployment of a highly available and secure Red Hat OpenShift Container Platform 4 on HPE Synergy Composable Infrastructure. This also includes the details on the configuration of the environment. This document demonstrates how Red Hat OpenShift Container Platform 4 can be configured to take advantage of the HPE Synergy composable architecture and leverage HPE Synergy D3940 Storage.

The Red Hat OpenShift Container Platform 4 deployment on HPE Synergy Composable Infrastructure configuration consists of the following:

- Three (3) OpenShift Container Platform master nodes
- Three (3) OpenShift Container Platform worker nodes

The six (6) HPE Synergy 480 Gen10 Compute Modules run Red Hat Enterprise Linux® CoreOS (RHCOS) to support the deployment. Local persistent volume leverages HPE Synergy D3940 Storage to provide local persistent storage for containers and registry as well as data management.

NOTE
Due to the ephemeral nature of containers, protecting persistent data associated with the containers becomes a crucial task. In this Reference Configuration, the pods which require persistent data use local persistent volumes with disks from the HPE Synergy D3940 Storage, distributed across all three (3) frames.

SOLUTION OVERVIEW

This provides an overview of Red Hat OpenShift Container Platform 4 on HPE Synergy using HPE Synergy D3940 Storage. Figure 1 provides an overview of the solution components.

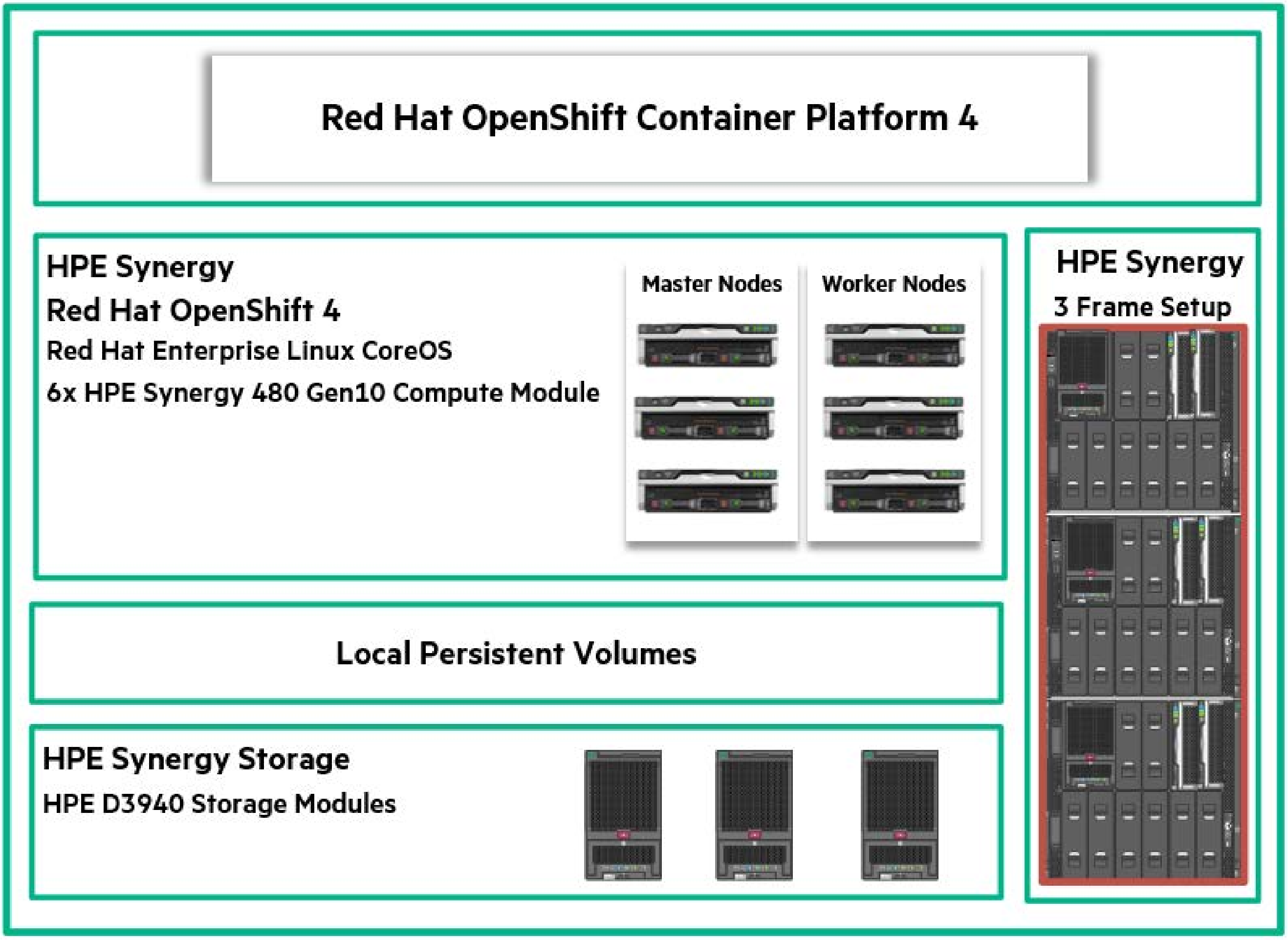

Red Hat OpenShift Container Platform 4
HPE Synergy
Red Hat OpenShift 4
Red Hat Enterprise Linux CoreOS
6x HPE Synergy 480 Gen10 Compute Module
Master Nodes
Worker Nodes
HPE Synergy
3 Frame Setup
Local Persistent Volumes
HPE Synergy Storage
HPE D3940 Storage Modules

FIGURE 1. Solution layout

This Reference Configuration describes the deployment of Red Hat OpenShift Container Platform 4 on both virtual and physical compute resources.

In a bare metal configuration, the master nodes are deployed in a highly available configuration running on three (3) HPE Synergy 480 Gen10 Compute Modules. Load balancing can be deployed as a virtual machine or as a physical appliance. Red Hat OpenShift worker nodes are deployed on the bare metal with three (3) HPE Synergy 480 Gen10 Compute Modules running RHCOS version 4. The OpenShift install tool is run to generate ignition files that contain information about the hosts that will be provisioned. The Core OS for the worker nodes is then PXE booted and the ignition files are passed with the OS image during installation. HPE Synergy D3940 Storage Modules provide support for ephemeral and persistent container volumes via local persistent volume.

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 Synergy 480 Gen10 Compute Modules. All virtual machines 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 worker nodes is then PXE booted and the ignition files are passed with the OS image during installation. HPE Synergy D3940 Storage Module provides support for both ephemeral and persistent container volumes.

HPE Synergy Composable Infrastructure security controls

Hewlett Packard Enterprise has security features and functionalities built into servers from the hardware level to the firmware. Customers require a holistic view of the security controls available in the composable infrastructure to make the most of their investment. HPE Synergy Composable Infrastructure enables IT organizations to accelerate application and service delivery with fluid resource pools, made up of compute, storage, and fabric with software-defined intelligence. Each resource within the composable infrastructure is made up of multiple products such as compute modules which in turn has multiple components such as Integrated Lights-Out (iLO), Unified Extensible Firmware Interface (UEFI), and so on. Another example is the management device such as HPE Synergy Composer, which exposes its functions using HPE OneView and the HPE Synergy frame link modules. With so many products available within the composable infrastructure, it is important to understand the security controls available within each of them and how they can be used to help avoid potential security breaches.

This solution provides a layered view of security controls that are available to Hewlett Packard Enterprise customers. Figure 2 shows the layered security view across various composable infrastructure components.

