Università di Pisa

Dept. of Information Engineering

Course Wireless Networks - 2021/2022

Virtualization (LAB)

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LAB organization

- **PART I (theoretical)**
  - Introduction to SDN, NFV, MEC * concepts
  - Cloud computing and service-based architectures
- **PART II**
  - OpenStack cloud computing platform
  - OpenStack and NFV
  - Live session: OpenStack platform of the DII CrossLab project

* SDN = Software Defined Networking,
NFV = Network Function Virtualization,
MEC = Multi-access Edge Computing

LAB organization

* VM = Virtual Machine

- **PART III**
  - Virtualization overview and different approaches
    - VMs* on hypervisors, containers, alternative solutions

- **PART IV**
  - Containers -> Docker
  - Orchestrators -> Kubernetes
  - Hands-on session: Docker, docker-compose, Kubernetes

PART II

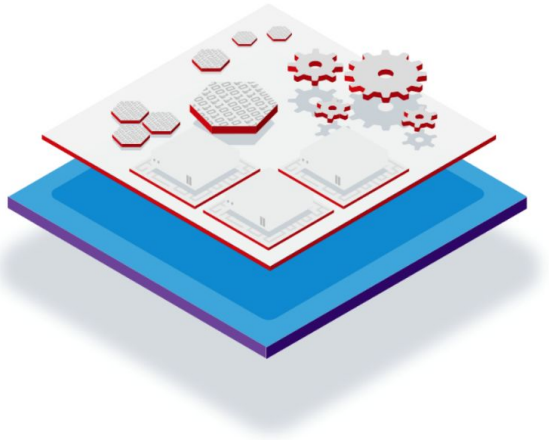
Outline

1) The OpenStack Cloud Computing Platform
   - Overview of the framework
   - Core services
   - The CrossLab real-world use case (live session)
2) OpenStack and NFV
   - ETSI NFV architecture
   - NFV platform components
     - General components (recap)
     - RedHat NFV components (brief overview)

The OpenStack Cloud Computing Platform

The Red Hat OpenStack Platform (RHOSP)

- Open source standard *cloud computing platform*
- Infrastructure-as-a-Service (IaaS)
- Build and manage *private*, *public* or *hybrid cloud platforms* from the available physical hardware



