Red Hat Partner Tech Days
OpenShift Virtualization

September 2020

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But, Before We Get Started,
A Few Announcements...

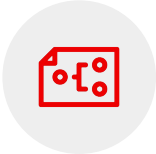
A **new virtual** technical enablement series that provides the latest in the Red Hat product strategy and enablement on the newest features to our technical field associates

Red Hat

Tech Ready

October & November 2020

- **Integrated into the Red Hat OPEN training system**
- **More communications to come…**



Hear the latest from Red Hat Business Unit and Engineering leaders on our product strategies and roadmaps

Gain hands-on experience with new product features through deep dive demos and labs

Session content dropped weekly on Monday's from October 19 through November 9

SmartPage on Red Hat Partner Content Hub for more information (Coming Soon)

Red Hat Tech Ready: Partner Experience

Red Hat Tech Ready is a new virtual, global technical series that provides the latest in the Red Hat product strategy and enablement, exclusively for our Red Hat internal teams and Red Hat Partners.

What are the Goals of RHTR?

Drive more **awareness** of what's coming, provide the field **applicable** knowledge and practices, and **connect it all** to the Red Hat Open Hybrid Cloud Strategy

Who are the Target Attendees?

Red Hat's technical field (SA, Services, CXnO) and Partners in a technical role

How will partners access content?

Partners will get access to the same on-demand content at the same time as Red Hatters. This content will be made available through Red Hat OPEN training system

What is Happening Each Week?

Each week focuses on a part of Red Hat's Open Hybrid Cloud Strategy. On-demand content will be launched each Monday and live experiences will be scheduled throughout the week.

Week of	Theme of the Week
Oct 19	Hybrid Cloud Infrastructure Week
Oct 26	Cloud Native Development
Nov 2	Management & Automation
Nov 9	Digital Transformation

NA Partner Tech Virtual Office Hours

For North America Red Hat Business Partners technical team members

Office Hour format: "Ask me anything/Open Mic" with remaining time to cover the Product/Technology topics

- See Office Hour schedule here -- https://www.redhatpartnertech.com

Virtual Partner Tech Office Hours

- *Meet with Red Hat Solution Architects & SME's to help answer your questions on product and technology topics*
- *Dedicated weekly time slot for you to pop in, ask a question, then get back to your schedule*
- *Collaborate/Brainstorm with peers on customer questions, projects, etc.*
- *Build and formulate new relationships*

Agenda

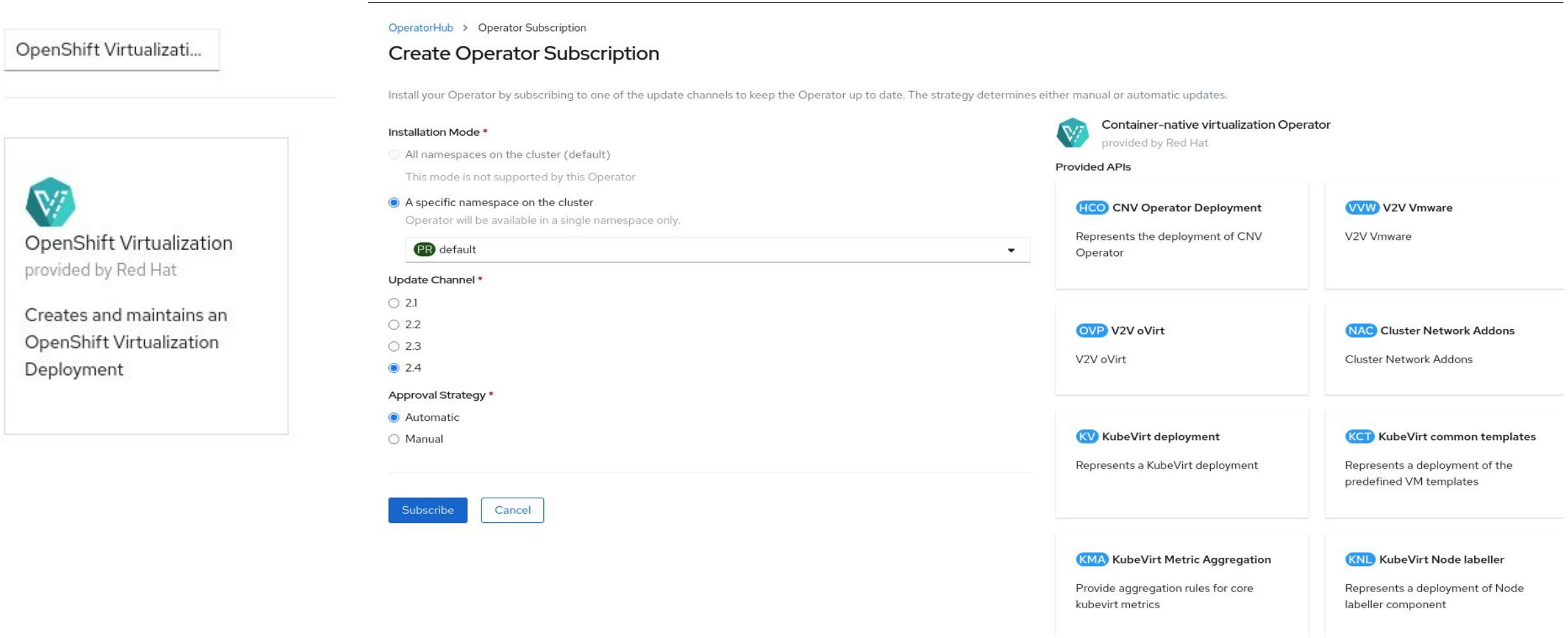
- Red Hat OpenShift Virtualization Overview and Use Cases
- Common Questions
- Workshop Architecture/Tools/Packet
- Feature Walkthroughs & Demos
  - VM Storage including add or edit persistent Storage
  - Creating VM Networks in OpenShift
  - General Virtual Machine Overview in OpenShift
  - VM creation and Management in OpenShift
- Next Steps

Common Questions OpenShift Virtualization

OPTIONAL

What version of OpenShift and what operator is required to run OpenShift Virtualization?

4.5 is minimum and the worker nodes must be physical or bare metal hosts. Operator 2.4 is most current with CNV operator Deployment.



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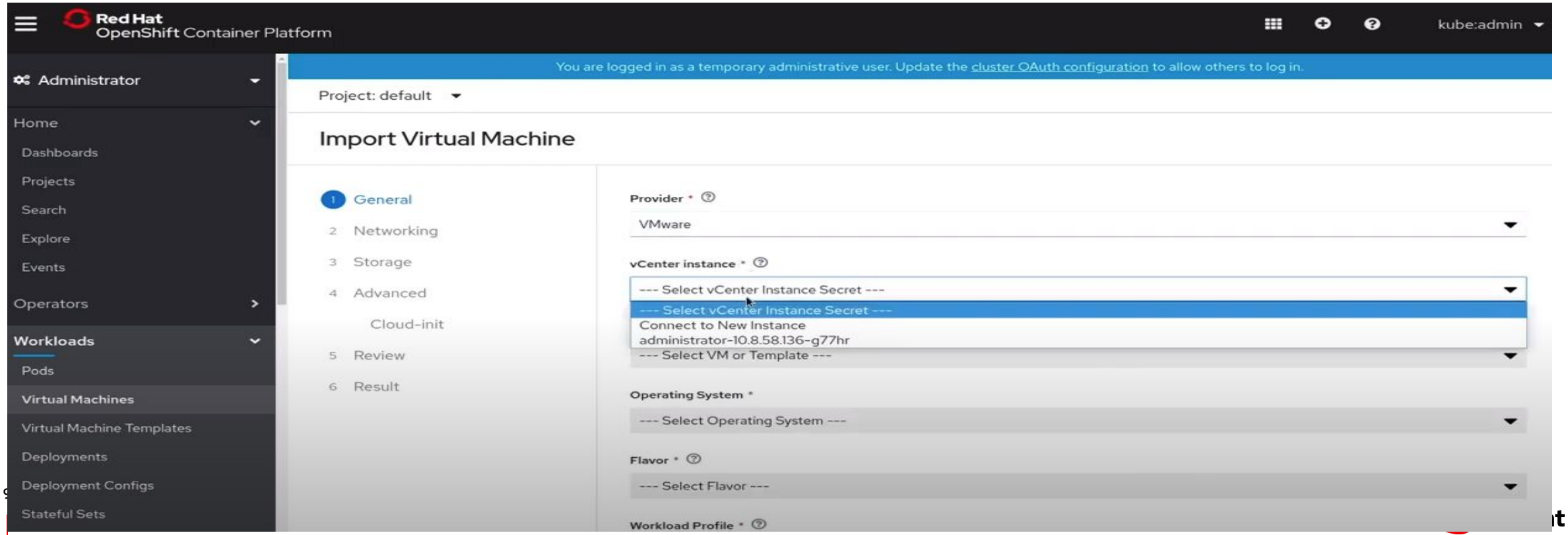
OPTIONAL

Are the Virtual Machines stateless or stateful? Virtual machines can be both, but the cluster must have access to RWX PVC or Persistent Volume Claims that is based on CephFS and can be used in conjunction with the MCG or multi-cloud gateway as a persistent storage solution for OCP workloads. **Are OpenShift Virtualization VMs are stateful and the pods that run them are stateless?** (generally) So all PODS are stateless regardless of OpenShift virtualization or applications. If the container using Persistent RWX storage it will be stateful.

Can Virtual machines be imported from VMware? Yes, there is a built in wizard in the Workload, virtual machines to import from VMware vCenter using VDDK. Beside Linux workloads Windows 2008-2019 VM's can be imported. Refer back to original use case on what are good candidates for importing into OCP. Also, this can be done from cli: documentation for that found at: https://docs.openshift.com/container-platform/4.5/virt/virtual_machines/importing_vms/virt-importing-vmware-vm.html



OPTIONAL

What versions of VMware can I import virtual machines from OpenShift Virtualization?
You can import a single virtual machine or template from VMware vSphere 6.5, 6.7, or 7.0 into OpenShift Virtualization.

Can I manage OpenShift Virtualization machines from VMware vCenter? No not supported. RHV supported though. But we will talk about use cases and why running native OpenShift Virtualization makes sense.

Do virtual machines in OpenShift Virtualization require Agents?
Although not required it is best practice to install the QEMU guest agent that is a daemon that runs on the Linux virtual machine. For Windows virtual machines the QEMU guest agent is included in the VirtIO drivers.

Does OpenShift Virtualization work with VMs on kvm hosts with nested virt enabled?
OpenShift Virtualization supports worker nodes with bare metal only.
If you want to run the Control Nodes/Bastion host virtualization you may as long as you have the DNS/Routes figured out. The Packet Installation for this demo and workshop assumes all nodes are bare metal.

What is running beneath the OpenShift Worker Nodes?
Red Hat Enterprise Linux CoreOS.

Are qemu/kvm tools available from the terminal/cli of OpenShift pods?
Yes, the virtctl client can be used. The qemu agent is already built into the image and then enabled

Red Hat OpenShift Virtualization Overview and Use Cases

OpenShift and Kubernetes crossing to early majority in IT adoption

Two emerging trends

1. **Need for a better modernization strategy for virtual machine (VM)-based workloads**

   An all-or-nothing approach to containerization is too slow, so organizations have a large investment in virtual machines.

2. **Desire for a single architecture for all workloads**

   Kubernetes supports stateful applications, and organizations desire to reduce costs by adopting a single cloud-native platform.

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What's in it for Operations?

Modernize and simplify your datacenter

Consistency of management

With OpenShift support for VMs, containers, and serverless, you can align your DevOps team on a simpler architecture to manage

Save on cost and innovate

Keep the VMs and leverage the scale advantages of Kubernetes. Apply the cost savings to fund innovation.

Maintain opex investments

Retain your infrastructure investment by repurposing existing hardware for OpenShift.

Kubernetes skills development

Motivate your team and provide career progression with training and skills development from Red Hat

Modernize operational models

OpenShift can provide the technology foundation for a cultural shift to new operating models like site reliability engineering (SRE)

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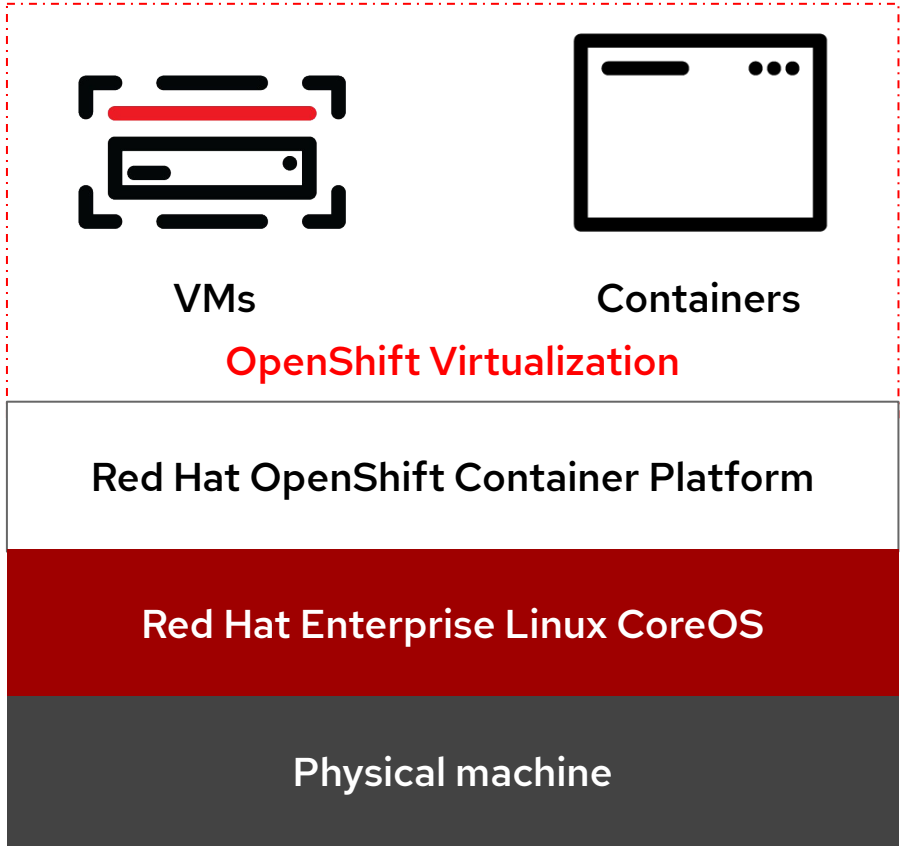
OpenShift and OpenShift Virtualization

Modernize workloads and support mixed applications

consisting of VMs, containers, and serverless

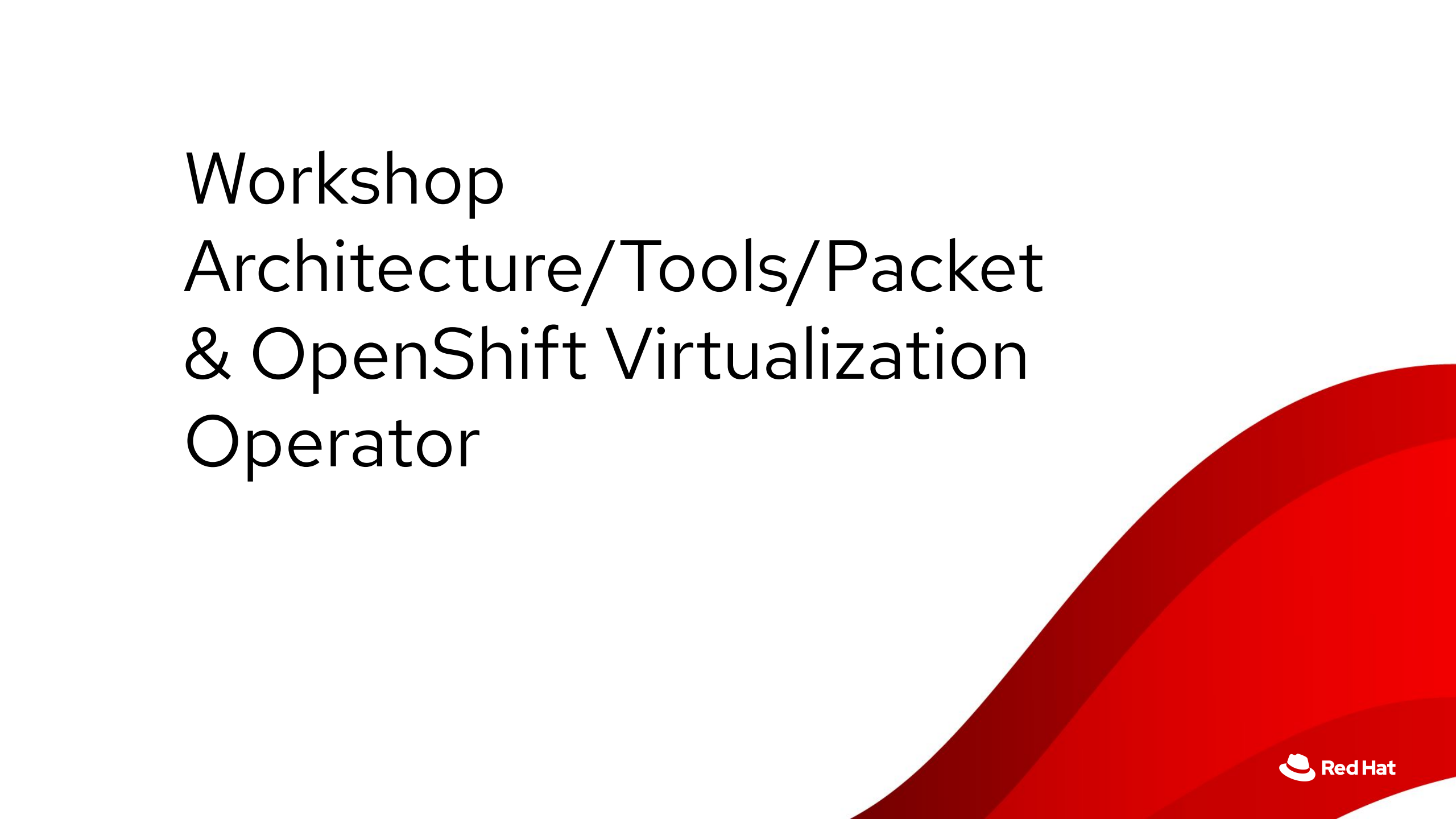


- Brings VMs to OpenShift 4.5+
- Accelerates application delivery with a single platform that can manage “mixed applications” with the same tools and teams
- Add VMs to new and existing applications
- Modernize legacy VM based applications over time, or maintain them as VMs
  - SAP’s open source project “Gardener” leveraged Red Hat OpenShift Virtualization
  - Goldman Sachs Revamps Virtualization Infrastructure

Targeted Opportunities and Use Cases -Developers

- Current, prospective OpenShift customers who have
  - Apps on containers and
  - Apps on VMs running RHEL and Windows guests
  - Developers with forward leaning and legacy app ownership
    - Value prop:
      - Standardize, accelerate app dev processes and delivery - NOW!
      - Modernize current apps running on VMs - NOW!
        - Convert to containers over time, or never
        - Migrate older Windows apps - NOW!
          - Same support matrix as RHV and RHOSP
      - Delivery “mixed” apps using containers, VMs - NOW!

Workshop Architecture/Tools/Packet & OpenShift Virtualization Operator



A couple of things...