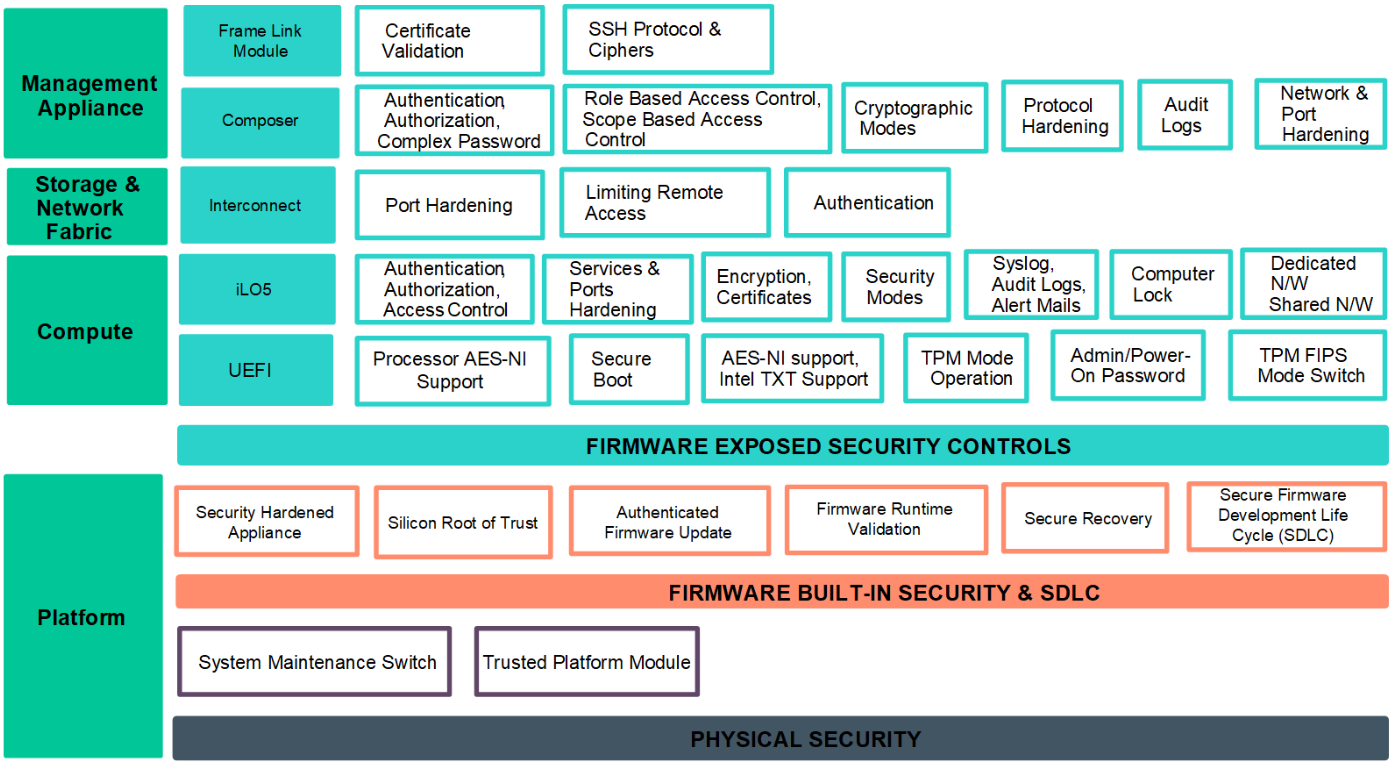


FIGURE 2. Layered security view for composable infrastructure

Table 1 describes the security control layers of physical security, firmware or hardware built-in security, and firmware exposed security control layer. The objective of this layered security view is to ensure that the customers will be aware of the depth of security risk that infrastructure can have. This also provides the knowledge of the in-depth defense that is built-in to the design of HPE composable infrastructure. Each security control at each layer is designed to comply with the requirements of some security tenets. The security tenets are a set of security principles that ensure the security within the information systems. Example: Authentication, Authorization, Access Control, Password Policies, Cryptographic Ciphers, Secure Protocols, Forensic Analytics – Logs, Alerts, Threat Modelling, Security Certifications and Standards.

TABLE 1: Physical and Firmware security controls within HPE composable infrastructure

SECURITY CONTROLS CATEGORY	DESCRIPTION
Physical security control	Physical security describes measures designed to ensure the physical protection and detection of threat event in the infrastructure
Firmware/Hardware built-in security control	The security technologies built-in firmware makes it more secure for any communication with the underlying hardware and safe for user data at rest or transit. The threat modelling followed by Hewlett Packard Enterprise provides enhanced security to the infra components.
Firmware exposed security control	This is the exhaustive list of security controls that let the customers: • Define the boundaries for accessing various infra components • Set quantum safe ciphers for encryption • Generate alert and log changes to infra

Firmware built-in security controls

Hewlett Packard Enterprise has used a variety of technologies to ensure that the built-in firmware security controls provide the highest level of infrastructure security. This section provides a brief overview of the security controls that Hewlett Packard Enterprise has built-in to the firmware used by HPE Synergy and how these security controls offer an added advantage for HPE Synergy customers.

Silicon Root of Trust

The iLO5 chipset contains a first of its kind Silicon Root of Trust for the HPE Synergy Gen10 compute platform which is included with the iLO standard license. Silicon Root of Trust provides an inextricably tied link between the silicon and firmware making it impossible to insert any malware, virus, or compromised code that would corrupt the boot process. The Silicon Root of Trust enables the boot process to provide a secure start. When the system boots, the iLO5 chip validates and boots its own firmware first, then validates the system BIOS. Since the Silicon Root of Trust is inextricably tied into the iLO5 hardware, every validated signature throughout the boot process can be trusted. However, in the unlikely event that iLO5 finds tampering or corruption at any point in the process, trusted firmware is immediately available for secure recovery. On startup, if iLO5 finds its own firmware that has been compromised, it will load its own authenticated firmware from an integrated backup. Regardless of license, the iLO5 firmware recovery is always available and always automatic. Remember that the Silicon Root of Trust in hardware is how the iLO5 firmware is verified. So, it can always be trusted. If the iLO5 finds that the system BIOS has been compromised, customers can connect to iLO5 and manually recover to authenticated firmware. Since the Silicon Root of Trust is embedded in the hardware itself, iLO5 can detect any compromised firmware as far back as the supply chain process. Hewlett Packard Enterprise can address platform security all the way back to the supply chain because it designs the hardware and firmware of iLO5 entirely and controls the iLO5 production process. Unlike other companies, Hewlett Packard Enterprise does not outsource the server management controller. Hewlett Packard Enterprise also has strict internal processes that dictates the firmware approval process. This gives customers an unprecedented level of assurance that no hackers have compromised the firmware before the server is received.

Secure recovery

Secure recovery is included in the iLO advanced premium security edition license and works alongside Silicon Root of Trust to automatically recover firmware back to a known good state in the unlikely event that it is compromised. The Silicon Root of Trust enables the secure start process. As the system boots and iLO5 verifies the series of digital signatures, iLO5 can access trusted firmware immediately and recover to a good state, if it finds tampering or corruption in its own firmware or the system BIOS. First, if iLO5 finds its own firmware has been compromised, it will load its own authenticated firmware from an integrated backup. Regardless of the license, the secure recovery of iLO5 firmware is always available and always automatic. Second, if iLO5 finds the system BIOS has been compromised, it will try to recover from a backup copy. If the backup copy is also compromised and the customer has upgraded to the iLO advanced premium security edition license, iLO5 can automatically recover authentic firmware. The standard license provides the opportunity for manual recovery. The Silicon Root of Trust is the foundation for the entire secure state and secure recovery process. This enables HPE Gen10 servers to be the world’s most secure industry standard server and provides the extraordinary ability to not only verify the digital signature throughout the boot process, but also to recover securely if any firmware is compromised.

Firmware runtime validation

With the iLO advanced premium security edition license, the iLO5 chipset enables runtime validation of firmware. With firmware runtime verification, the iLO5 chipset performs the same checking process that happens during the boot process on a continual basis while the server is running. With the frequency of once a day, iLO5 along with its Silicon Root of Trust runs a background verification check on the iLO5 firmware, UEFI, and other firmware loaded after including the system programmable logic devices (SPLD), Innovation Engine (IE), and Management Engine (ME).

Authenticated firmware updates

The iLO5 chipset expands the number of firmware items that customers can update directly and securely in the HPE Gen10 servers. This is a standard feature of the iLO5. Firmware items that can be securely validated and updated from the iLO now include SPLDs, HPE ProLiant power interface control utility (PowerPIC) firmware, the Intel® IE and ME, and other low-level system components. The iLO5 contains a firmware repository stored on non-volatile flash memory (NAND), which allows components such as the service pack for HPE ProLiant (SPP) and other firmware updates to be applied and installed offline through iLO5.

Best practices followed by Hewlett Packard Enterprise to deliver security hardened HPE Synergy Composer appliance

Hewlett Packard Enterprise follows secure development lifecycle and used a security assessment tool called Comprehensive Applications Threat Analysis (CATA) to identify and remediate security defects in the appliance operating system.

NOTE
The design of the appliance is based on CATA fundamentals and underwent CATA review.

The factors that contribute to appliance security hardening are as follows:

- Appliance is hardened to enforce mandatory access control. This means users of HPE Synergy are provided the role-based access control (RBAC) that enables an administrator to establish access control and authorization for users based on their responsibilities.
- Important services of the appliance run with required privileges. This implies HPE Synergy Composer is governed by scope-based access control that enables an administrator to establish access control for users by allowing a role to be restricted to a subset of resources managed by the appliance.
- The appliance is configured and maintained by a firewall, which blocks unused ports. Restricting the usage of all non-essential ports reduces the attack surface for HPE Synergy Composer.
- The appliance operating system bootloader is password protected. This means HPE Synergy Composer cannot be compromised by someone attempting to boot in single-user mode.
- The appliance is designed to operate in an isolated management LAN. Hewlett Packard Enterprise recommends creating a private management LAN and keep that separate, known as air-gapped, from production LANs, using VLAN or firewall technology or both.
- Hewlett Packard Enterprise supports digital signature of all software or firmware updates to ensure their integrity and authenticity. This implies that when the customer is re-imaging the composer to quickly bring it to a specific firmware revision level, the digital signature is verified by the reimaging process.
- Operating system level users are not allowed to access the appliance, with the following exceptions:
  - A special preset command can be used only if the Infrastructure administrator password is lost or forgotten. This command requires that you contact your authorized support representative to obtain a one-time password.
  - A setting that enables an authorized support representative to obtain a one-time password, so that they can log in to the appliance console (and only the console) to perform advanced diagnostics. Customer can either enable or disable access with this setting.
- Hewlett Packard Enterprise closely monitors the security bulletins for threats to appliance software components and, if necessary, issues software updates.

Data protection

The business requirements should define a container application data protection architecture. These requirements include factors such as the speed of recovery, the maximum permissible data loss, and data retention needs. The data protection plan must also take into consideration with various regulatory requirements for data retention and restoration. Finally, different data recovery scenarios must be considered, ranging from the typical and foreseeable recovery resulting from user or application errors to disaster recovery scenarios that include the complete loss of a site. For basic data protection at a hardware layer, HPE Synergy D3940 Storage offers RAID protected volumes. For more information, see HPE Synergy 12Gb SAS Storage User Guide.

For advanced data protection features such as scheduling snapshots, application-aware and application-consistent snapshots, replication of snapshots, local and cloud snapshots are recommended for production use-cases. It is recommended to go with the third-party data protection providers that provides Kubernetes application backup.

SOLUTION LAYOUT

Figure 3 highlights the solution at a high level.

