OPENSHEET CONTAINER STORAGE

OpenShift commons Milan

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Storage SA

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Storage BU
POSSIBLE STORAGE PROVIDERS

- NFS
- GlusterFS
- OpenStack Cinder
- iSCSI
- Fibre Channel
- Ceph RBD
- AWS Elastic Block Store (EBS)
- GCE Persistent Disk
- VMWare vSphere
- Container Storage Interface (CSI)
- Dynamic Provisioning and Creating Storage Classes
- Azure Disk
- Azure File
- FlexVolume

https://docs.openshift.com
STORAGE PROVISIONING IN OPENSSHIFT

● STATIC PROVISIONING
  Storage Admin creates storage volumes upfront
  OpenShift selects a predefined volume based upon claim, nearest available size
  No automated housekeeping - causing administrative burden
  Error Prone due to increasing complexity and resulting administrative overhead

● DYNAMIC PROVISIONING
  OpenShift user requests for storage by persistent volume claim (PVC)
  Storage system does the needful in an automated way
  Delivers the exact requested size and type storage volume
  No administrative overhead and storage admin involvement upfront
  Automated housekeeping, better efficiency
4 BASIC STORAGE NEEDS IN OCP

- **REGISTRY STORE**
  Where container base images reside.
  By default not redundant, therefore possible point of failure. OCS resolves this.

- **PERSISTENT FILE STORAGE FOR CONTAINERS**
  Container application state is held in this persistent file storage.

- **PERSISTENT BLOCK STORAGE FOR CONTAINERS**
  Specific storage type for specific workloads that require certain performance.
  i.e. Database workloads, Logging where Elastic or equivalents are involved.

- **EPHEMERAL STORAGE**
  Application internal storage, also named EmptyDir.
  Outside scope for container storage.
STORAGE OPTIONS FOR CONTAINERS

**STORAGE ARRAYS AND APPLIANCES**
- Scalability and high availability fall short of customer needs
- Vendor lock in and high TCO
- Monolithic appliance model

**SILOED OR POINT PLAY STORAGE SOLUTIONS**
- No hybrid cloud support
- No unified control plane (K8s)
- Lack of automated or dynamic handling of storage needs

**PORTABLE STORAGE ACROSS ON-PREM / MULTIPLE PUBLIC CLOUDS**
*OpenShift Container Storage from Red Hat*
- Runs in public clouds
- Single Vendor Support model
- Seamless user experience for developers and DevOps
- Full integration and all automated
Consistent Storage Experience Across Hybrid Cloud

APPLICATION PORTABILITY AND LOWER COSTS

BARE METAL

VIRTUAL MACHINES

CONTAINERS

PRIVATE CLOUD

PUBLIC CLOUD

LEGACY STORAGE

RED HAT® ENTERPRISE LINUX®

RED HAT® VIRTUALIZATION

RED HAT® OPENSFILE CONTAINER PLATFORM

PRIVATE CLOUD

PUBLIC CLOUD

RED HAT® OPENSFILE CONTAINER STORAGE

RED HAT® OPENSFILE CONTAINER PLATFORM
OCS 3
OpenShift Container Storage
Based on GlusterFS technology
OPENSHEET PLATFORM STORAGE NEEDS

OCP Infrastructure
- Registry
- Metrics
- Logging

OCP Application
- Service 1
- Service 2

Local/Ephemeral Storage

Openshift Container Storage focus
PERSISTENT STORAGE FOR CONTAINERS

VALUE PROPOSITION FOR STORAGE ADMIN VS. DEVOPS

**STORAGE FOR CONTAINERS**

Persona: Storage Admins, Infrastructure Admins

- Leverage existing investment in traditional storage, managed by storage admin
- Attach to stand alone storage

**STORAGE IN CONTAINERS**

Persona: DevOps, App Architects

- Highly scalable, enterprise-grade storage, fully integrated into OpenShift Container Platform
OCS Data Plane