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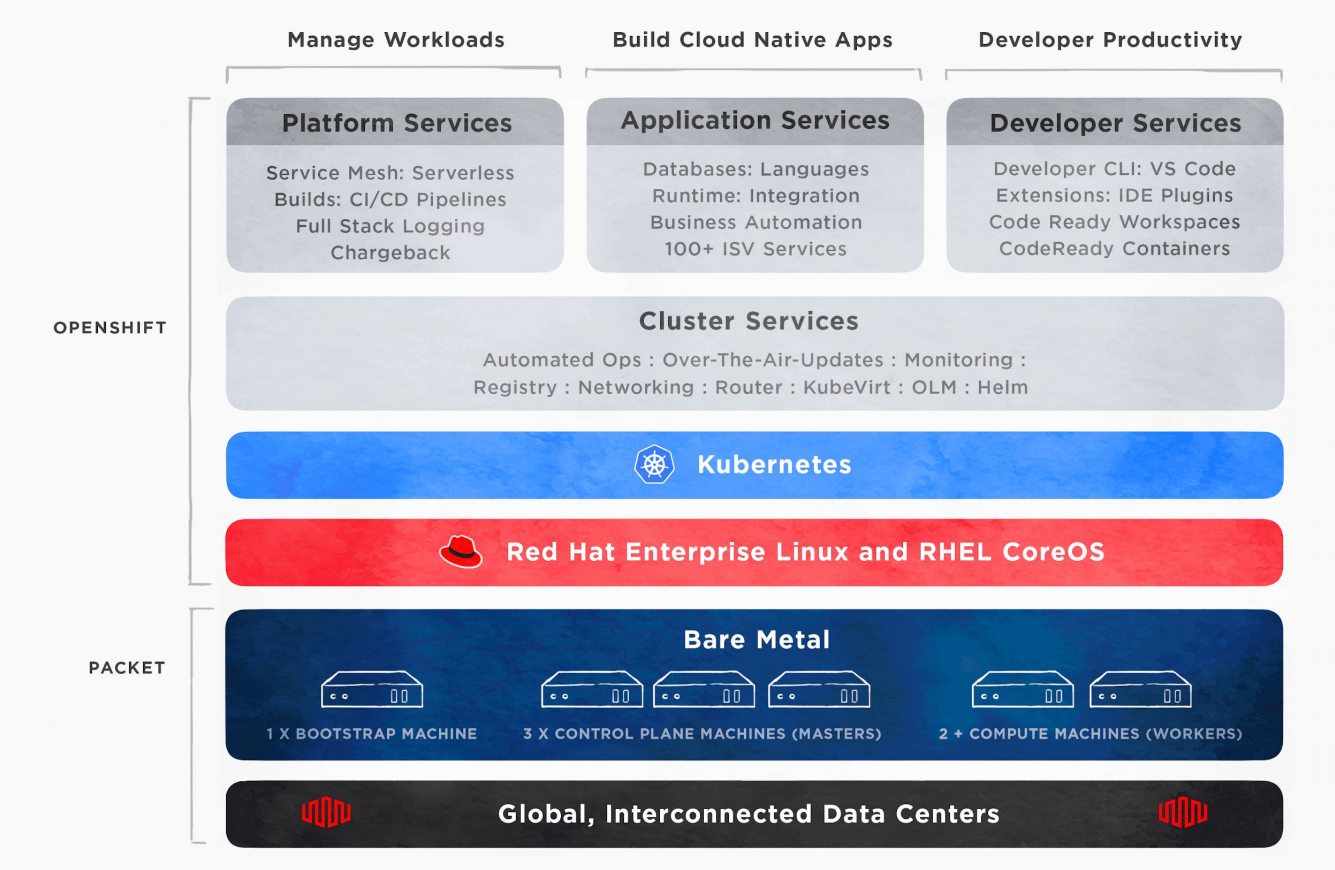
OpenShift, Made Simple

Automate the end-to-end install of Red Hat OpenShift on Packet bare metal servers



Deliver better applications faster. We provide:

- API-driven bare metal in global locations
- Fast, automated deployments – takes about 20 minutes
- Consistent user experience across on-prem, Packet or public cloud

packet
AN EQUINIX COMPANY

Products Solutions Developers Resources Company Log in SIGN UP

NEW

m3.large.x86

$2.00 / hr

AMD EPYC 7502P
32 Cores @ 2.5 GHz
256 GB DDR4 RAM
2 x 3.8TB NVMe Drives
2 x 10Gbps Network

1x Bastion/LB (utility node)

NEW

c3.medium.x86

$1.10 / hr

AMD EPYC 7402P
24 Cores @ 2.8 GHz
64 GB DDR4 RAM
960 GB SSD
2 × 10Gbps Network

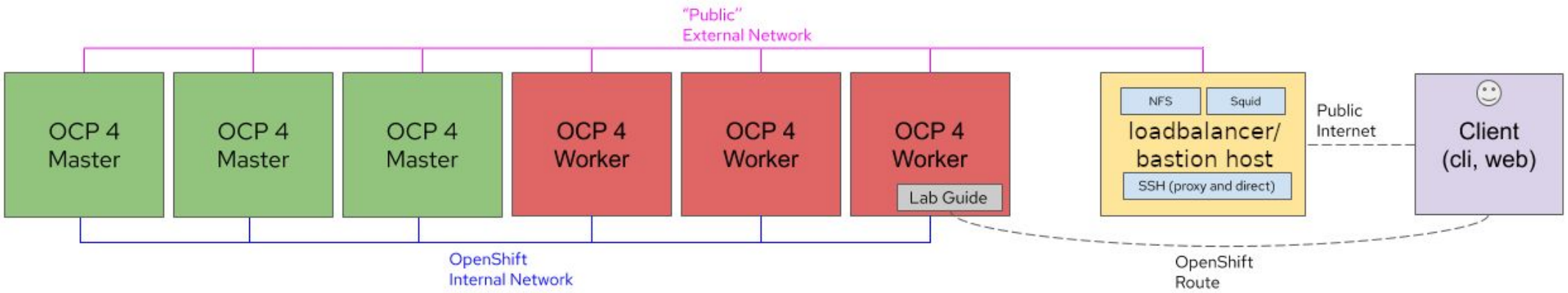
3x Masters

n2.xlarge.x86

$2.25 / hr

2 x Intel Xeon Gold 5120
28 Cores @ 2.2 GHz
384 GB RAM
3.8 TB NVMe
4 × 10Gbps Network

3x Workers



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GitHub repos and tools

HashiCorp Terraform

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OpenShift UPI Deploy to Packet Cloud

https://github.com/RedHatSI/terraform-packet-openshift ==> https://github.com/heatmiser/openshift-packet-deploy

CLOUDFLARE

AgnosticD - Ansible Deployer for multiple Cloud Deployers

https://github.com/redhat-cop/agnosticd ==> https://github.com/heatmiser/agnosticd

ANSIBLE

OpenShift Virtualization Lab on Packet Cloud

https://github.com/RHFieldProductManagement/openshift-virt-labs ==> https://github.com/heatmiser/openshift-virt-labs/tree/packet

Openshift Virtualization

Red Hat OpenShift 4

podman

containers

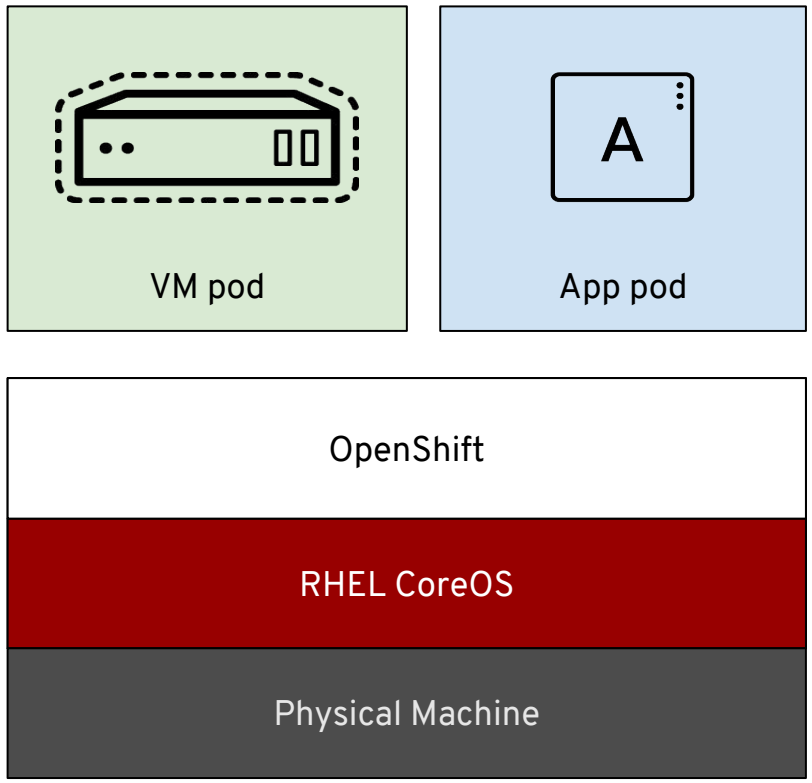
Red Hat

- Feature Walk Throughs and Demos

- VM Storage including add or edit persistent Storage

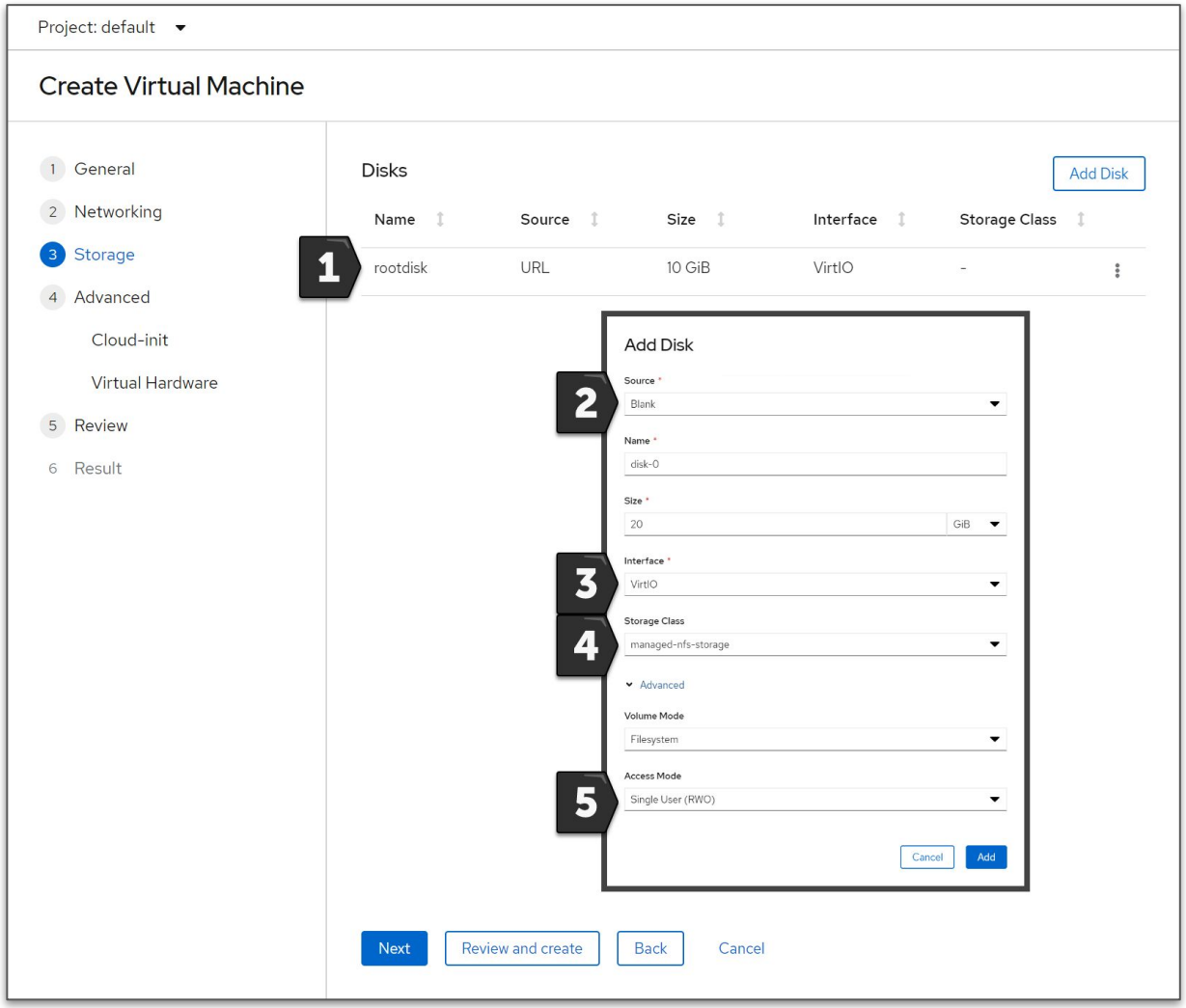
Virtual machines in a container world

- Provides a way to transition application components which can't be directly containerized into a Kubernetes system
  - Integrates directly into existing k8s clusters
  - Follows Kubernetes paradigms:
    - Container Networking Interface (CNI)
    - Container Storage Interface (CSI)
    - Custom Resource Definitions (CRD, CR)
- Schedule, connect, and consume VM resources as container-native



Create Virtual Machine - Storage

- Add or edit persistent storage
- Disks can be sourced from
  - Imported QCOW2 or raw images
  - New or existing PVCs
  - Clone existing PVCs
- Use SATA/SCSI interface for compatibility or VirtIO for paravirtual performance
- For new or cloned disks, select from available storage classes
  - Customize volume and access mode as needed



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Demo: Storage

Creating VM Networks in OpenShift

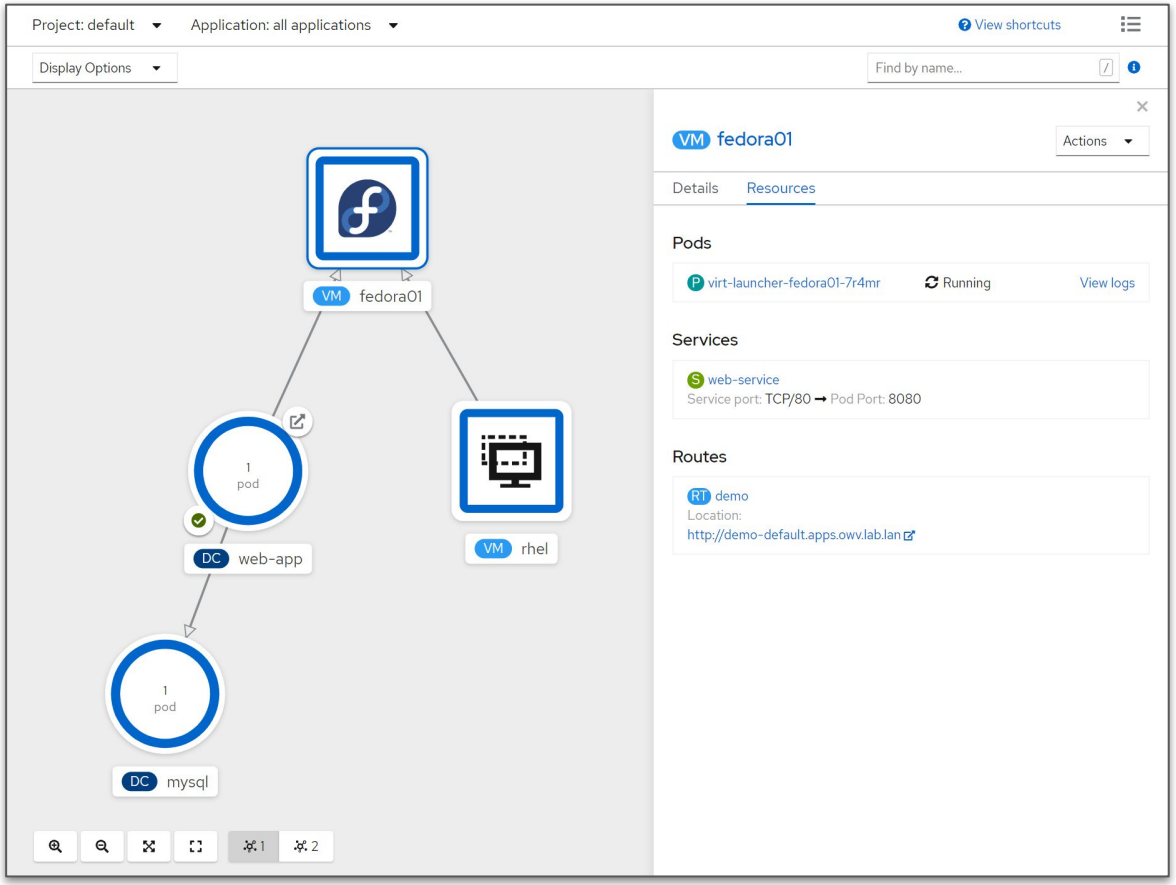
Connecting VMs to networks

- Virtual machine interfaces describe NICs attached to the VM
  - `spec.domain.devices.interfaces`
  - Model: virtio, e1000, pcnet, rtl8139, etc.
  - Type: masquerade, bridge
  - MAC address: customize the MAC
- The networks definition describes the connection type
  - `spec.networks`
  - Pod = default SDN
  - Multus = secondary network using Multus
- Using the GUI makes this simple and removes the need to edit / manage connections in YAML

```yaml
apiVersion: kubevirt.io/v1alpha3
kind: VirtualMachine
  name: demo-vm
spec:
  template:
    spec:
      domain:
        devices:
          interfaces:
            - bridge: {}
              model: virtio
              name: nic-0
      hostname: demo-vm
      networks:
        - multus:
            networkName: bond1-br1
          name: nic-0
```

Using VMs and containers together

- Virtual Machines connected to pod networks are accessible using standard Kubernetes methods:
  - Service
  - Route
  - Ingress
- Network policies apply to VM pods the same as application pods
- VM-to-pod, and vice-versa, communication happens over SDN or ingress depending on network connectivity



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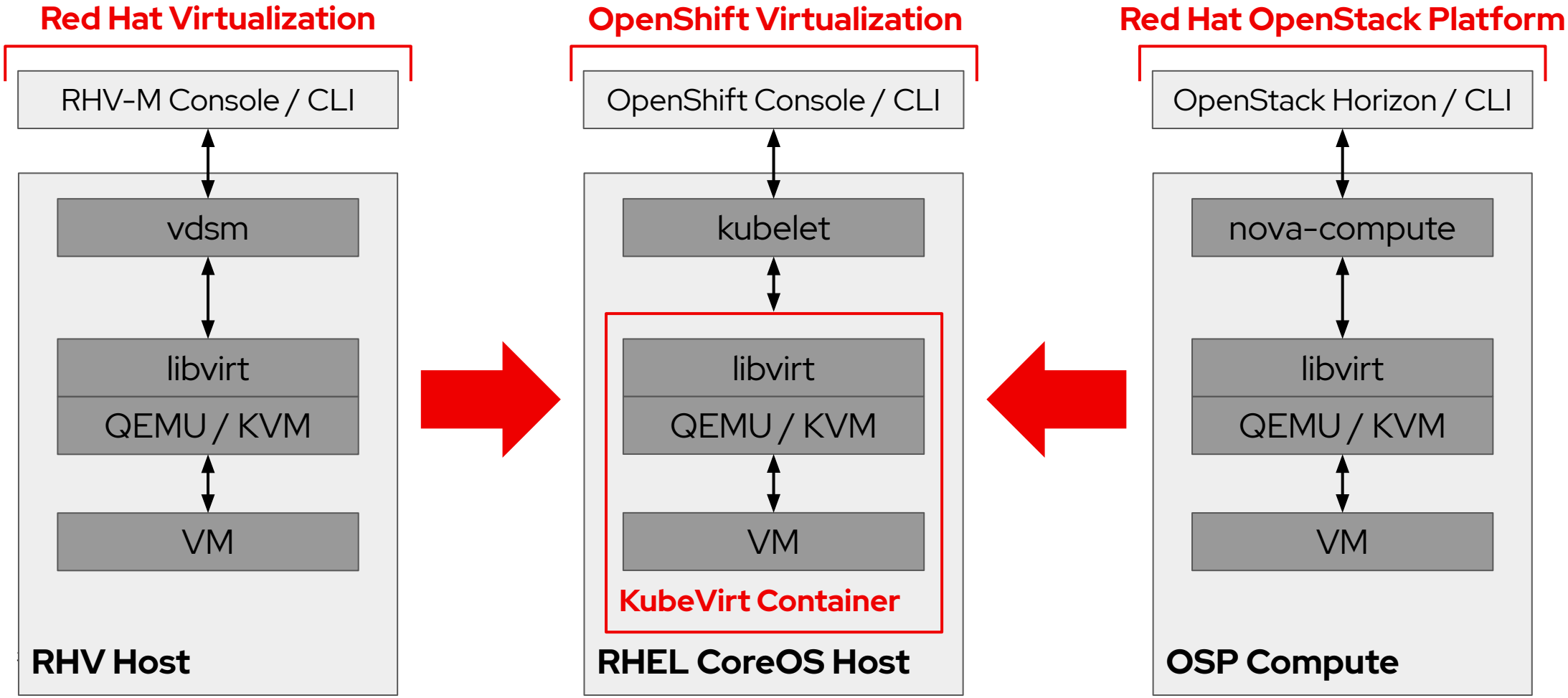
Demo: Networking