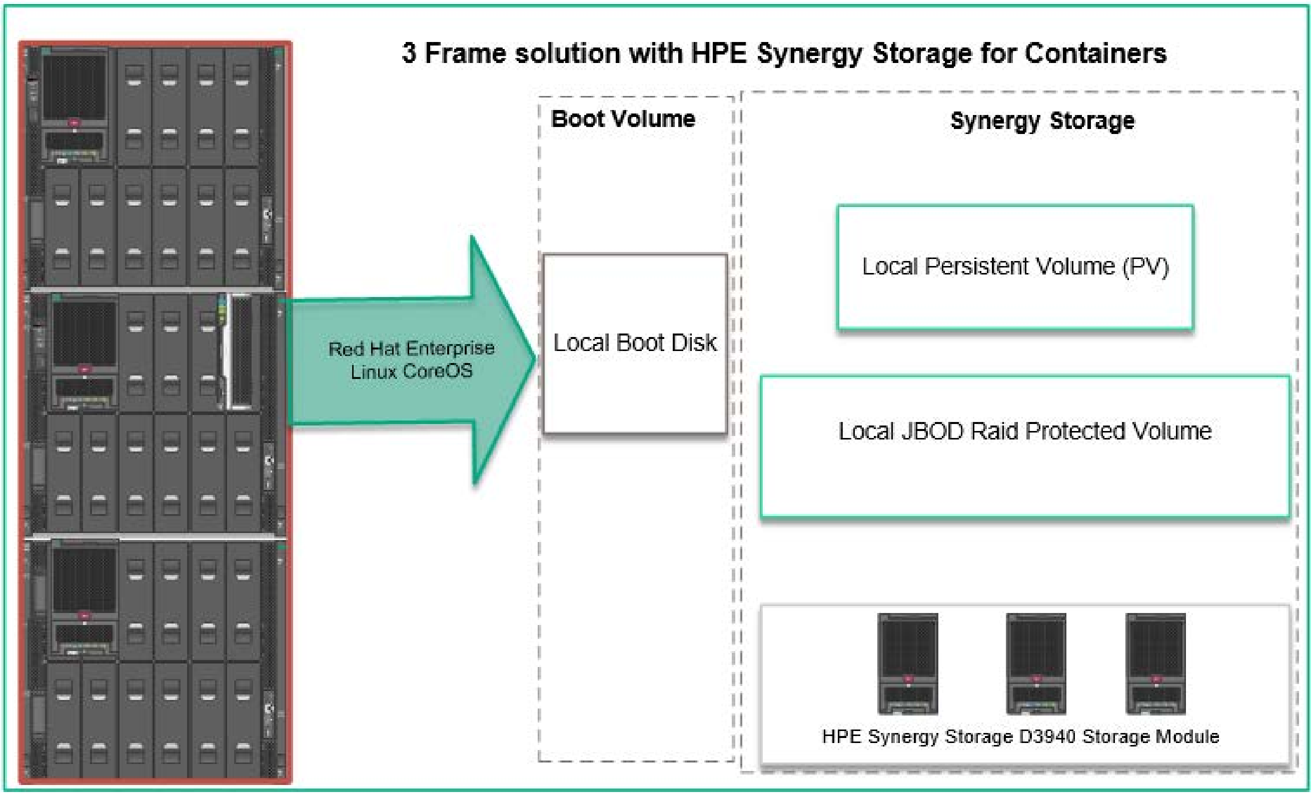

3 Frame solution with HPE Synergy Storage for Containers
Boot Volume
Synergy Storage
Red Hat Enterprise Linux CoreOS
Local Boot Disk
Local Persistent Volume (PV)
Local JBOD Raid Protected Volume
HPE Synergy Storage D3940 Storage Module

FIGURE 3. High level overview of the solution

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

- LDAP/Active Directory
- DHCP
- DNS
- NTP
- TFTP
- PXE

Figure 4 shows the layout of the hardware within the racks.

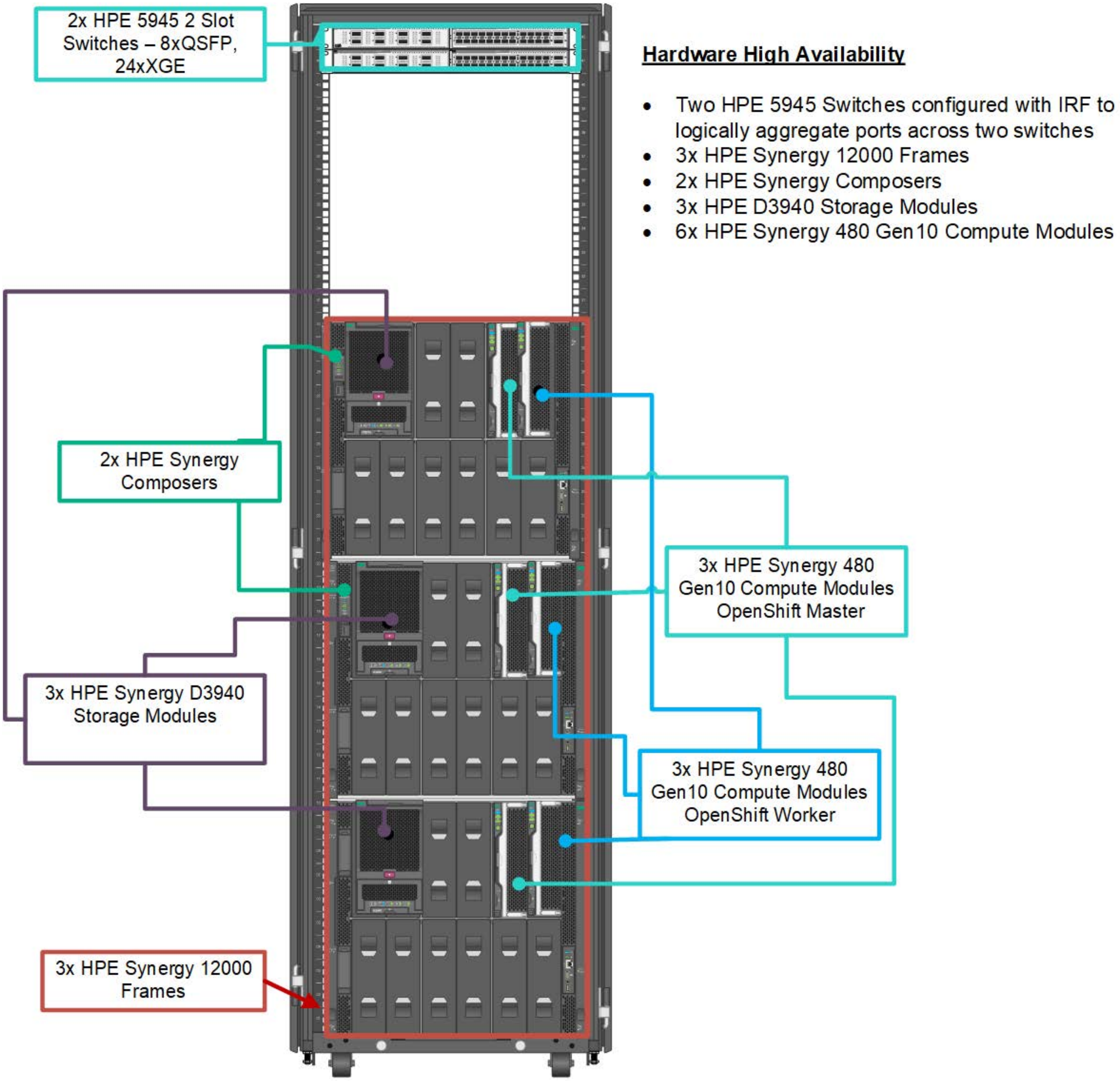

2x HPE 5945 2 Slot Switches – 8xQSFP, 24xXGE
Hardware High Availability
Two HPE 5945 Switches configured with IRF to logically aggregate ports across two switches
3x HPE Synergy 12000 Frames
2x HPE Synergy Composers
3x HPE D3940 Storage Modules
6x HPE Synergy 480 Gen10 Compute Modules
2x HPE Synergy Composers
3x HPE Synergy 480 Gen10 Compute Modules OpenShift Master
3x HPE Synergy D3940 Storage Modules
3x HPE Synergy 480 Gen10 Compute Modules OpenShift Worker
3x HPE Synergy 12000 Frames

FIGURE 4. Hardware layout within the rack

SOLUTION COMPONENTS

Hardware

Table 2 shows the list of hardware components used in this solution.

TABLE 2: List of hardware components

Component	Qty	Description
HPE Synergy 12000 Frame	3x	Three (3) HPE Synergy 12000 Frames house the infrastructure used for the solution.
• HPE Synergy Composer	2x	Two (2) HPE Synergy Composers for core configuration and lifecycle management for the Synergy components.
• HPE Virtual Connect SE 40Gb F8 Module	2x	Two (2) HPE Virtual Connect SE 40Gb F8 modules provide network connectivity into and out of the frames.
• HPE Synergy 12G SAS Connection Module	6x	Six (6) HPE 12G SAS Connection Modules (two (2) per frame).
HPE Synergy 480 Gen10 Compute Module	6x	Three (3) bare metal master nodes and three (3) bare metal worker nodes as described in this document.
HPE Synergy D3940 Storage	3x	Three HPE Synergy D3940 12Gb SAS CTO Drive Enclosure with 40 SFF (2.5in) Drive Bays
HPE FlexFabric 5945 2-Slot Switch	2x	Each switch contains one each of the HPE 5930 modules listed as follows:
• HPE 5945 24p SFP+ and 2p QSFP+ module	2x	• One (1) module per HPE FlexFabric 2-Slot Switch
• HPE 5945 8p QSFP+ module	2x	• One (1) module per HPE FlexFabric 2-Slot Switch

HPE Synergy

HPE Synergy, the first platform built for composable infrastructure empowers IT to create and deliver new value instantly and continuously. This single infrastructure reduces operational complexity for traditional workload and increases operational velocity for the new breed of applications and services. Through a single interface, HPE Synergy composes compute, storage, and fabric pools into configurations for any application. It also enables a broad range of applications from bare metal to virtual machines, to containers, and operational models such as hybrid cloud and DevOps. HPE Synergy enables IT to rapidly react to new business demands.

HPE Synergy Frames contain a management appliance called the HPE Synergy Composer which hosts HPE OneView. HPE Synergy Composer manages the composable infrastructure and delivers:

- Fluid pools of resources, where a single infrastructure of compute, storage, and fabric boots up ready for workload and demonstrates self-assimilating capacity
- Software-defined intelligence, with a single interface that precisely composes logical infrastructures at near-instant speed and demonstrates template-driven frictionless operations
- Unified API access, which enables simple line-of-code programming of every infrastructure element, easily automates IT operational processes and effortlessly automates applications through infrastructure deployment

HPE Synergy Composer provides the enterprise-level management to compose and deploy system resources to meet your application needs. This management appliance uses software-defined intelligence to aggregate compute, storage, and fabric resources in a manner that scales to your application needs, instead of being restricted to the fixed ratios of traditional resource offerings. HPE Synergy template-based provisioning enables fast time to service with a single point for defining compute module state, pooled storage, network connectivity, and boot image.