CONTAINERIZED RED HAT STORAGE

STORAGE VOLUMES

RED HAT STORAGE POD

HOST NETWORK

PHYSICAL DISK

RHEL HOST OS

DEVELOPER

OPERATIONS
## OCS product features

More relevant since v3.9

<table>
<thead>
<tr>
<th>Integration</th>
<th>Features</th>
<th>CNS 3.9</th>
<th>OCS 3.10</th>
<th>OCS 3.11</th>
</tr>
</thead>
<tbody>
<tr>
<td>kubernetes</td>
<td>Support RWX, RWO, ROX</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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<td></td>
<td>Dynamic provisioning</td>
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<td>PVC resize (oc edit pvc)</td>
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<td>Openshift</td>
<td>Prometheus storage API metrics</td>
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<tr>
<td></td>
<td>Deploy with OCP ansible playbook</td>
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<td>✔️</td>
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<td></td>
<td>PVC resize (web-console)</td>
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<td></td>
<td>Storage class volume options</td>
<td></td>
<td>✔️</td>
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<tr>
<td></td>
<td>Infra support registry, metrics, logging</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td>Storage</td>
<td>Block storage with iSCSI support</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td></td>
<td>File sharing with glusterfs-fuse</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td></td>
<td>Object with S3/Swift (tech preview)</td>
<td>✔️</td>
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<tr>
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<td>Snapshot and geo-replication</td>
<td>✔️</td>
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<tr>
<td></td>
<td>Arbiter volume (replica 2 + metadata)</td>
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<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Public Azure, AWS, GCP</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td></td>
<td>Private Openstack</td>
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<tr>
<td></td>
<td>Virtualization (VMW, RHV)</td>
<td>✔️</td>
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</tr>
</tbody>
</table>
OCS 3.11 support
Aligned with the OCP lifecycle support

Life Cycle Phases

Full Support

Full support is provided according to the published Scope of Coverage and Service Level Agreement. Likewise, Development Support is provided according to the published Scope of Coverage and Service Level Agreement.

During the Full Support Phase, qualified Critical and Important Security errata advisories (RHSAs) and Urgent and Selected High Priority Bug Fix errata advisories (RHBAs) may be released as they become available, all other available fix and qualified patches may be released via periodic updates. Customers are expected to upgrade their OpenShift environment to the most current supported version. On request, and at Red Hat’s discretion, qualified Critical Security errata advisories (RHSAs) and Critical Bug Fix errata advisories (RHBAs) may be made available to non-current minor versions.

Non-current releases within the full support phase which are no longer eligible for maintenance updates of any kind are marked as unmaintained. The following table outlines the schedule for which minor versions of OpenShift v3 will no longer be eligible for maintenance updates:

v3.X End of Maintenance Schedule

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>3.0 &amp; 3.1</td>
<td>3.2 &amp; 3.3</td>
<td>3.4 &amp; 3.5</td>
<td>3.6 &amp; 3.7</td>
<td>3.9 &amp; 3.10</td>
<td>3.11</td>
</tr>
</tbody>
</table>

https://access.redhat.com/support/policy/updates/openshift
OCP v4 storage integration requirements

New challenge for storage vendors

- Operator framework for standard lifecycle management
- New industry standard storage API with CSI (Container Storage Interface) integrated with kubernetes offering:
  - Storage Classes which provide configuration to CSI drivers
  - Ability to encrypt credentials
  - Multiple CSI drivers can co-exist
  - Ensure that one controller service start at a time
CSI plugin components (API calls)

<table>
<thead>
<tr>
<th>CONTROLLER Service</th>
<th>NODE Service</th>
<th>IDENTITY Service</th>
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</thead>
<tbody>
<tr>
<td>. ListVolume</td>
<td>. NodePublishVolume</td>
<td>. Probe(ProbeRequest)</td>
</tr>
<tr>
<td>. ControllerPublishVolume</td>
<td>. NodeUnpublishVolume</td>
<td></td>
</tr>
<tr>
<td>. ControllerUnpublishVolume</td>
<td>. ValidateVolumeCapabilities</td>
<td></td>
</tr>
<tr>
<td>. GetCapacity</td>
<td>. NodeGetVolumeStats</td>
<td></td>
</tr>
<tr>
<td>. CreateSnapshot</td>
<td>. NodeGetInfo</td>
<td></td>
</tr>
<tr>
<td>. DeleteSnapshot</td>
<td>. NodeGetCapabilities</td>
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</tr>
<tr>
<td>. ListSnapshot</td>
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<tr>
<td>. ControllerGetCapabilities</td>
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</tbody>
</table>
It’s OCS 3.11 ready for OCP 4.2?