General Virtual Machine Overview in OpenShift

Containerizing KVM



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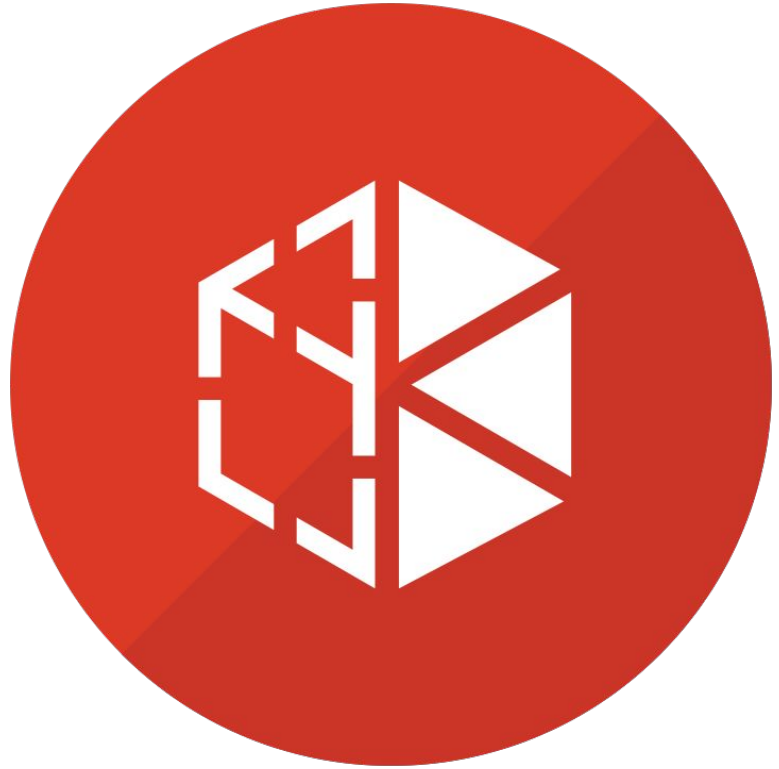
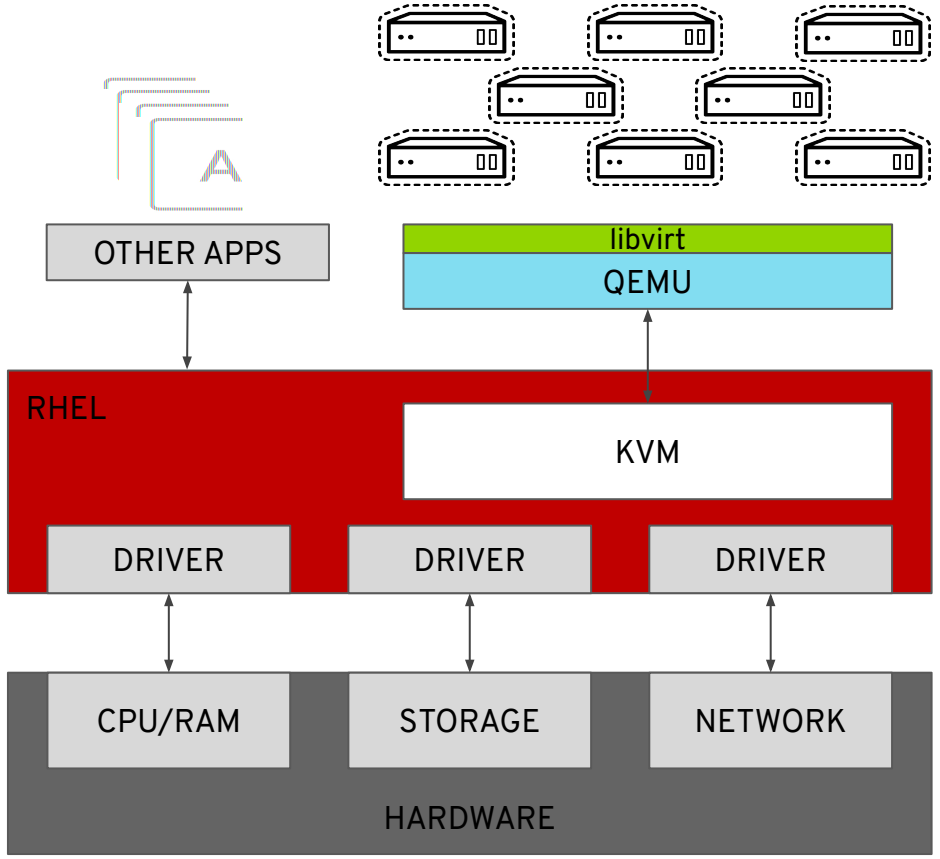
OpenShift Virtualization

- Virtual machines
  - Running in containers
  - Using the KVM hypervisor
- Scheduled, deployed, and managed by Kubernetes
- Integrated with container orchestrator resources and services
  - Traditional Pod-like SDN connectivity and/or connectivity to external VLAN and other networks via multus
  - Persistent storage paradigm (PVC, PV, StorageClass)



VM containers use KVM

- OpenShift Virtualization uses KVM, the Linux kernel hypervisor
- KVM is a core component of the Red Hat Enterprise Linux kernel
  - KVM has 10+ years of production use: Red Hat Virtualization, Red Hat OpenStack Platform, and RHEL all leverage KVM, QEMU, and libvirt
- QEMU uses KVM to execute virtual machines
- `libvirt` provides a management abstraction layer
- Traditional toolset `virsh`, `qemu-img`



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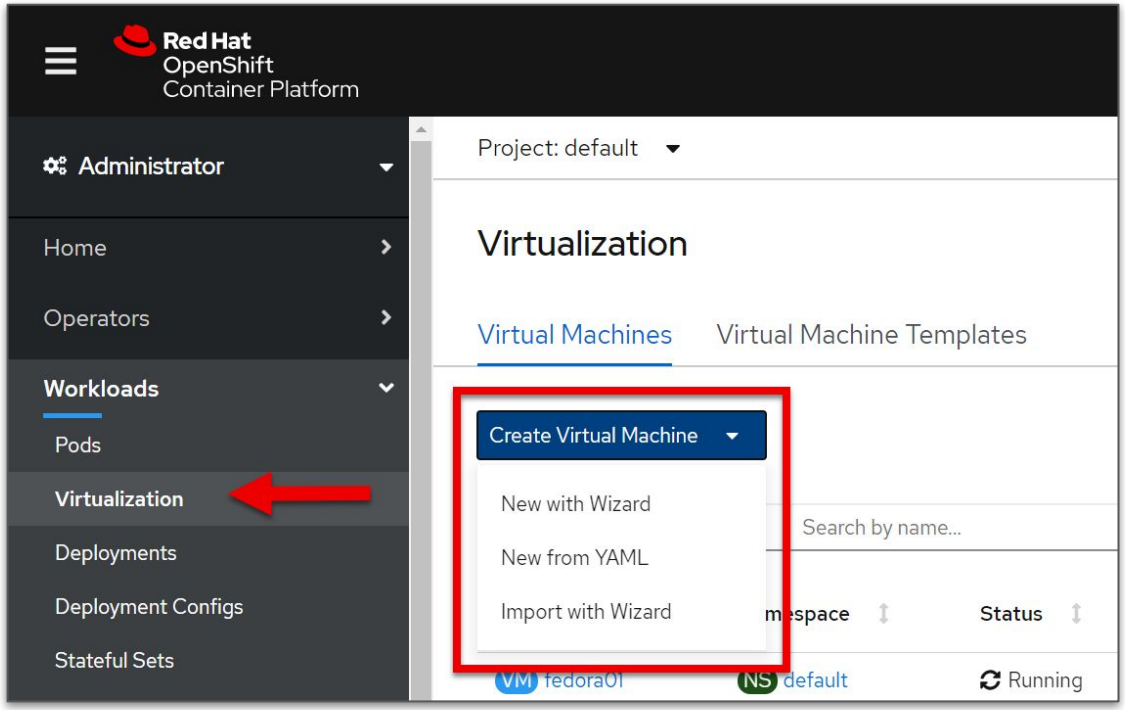
- VM creation and Management in OpenShift

Virtual Machine creation

- Streamlined and simplified creation via the GUI or create VMs programmatically using YAML
- Full configuration options for compute, network, and storage resources
  - Clone VMs from templates or import disks using DataVolumes
  - Pre-defined and customizable presets for CPU/RAM allocations
  - Workload profile to tune KVM for expected behavior
- Import VMs from VMware vSphere or Red Hat Virtualization



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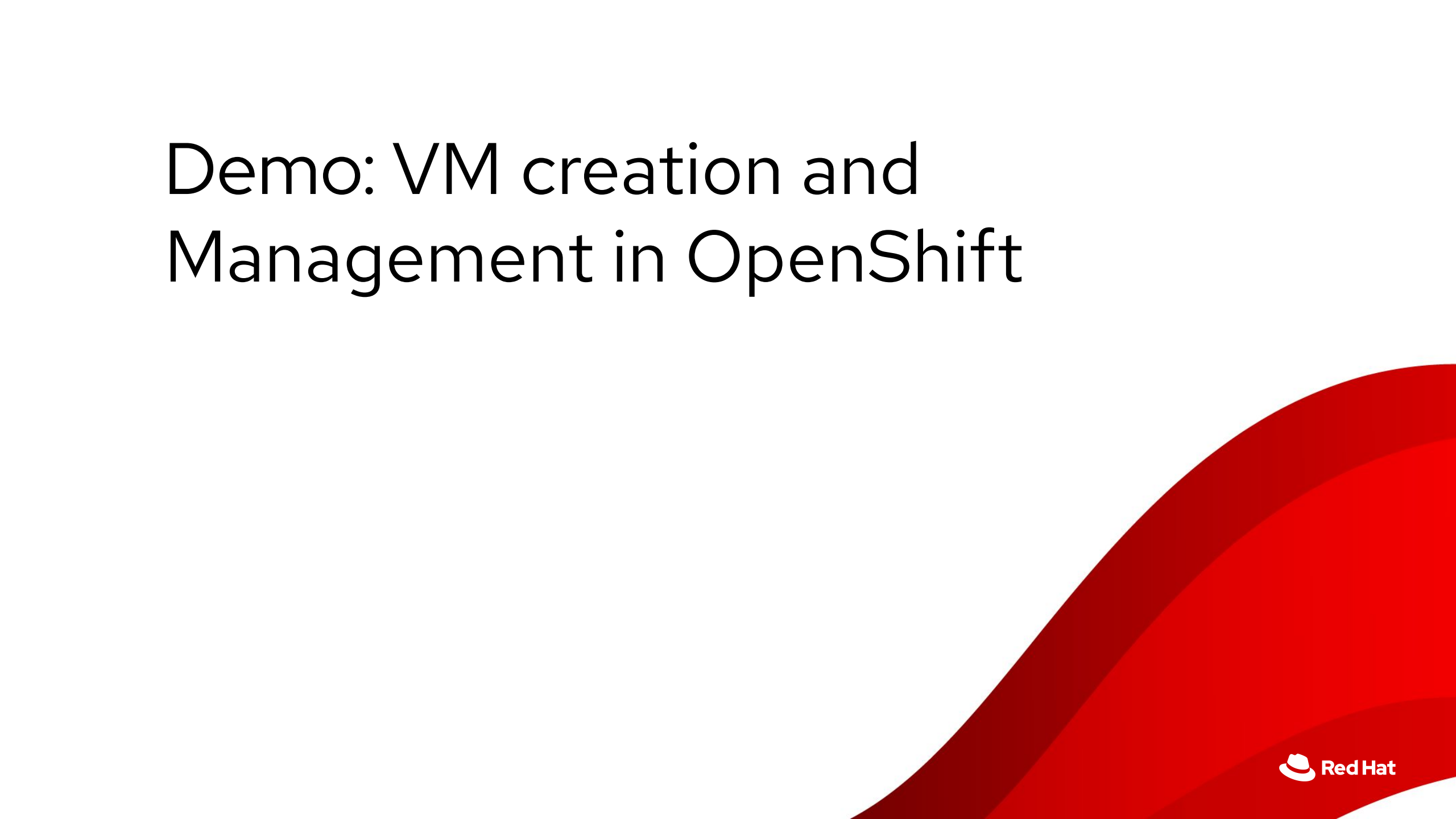
Virtualization native to Kubernetes

- Operators are a Kubernetes-native way to introduce new capabilities
- New CustomResourceDefinitions (CRDs) for native VM integration, for example:
  - `VirtualMachine`
  - `VirtualMachineInstance`
  - `VirtualMachineInstanceMigration`
  - `DataVolume`

```yaml
apiVersion: kubevirt.io/v1alpha3
kind: VirtualMachine
metadata:
  labels:
    app: demo
    flavor.template.kubevirt.io/small: "true"
  name: rhel
spec:
  dataVolumeTemplates:
  - apiVersion: cdi.kubevirt.io/v1alpha1
    kind: DataVolume
    metadata:
      creationTimestamp: null
      name: rhel-rootdisk
    spec:
      pvc:
        accessModes:
        - ReadWriteMany
        resources:
          requests:
            storage: 20Gi
        storageClassName: managed-nfs-storage
        volumeMode: Filesystem
```

Demo: VM creation and Management in OpenShift



Resources

Red Hat OpenShift

https://demo.openshift.com/en/latest/openshift-virtualization/

OpenShift Virtualization

https://www.openshift.com/learn/topics/virtualization/?extIdCarryOver=true&sc_cid=701f2000001OH7iAAG

OpenShift - OneStop Partner Content Hub

https://redhat-partner.highspot.com/items/5cbec24566bbaa0b941b04f0?lfrm=srp.0

Packet Cloud - Sign Up

https://baremet.al/openshift

- Refer to next slide for details

OpenShift on Packet @ RH Partner Tech Days

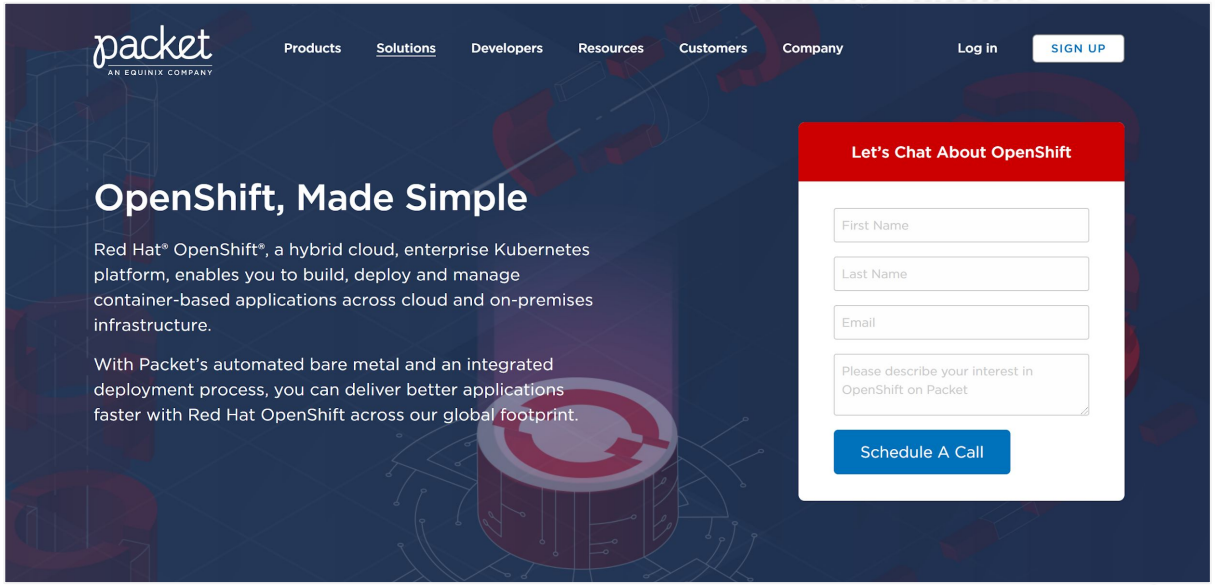
When: **Friday, Sept 11th, 1:30p EST**
Wed, Sept 16h, 12:00p EST

Where: Red Hat Partner Tech Days
https://events.redhat.com/profile/web/index.cfm?PKwebID=0x51871abcd

Who: **Red Hat Team including**
Mike Savage, Sr. Channel Solutions Architect

CALL-TO-ACTION: *Give it a Test Drive!*

- Sign-Up @ https://baremet.al/openshift and mention you attended Partner Tech Days
- Get $1,000 Packet Credits [for a 3-5 day experience]



Want more?
Packet Community Slack @ #redhat-openshift

Survey

THANK YOU for attending!