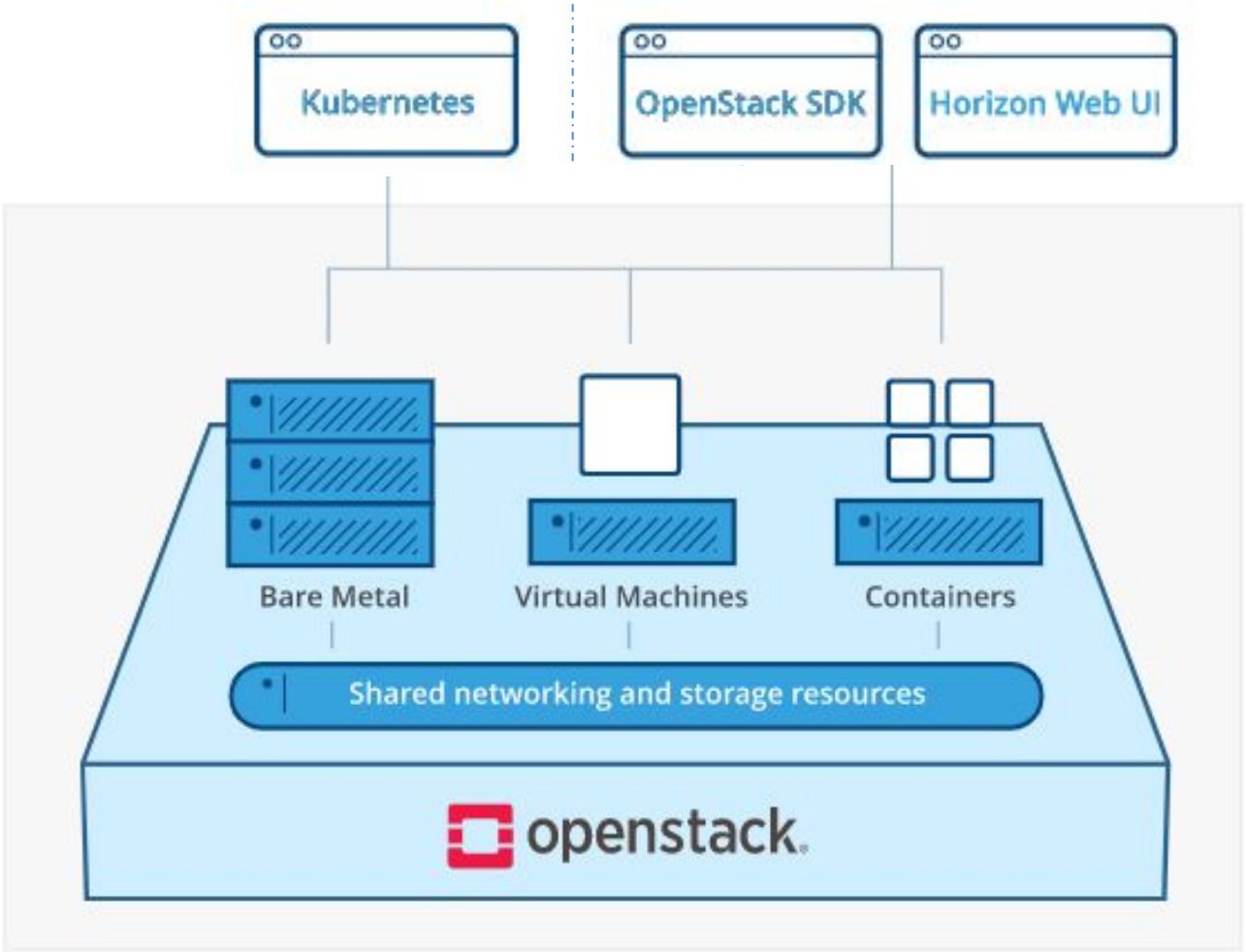
openstack™

The Red Hat OpenStack Platform (RHOSP)

- Cloud operating system
  - controls large pools of compute, storage, and networking resources throughout a datacenter
  - all managed and provisioned through APIs
    - virtual resources made available to users through a common API abstraction layer
- Beyond standard infrastructure-as-a-service functionality
  - additional components to provide
    - orchestration
    - fault management
    - service management

The Red Hat OpenStack Platform (RHOSP)

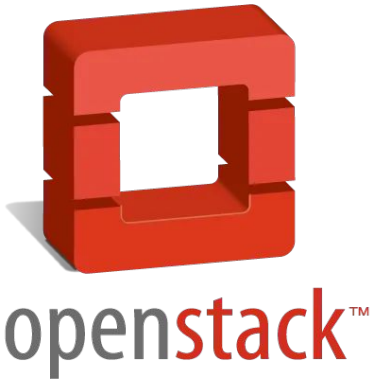
Deploy third-party services **OR** **Use provided built-in tools**