Use case for fresh new OCP 4.2 cluster

New OCP v4 cluster

Is OCS 3.11 supported?

No

Do we have a solution?

Yes

OCS v4.2

No
It’s OCS 3.11 ready for OCP 4.2?

Use case for existent OCP 3.11 to OCP 4.2

From OCP v3.11 to OCP 4.2

Is OCS 3.11 supported?

No

Do we have a solution?

Yes

OCS v4.2

OK but what do we do with my existent pvc?

Do we have a migration plan?

Yes

Migration tool Integrated in OCP
OCS 4
OpenShift Container Storage
OPENSHIFT OPERATOR FRAMEWORK

● Goal of an Operator: Put operational knowledge into software

● Day-1: Operators implement and automate common installation, configuration

● Day-2: Re-configuration, update, backup, failover, restore

● Kubernetes-native application
  (integrating natively with Kubernetes concepts and APIs)
WHAT CHANGED

● **OPENSSHIFT**
  OpenShift transitions from OCP 3 to OCP 4

● **OPENSSHIFT CONTAINER STORAGE**
  also transitions from OCS 3 to OCS 4

● **OCS 4** will be based on [ROOK.IO](https://rook.io), which uses [Red Hat Ceph Storage](https://www.redhat.com/en/ceph) and the recently acquired [NooBaa](https://www.redhat.com/products/ceph) technology as the [Red Hat Multi Cloud Gateway](https://www.redhat.com/en/solutions/red-hat-multi-cloud-gateway)

● Will OCS 3 work with OCP 4?  
  **NO.** [Migration tooling](https://www.redhat.com/en/products/migration-tooling) will be available to facilitate the move to OCS 4.x.

● **MIGRATION PATH**
  There will be a supported migration path offered for OCS 3 to OCS 4
THE OCS 4 TECHNOLOGY STACK
MOTIVATION

As cloud-native applications have evolved, we are noticing more customer requests for a native, easy to use S3/object interface (apps like registry, chargeback, metering, AI/ML) in addition to traditional persistent volumes (RWX & RWO) on the platform.

By leveraging Ceph, OCS can now provide a production-grade S3 interface in addition to persistent volumes for stateful applications.
ROOK

- ROOK Project

CLOUD-NATIVE STORAGE ORCHESTRATOR
automated deployment and life-cycle management

- Bootstrapping
- Configuration, provisioning, scaling, upgrading, migration, disaster recovery, monitoring, and resource management

https://rook.io
ROOK ARCHITECTURE

New Objects:
- Storage
- Clusters
- Storage Pools
- Object Store
- File Store

Rook Operators
- Deployments
- DaemonSets
- Pods
- Services
- StorageClass / PV / PVC
- ClusterRole
- Namespace
- Config Maps

Client Pods (RBD/CephFS Clients)

Management

Attach/Mount

Daemons

Rook Agent (flex)

Ceph CSI Driver

Kubelet

kubectl

New Objects:
- Storage
- Clusters
- Storage Pools
- Object Store
- File Store
CEPH ON OPENSIFT WITH ROOK

ROOK pods

Agent

Agent

Operator

Agent

Agent

Agent

Mon

MGR

MDS

Mon

RGW

RGW

Mon

OSD's

OSD's

OSD's

OSD's

OSD's

OSD's
ABOUT NOOBA

- **OCS MULTI CLOUD GATEWAY (NOOBA)**
  NooBaa provides a consistent S3 endpoint across different infrastructures (AWS, Azure, GCP, Bare Metal, VMware)

- **OCS MCG FUNCTIONALITY**
  Multi Cloud Object Gateway: Active/Active read/write across different clouds.