HPE OneView is a comprehensive unifying platform designed for converged infrastructure management. A unifying platform increases the productivity of every member of the internal IT team across servers, storage, and networking. HPE OneView provides organizations a more efficient way to work by streamlining processes, incorporating best practices, and creating a new holistic way to work. It is designed for open integration with existing tools and processes to extend these efficiencies.

HPE OneView is instrumental for the deployment and management of HPE servers and enclosure networking. It collapses infrastructure management tools into a single resource-oriented architecture that provides direct access to all logical and physical resources of the solution.

Logical resources include server profiles and server profile templates, enclosures and enclosure groups, and logical interconnects and logical interconnect groups. Physical resources include compute modules, interconnects, and storage modules.

HPE OneView offers a uniform way for administrators to interact with resources by providing a RESTful API foundation. The RESTful APIs enable administrators to utilize a growing ecosystem of integrations to further expand the advantages of the integrated resource model. This model removes the need for the administrator to enter and maintain the same configuration data more than once and keep all versions up-to-date. It encapsulates and abstracts many underlying tools behind the integrated resource model. This enables the administrator to operate with new levels of simplicity, speed, and agility to provision, monitor, and maintain the solution.

Within the context of the solution, HPE OneView for Synergy is utilized to:

- Configure the profiles of the HPE Synergy compute modules
- Apply and maintain compliance for firmware across the HPE Synergy infrastructure
- Configure networking from the HPE Synergy compute modules to internal and outbound destinations

HPE Synergy 480 Gen10 Compute Module

The HPE Synergy 480 Gen10 Compute Module delivers an efficient and flexible two-socket server to support the most demanding workload. The compute module is powered by Intel Xeon® Scalable family of processors, up to 3TB DDR4, and a large storage capacity within a composable architecture. HPE Synergy 480 Gen10 Compute Module:

- Is the most secure server with exclusive HPE Silicon Root of Trust. This secure server protects your applications and assets against downtime associated with hacks and viruses.
- Offers customer choice for greater performance and flexibility with Intel Xeon Scalable family of processors on the HPE Synergy 480 Gen10 architecture.
- Offers intelligent system tuning with processor smoothing and workload matching to improve processor throughput and an increase in overall performance by 8% over earlier generation.
- Features a maximum memory footprint of 3TB for large in-memory database and analytic applications.
- Features a hybrid HPE Smart Array for both RAID and HBA zoning in a single controller.

The HPE Synergy 480 Gen10 provides the required compute to power this solution running both Red Hat Virtualization for the core management pieces of Red Hat OpenShift and RHCOS to host the worker nodes.

The bill of materials found in Appendix A of this document outlines the configuration of the HPE Synergy compute modules used in this solution.

HPE Synergy D3940 Storage Module

The HPE Synergy D3940 Storage Module is a direct-attached storage module with 40 Small Form Factor (SFF) drive bays designed to use in HPE Synergy 12000 Frames. Through the HPE Synergy 12Gb SAS connection module, it provides composable storage for up to 10 compute modules in a single frame. HPE Synergy storage is optimized to use either as a direct-attached storage array or with software-defined storage solutions, such as Red Hat OpenShift Container Storage.

HPE Synergy storage enables a variety of workload by permitting multiple drive types to be configured in the same storage module. HPE Synergy D3940 Storage Modules support a family of 12G SAS or 6G SATA HDD and SSD Smart Drives. Storage modules connect to compute modules within a frame through the HPE Synergy 12 Gb SAS Connection Module. Any number of drive bays in a storage module can be composed with any compute module containing a Smart Array controller connected to the SAS fabric. This allows efficient utilization of available drives. HPE Synergy storage can scale up to 200 SFF drives with five storage modules in a single HPE Synergy 12000 Frame. Adding a second I/O adapter and second SAS connection module provides a redundant path to SAS drives inside the storage module, ensuring high availability. The modular design of the HPE Synergy D3940 Storage Module allows to slide out from the frame to service drives or I/O adapters without interrupting operation of other drives within the module. Additionally, the HPE Synergy D3940 Storage Module is optimized for solid state drives using a high-performance SAS connection with sixteen 12 Gb/s SAS lanes. This allows a single HPE Synergy storage module to deliver as much as 8 times the bandwidth of other JBOD options reaching up to 2M IOPs.

Software

Red Hat Enterprise Linux CoreOS (RHCOS)

RHCOS represents the next generation of single-purpose container operating system technology. RHCOS combines the quality standards of Red Hat Enterprise Linux (RHEL) with the automated and remote upgrade features from Linux container. RHCOS is supported only as a component of Red Hat OpenShift Container Platform 4 for all Red Hat OpenShift Container Platform machines. RHCOS is the only supported operating system for Red Hat OpenShift Container Platform control plane, or master machines. While RHCOS is the default operating system for all cluster machines, you can create compute, or worker machines that use Red Hat Enterprise Linux 7 as their operating system.

This solution is built on RHCOS. Each Red Hat OpenShift Container Platform 4 control plane and worker nodes are running on RHCOS as the dedicated physical server node functions.

Red Hat OpenShift Container Platform 4

Red Hat OpenShift Container Platform 4 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 Container Platform helps businesses achieve greater value by delivering modern and traditional applications with shorter development cycles and lower operating costs. Red Hat OpenShift Container Platform 4 is built on open source innovation and industry standards, including Kubernetes and RHCOS, the enterprise Linux container distribution.

Red Hat OpenShift Container Platform 4 can be provisioned with persistent storage by using local volumes. Local persistent volume allows you to access local storage devices, such as a disk or partition, by using the standard PVC interface. Local volumes can be used without manually scheduling pods to nodes, because the system is aware of the volume node constraints. However, local volumes are still subject to the availability of the underlying node and are not suitable for all applications.

Figure 5 describes how the individual Red Hat OpenShift Container Platform 4 pieces are laid out.

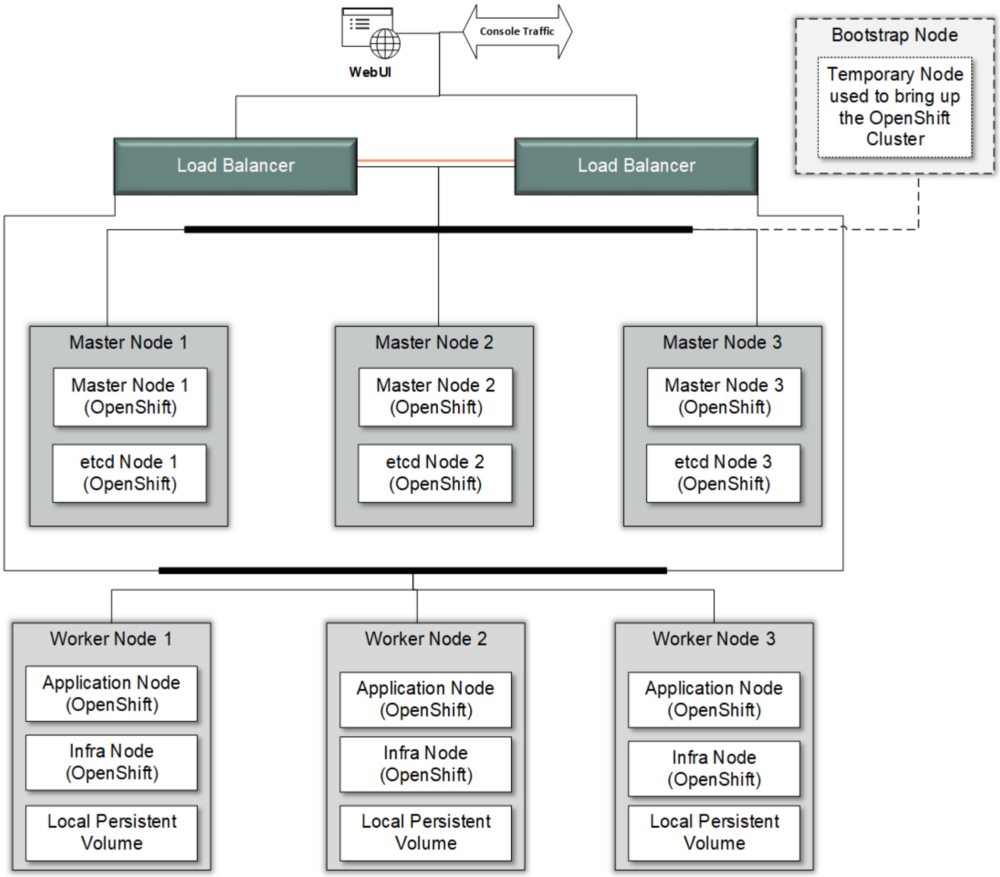


FIGURE 5. Red Hat OpenShift Container Platform 4 layout

BEST PRACTICES AND CONFIGURATION GUIDANCE FOR THE SOLUTION

This section discusses the high-level cabling and configuration of the solution hardware and software.

Solution cabling

Figure 6 describes the cabling configuration of the three (3) HPE Synergy 12000 Frames as well as the HPE FlexFabric 5945 Switches and Intelligent Resilient Fabric (IRF) within the context of this solution. These cables carry frame management, inter-frame and interconnect traffic between frames.