Open Source Cloud Computing Platform Software - OpenStack

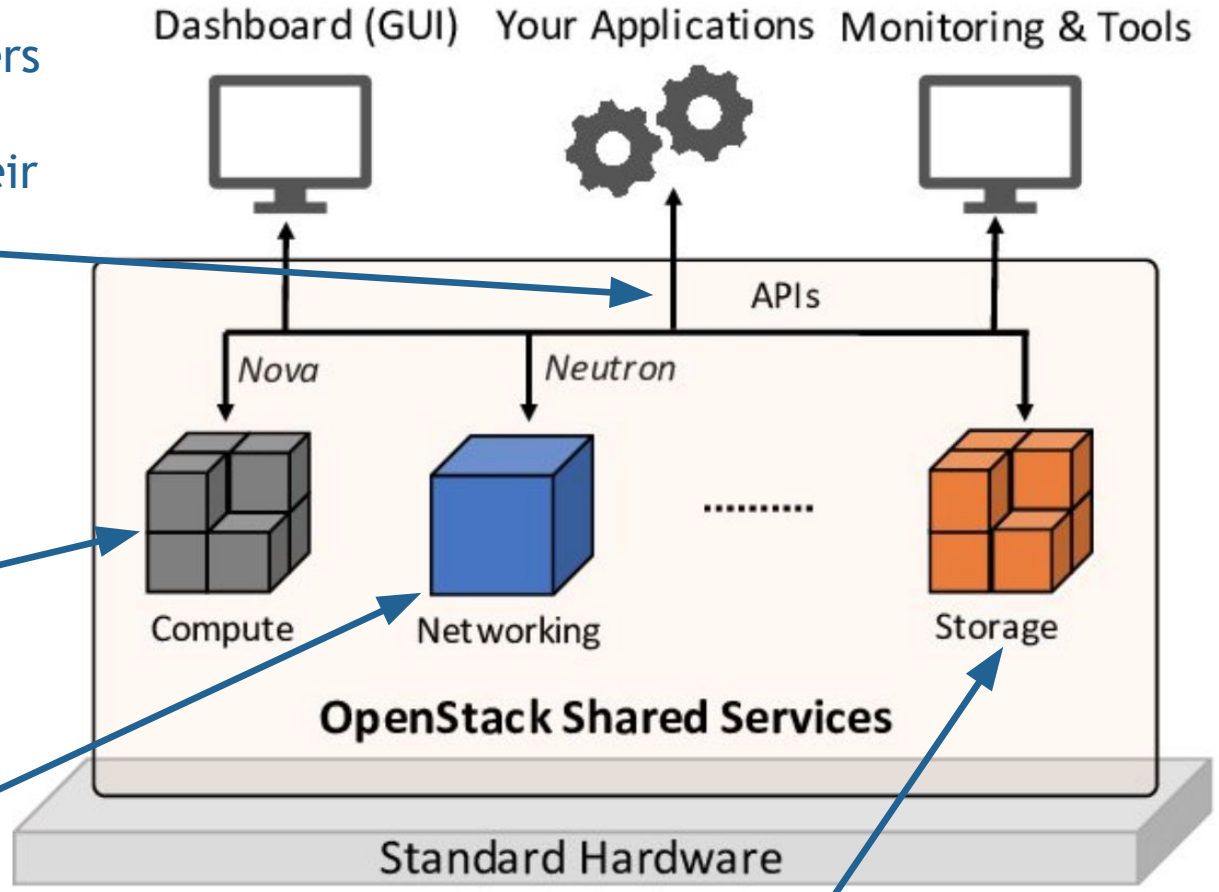
The Red Hat OpenStack Platform (RHOSP)

- Collection of *interacting services*
  - Control computing, storage, network resources, …
- Scale up or down the created cloud, based on the current requirements
- On-demand deploy of cloud workloads
- Security and performance
- Stability and agility



OpenStack Framework Overview (1/3)

Applications developers and owners can use the API to deploy the infrastructure on top of which their applications run on