- **PRODUCTIZATION**
  productized as RHOCs Multi-Cloud Gateway, starting with OCS 4.2 (NooBaa, is upstream only, downstream OCS Multi-Cloud-Gateway)
MULTI-CLOUD OBJECT GATEWAY

App

S3 API

Multi-Cloud Bucket

Multi-Site Bucket

Hybrid Bucket

RED HAT OPENSSHIFT CONTAINER STORAGE

ACTIVE - ACTIVE MULTI CLOUD - READ/WRITE
SUMMARIZING
OpenShift Container Storage
OCS 4.x Operator Install, Upgrade, Expansion

OCS Operator based on Rook.io with Operator Lifecycle Manager (OLM)

- App
  - Volume Claim
    - Block
- App
  - Volume Claim
    - File
- App
  - Object Bucket Claim
    - Object

OCS Pods

- Operator
  - Mon
    - OSDs
      - OSD
      - OSD
      - OSD
- MDS
  - OSDs
    - OSD
    - OSD
    - OSD
- Mon
  - RGW
    - OSDs
      - OSD
      - OSD
      - OSD
- MCG
  - Mon
    - OSDs
      - OSD
      - OSD
      - OSD
OCS 4.x Operator Driven Install from OperatorHub
INTEGRATED MONITORING AND MANAGEMENT

OCS Dashboard
OCS INTEGRATED DASHBOARD

Health, Capacity, Performance, Configuration
OCS INTEGRATED DASHBOARD - ALERTS

Monitoring and Alerts
FUNCTIONALITIES AND SUPPORTABILITY

● FUNCTIONALITIES
  - OCS 4.2 has FILE, BLOCK, and OBJECT support
  - OCS 4.2 supports Prometheus
  - OCS 4.2 will be FIPS compliant

● SUPPORTABILITIES
  - VMWare
    storage provisioned from VMDKs and RDMs
  - PUBLIC CLOUD
    supported in all public cloud environments where OCS 3 is supported today, including AWS (OCS 4.2), Azure and Google Cloud (OCS 4.3)
ANY CLOUD, ANY APP, ONE STORAGE EXPERIENCE

Consistent consumption, management, operations
Future Proof against cloud or infrastructure lock-in
COMPLETE STORAGE FOR CONTAINER PLATFORM

RED HAT OPENSOURF CONTAINER STORAGE

BARE METAL | VIRTUAL | CONTAINERS | PUBLIC CLOUD | LEGACY

RWO - Block | RWX - File | Object S3

Provides Storage for All Apps and infrastructure Services in their native interfaces
SKU’s

- **NO SKU CHANGES**

  OCS 3.X and OCS 4.x will have the same subscription model; there are no plans to change this.

  Please note that customers will still be buying and consuming OCS (even though the underlying technology will be different) using the same SKUs that we have today which will provide access to the new Ceph-related content set.
THE FACTS - SUMMARY

- Containers are system processes and are volatile by default.
- Containers therefore need persistent storage.
- OCP 4 uses Operators to manage the entire OCP cluster.
- RHOCs now changes and will now use Ceph and Noobaa ‘under the hood’.
- OCS 4.2 is planned to become general available starting at OCP 4.2.
- OCS 4.2 will offer file, block and object storage.
- SKU proposition will remain the same.
Thank you

Red Hat is the world’s leading provider of enterprise open source software solutions. Award-winning support, training, and consulting services make Red Hat a trusted adviser to the Fortune 500.

linkedin.com/company/red-hat
youtube.com/user/RedHatVideos
facebook.com/redhatinc
twitter.com/RedHat
REFERENCE HYPERLINKS

OCS Sales Enablement
https://mojo.redhat.com/docs/DOC-1204753

Velero Migration Tooling
https://youtu.be/VvqsKjAvCx4

OpenShift Storage for Admins
http://admin-labguides.6923.rh-us-east-1.openshiftapps.com/workshop/ocp-for-admins/lab/environment
AGENDA - Part I

- APPLICATION PROPERTIES AND BEHAVIOUR
- TRANSITION FROM APPLICATION INTO MICROSERVICES
- TYPICAL PROPERTIES OF A MICROSERVICE
- APPLICATION STATE AND PERSISTENCE
- STORAGE PROVIDERS THAT CAN BE CONSUMED BY OPENSSHIFT
- STORAGE PROVISIONING OPTIONS
- THE FOUR STORAGE NEEDS IN OPENSSHIFT
- OCS: VALUE ADD TO THE BUSINESS
- FACTS
APPLICATION PROPERTIES AND BEHAVIOUR