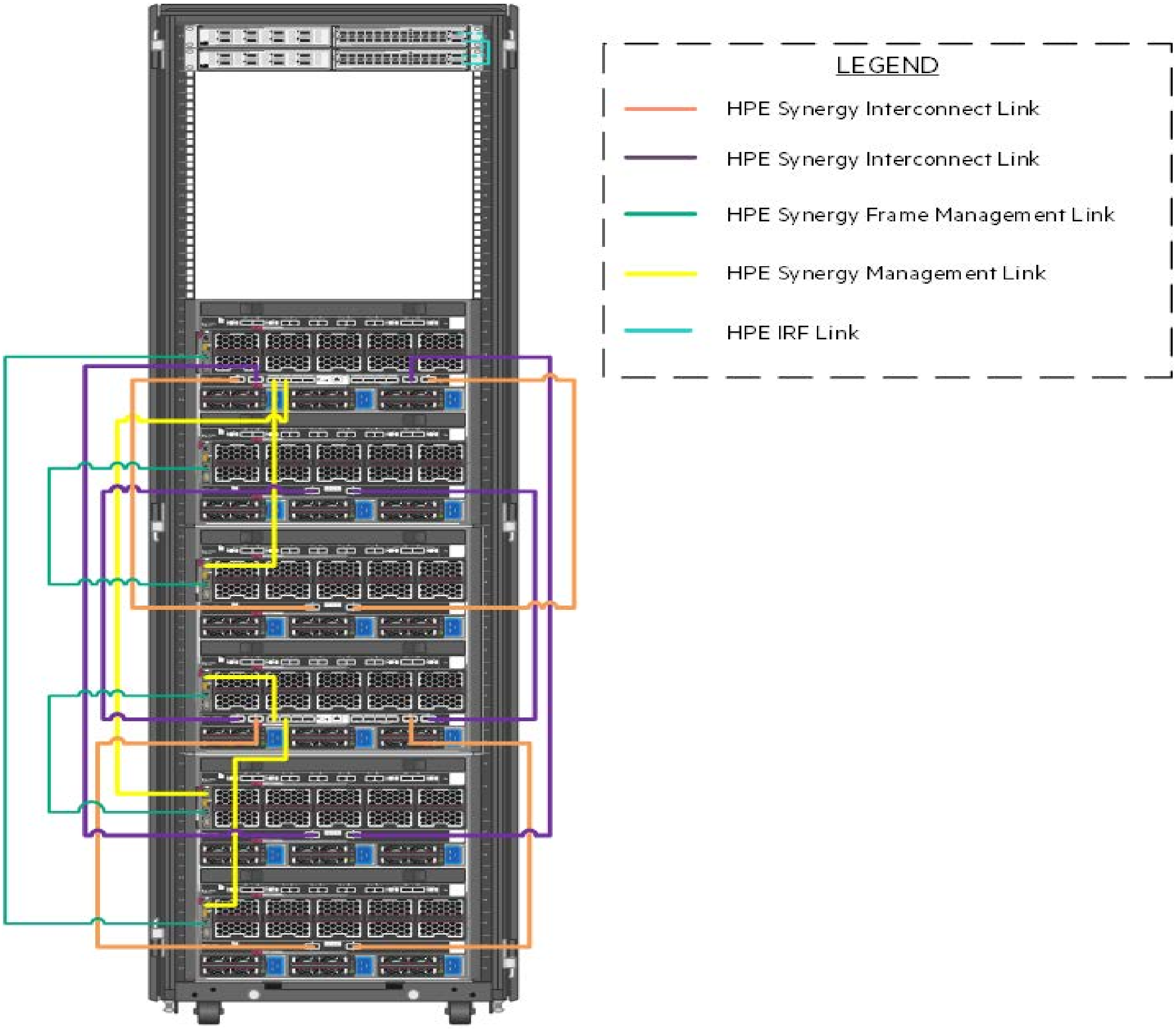

LEGEND
HPE Synergy Interconnect Link
HPE Synergy Interconnect Link
HPE Synergy Frame Management Link
HPE Synergy Management Link
HPE IRF Link

FIGURE 6. Frame and switch cabling within the solution

Networking

Figure 7 documents the cabling of the solution from the HPE Virtual Connect SE 40 GB modules to the switches. All egressing Ethernet networks are carried on a single bridge-aggregation group (BAGG). Top of rack switching was used in the creation of this solution, but end of row switching is equally effective in HPE Synergy environments and can reduce overall solution costs by reducing the number of physical switches.

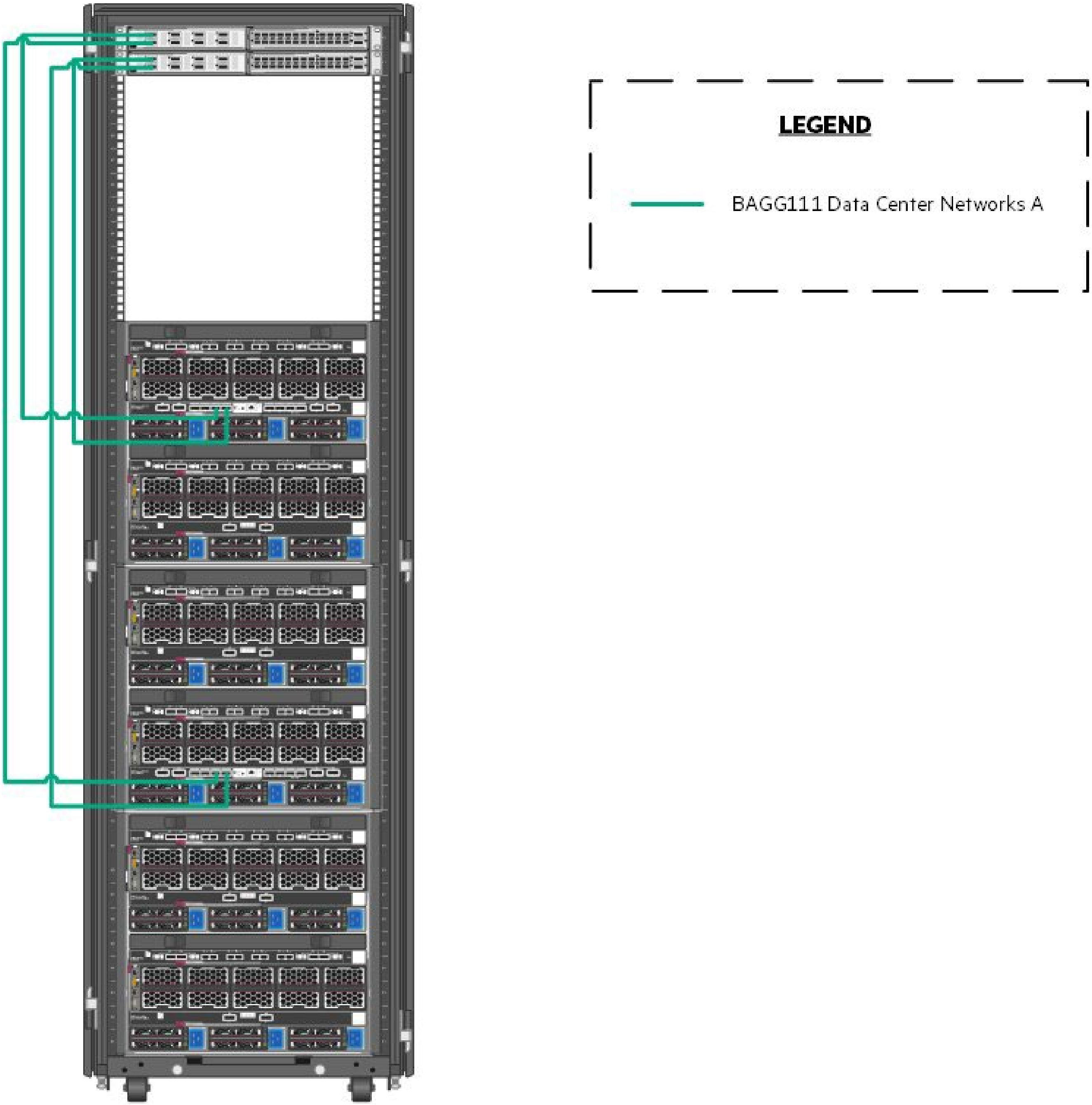


FIGURE 7. Network cabling from the HPE Synergy 12000 Frames to the switches

Table 3 describes the configuration of the networks as defined within HPE OneView for HPE Synergy and the bandwidth associated with each network. Except for the Synergy Management network, networks are carried outbound on a single BAGG.

TABLE 3: Networks defined within HPE OneView for HPE Synergy

Network Name	Type	VLAN Number	Purpose	Requested Bandwidth (Gb)	Maximum Bandwidth (Gb)
Management	Ethernet	1193	Solution management	5	20
Data_Center	Ethernet	2193	Application access, authentication and other user networks	10	20
Synergy Management	Ethernet	193	OneView for Synergy	2	20
PXE_Boot	Ethernet	2193	PXE boot for compute	3	20

Table 4 explains the cabling of the Virtual Connect Interconnect Modules to the HPE FlexFabric 5945 Switch.

TABLE 4: Uplink set mapping

Uplink Set	Synergy Source	Switch Destination
Network	Enclosure 1 Port Q3	FortyGigE1/1/1
	Enclosure 1 Port Q4	FortyGigE2/1/1
	Enclosure 2 Port Q3	FortyGigE1/1/2
	Enclosure 2 Port Q4	FortyGigE2/1/2

Utilizing HPE Synergy, the networks within the solution can traverse the HPE Synergy infrastructure in an east-west fashion across high speed, low latency links both within and between HPE Virtual Connect Modules. The communication between the Red Hat OpenShift Container Platform 4 management pieces remains within the HPE Synergy Frames.

Storage

The HPE Synergy D3940 Storage Module provides SSDs and optional Hard Disk Drives (HDDs) consumed by the Local Storage Operator, if not utilizing local disks within the HPE Synergy 480 Gen 10 Compute Modules. It can also provide boot volumes. Figure 8 describes the logical storage layout used in the solution. The HPE Synergy D3940 Storage Module provides SAS volumes.