- Please complete the survey to be entered into a raffle to receive a limited amount of $25 eGift Cards
- Link here

Thank you

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Backup Slides

OpenShift Virtualization Roadmap

Near Term
(3-6 months)

CORE
- Streamline 'oc drain'
- Improve performance with Hyper-V enlightenments
- Improve golden image template workflow
- Sizing guidance for field

NETWORK

IPv6
- Dual stack
- Multicast
- IPv6 multi-address
- Enhance CNI test suite for VMs

STORAGE
- Offline snapshots
- Hotplug disk PoC
- Performance and scale of VMs on OCS
- Enhance CNI test suite for VMs

Mid Term
(6-9 months)

CORE

Virt gaps - vCPU & vNUMA pinning

Security - FIPS

Developer
- Using VMs naturally in Developer Pipelines

NETWORK
- Hotplug - NIC

Ecosystem CNI certification
- Tigera - Calico

STORAGE
- Application consistent snapshots and cloning
- Improve default performance with io=native

Backup and DR
- via OCS data protection
- Ecosystem CSI certification

Long Term
(9+ months)

CORE
- OCP as on-prem infrastructure
- **Cloud** - Bare Metal where supported by public cloud provider
- **Mass migration**- VMw to OCP & RHV to OCP

NETWORK
- OVS HW offload

Ecosystem CNI certification
- Nuage
- Juniper

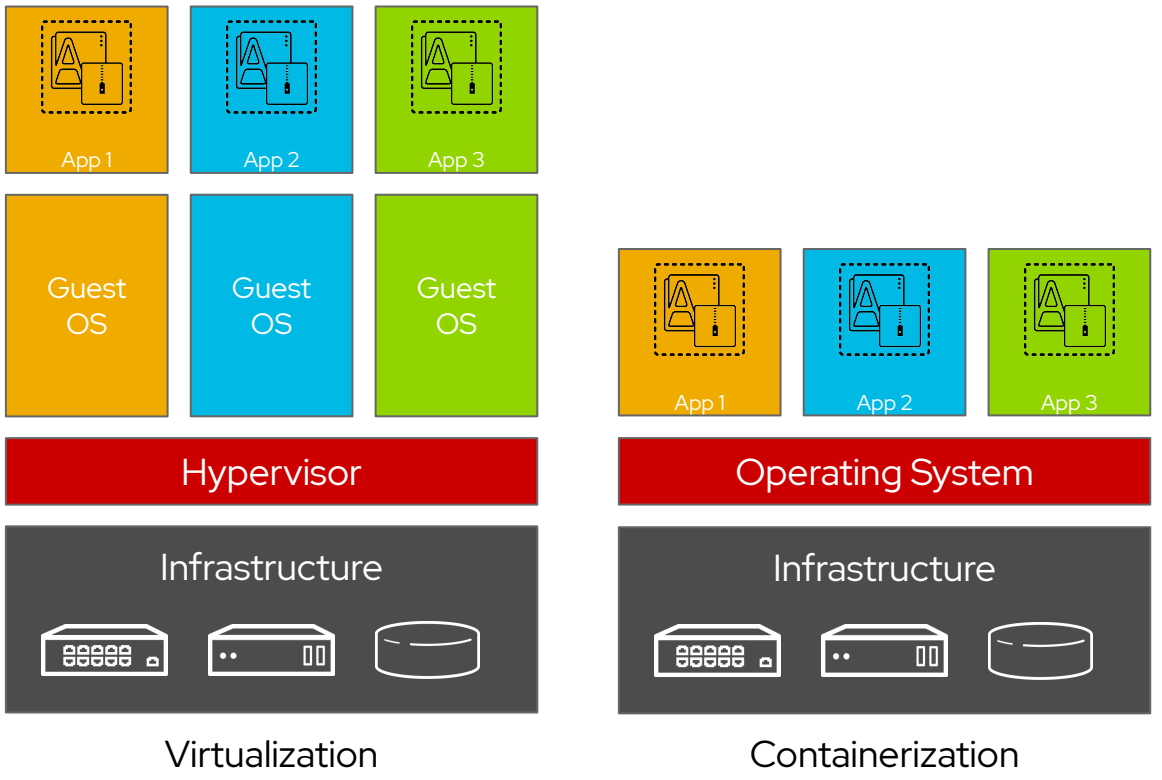
STORAGE
- **High Availability**

Product Manager: Peter Lauterbach, Ronen Sde-Or, and Rob Young

Red Hat

Containers are not virtual machines

- Containers are process isolation
- Kernel namespaces provide isolation and cgroups provide resource controls
- No hypervisor needed for containers
- Contain only binaries, libraries, and tools which are needed by the application
- Ephemeral



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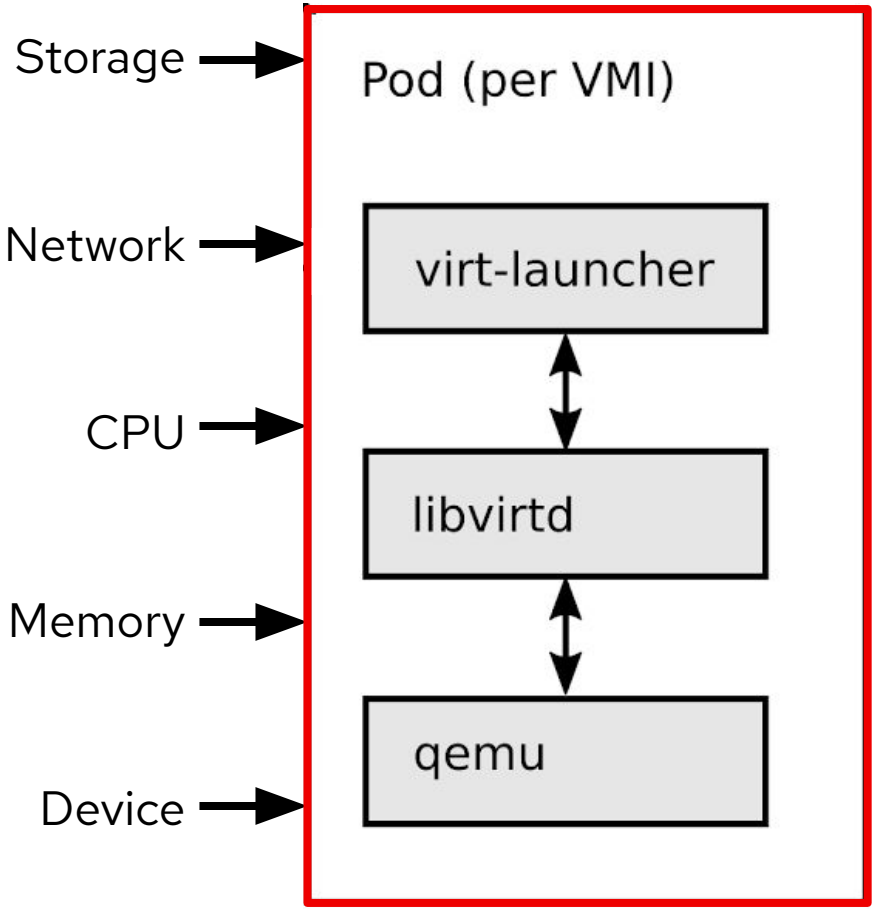
Containerized virtual machines



Kubernetes resources

- Every VM runs in a launcher pod. The launcher process will supervise, using libvirt, and provide pod integration.

Red Hat Enterprise Linux

- libvirt and qemu from RHEL are mature, have high performance, provide stable abstractions, and have a minimal overhead.

Security - Defense in depth

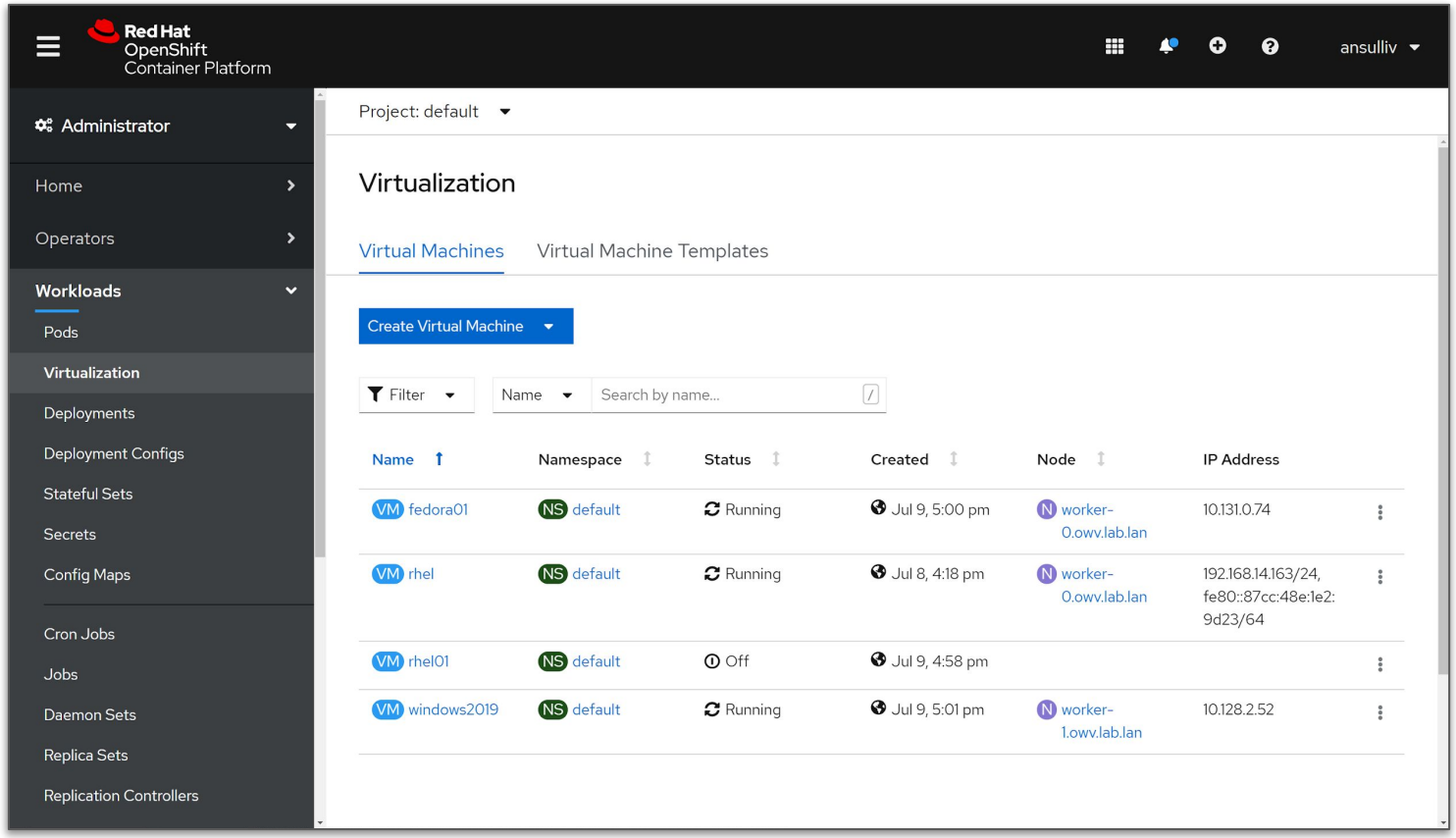
- Immutable RHCOS by default, SELinux MCS, plus KVM isolation - inherited from the Red Hat Portfolio stack

Managed with OpenShift

Red Hat

Virtual Machine Management

- Create, modify, and destroy virtual machines, and their resources, using the OpenShift web interface or CLI
- Use the `virtctl` command to simplify virtual machine interaction from the CLI



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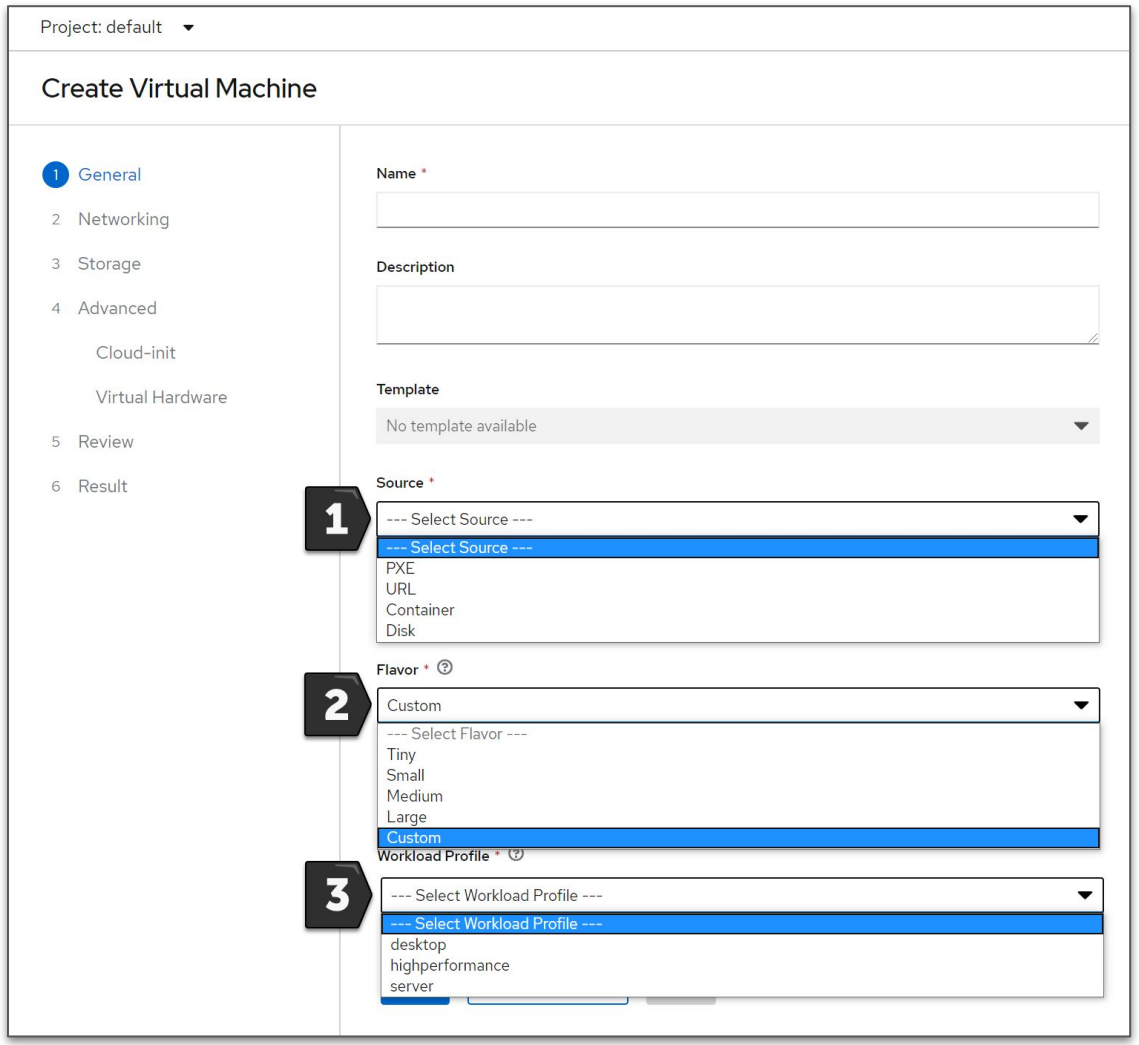
Create VMs

Create Virtual Machine - General

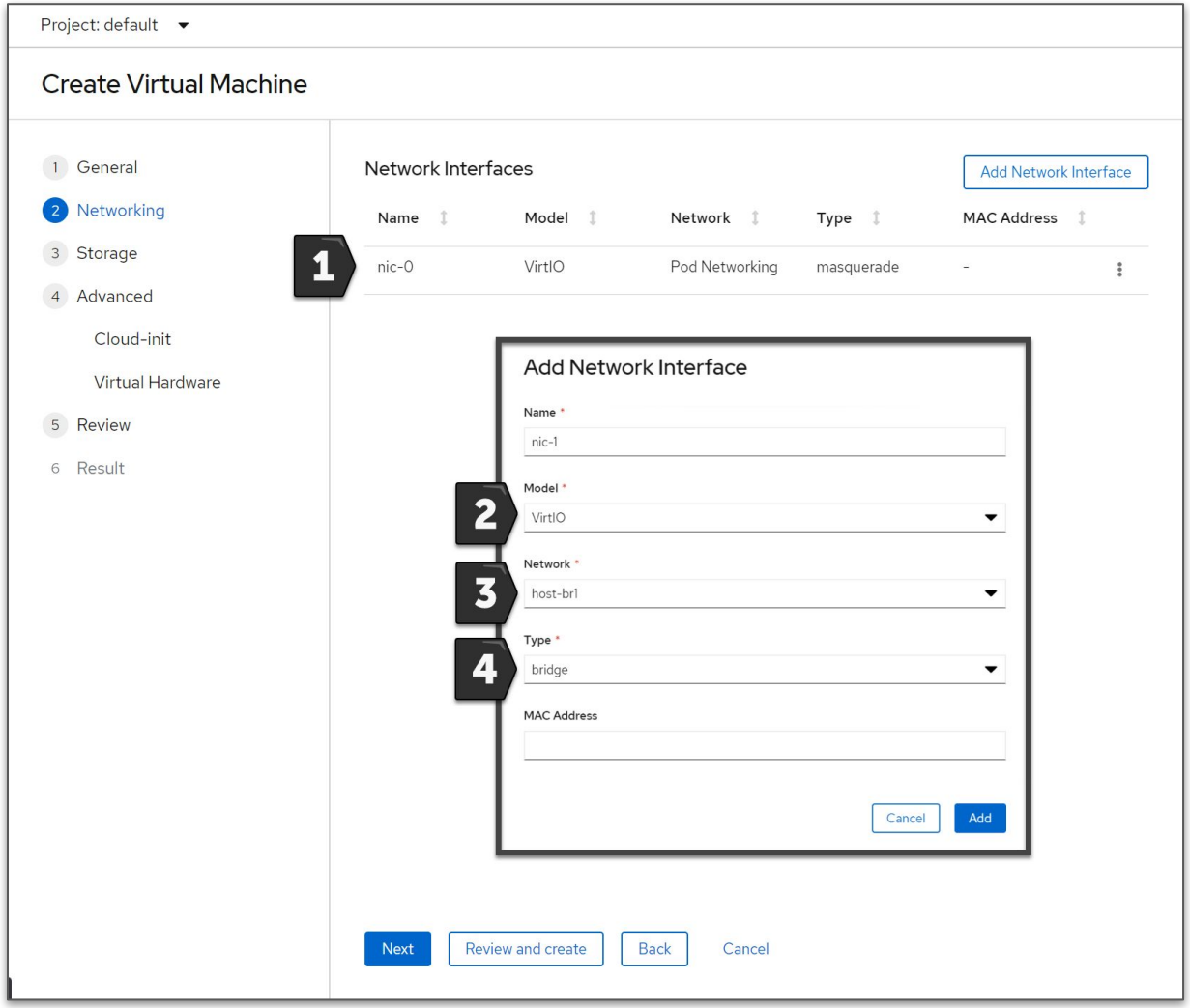
- Source represents how the VM will boot
  - Boot via PXE, optionally diskless
  - URL will import a QCOW2 or raw disk image using a DataVolume
  - Container uses a container image, pulled from a registry, for the disk
  - Disk uses an existing PVC
- Flavor represents the preconfigured CPU and RAM assignments
  - Tiny = 1 vCPU and 1GB RAM, Small = 1 vCPU and 2GB RAM, etc.
- Workload profile defines the category of workload expected and is used to set KVM performance flags



Red Hat

Create Virtual Machine - Networks

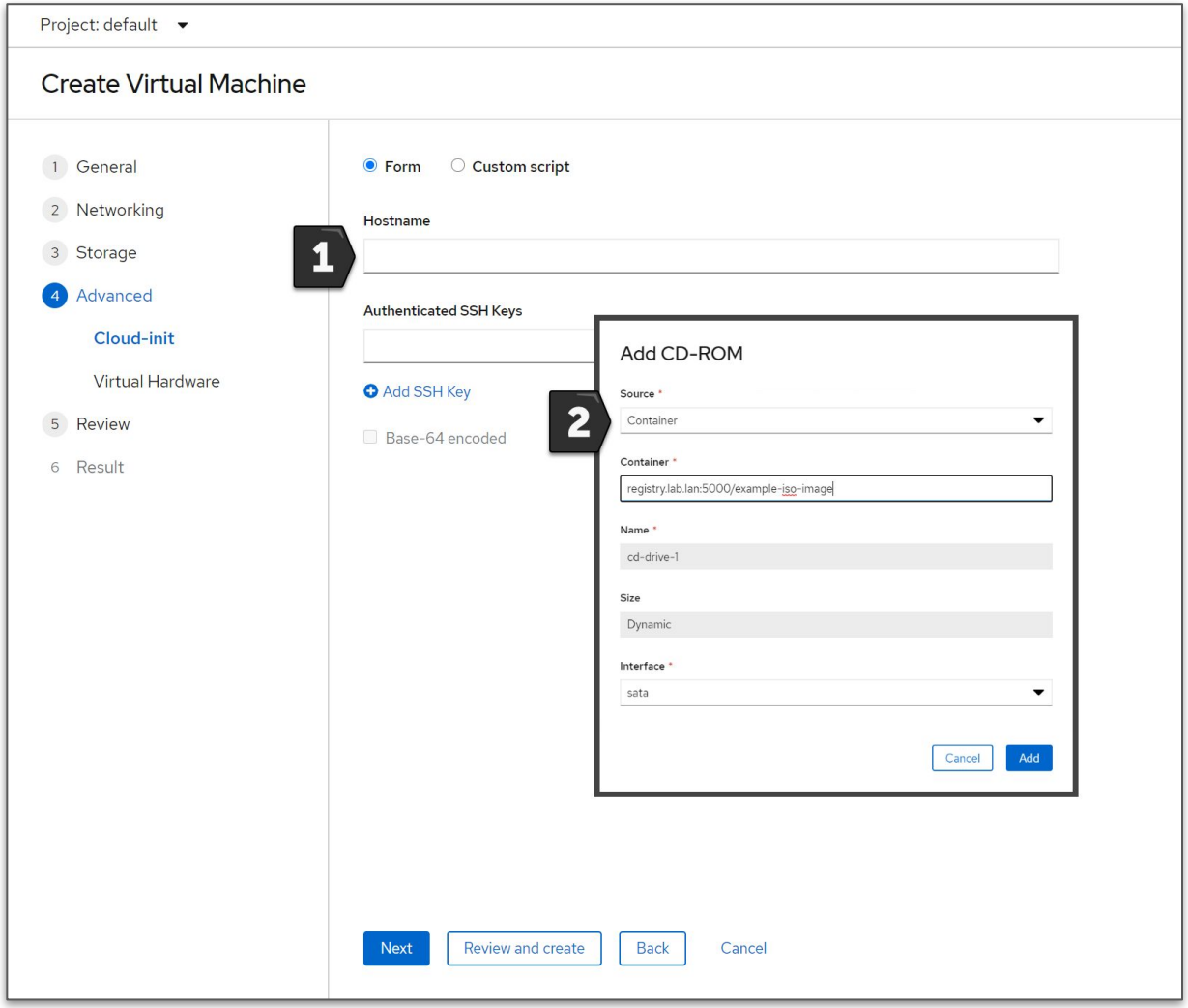
- Add or edit network adapters
- One or more network connections
  - Pod network for the default SDN
  - Additional multus-based interfaces for specific connectivity
- Multiple NIC models for guest OS compatibility or paravirtualized performance with VirtIO
- Masquerade, bridge, or SR-IOV connection types
- MAC address customization if desired