TRADITIONAL APPLICATION
APPLICATION PROPERTIES AND BEHAVIOUR

MODERN APPLICATION
MICRO-SERVICES & CONTAINERS
Microservices architecture is different from containers

- Microservices architecture is about writing applications so that components can be independently updated and delivered to complete the product
  - May use containers for each of the components
  - Monolith vs componentized
  - Each component can evolve independently

Refactoring of application into components (micro-services)
A CONTAINER IS A SYSTEM PROCESS
A SYSTEM PROCESS THAT PRODUCES STATE
A STOPPED PROCESS CAUSES LOSS OF THAT STATE
CONTAINERS NEED STORAGE
Containers are not persistent by default. App data is lost when containers die.
RED HAT SOLUTION: RHOCS

RED HAT OFFERS A FULLY INTEGRATED STORAGE SOLUTION FOR OPENSIFT

Objection: “We don’t need your storage, we already have an existing storage solution present”
LEVERAGE LEGACY STORAGE...
WITH OPENSHIFT CONTAINER STORAGE CONVERGED MODE

PERSISTENT VOLUMES PROVIDED BY OPENSHIFT CONTAINER STORAGE

OPENSHIFT CONTAINER STORAGE POD

BLOCK DEVICE

FIBRE-CHANNEL ARRAY

OPENSHIFT CONTAINER STORAGE POD

BLOCK DEVICE

ISCSI SAN

OPENSHIFT CONTAINER STORAGE POD

BLOCK DEVICE

SHARED SAS
SNAPSHOTS AND GEO-REPLICATION

Asynchronous Replication

OPENSHIFT CONTAINER
STORAGE VOLUME
Read-Write

Site A

OPENSHIFT CONTAINER
STORAGE VOLUME
Read Only

Site B

CURRENT FILE SYSTEM

BEFORE SNAPSHOT

A
B
C
D

AFTER SNAPSHOT

SNAPSHOT

A
B
C
D

AFTER MODIFICATIONS

SNAPSHOT

A
B
C
D

Deleted Data

Modified Data

New Data
SUMMARY FACTS

- Containers are system processes
- Container states are volatile by default
- Containers therefore need persistent storage
- Existing storage entities can be used in conjunction with OpenShift
- Existing storage entities often just address one single part of the 4 needs
- Provisioning and handling of container storage becomes complex soon
- Different storage needs in OpenShift require different solutions
- Red Hat offers **OCS** - Not just another storage solution - A storage manager
- OCS: Value add to the business - No DIY plumbing of existing things -
AGENDA - Part II

- OCP 4 - BRIEF INTRODUCTION
- INSTALLATION EXPERIENCES: IPI & UPI
- OPERATOR FRAMEWORK
- WHAT HAS CHANGED WITH RHOCS
- COMPONENTS: ROOK, CEPH & NOOBAA
- RED HAT ENTERPRISE SOLUTION
- FUNCTIONALITIES AND SUPPORTABILITY
- THE FACTS - SUMMARY
OCP 4
brief introduction
TRUSTED ENTERPRISE KUBERNETES
● Trusted Host, Content, Platform
● Full Stack Automated Install
● Over the Air Updates & Day 2 Mgt

A CLOUD-LIKE EXPERIENCE, EVERYWHERE
● Hybrid, Multi-Cluster Management
● Operator Framework
● Operator Hub & Certified ISVs

EMPOWERING DEVELOPERS TO INNOVATE
● OpenShift Service Mesh (Istio)
● OpenShift Serverless (Knative)
● CodeReady Workspaces (Che)

Developer Preview: try.openshift.com
FULL STACK AUTOMATED INSTALL + UPGRADE

OPENSFiTH 3

OPENSFiTH PLATFORM

OPERATING SYSTEM

INFRASTRUCTURE

OPENSFiTH 4

OPENSFiTH PLATFORM

OPERATING SYSTEM

RED HAT ENTERPRISE LINUX CoreOS
INSTALLATION EXPERIENCES

OPENSHIFT CONTAINER PLATFORM

FULL STACK AUTOMATED

Simplified opinionated “Best Practices” for cluster provisioning

Fully automated installation and updates including host container OS.