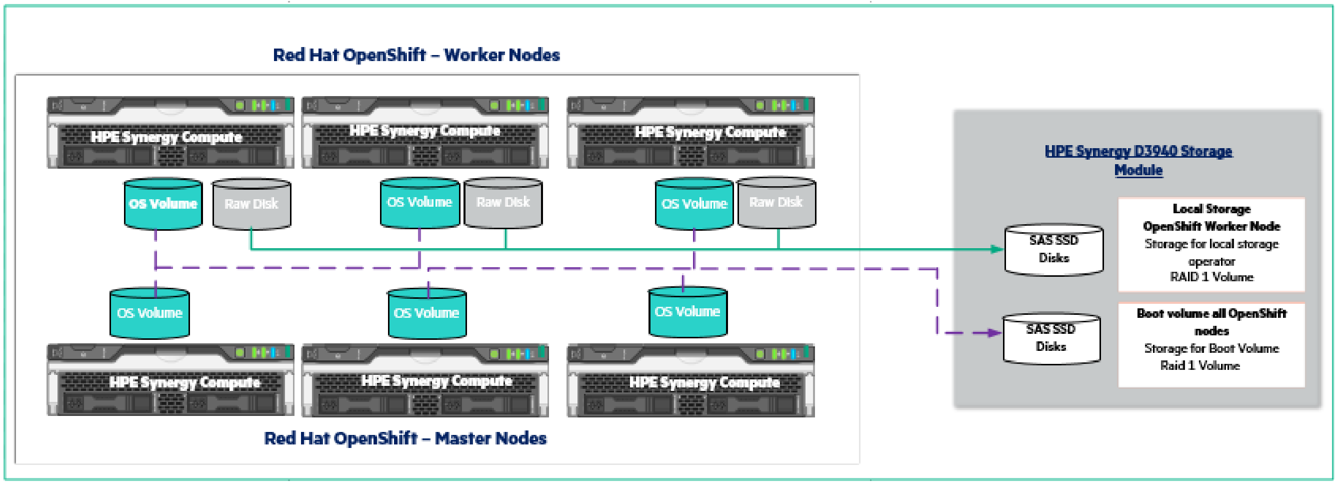


FIGURE 8. Logical storage layout within the solution

Table 5 lists all volumes used within the solution and highlights what storage provides the capacity and performance for each function.

TABLE 5: Details of volume

Volume/Disk Function	Qty	Size	Source	Hosts	Shared/Dedicated
Local Volume	3	960GB	HPE Synergy D3940 Storage	OpenShift worker nodes	Dedicated
Operating System (Optional)	6	300GB	HPE Synergy D3940 Storage	All Nodes	Dedicated

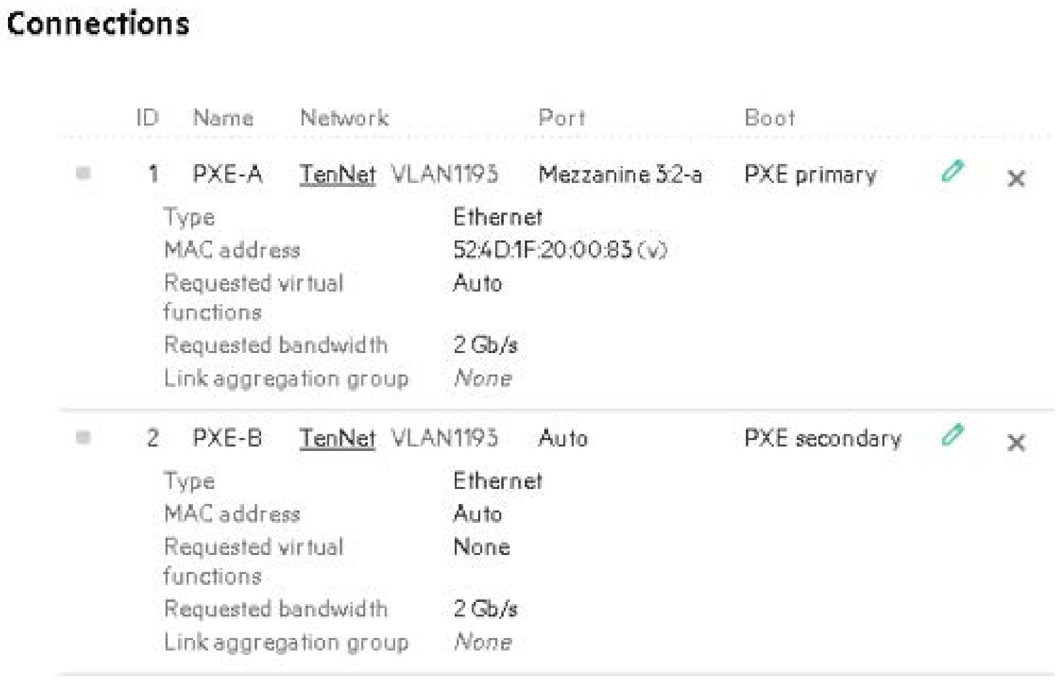
NOTE

The OpenShift Container registry data is hosted on the persistent application data store.

Server profiles

HPE Synergy Composable Infrastructure using HPE Virtual Connect provides the construct of a server profile. A server profile allows a suite of configuration parameters including network and storage connectivity, BIOS tuning, boot order configuration, local storage configuration and applied programmatically to compute resources. These templates are the key to deliver the "infrastructure-as-code" capabilities of the HPE Synergy platform. For the purpose of this solution, a single template was created that was applied to all OpenShift worker compute modules.

The critical items configured as part of the template supporting Red Hat OpenShift Container Platform 4 are the network connections and storage. Figure 9 describes the configuration of the network interfaces as part of the profile template for the worker nodes. There are two (2) redundant Ethernet networks that are used for PXE boot and network communication.



Connections

ID	Name	Network	Port	Boot
1	PXE-A	TenNet VLAN1193	Mezzanine 3:2-a	PXE primary

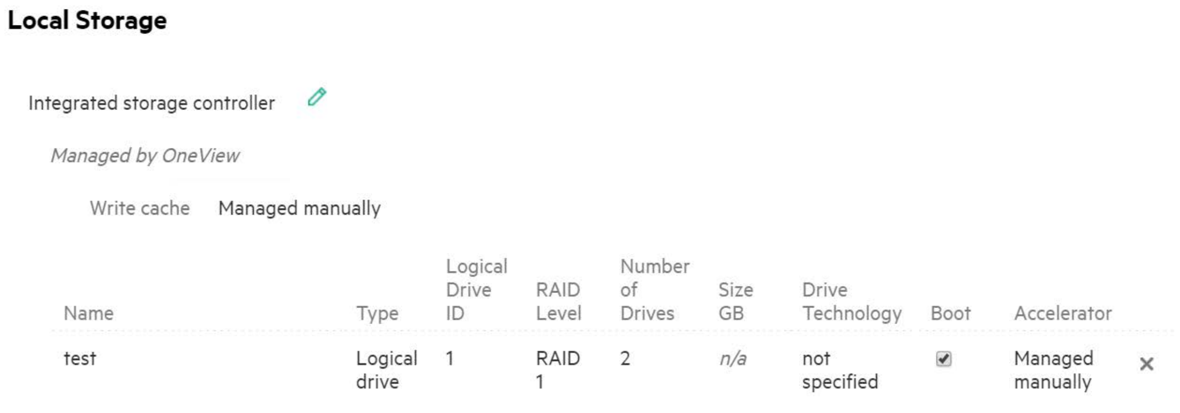
Type	Ethernet
MAC address	52:4D:1F:20:00:83 (v)
Requested virtual functions	Auto
Requested bandwidth	2 Gb/s
Link aggregation group	*None*

ID	Name	Network	Port	Boot
2	PXE-B	TenNet VLAN1193	Auto	PXE secondary

Type	Ethernet
MAC address	Auto
Requested virtual functions	None
Requested bandwidth	2 Gb/s
Link aggregation group	*None*

FIGURE 9. Server connections as part of the profile for OpenShift nodes

HPE Synergy D3940 Storage Modules are used to create the HPE Data Fabric as shown in Figure 10. The solid-state disks and/or hard disk drives provided by HPE Synergy D3940 is consumed by the HPE Data Fabric, and optionally, by compute nodes as boot devices.



Local Storage

Integrated storage controller

Managed by OneView

Write cache Managed manually

Name	Type	Logical Drive ID	RAID Level	Number of Drives	Size GB	Drive Technology	Boot	Accelerator	
test	Logical drive	1	RAID 1	2	*n/a*	not specified	☑	Managed manually	×

FIGURE 10. Local storage as part of the profile for OpenShift nodes

Software

This section describes the software versions utilized in the solution as well as noting any special installation or configuration requirements. Table 6 lists the software versions used in this solution.

TABLE 6: Software version

Component	Version
Red Hat Enterprise Linux CoreOS (RHCOS)	4.3
Red Hat OpenShift Container Platform	4.3

Capacity and sizing

Sizing for a Red Hat OpenShift Container Platform 4 environment varies depending on the requirements of the organization and type of deployment. The installer should read and understand Red Hat recommendations around scalability and performance prior to installation. This ensures the need of their environment are 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/4.3/scalability_and_performance/recommended-host-practices.html. The 4.3 section within the URL represents the version of Red Hat OpenShift being installed.

Non-root privileges and sudo command

The industry-wide security best practice is not to use the root user account for administration of the Linux distro-based servers. However, certain operations require root user privileges. Sudo command is used in such scenarios. The sudo command allows you to run programs with the security privileges of another user (by default, as the root). It prompts user for their password and confirms request to execute a command by checking a file, called sudoers, which the system administrator configures. Using the sudoers file, system administrators can give certain users or groups access to some or all commands without those users having to know the root password. It also logs all commands and arguments for traceability.

The root user is not active by default in RHCOS. So, root login is not available. Instead, log in as the core user.

DEPLOYMENT OVERVIEW

Figure 11 shows the overall deployment flow for the solution.