Red Hat

Create Virtual Machine - Advanced

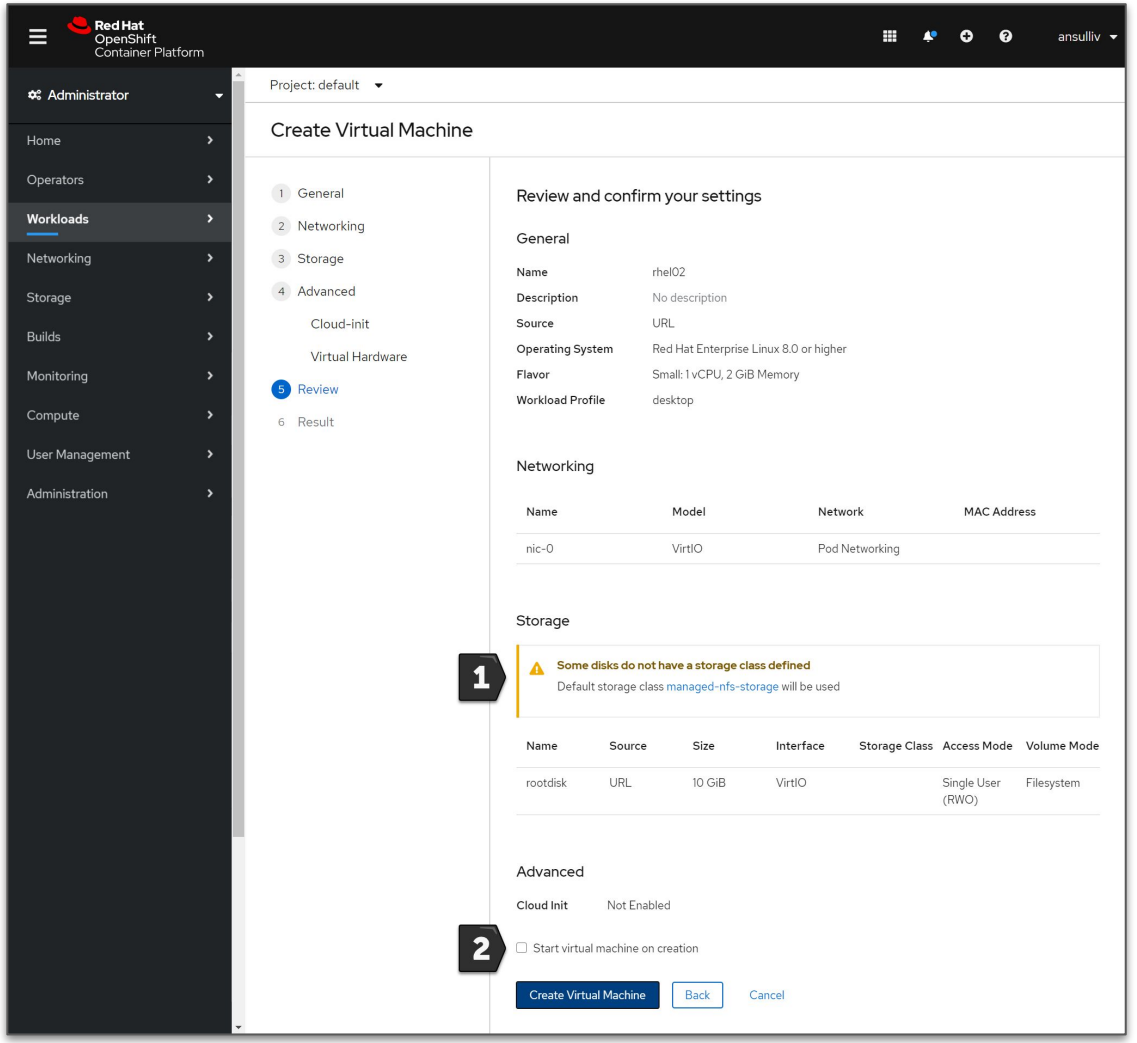
- Customize the operating system deployment using cloud-init scripts
  - Guest OS must have cloud-init installed
  - RHEL, Fedora, etc. cloud images
- Attach ISOs to the VM CD/DVD drive
  - ISOs stored in container images (registry), existing PVC, or imported from URL



Red Hat

Create Virtual Machine - Review

- A summary of the decisions made
- Warnings and other important information about the configuration of the VM are displayed
- Choose to automatically power on the VM after creation



Red Hat

Import VMs

Red Hat

Virtual Machine Import

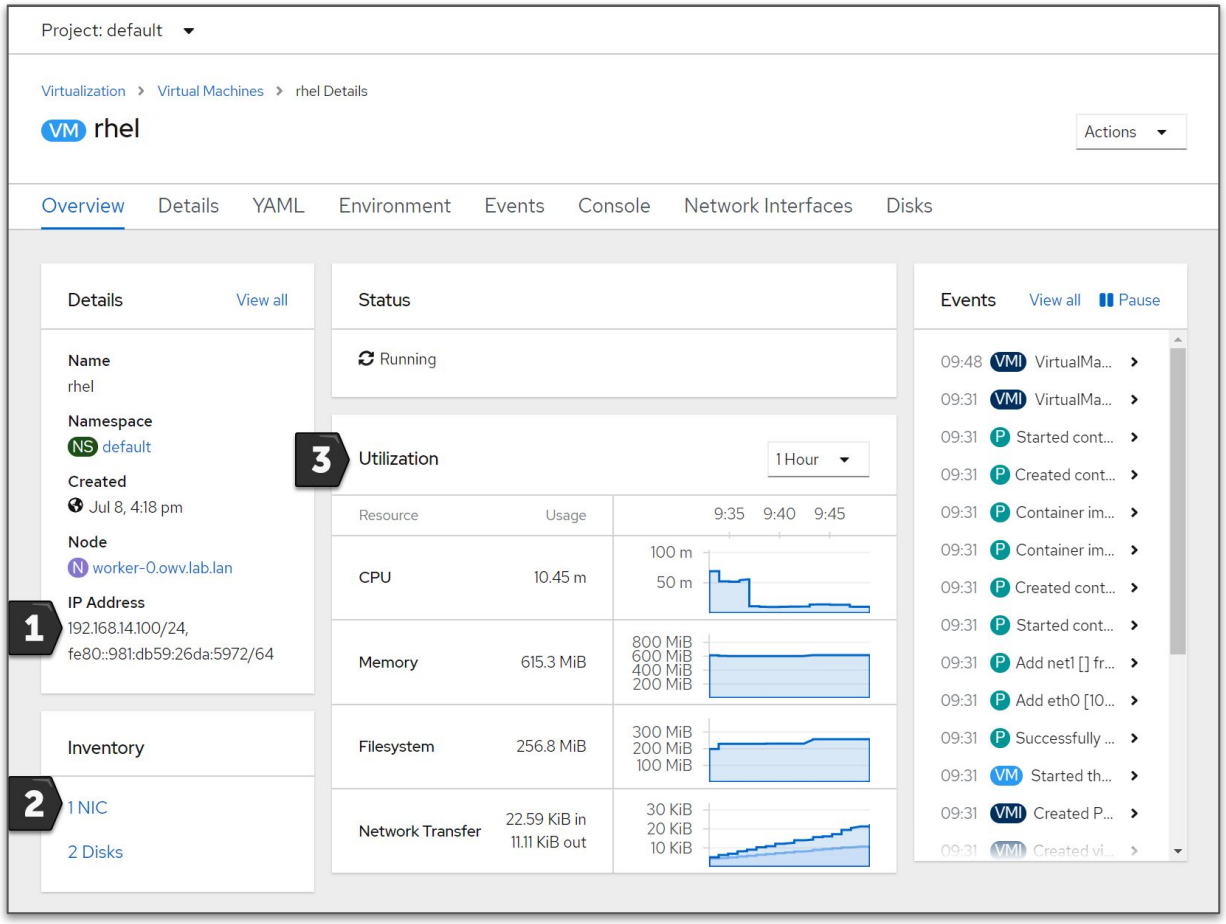
- Wizard supports importing from VMware or Red Hat Virtualization
  - Single-VM workflow
- VMware import uses VDDK to expedite the disk import process
  - User is responsible for downloading the VDDK from VMware and adding it to a container image
- Credentials stored as Secrets
- `ResourceMapping` CRD configures default source -> destination storage and network associations

Red Hat

View / manage VMs

Virtual Machine - Overview

- General overview about the virtual machine
- Information populated from guest when integrations are available
  - IP address
- Inventory quickly shows configured hardware with access to view/manage
- Utilization reporting for CPU, RAM, disk, and network



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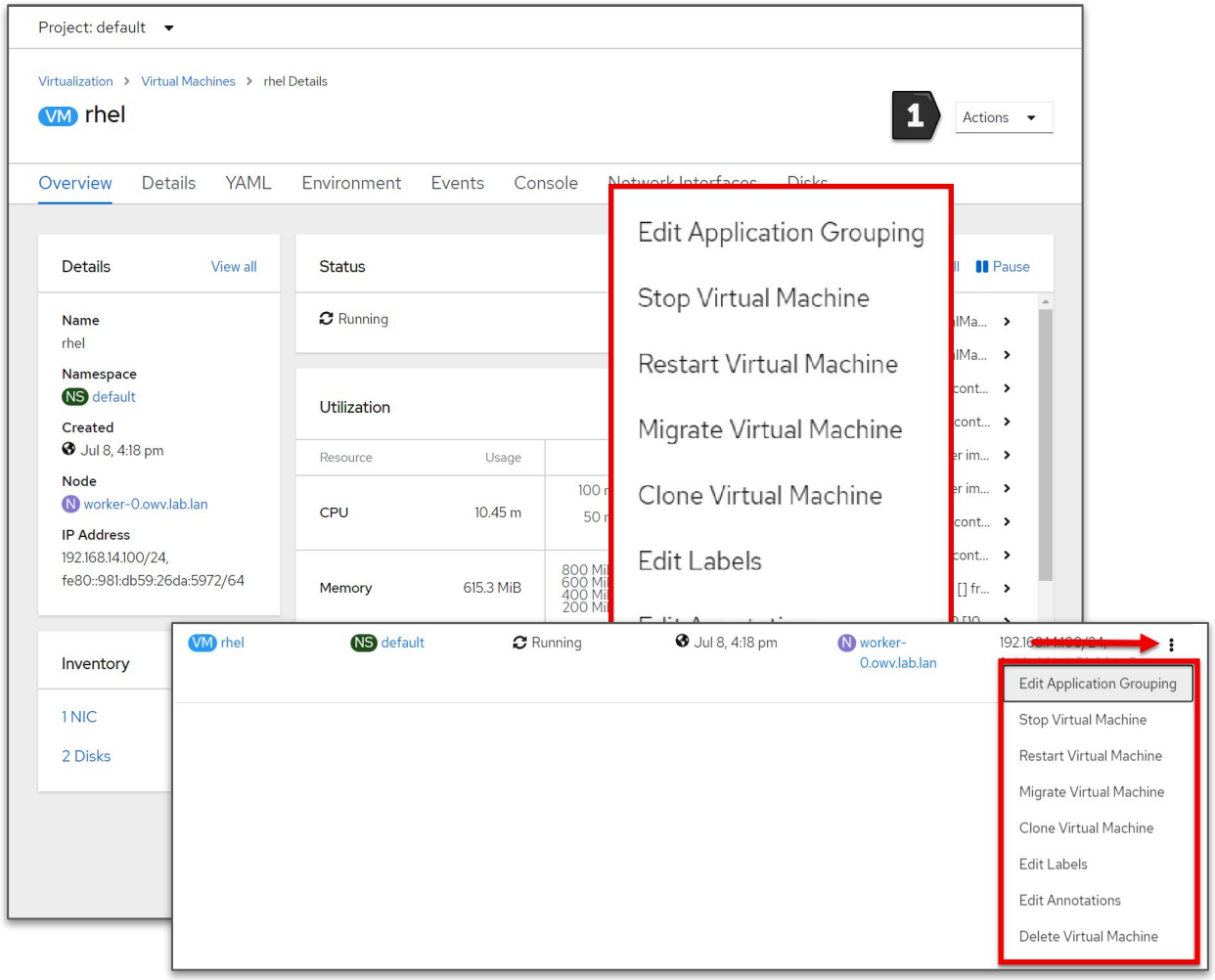
Virtual Machine - Actions

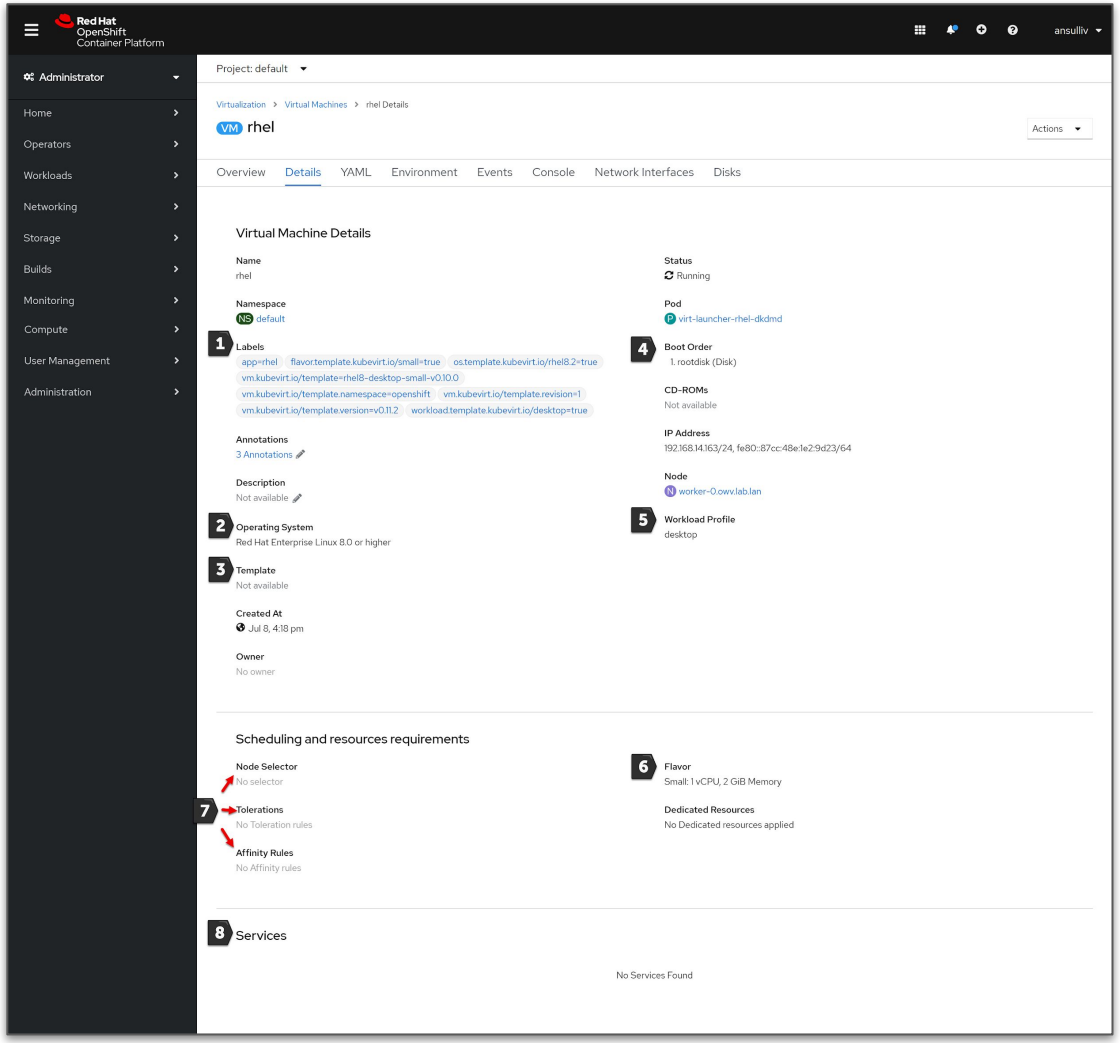
- Actions menu allows quick access to common VM tasks
  - Start/stop/restart
  - Live migration
  - Clone
  - Edit application group, labels, and annotations
  - Delete
- Accessible from all tabs of VM details screen and the VM list