PRE-EXISTING INFRASTRUCTURE

Customer managed resources & infrastructure provisioning

Plug into existing DNS and security boundaries

Red Hat
Enterprise Linux
CoreOS
IPI: FULL STACK AUTOMATED DEPLOYMENT

Day 1: openshift-install - Day 2: Operators

User managed
Operator managed

deployed

Control Plane
Worker Nodes

OCP Cluster Resources

OCP Cluster

RHEL CoreOS

Cloud Resources

RHEL CoreOS

Cloud Resources

openshift-install deployed

Cloud Resources
UPI: DEPLOYING TO EXISTING INFRASTRUCTURE

Day 1: openshift-install - Day 2: Operators + Customer Managed Infra & Workers

- `openshift-install` deployed
- Customer deployed

Control Plane
- OCP Cluster Resources
- OCP Cluster
- RHEL CoreOS
- Cloud Resources

Operator managed

Worker Nodes
- RHEL CoreOS
- RHEL 7

User managed

Note: Control plane nodes must run RHEL CoreOS!
# RED HAT ENTERPRISE LINUX

<table>
<thead>
<tr>
<th><strong>RED HAT ENTERPRISE LINUX</strong></th>
<th><strong>RED HAT ENTERPRISE LINUX CoreOS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>General Purpose OS</td>
<td>Immutable container host</td>
</tr>
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</table>

## BENEFITS

<table>
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<tr>
<th>RED HAT ENTERPRISE LINUX</th>
<th>RED HAT ENTERPRISE LINUX CoreOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 10+ year enterprise life cycle</td>
<td>• Self-managing, over-the-air updates</td>
</tr>
<tr>
<td>• Industry standard security</td>
<td>• Immutable and tightly integrated with OpenShift</td>
</tr>
<tr>
<td>• High performance on any infrastructure</td>
<td>• Host isolation is enforced via Containers</td>
</tr>
<tr>
<td>• Customizable and compatible with wide ecosystem of partner solutions</td>
<td>• Optimized performance on popular infrastructure</td>
</tr>
</tbody>
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## WHEN TO USE

<table>
<thead>
<tr>
<th>RED HAT ENTERPRISE LINUX</th>
<th>RED HAT ENTERPRISE LINUX CoreOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>When customization and integration with additional solutions is required</td>
<td>When cloud-native, hands-free operations are a top priority</td>
</tr>
</tbody>
</table>
OPENSHEET
OPERATOR
FRAMEWORK
OpenShift 4 uses OPERATORS to manage EVERY ASPECT of the cluster.

This includes operators that manage essential Kubernetes project components like the api server, scheduler, and controller manager.

Additional operators for components like the cluster-autoscaler, cluster-monitoring, web console, dns, ingress, networking, node-tuning, and authentication are included to provide management of the entire platform.
Welcome to OperatorHub.io

OperatorHub.io is a new home for the Kubernetes community to share Operators. Find an existing Operator or list your own today.

Categories:
- AI/Machine Learning
- Application Runtime
- Big Data
- Cloud Provider
- Database
- Developer Tools
- Integration & Delivery
- Logging & Tracing
- Monitoring
- Networking
- OpenShift Optional
- Security
- Storage
- Streaming & Messaging

Provider:
- Robin Storage: Robin.io
- NooBaa Operator: NooBaa
- OpenEBS: OpenEBS project
- Portworx Enterprise: Portworx
- Rook-Ceph: The Rook Authors
- Rook-EdgeFS: The Rook Authors
- StorageOS: StorageOS, Inc

Operators:
- AWS S3 Operator: provided by Red Hat
  Manage the full lifecycle of installing, configuring and managing AWS S3 Provisioning.
- NooBaa Operator: provided by NooBaa
  NooBaa is an object storage service for hybrid and multi cloud environments.
- OpenEBS: provided by OpenEBS project
  Creates and maintains OpenEBS Control Plane deployments
- Portworx Enterprise: provided by Portworx
  Cloud native storage solution for production workloads
- Robin Storage: provided by Robin.io
- Rook-Ceph: provided by The Rook Authors
  Install and maintain Ceph Storage cluster
- Rook-EdgeFS: provided by The Rook Authors
  Install and maintain EdgeFS Storage cluster
- StorageOS: provided by StorageOS, Inc
  Cloud-native, persistent storage for containers.