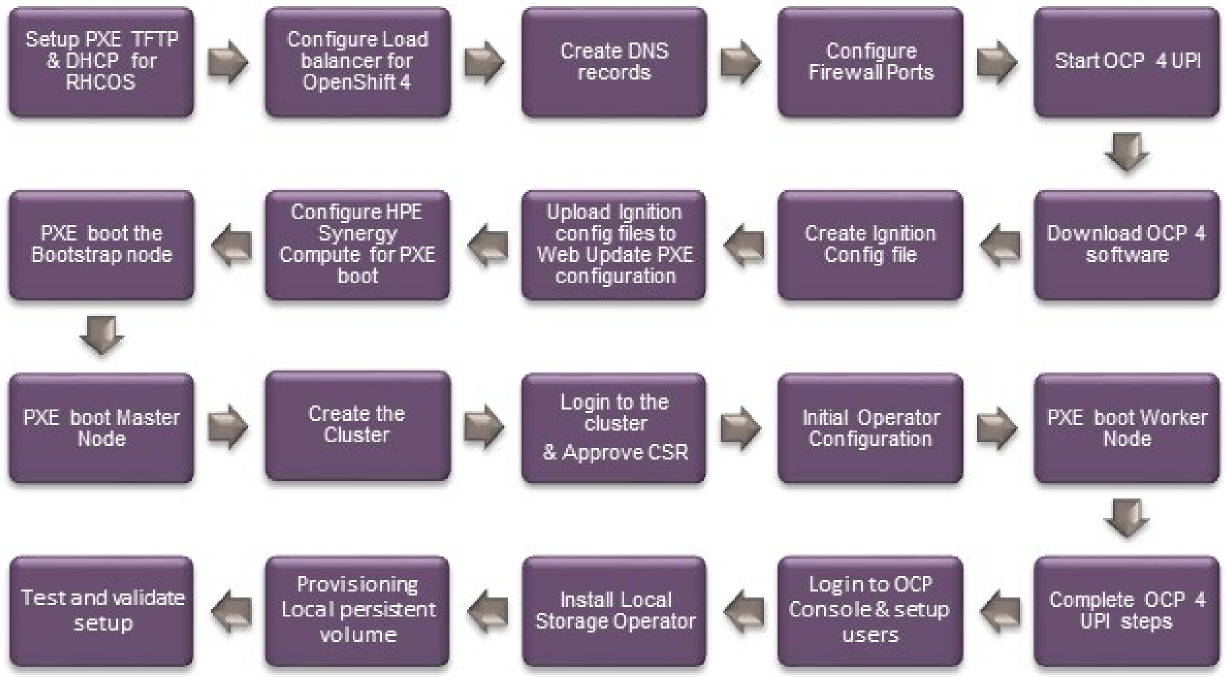

Setup PXE TFTP & DHCP for RHCOS
Configure Load balancer for OpenShift 4
Create DNS records
Configure Firewall Ports
Start OCP 4 UPI
Download OCP 4 software
Create Ignition Config file
Upload Ignition config files to Web Update PXE configuration
Configure HPE Synergy Compute for PXE boot
PXE boot the Bootstrap node
PXE boot Master Node
Create the Cluster
Login to the cluster & Approve CSR
Initial Operator Configuration
PXE boot Worker Node
Complete OCP 4 UPI steps
Login to OCP Console & setup users
Install Local Storage Operator
Provisioning Local persistent volume
Test and validate setup

FIGURE 11. Red Hat OpenShift Container Platform 4 deployment overview

Setup PXE, TFTP and DHCP for RHCOS

In this setup, the machine is booted on the PXE server. This prepares the PXE and TFTP server to able to boot RHCOS. This is the initial stage and DHCP is an integral part of the PXE boot process. So, configuring the DHCP is also important. This configuration can be done using sudo access.

Configure load balancer for Red Hat OpenShift 4 nodes

In multi node cluster deployment of OpenShift, the load balancer is mandatory. Hewlett Packard Enterprise has leveraged HAProxy load balancing required traffic. This configuration can be done using sudo access. For commercial load balancer such as F5 Big-IP or any other OpenShift Container Platform 4.x supported load balancer, you need to visit the manufacture website. For more details on configuring sudo to allow non-root users to execute root level commands and for information on HAProxy configuration, see the HPE solutions for Red Hat OpenShift Container Platform GitHub at https://github.com/HewlettPackard/hpe-solutions-openshift/tree/master/synergy/scalable.

Configure DNS

In user provisioned infrastructure (UPI), DNS records are required for each machine. These records must be able to resolve the host names of all other machines in a Red Hat OpenShift Container Platform cluster. This component too can be configured using sudo access for Linux- based DNS solution or Windows- based DNS solution. For more information, see Windows Role based Access. For third party DNS solutions, you need to visit the manufacture website. This provides more details to configure the sudo to allow non-root users to execute root level commands. For more information, see User-provisioned DNS requirements.

Configure firewall ports

In user provisioned infrastructure (UPI), network connectivity between machines allows cluster components to communicate within the Red Hat OpenShift Container Platform cluster. Hence, the required ports must be open between Red Hat OpenShift cluster nodes. This component too can be configured using sudo access for Linux- based firewall. For third party firewall solutions, you need to visit the manufacture website. This provides details on configuring sudo to allow non-root users to execute root level commands. For more information, see Networking requirements for user-provisioned infrastructure.

Start OpenShift Container Platform 4 user provisioned infrastructure (UPI) setup

In UPI, it begins with installing bastion host. This setup uses RHEL 7.6 virtual machine as bastion host. This bastion host is used for deployment and management of the Red Hat OpenShift Container Platform 4.x version clusters. The setup and configuration can be completed using sudo user access. ..For more information, see Generating an SSH private key and adding it to the agent.

Download OpenShift Container Platform 4 software versions

Download OpenShift Container Platform 4.x. Check the access token for your cluster and install it on bastion host. The bastion host is used for deploying and managing the OpenShift Container Platform 4.x version clusters. The setup and configuration can be completed using sudo user access. For more information, see Obtaining the installation program.

Create ignition config files

This step begins with creation of the `install-config.yaml` in a new folder. Use the OpenShift install tool to convert the yaml to the ignition config files required to install Red Hat OpenShift Container Platform 4.x. There is no system modification done on the bastion host or the provisioning server. This setup can be completed using sudo access. For more information, see Manually creating the installation configuration file.

In a virtualized setup to deploy OpenShift Container Platform 4, the ignition config files for master, worker and bootstrap nodes are converted to Base64 encoding. For more information, see creating installation configuration file at https://docs.openshift.com/container-platform/4.3/installing/installing_vsphere/installing-vsphere.html .

Upload ignition config files to web

This step involves uploading the ignition config files to internal website that allows anonymous access to the PXE boot process. Update the PXE default file to point to the website location of the ignition file. The action required in this step can be done using sudo user. For more information, see Creating Red Hat Enterprise Linux CoreOS (RHCOS) machines by PXE or iPXE booting.

In a virtualized set-up to deploy OpenShift Container Platform 4, a template for OVA image is created. This template is used for creating nodes on the cluster. The ignition config files are provided on each node, while provisioning the VMs. For more information see Create template for OVA Image at https://docs.openshift.com/container-platform/4.3/installing/installing_vsphere/installing-vsphere.html.

Configure the HPE Synergy Compute for PXE boot

The configuration involves setting up the server profile in HPE Synergy Composer for PXE boot and for required storage. Hewlett Packard Enterprise uses the HPE Synergy Composer to create the server profiles and templates. The access to the composer UI is that of non-root user. Hence, from a security standpoint, no root access is being used for HPE Synergy composer access. For more information, see Server profiles and server profile templates.

PXE boot the bootstrap node

The bootstrap node is a temporary node that is used to bring up the OpenShift cluster. After the cluster is up, this machine can be decommissioned, and the hardware will be reused. The PXE boot process must use bootstrapping information as a part of PXE boot parameter to install the RHCOS on this node.

PXE boot the master node

The master node uses PXE image for RHCOS after the bootstrap node. The PXE boot process must use `master.ign` information as part of PXE boot parameter to install the RHCOS on this node. The root user is not active by default in RHCOS. So, root login is not available. Instead, log in as the core user.

Create the cluster

The four nodes, one bootstrap and three master nodes boot up and are at the login prompt for RHCOS. Use the OpenShift install tool to complete the bootstrap process. For more information, see Creating the cluster. This action is taken using the sudo user logged in on the bastion host or provision server.

Login to the cluster

After the bootstrap process has completed successfully, log in to the cluster. The `kubeconfig` file is present in the `auth` directory where the ignition files are created on the bastion host. Log in to your cluster as a default system user by exporting the `cluster kubeconfig` file. The kubeconfig file contains information about the cluster that is used by the CLI to connect a client to the correct cluster and API server. The file is specific to a cluster and is created during Red Hat OpenShift Container Platform installation. After logging in, approve the pending OpenShift CSR for the nodes. For more information, see Logging in to the cluster.

Initial operator configuration

After the control plane initializes, you must immediately configure operators that are not available. This ensures their availability. Example: image-registry. For more information, see Initial Operator Configuration. This action is taken using the sudo user logged in on the bastion host or provision server as this user.

PXE boot the worker node

This step involves decommissioning of the bootstrap node and deleting the associated HPE Synergy server profile. Boot the compute nodes associated with worker node profile that has second volume for local storage setup using PXE. The root user is not active by default in RHCOS. So, root login is not available, instead log in as the core user.

Complete the installation of OpenShift Container Platform 4 and higher versions for user provisioned infrastructure

After the worker node boots up successfully, use the `oc get nodes` from the bastion host. The admin can see the worker nodes as part of the OpenShift cluster. Run the OpenShift install tool to complete the installation. For more information, see completing installation on user-provisioned infrastructure. After this process is completed, it will provide the URL for the Red Hat OpenShift Container Platform 4 version of the console along with the temporary `user kubeadmin` and temporary password for login.

Log in to the OpenShift Container Platform 4 and higher versions of the console

Log in to the OpenShift Container Platform 4 version of the console using the URL, username, and password provided in the complete Red Hat OpenShift Container Platform 4 user provisioned infrastructure. Setup a new user with cluster admin privileges. For more information, see Understanding authentication.

Install local storage operator

The local storage operator is not installed in Red Hat OpenShift Container Platform by default. Use the following procedure to install and configure this operator to enable local volume in your cluster. This action can be completed using the bastion host. For more information, see installing the Local Storage Operator for the Red Hat OpenShift Container Platform 4 section in the Deployment guide at https://github.com/HewlettPackard/hpe-solutions-openshift/tree/master/synergy.

Provision local volume

Local volume cannot be created by dynamic provisioning. Instead, persistent volumes must be created by the local storage operator. This provisioner will look for any devices, both filesystem and block volumes, at the path specified in the defined resource. Local volume must be statically created as a Persistent Volume Claim (PVC) that can be accessed by the pod. After a local volume has been mapped to a PVC, it can be specified inside of a resource. For more information, see Provision the local volumes.