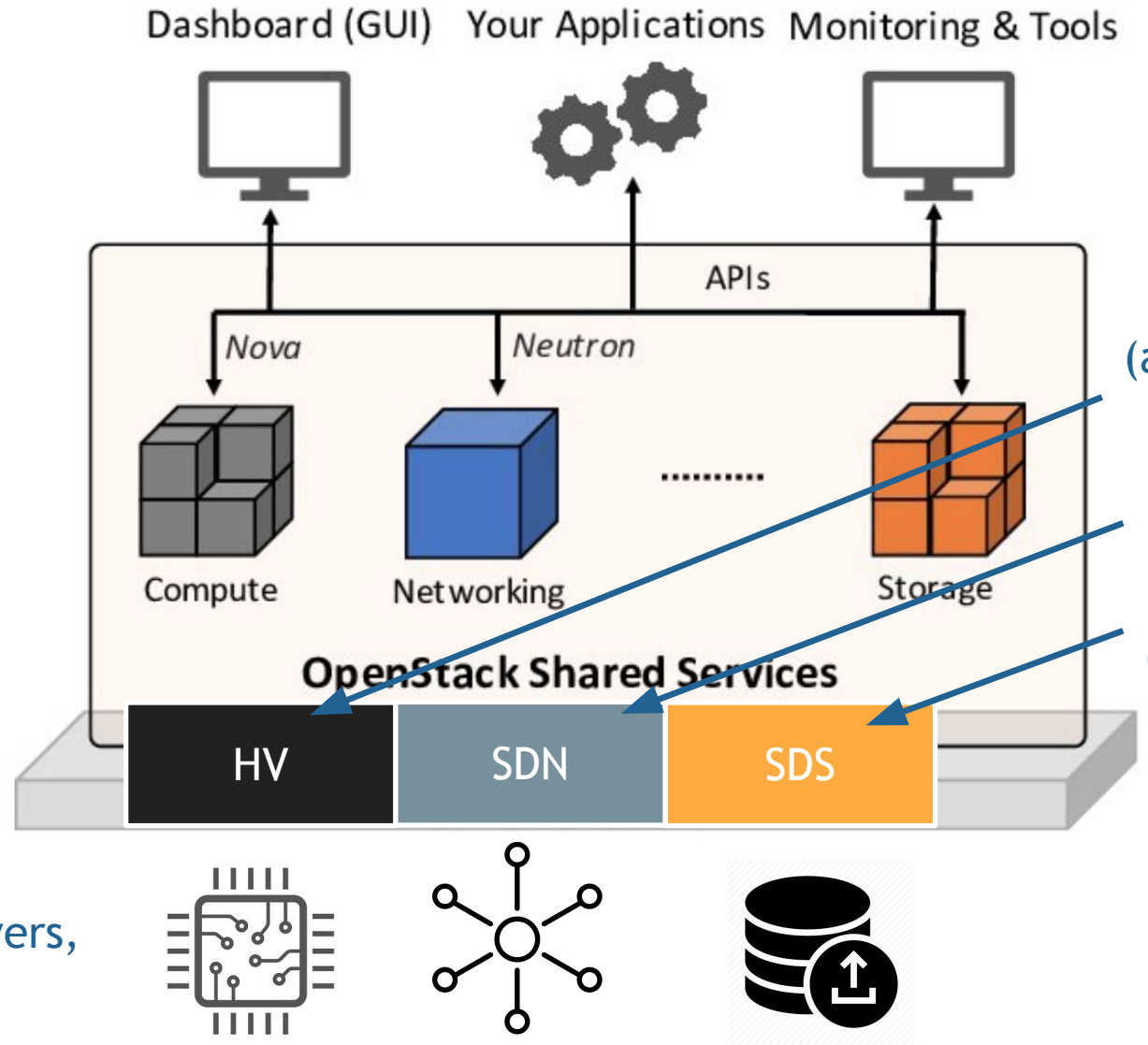
Nova Service
(manage computing resources)

Neutron Service
(manage networking and security aspects)

Cinder Service
(manage block storage)

Bibliography:
https://www.researchgate.net/publication/326359592_GSaaS_A_service_to_cloudify_and_schedule_GPUs

OpenStack Framework Overview (2/3)



Hypervisor
(abstract hardware resources)