Red Hat

Virtual Machine - Details

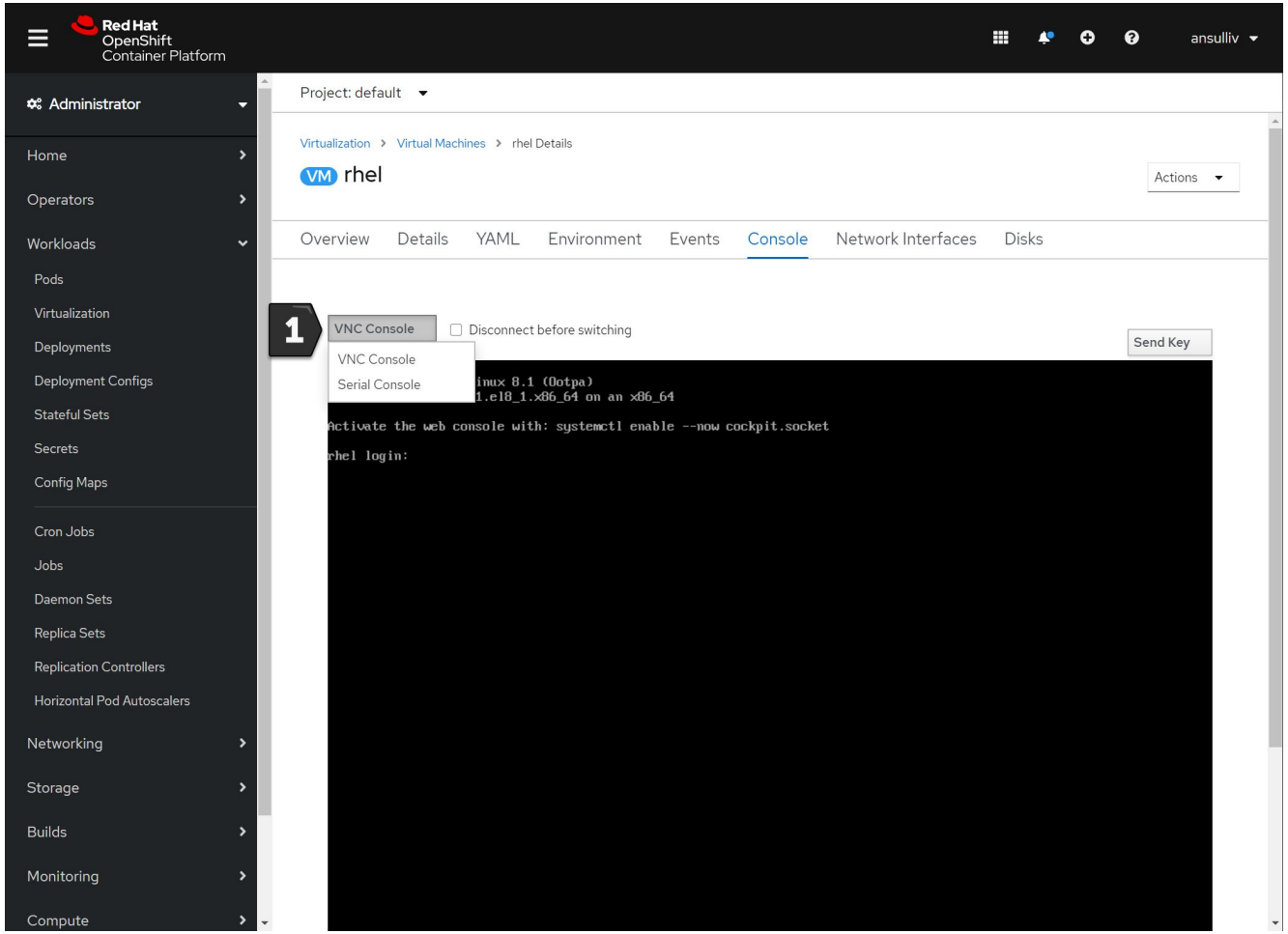
- Details about the virtual machine
  - Labels, annotations
  - Configured OS
  - Template used, if any
  - Configured boot order
  - Associated workload profile
  - Flavor
- Additional details about scheduling
  - Node selector, tolerations, (anti)affinity rules
- Services configured for the VM



Red Hat

Virtual Machine - Console

- Browser-based access to the serial and graphical console of the virtual machine
- Access the console using native OS tools, e.g. `virt-viewer`, using the `virtctl` CLI command
  - `virtctl console vmname`
  - `virtctl vnc vmname`



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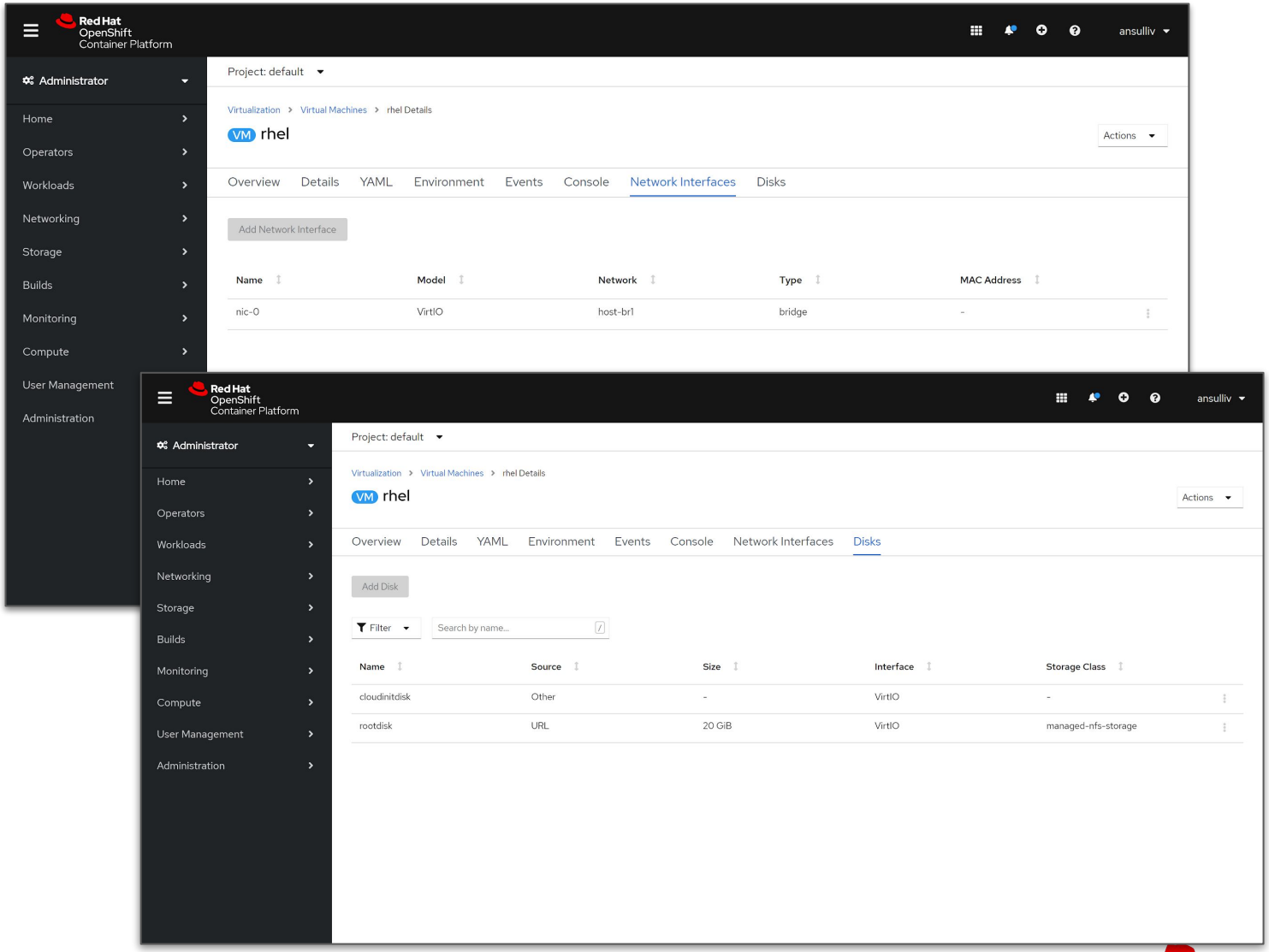
Virtual Machine - Disks and NICs

- Add, edit, and remove NICs and disks for non-running virtual machines

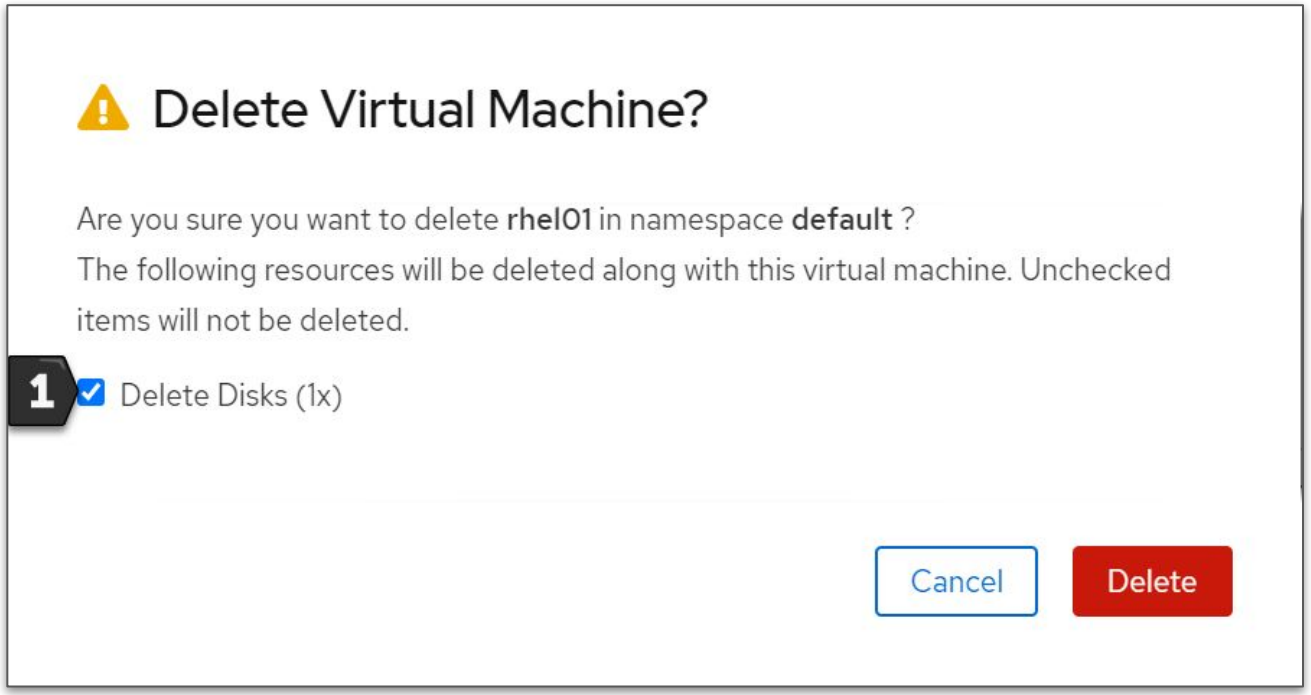


Red Hat

Destroy VMs

Destroying a Virtual Machine

- Deleting a VM removes the VM definition
  - Optionally delete PVC-backed disks associated with the VM
- Running VMs are terminated first
- Other associated resources, e.g. Services, are not affected



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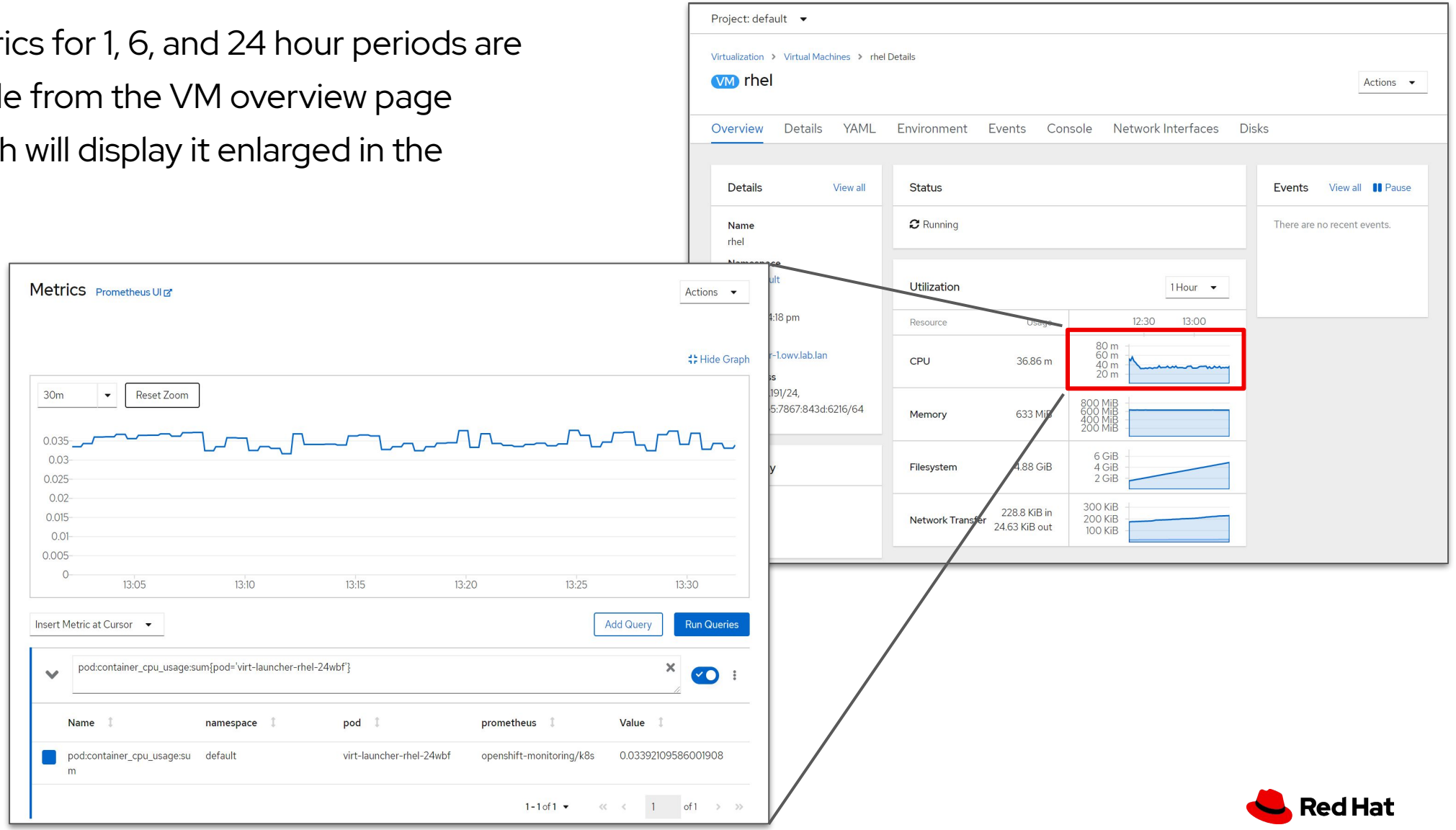
Metrics

Overview Virtual Machine metrics

- Summary metrics for 1, 6, and 24 hour periods are quickly viewable from the VM overview page
- Clicking a graph will display it enlarged in the metrics UI



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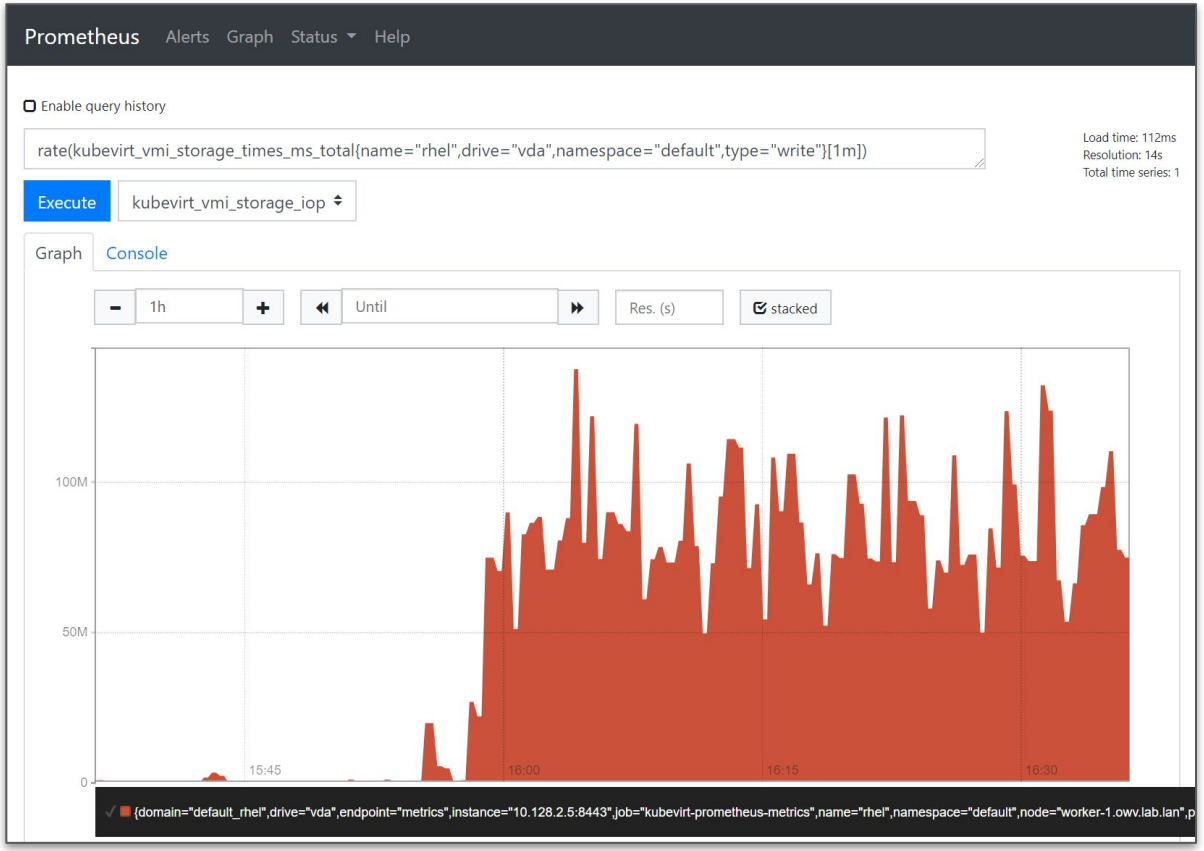
Detailed Virtual Machine metrics

- Virtual machine, and VM pod, metrics are collected by the OpenShift metrics service
  - Available under the `kubevirt` namespace in Prometheus
- Available per-VM metrics include
  - Active memory
  - Active CPU time
  - Network in/out errors, packets, and bytes
  - Storage R/W IOPS, latency, and throughput
- VM metrics are for VMs, not for VM pods
  - Management overhead not included in output
  - Look at virt-launcher pod metrics for
- No preexisting Grafana dashboards



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Deeper into the technology

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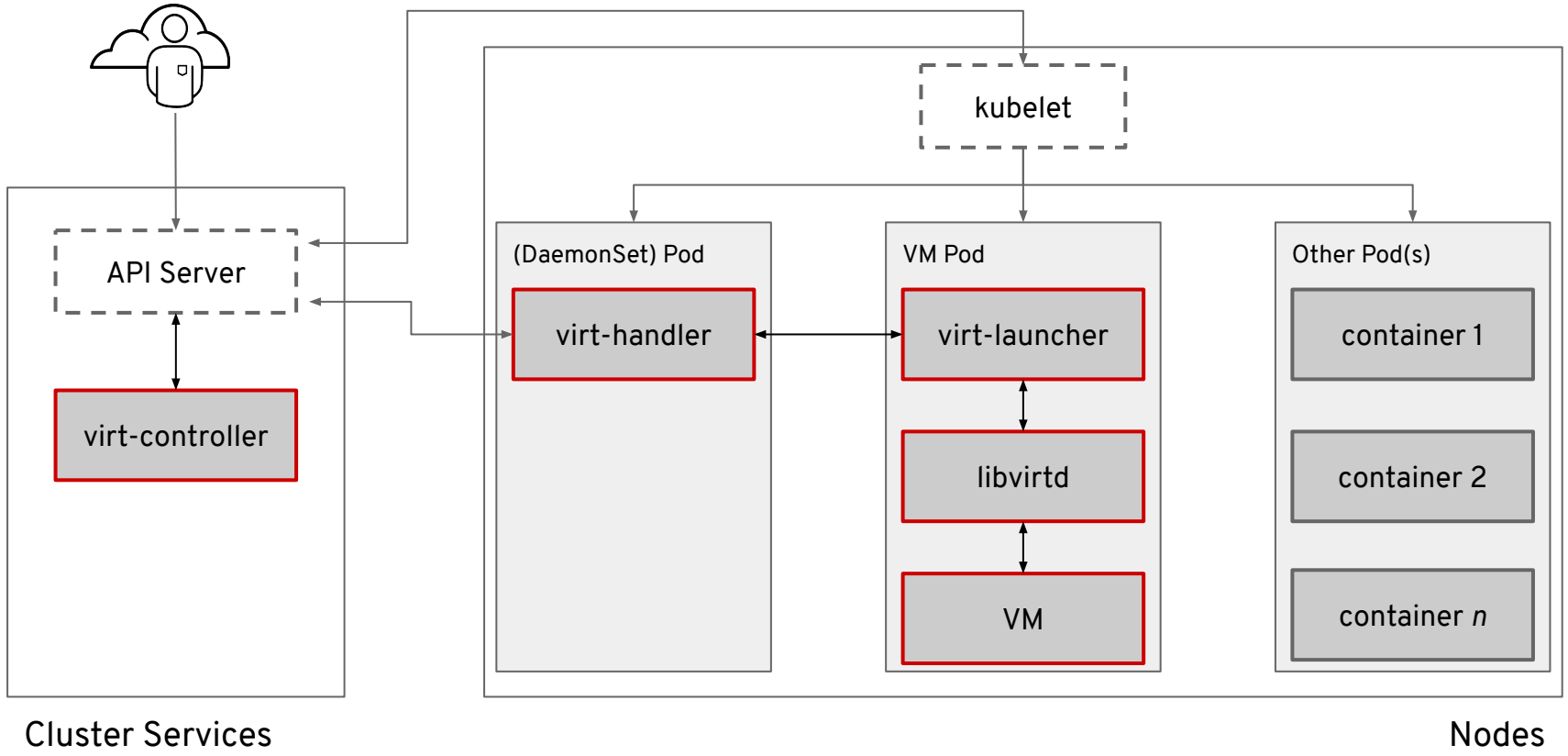
Architectural Overview