NOTE
Local volume can only be used as a statically created persistent volume.

Test and validate the setup

It involves creating storage class, persistent volume claim, persistent volume, and pods as per your workload requirements on Red Hat OpenShift Container Platform 4 using local storage operator as persistent storage provider.

Physical worker node labeling in OpenShift

Discovering the node properties and advertising them through node labels 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 HPE server platforms, 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/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 of application pods on desired node based on application requirements. For example, if the compute module in the HPE Synergy Composable Infrastructure must support for Intel TXT, which is specifically designed to harden platforms from the emerging threats of hypervisor attacks, malicious root kit installations, or other software-based attacks. Administrators can use this information to restrict confidential data or sensitive workloads to nodes that are better controlled and have their configurations more thoroughly evaluated using Intel TXT-enabled platform. For more information about node labeling configuration, see the HPE solutions for Red Hat OpenShift GitHub at https://github.com/HewlettPackard/hpe-solutions-openshift/tree/master/synergy/scalable/.

Securing and monitoring OpenShift with Sysdig SaaS

To address the security challenges that exist in containerized environments, this solution leverages Sysdig SaaS Platform to secure and monitor Red Hat OpenShift Container Platform, an enterprise-ready Kubernetes platform that is installed and configured on HPE Synergy Composable 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 subscription they have chosen. 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 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 security 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 your 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://github.com/HewlettPackard/hpe-solutions-openshift/tree/master/synergy/scalable/.

NOTE
The Sysdig functionality is not turned on by default in this solution. For more information on how to enable Sysdig, see Sysdig configuration section listed in HPE solutions for Red Hat OpenShift Container Platform GitHub at https://github.com/HewlettPackard/hpe-solutions-openshift/tree/master/synergy/scalable/.

SUMMARY

Red Hat OpenShift Container Platform 4 on HPE Synergy provides a container solution that eliminates many of the complexities associated with implementing a container platform at scale. Red Hat OpenShift Container Platform 4 provides organizations with a reliable platform for deploying and scaling container-based applications. HPE Synergy provides the flexible infrastructure you need to run that container platform to dynamically provision and scale applications, whether they run on-premises, in the cloud, or somewhere in between.

This Reference Configuration utilizes HPE Synergy to deploy Red Hat OpenShift Container Platform 4 and local persistent volumes. The following benefits can be realized by implementing this solution:

- Deploying the management, etcd, and worker nodes on bare metal which eliminates the overhead associated with hypervisors and thus optimizes performance.
- Using an HPE Synergy storage solution such as HPE Synergy D3940 Storage for local persistent storage with containers to enable speed, portability, agility, data protection for traditional enterprise applications and data.
- Using HPE Synergy Composable Infrastructure provides a layered view of security controls. The objective to choose this layered security view is to ensure that the customers are aware of the depth of security risk that an infrastructure can have and also depth of defense that is built in the HPE Synergy Composable Infrastructure design.
- Utilizing HPE Synergy Composable Infrastructure provides the ability to programmatically define and deploy servers, storage, and networking as part of a comprehensive container solution.

APPENDIX A: BILL OF MATERIALS

The following bill of materials contains the core components utilized in the creation of this solution. Services, support, and software are not included in the BOM and the power distribution should be customized based on customer needs.

NOTE

Part numbers are at time of 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 your HPE Reseller or HPE Sales Representative. For more details, see. hpe.com/us/en/services/consulting.html.

TABLE A1. Bill of materials

Qty	Part number	Description
		Rack and Network Infrastructure
1	P9K10A	HPE 42U 600mmx1200mm G2 Kitted Advanced Shock Rack with Side Panels and Baying
1	P9K10A 001	HPE Factory Express Base Racking Service
1	H6J85A	HPE Rack Hardware Kit
1	BW932A	HPE 600mm Rack Stabilizer Kit
1	BW932A B01	HPE 600mm Rack include with Complete System Stabilizer Kit
4	AF533A	HPE Intelligent Modular 3Ph 14.4kVA/CS8365C 40A/208V Outlets (6) C19/Horizontal NA/JP PDU
		HPE Synergy Composable Infrastructure
3	797740-B21	HPE Synergy 12000 Configure-to-order Frame with 1x Frame Link Module 10x Fans
4	779218-B21	HPE Synergy 20Gb Interconnect Link Module
2	794502-B23	HPE Virtual Connect SE 40Gb F8 Module for Synergy
6	755985-B21	HPE 12G SAS Connectivity Module for Synergy
3	798096-B21	HPE 6x 2650W Performance Hot Plug Titanium Plus FIO Power Supply Kit
2	804353-B21	HPE Synergy Composer
3	804938-B21	HPE Synergy Frame Rack Rail Kit
3	804942-B21	HPE Synergy Frame Link Module
1	804943-B21	HPE Synergy Frame 4x Lift Handles
1	859493-B21	HPE Synergy Multi Frame Master1 FIO
1	859494-B22	HPE Synergy Multi Frame Master2 FIO
8	804101-B21	HPE Synergy Interconnect Link 3m Active Optical Cable
2	720199-B21	HPE Blade System c-Class 40G QSFP+ to QSFP+ 3m Direct Attach Copper Cable
2	861412-B21	HPE Synergy Frame Link Module CAT6A 1.2m Cable
1	861413-B21	HPE Synergy Frame Link Module CAT6A 3m Cable
		Master Nodes
3	871940-B21	HPE Synergy 480 Gen10 Configure-to-order Compute Module
3	873381-L21	HPE Synergy 480/660 Gen10 Intel Xeon-Gold 6130 (2.1GHz/16-core/125W) FIO Processor Kit
3	873381-B21	HPE Synergy 480/660 Gen10 Intel Xeon-Gold 6130 (2.1GHz/16-core/125W) Processor Kit
54	815097-B21	HPE 8GB (1x8GB) Single Rank x8 DDR4-2666 CAS-19-19-19 Registered Smart Memory Kit
18	815098-B21	HPE 16GB (1x16GB) Single Rank x4 DDR4-2666 CAS-19-19-19 Registered Smart Memory Kit
6	875478-B21	HPE 1.92TB SATA 6G Mixed Use SFF (2.5in) SC 3yr WTY Digitally Signed Firmware SSD
3	P01367-B1	HPE 96W Smart Storage Battery (up to 20 Devices) with 260mm Cable Kit
3	804424-B21	HPE Smart Array P204i-c SR Gen10 (4 Internal Lanes/1GB Cache) 12G SAS Modular Controller

Qty	Part number	Description
3	777430-B21	HPE Synergy 3820C 10/20Gb Converged Network Adapter
		Worker Nodes
6	871943-B21	HPE Synergy 480 Gen10 6130 2P 64GB-R P204i-c SAS Performance Compute Module
6	873381-L21	HPE Synergy 480/660 Gen10 Intel Xeon-Gold 6130 (2.1GHz/16-core/125W) FIO Processor Kit
6	873381-B21	HPE Synergy 480/660 Gen10 Intel Xeon-Gold 6130 (2.1GHz/16-core/125W) Processor Kit
108	815097-B21	HPE 8GB (1x8GB) Single Rank x8 DDR4-2666 CAS-19-19-19 Registered Smart Memory Kit
36	815098-B21	HPE 16GB (1x16GB) Single Rank x4 DDR4-2666 CAS-19-19-19 Registered Smart Memory Kit
6	P01367-B1	HPE 96W Smart Storage Battery (up to 20 Devices) with 260mm Cable Kit
6	804424-B21	HPE Smart Array P204i-c SR Gen10 (4 Internal Lanes/1GB Cache) 12G SAS Modular Controller
6	777430-B21	HPE Synergy 3820C 10/20Gb Converged Network Adapter
3	SAS MEZZ	SAS MEZZ
		HPE Synergy D3940 Storage
3	835386-B21	HPE Synergy D3940 12Gb SAS CTO Drive Enclosure with 40 SFF (2.5 in.) Drive Bays
		HPE 5945 FlexFabric Switching
2	JQ075A	HPE FF 5945 2-Slot Switch
2	JH180A	HPE 5930 24p SFP+ and 2p QSFP+ Module
2	JH183A	HPE 5930 8-port QSFP+ Module
4	JH389A	HPE X712 Back (Power Side) to Front (Port Side) Airflow High Volume Fan Tray
4	JC680A	HPE 58x0AF 650W AC Power Supply
4	JC680A B2B	INCLUDED: Jumper Cable - NA/JP/TW
2	JG326A	HPE X240 40G QSFP+ QSFP+ 1m DAC Cable
4	JG327A	HPE X240 40G QSFP+ QSFP+ 3m DAC Cable
		Red Hat OpenShift Container Platform
1	R1Z92AAE	Red Hat OpenShift Container Platform 4 for HPE Synergy 1-32 Cores 1yr Subscription 24x7
		Red Hat Enterprise Linux CoreOS (RHCOS) Server
6	J8J36AAE	Red Hat Enterprise Linux CoreOS (RHCOS) Server 2 Sockets 1 Guest 1 Year Subscription 24x7 Support
		Red Hat Enterprise Linux CoreOS (RHCOS) for Virtual data centers
11	G3J22AAE	Red Hat Enterprise Linux CoreOS (RHCOS) for Virtual Datacenters 2 Sockets 1 Year Subscription 24x7 Support

RESOURCES AND ADDITIONAL LINKS

Red Hat, redhat.com

Red Hat OpenShift Container Platform 4 documentation https://docs.openshift.com/container-platform/4.3/welcome/index.html

HPE Synergy, hpe.com/info/synergy

HPE Synergy D3940 Storage, https://buy.hpe.com/us/en/synergy/synergy-storage/synergy-storage-modules/synergy-storage-modules/hpe-synergy-d3940-storage-module/p/1008615217

HPE FlexFabric 5945 switching, hpe.com/us/en/product-catalog/networking/networking-switches/pip.hpe-flexfabric-5945-switch-series.1009148840.html

To help us improve our documents, please provide feedback at hpe.com/contact/feedback.

a50001254enw, version 2.0, April 2022

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