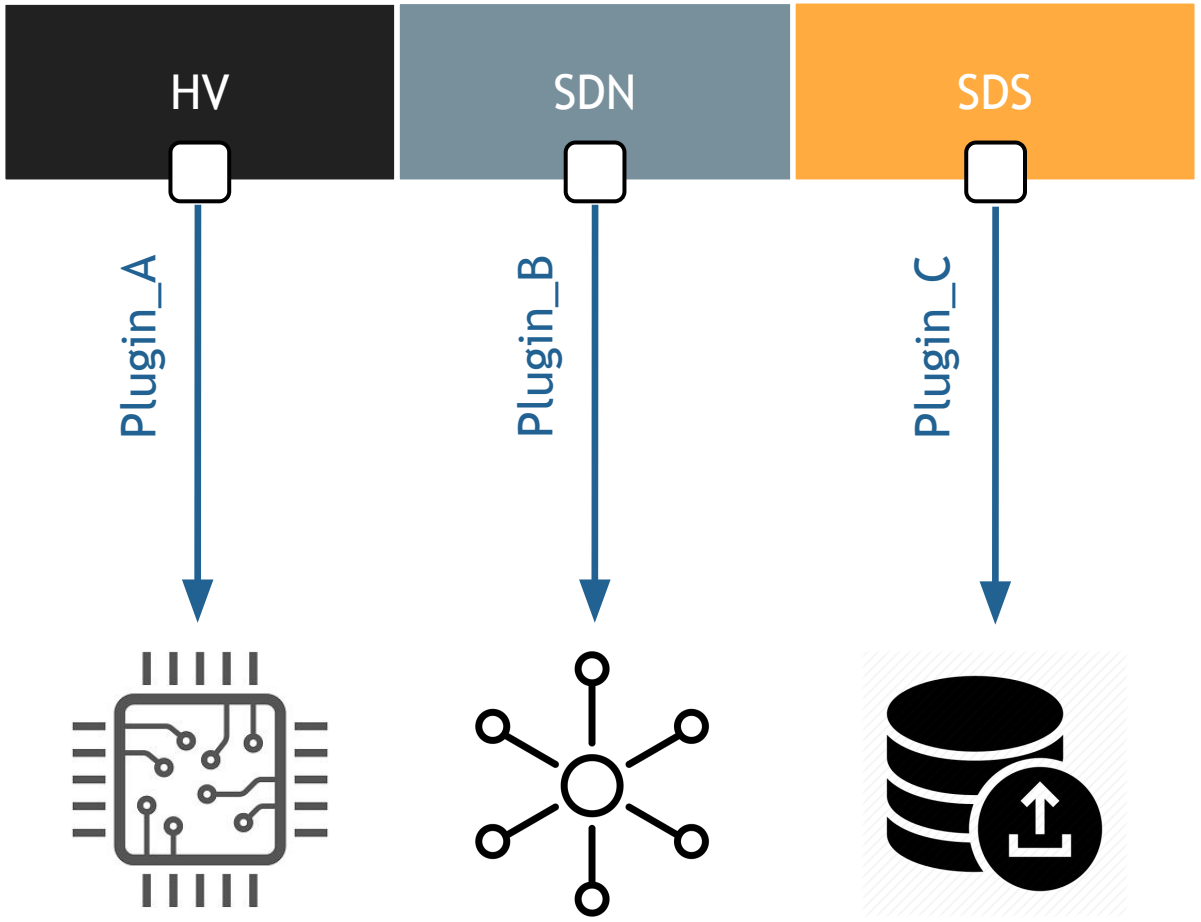
Software Defined Network
(abstract network resources)

Software Defined Storage
(abstract storage resources)