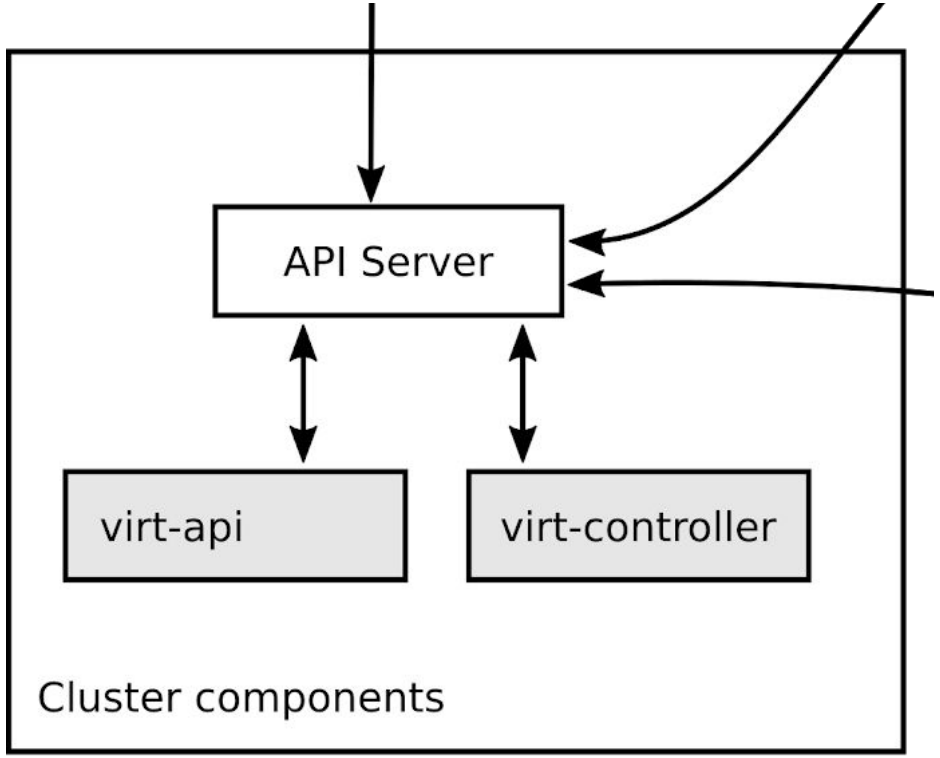
Adding virtualization to the Kubernetes API

CRD and aggregated API servers

- These are the ways to extend the Kubernetes API in order to support new entities
- For users, the new entities are indistinguishable from native resources

Single API entry point for all workloads

- All workloads (containers, VMs, and serverless) are managed through a single API



OpenShift cluster architecture

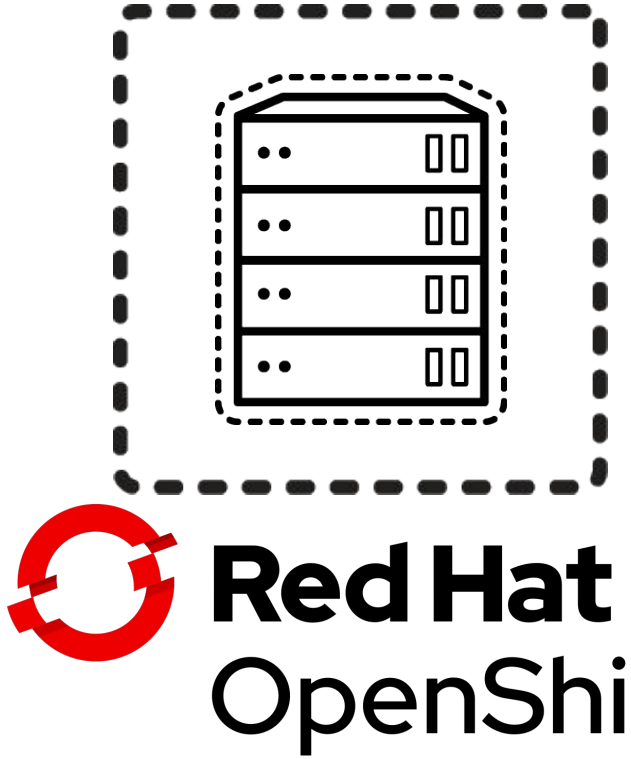
- Everything everywhere - all 8 nodes are "workers"
  - Create the cluster with the control plane as schedulable
  - No dedicated infra nodes, no dedicated OCS nodes
  - Pros: no wasted resources
  - Cons: must pay for all cores of all nodes, extra effort should be taken to ensure pods have appropriate QoS to prevent resource contention exacerbating performance problems
- Shared control plane, dedicated + combined infra
  - Schedulable control plane
  - Dedicated infra nodes for registry, logging, metrics, and OCS
  - Pros: don't have to pay for infra node licenses
  - Cons: care needs to be taken to size nodes appropriately to not strand resources, e.g. "infra nodes are only 15% utilized, but we can't put workload on those nodes without paying for the OCP entitlements"
- Dedicated control plane, dedicated infra
  - Non-schedulable control plane
  - Dedicated infra nodes for registry, logging, metrics, and OCS
  - Pros: control plane resource isolation prevents contention from causing performance ripples
  - Cons: control plane nodes will almost certainly be dramatically under utilized, minimum 6 dedicated nodes (3 control plane, 3 infra)
- Shared control plane/worker/infra, dedicated OCS
  - Scheduleable control plane, no dedicated infra
  - Pros: isolates OCS for performance/scale reasons
  - Cons: same as above - care needs to be taken to protect control plane workloads, must pay for infra cores
- Dedicated everything
  - Dedicated control plane, infra, and OCS nodes
  - Pros: lots of isolation and protection for workloads
  - Cons: lots of potentially wasted resources (node right sizing is important!) and lots of nodes needed: 3 control plane, 3 OCS, 2 infra, + workers

Virtual machines

Red Hat

Containerized virtual machines

- Inherit many features and functions from Kubernetes
  - Scheduling, high availability, attach/detach resources
- Containerized virtual machines have the same characteristics as non-containerized
  - CPU, RAM, etc. limitations dictated by libvirt and QEMU
  - Linux and Windows guest operating systems
- Storage
  - Use Persistent Volumes Claims (PVCs) for VM disks
  - Containerized Data Importer (CDI) import VM images
- Network
  - Inherit pod network by default
  - Multus enables direct connection to external network



Virtual Machine Instances

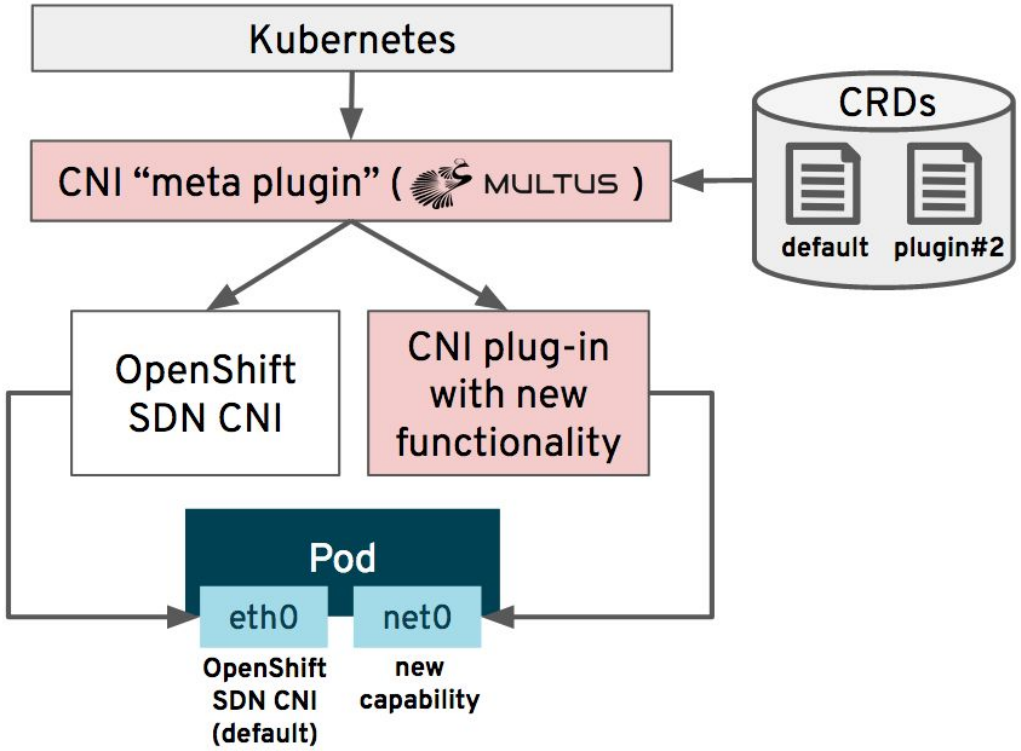
- A VirtualMachine (VM) CRD represents a VM definition
- A VirtualMachineInstance (VMI) CRD represents a running virtual machine
- The VM definition is optional, a VMI can be created directly
  - Can be used with standard network and storage connections
  - If persisting the VMI disks, a DataVolume is highly encouraged to prevent the VMI from launching before the import is done

Network

Red Hat

Virtual Machine Networking

- Virtual machines optionally connect to the standard pod network
  - OpenShift SDN, OVNKubernetes, etc.
- Additional network interfaces accessible via Multus:
  - Bridge, SR-IOV
  - VLAN and other networks can be created using nmstate at the host level
- When using at least one interface on the default SDN, Service, Route, and Ingress configuration applies to VM pods the same as others



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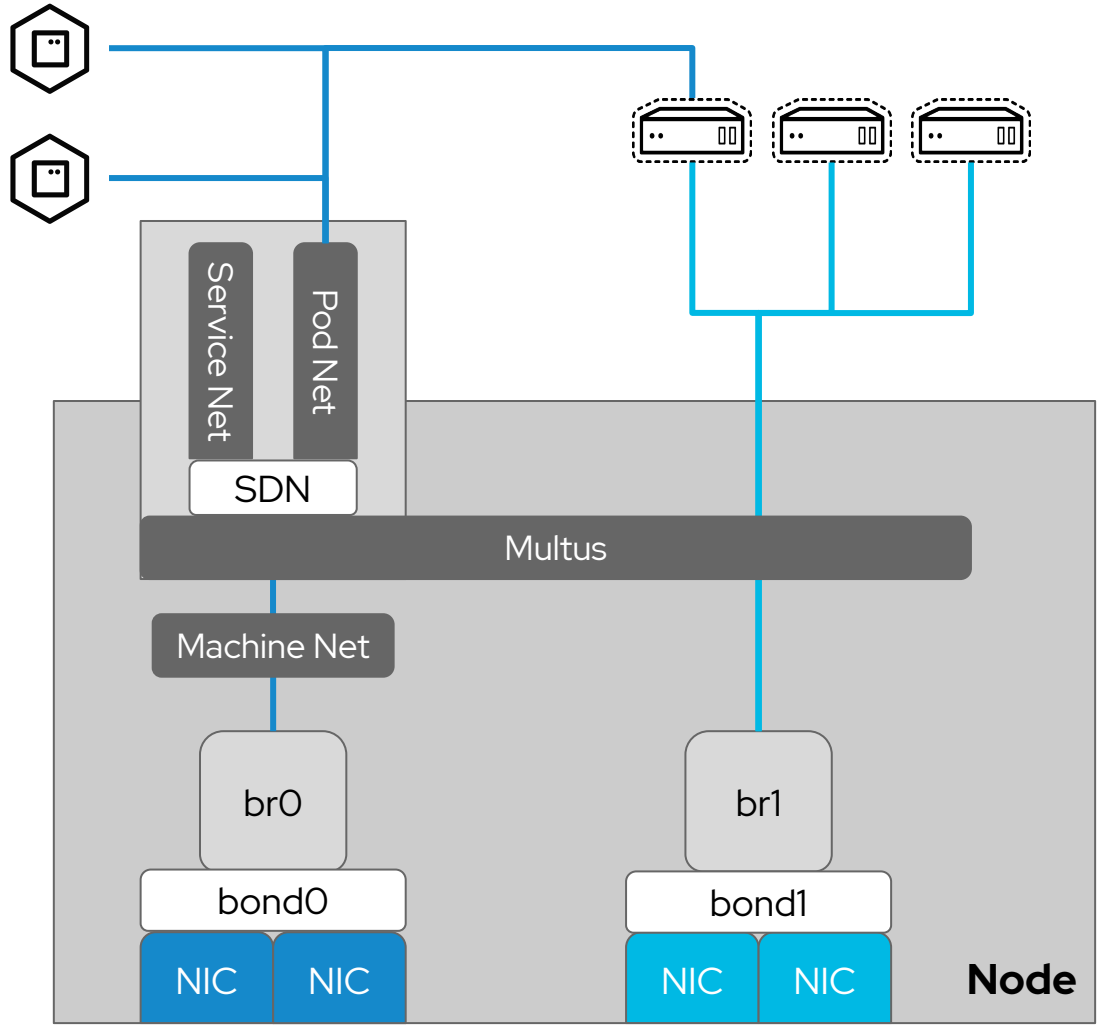
Example host network configuration

- Pod, service, and machine network are configured by OpenShift automatically
  - Use kernel parameters (dracut) for configuration at install
- Use `kubernetes-nmstate`, via the nmstate Operator, to configure additional host network interfaces
  - `bond1` and `br1` in the example to the right
- VM pods connect to one or more networks simultaneously

The following slides show an example of how this setup is configured



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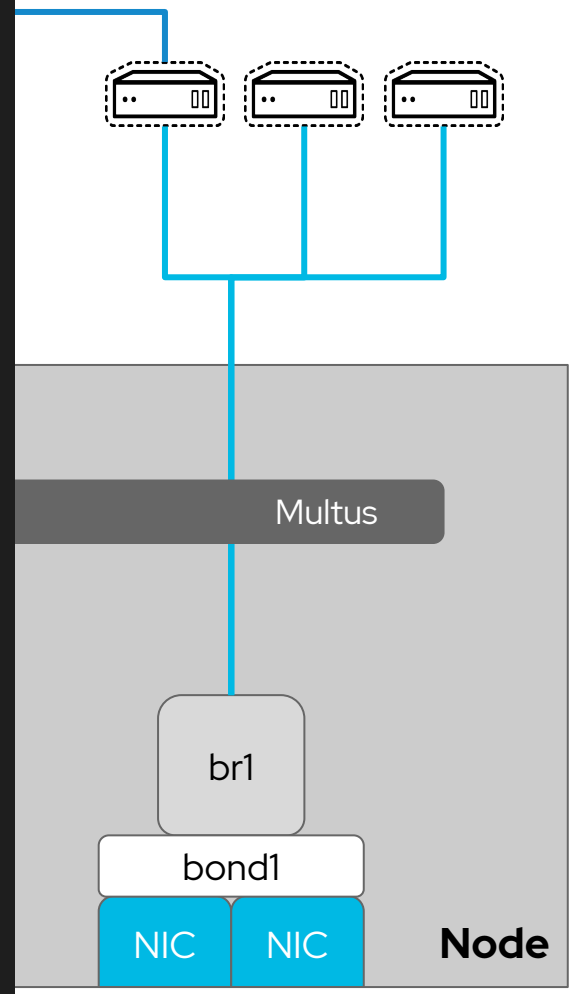
Host bond configuration

- NodeNetworkConfigurationPolicy (NNCP)
  - Nmstate operator CRD
  - Configure host network using declarative language
- Applies to all nodes specified in the `nodeSelector`, including newly added nodes automatically
- Update or add new NNCPs for additional host configs

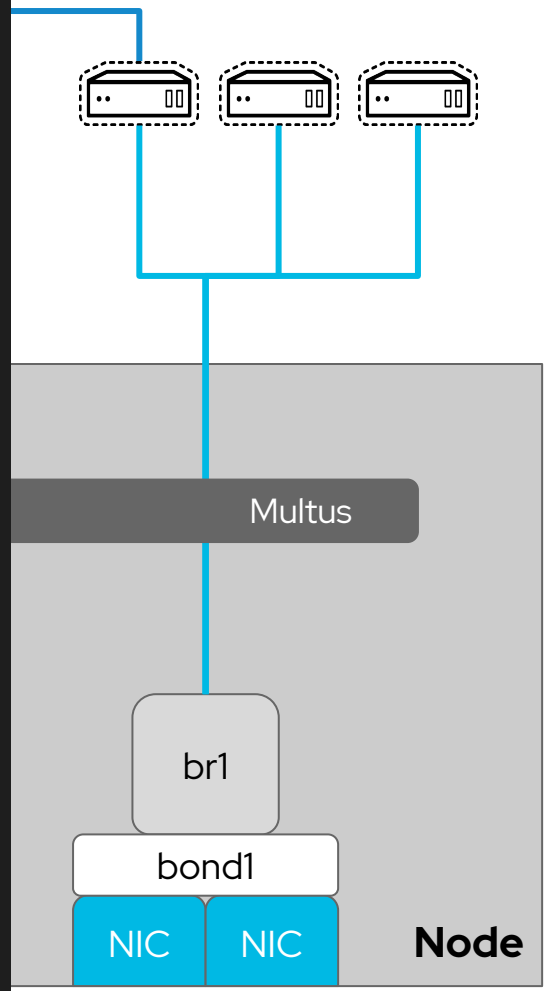
```yaml
apiVersion: nmstate.io/v1alpha1
kind: NodeNetworkConfigurationPolicy
metadata:
  name: worker-bond1
spec:
  nodeSelector:
    node-role.kubernetes.io/worker: ""
  desiredState:
    interfaces:
    - name: bond1
      type: bond
      state: up
      ipv4:
        enabled: false
      link-aggregation:
        mode: balance-alb
        options:
          miimon: '100'
        slaves:
        - eth2
        - eth3
      mtu: 1450
```



Red Hat

Host bridge configuration

```yaml
apiVersion: nmstate.io/v1alpha1
kind: NodeNetworkConfigurationPolicy
metadata:
  name: worker-bond1-br1
spec:
  nodeSelector:
    node-role.kubernetes.io/worker: ""
  desiredState:
    interfaces:
      - name: br1
        description: br1 with bond1
        type: linux-bridge
        state: up
        ipv4:
          enabled: false
        bridge:
          options:
            stp:
              enabled: false
          port:
            - name: bond1
```



Red Hat

Host network status

- Use the `NodeNetworkConfigurationEnactment` (NNCE) object to view status of NNCP application
- Further details of the node network state can be seen using the NodeNetworkState CRD
  - oc get nns/node-name -o yaml

```
API Version:  nmstate.io/v1alpha1
Kind:         NodeNetworkConfigurationEnactment
Name:         worker-1.owv.lab.lan.worker-br1-bond1
Status:
  Conditions:
    Last Hearbeat Time:    2020-07-08T20:15:46Z
    Last Transition Time:  2020-07-08T20:15:46Z
    Message:               successfully reconciled
    Reason:                SuccessfullyConfigured
    Status:                True
    Type:                  Available
  Desired State:
    Interfaces:
      Bridge:
        Options:
          Stp:
            Enabled:  false
        Port:
          Name:     bond1
      Description:  br1 with bond1
      ipv4:
        Enabled:      false
      Name:           br1
      State:          up
      Type:           linux-bridge
```