Infrastructure below the framework

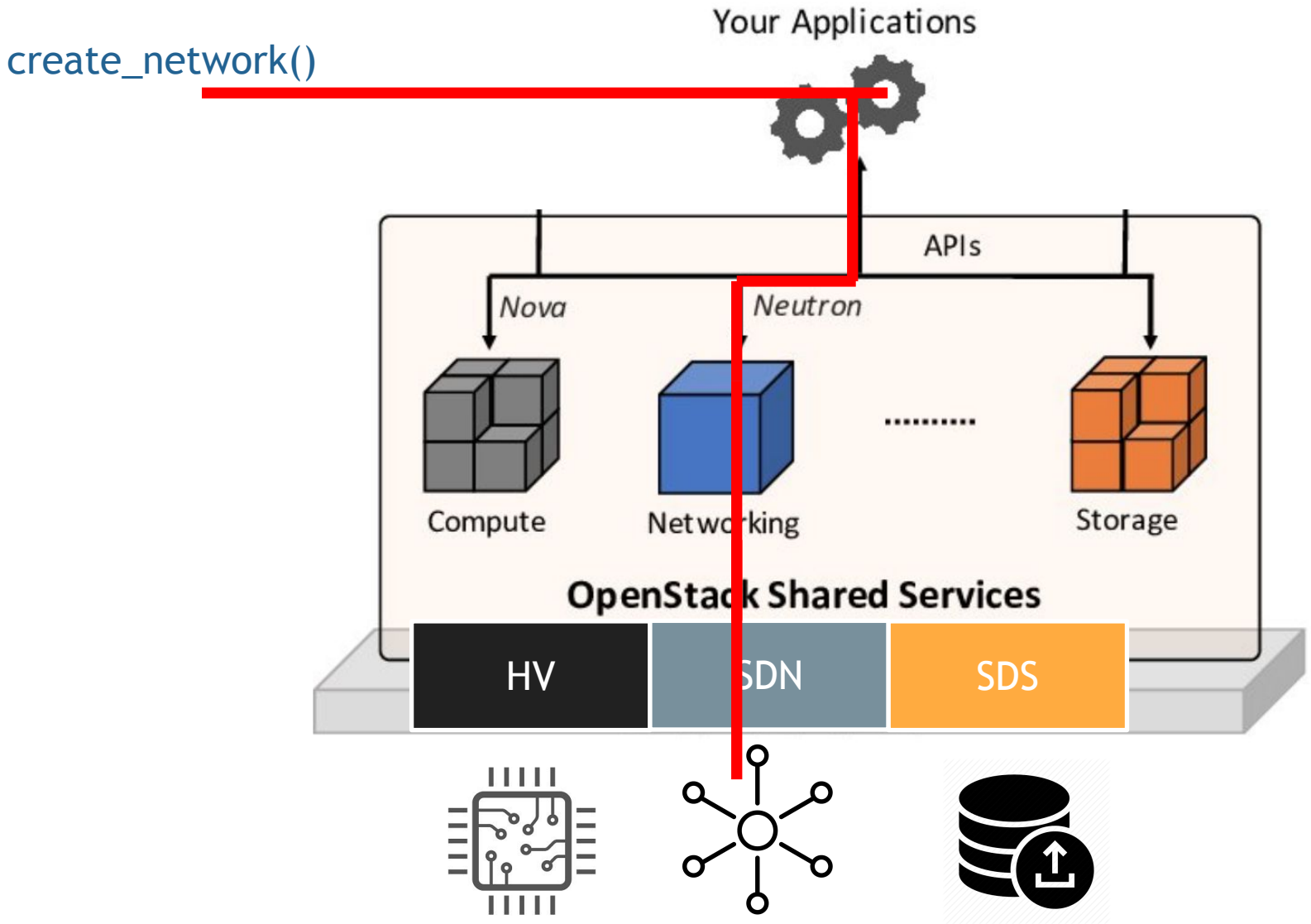
Physical layer (servers, network, storage)

OpenStack Framework Overview (3/3)