Connecting Pods to networks

- Multus uses CNI network definitions in the NetworkAttachmentDefinition to allow access
  - `Net-attach-def` are namespaced
  - Pods cannot connect to a `net-attach-def` in a different namespace
- `cnv-bridge` and `cnv-tuning` types are used to enable VM specific functions
  - MAC address customization
  - MTU and promiscuous mode
  - sysctls, if needed

```
apiVersion: k8s.cni.cncf.io/v1
kind: NetworkAttachmentDefinition
metadata:
  name: br1-public
  annotations:
    k8s.v1.cni.cncf.io/resourceName: bridge.network.kubevirt.io/br1
spec:
  config: '{
    "cniVersion": "0.3.1",
    "name": "br1-public",
    "plugins": [
      {
        "type": "cnv-bridge",
        "bridge": "br1"
      },
      {
        "type": "cnv-tuning"
      }
    ]
  }'
```

- Pod connections are defined using an annotation
  - Pods can have many connections to many networks

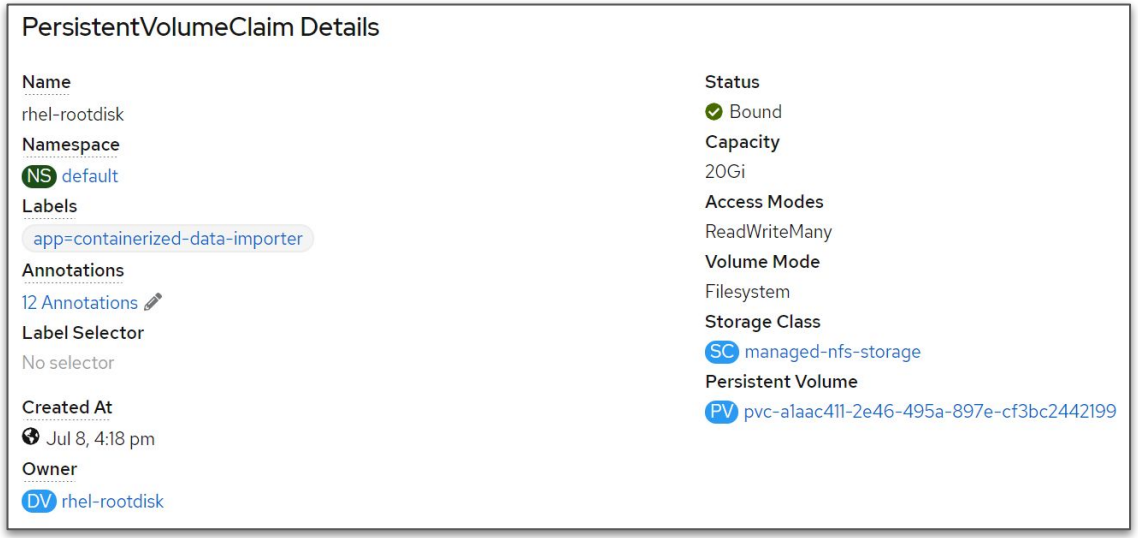
```
kind: Pod
apiVersion: v1
metadata:
  name: application-pod
  annotations:
    k8s.v1.cni.cncf.io/networks: bond1-br1
```

Storage

Red Hat

Virtual Machine Storage

- OpenShift Virtualization uses the Kubernetes PersistentVolume (PV) paradigm
- PVs can be backed by
  - In-tree iSCSI, NFS
  - CSI drivers
  - Local storage using host path provisioner
  - OpenShift Container Storage
- Dynamically or statically provisioned PVs
- RWX required for live migration
- Disks are attached using VirtIO or SCSI controllers
  - Connection order defined in the VM definition
- Boot order customized via VM definition



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VM disks in PVCs

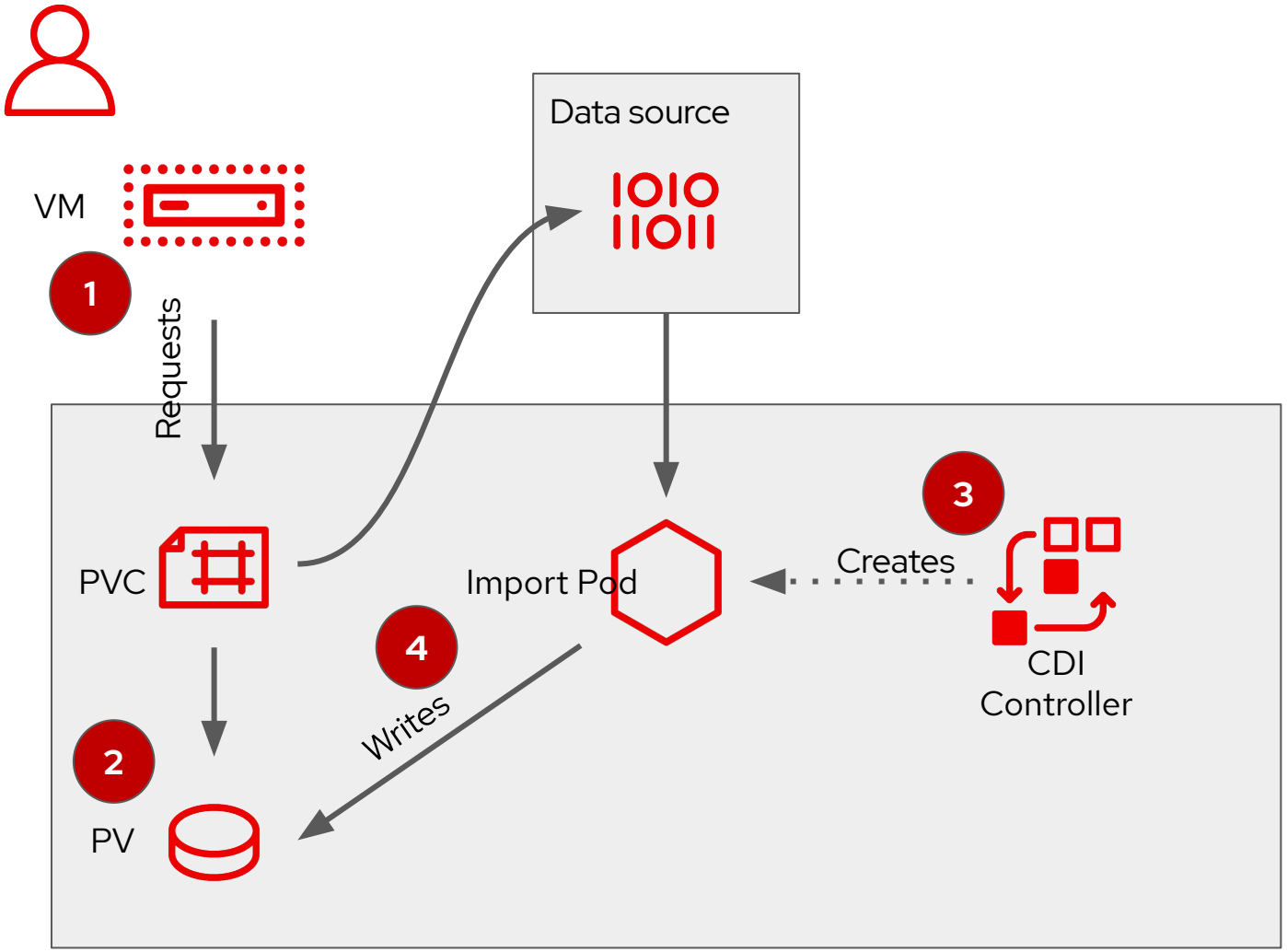
- VM disks on FileSystem PVCs are created as thin provisioned raw images
  - Thick provisioned disks are not created by CDI, may be possible manually
- Block PVCs are attached directly to the VM
- CSI operations, e.g. snapshot and clone, are not supported with VM disk PVCs
  - Use DataVolumes to clone VM disks
- PVC resize does not modify the size of the VM disk
  - Not currently supported
- Hot add is not supported (for any virtual hardware)

DataVolumes

- VM disks can be imported from multiple sources using DataVolumes, e.g. an HTTP(S) or S3 URL for a QCOW2 or raw disk image, optionally compressed
- DataVolumes are created view explicit object definition or as a part of the VM definition
- DataVolumes use the `ContainerizedDataImporter` to connect, download, and prepare the image for OpenShift Virtualization
- DataVolumes create PVCs based on defaults defined in the `kubevirt-storage-class-defaults` ConfigMap

```yaml
dataVolumeTemplates:
  - apiVersion: cdi.kubevirt.io/v1alpha1
    kind: DataVolume
    metadata:
      creationTimestamp: null
      name: vm-rootdisk
    spec:
      pvc:
        accessModes:
          - ReadWriteMany
        resources:
          requests:
            storage: 20Gi
        storageClassName: my-storage-class
        volumeMode: Filesystem
      source:
        http:
          url: 'http://web.server/disk-image.qcow2'
```

Containerized Data Importer



1. The user creates a virtual machine with a DataVolume
2. The StorageClass is used to satisfy the PVC request
3. The CDI controller creates an importer pod, which mounts the PVC and retrieves the disk image. The image could be sourced from S3, HTTP, or other accessible locations
4. After completing the import, the import pod is destroyed and the PVC is available for the VM

Ephemeral Virtual Machine Disks

- VMs booted via PXE or using a container image can be “diskless”
  - PVCs may be attached and mounted as secondary devices for application data persistence
- VMs based on container images use the standard copy-on-write graph storage for OS disk R/W
  - Consider and account for capacity and IOPS during RHCOS disk sizing if using this type
- An `emptyDisk` may be used to add additional ephemeral capacity for the VM

```
spec:
  domain:
    disks:
      - bootOrder: 1
        disk:
          bus: virtio
        name: rootdisk
  volumes:
    - containerDisk:
        image: registry.lab.lan:5000/fedora:31
      name: rootdisk
```

Helper disks

- OpenShift Virtualization attaches disks to VMs for injecting data
  - Cloud-Init
  - ConfigMap
  - Secrets
  - ServiceAccount
- These disks are read-only and can be mounted by the OS to access the data within

```
spec:
  domain:
    devices:
      - disk:
          bus: virtio
        name: cloudinitdisk
  volumes:
    - cloudInitNoCloud:
        userData: |-
          #cloud-config
          password: redhat
          chpasswd: { expire: False }
      name: cloudinitdisk
```

Name	Source	Size	Interface	Storage Class
cloudinitdisk	Other	-	VirtIO	-

Comparing with traditional virtualization platforms

Red Hat

Live Migration

- Live migration moves a virtual machine from one node to another in the OpenShift cluster
- Can be triggered via GUI, CLI, API, or automatically
- RWX storage is required, cannot use bridge connection to pod network
- Live migration is cancellable by deleting the API object
- Default maximum of five (5) simultaneous live migrations
    - Maximum of two (2) outbound migrations per node, 64MiB/s throughput each

Migration Reason	vSphere	RHV	OpenShift Virtualization
Resource contention	DRS	Cluster policy	Pod eviction policy, pod descheduler
Node maintenance	Maintenance mode	Maintenance mode	Maintenance mode, node drain

Automated live migration

- OpenShift / Kubernetes triggers pod rebalance actions based on multiple factors
  - Pod rebalance applies to VM pods equally and will result in a live migration
- Eviction policies
  - Soft
  - Hard
- Pod descheduler
- Pod disruption policy

VM scheduling

- VM scheduling follows pod scheduling rules
  - Node selectors
  - Taints / tolerations
  - Pod and node affinity / anti-affinity
- Kubernetes scheduler takes into account many additional factors
  - Resource load balancing - requests and reservations
  - CPU pinning, NUMA
  - Large / Huge page support for VM memory
- Resources are managed by Kubernetes
  - CPU and RAM requests match VM requirements - `Guaranteed` QoS by default
  - K8s QoS policy determines scheduling priority: `BestEffort` class is evicted before `Burstable` class, which is evicted before `Guaranteed` class

Node Resource Management

- VM density is determined by multiple factors controlled at the cluster, OpenShift Virtualization, pod, and VM levels
- Pod QoS policy
  - Burstable (limit > request) allows more overcommit, but may lead to more frequent migrations
  - Guaranteed (limit = request) enables less overcommitment, but may have less physical resource utilization on the hosts
- Cluster Resource Override Operator provides global overcommit policy, can be customized per project for additional control
- VM pods request a small amount of additional memory, used for libvirt/QEMU overhead
  - Administrator can set this to be overcommitted
- Enable kernel same-page merging (KSM) by starting the daemon using a MachineConfig

High availability

- Node failure is detected by Kubernetes and results in the pods from the lost node being rescheduled to the surviving nodes
- VMs are not scheduled to nodes which have not had a heartbeat from `virt-handler`, regardless of Kubernetes node state
- Additional monitoring may trigger automated action to force stop the VM pods, resulting in rescheduling
  - May take up to 5 minutes for `virt-handler` and/or Kubernetes to detect failure
  - Liveness and Readiness probes may be configured for VM-hosted applications

Terminology comparison

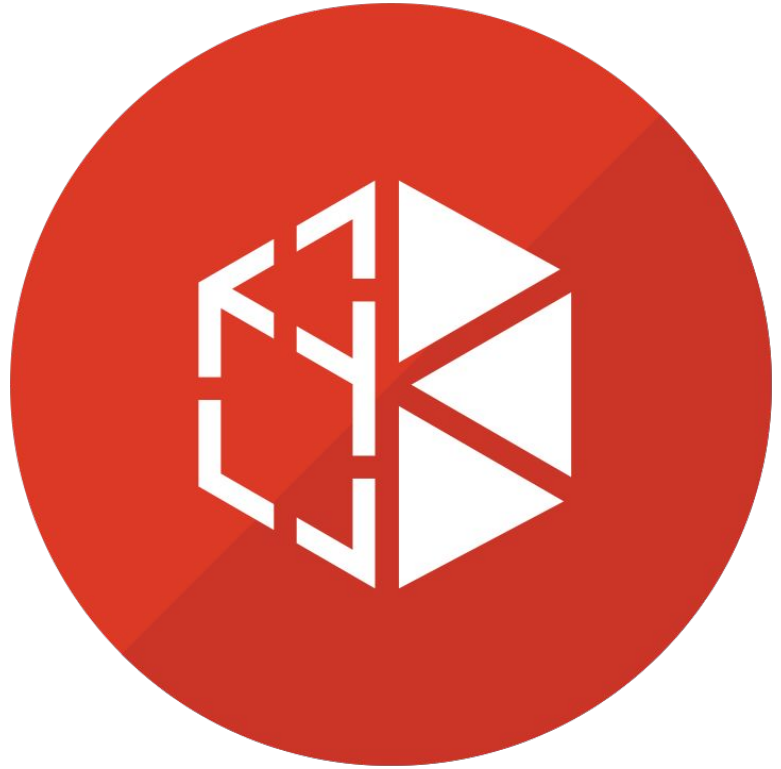
Feature	RHV	OpenShift Virtualization	vSphere
Where VM disks are stored	Storage Domain	PVC	datastore
Policy based storage selection	None	StorageClass	SPBM
Non-disruptive VM migration	Live migration	Live migration	vMotion
Non-disruptive VM storage migration	Storage live migration	N/A	Storage vMotion
Active resource balancing	Cluster scheduling policy	Pod eviction policy, descheduler	Dynamic Resource Scheduling (DRS)
Physical network configuration	Host network config (via nmstate w/4.4)	nmstate Operator, Multus	vSwitch / DvSwitch
Overlay network configuration	OVN	OCP SDN (OpenShiftSDN, OVNKubernetes, and partners), Multus	NSX-T
Host / VM metrics	Data warehouse + Grafana (RHV 4.4)	OpenShift Metrics, health checks	vCenter, vROps

Runtime awareness

Red Hat

Deploy and configure

- OpenShift Virtualization is deployed as an Operator utilizing multiple CRDs, ConfigMaps, etc. for primary configuration
- Many aspects are controlled by native Kubernetes functionality
  - Scheduling
  - Overcommitment
  - High availability
- Utilize standard Kubernetes / OpenShift practices for applying and managing configuration



Compute configuration

- VM nodes should be physical with CPU virtualization technology enabled in the BIOS
  - Nested virtualization *works*, but is not supported
  - Emulation *works*, but is not supported
- Node labeler detects CPU type and labels nodes for compatibility and scheduling
- Configure overcommitment using native OpenShift functionality - Cluster Resource Override Operator
  - Optionally, customize the default project so that non-VM pods are not overcommitted
  - Customize projects hosting VMs for overcommit policy
- Enable KSM using MachineConfig, ballooning is not supported
- Apply Quota and LimitRange controls to projects with VMs to manage resource consumption

Network configuration

- Apply traditional network architecture decision framework to OpenShift Virtualization
  - Resiliency, isolation, throughput, etc. determined by combination of application, management, storage, migration, and console traffic
  - Most clusters are not VM only, include non-VM traffic when planning
- Node interface on the `MachineNetwork` is used for “primary” communication, including SDN
  - This interface should be both resilient and high throughput
  - Used for migration and console traffic
  - Configure this interface at install time using kernel parameters, reinstall node if configuration changes
- Additional interfaces, whether single or bonded, may be used for traffic isolation, e.g. storage and VM traffic
  - Configure using nmstate Operator, apply configuration to nodes using selectors on NNCP

Storage configuration

- Local storage may be utilized via the Host Path Provisioner
  - Local-only, non-shared storage means no live migration
- Create shared storage from local resources using OpenShift Container Storage
  - RWX file and block devices for live migration
- No preference for storage protocol, use what works best for the application(s)
- Storage backing PVs should provide adequate performance for VM workload
  - Monitor latency from within VM, monitor throughput from OpenShift
- For IP storage (NFS, iSCSI), consider using dedicated network interfaces
  - Will be used for all PVs, not just VM PVs
- Certified CSI drivers are recommended
  - No CSI snapshot integration
  - Non-certified work, but do not have same level of OpenShift testing

Deploying a VM operating system

Creating virtual machines can be accomplished in multiple ways, each offering different options and capabilities

- Start by answering the question “Do I want to manage my VM like a container or a traditional VM?”
- Deploying the OS persistently, i.e. “I want to manage like a traditional VM”
  - Methods:
    - Import a disk with the OS already installed (e.g. cloud image) from a URL or S3 endpoint using a DataVolume, or via CLI using virtctl
    - Clone from an existing PVC or VM template
  - VM state will remain through reboots and, when using RWX PVCs, can be live migrated
- Deploying the OS non-persistently, i.e. “I want to manage like a container”
  - Methods:
    - Diskless, via PXE
    - Container image, from a registry
  - VM has no state, power off will result in disk reset. No live migration.
- Import disks deployed from a container image using CDI to make them persistent

Deploying an application

Once the operating system is installed, the application can be deployed and configured several ways

- The application is pre-installed with the OS
  - This is helpful when deploying from container image or PXE as all components can be managed and treated like other container images
- The application is installed to a container image
  - Allows the application to be mounted to the VM using a secondary disk. Decouples OS and app lifecycle. When used with a VM that has a persistently deployed OS this breaks live migration
- The application is installed after OS is installed to a persistent disk
  - cloud-init - perform configuration operations on first boot, including OS customization and app deployment
  - SSH/Console - connect and administer the OS just like any other VM
  - Ansible or other automation - An extension of the SSH/console method, just automated

Additional resources

Red Hat

More information

- Documentation:
  - OpenShift Virtualization: https://docs.openshift.com
  - KubeVirt: https://kubevirt.io
- Demos and video resources: http://demo.openshift.com
- Labs and workshops: coming soon to RHPDS