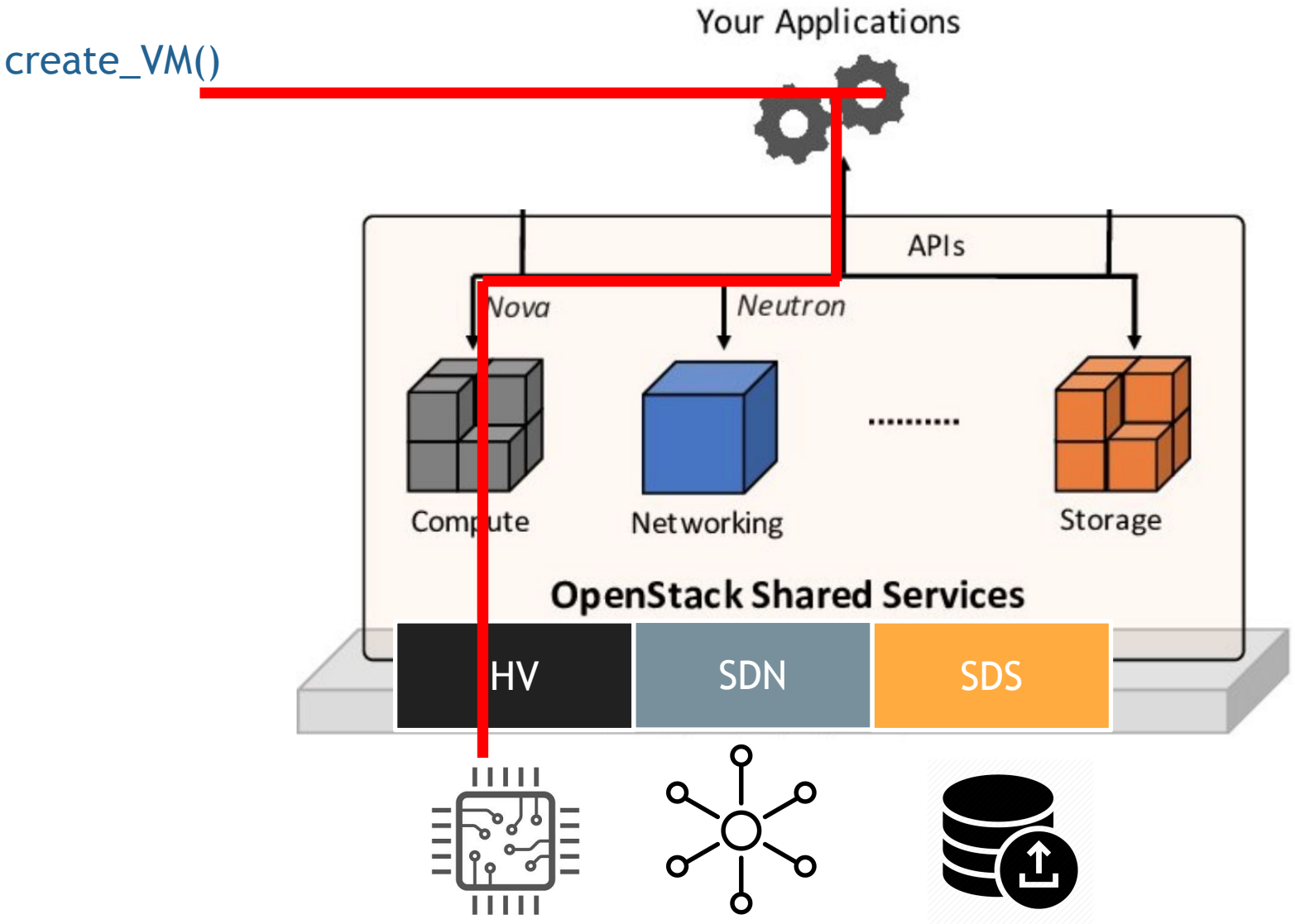


Plugin or driver interface with the physical resources

OpenStack Framework Overview: example



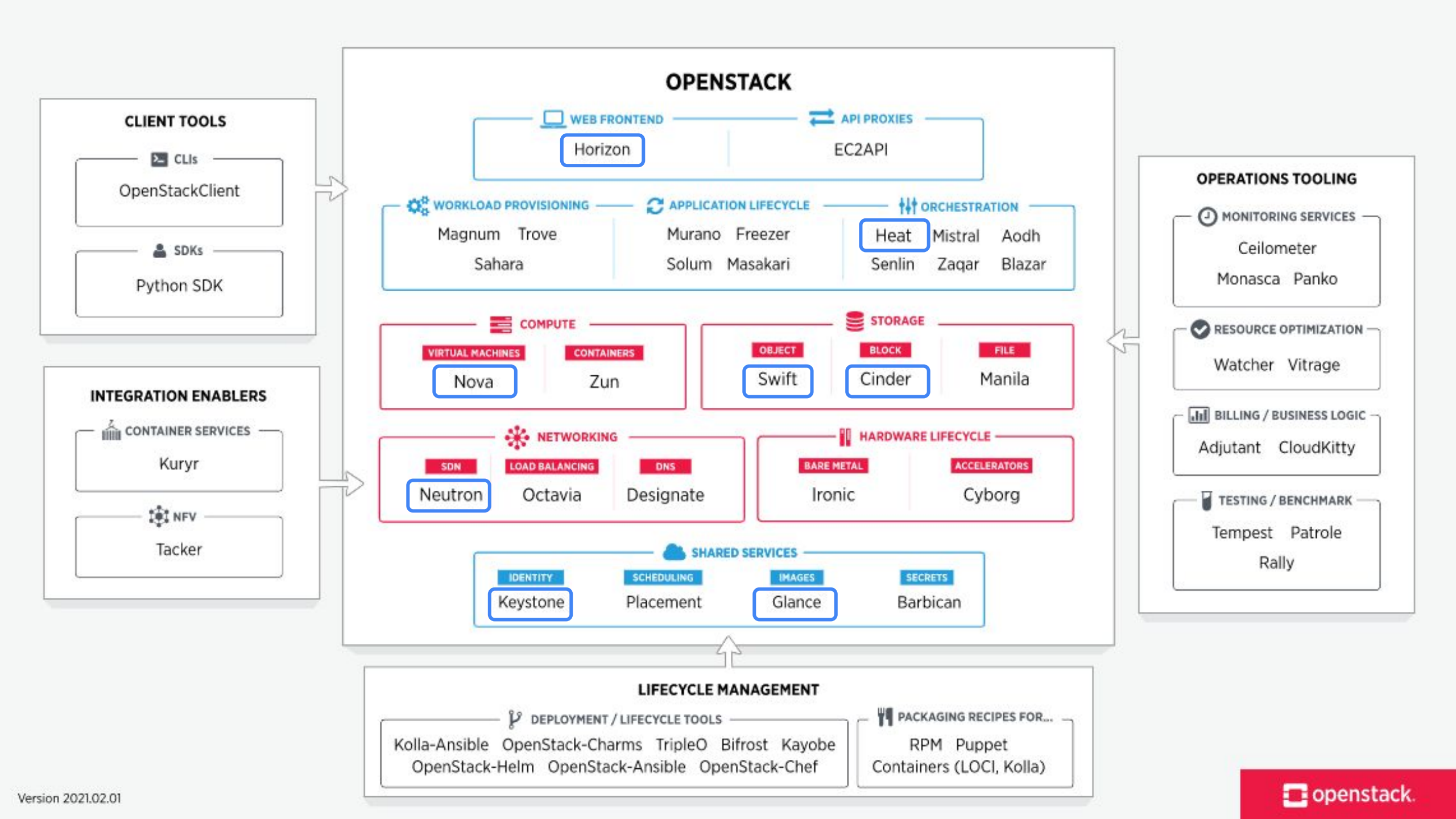
OpenStack Framework Overview: example



OpenStack Framework: core services

- A number of components (projects) provide APIs to access infrastructure resources
  - Different services can be deployed to provide various types of resources to cloud end users
  - Possibility to deploy third-party services too (e.g. Kubernetes)

- A full list of the OpenStack components can be found here: https://www.openstack.org/software/project-navigator/openstack-components#openstack-services


CLIENT TOOLS
CLIs
OpenStackClient
SDKs
Python SDK
INTEGRATION ENABLERS
CONTAINER SERVICES
Kuryr
NFV
Tacker
OPENSTACK
WEB FRONTEND
Horizon
API PROXIES
EC2API
WORKLOAD PROVISIONING
Magnum Trove
Sahara
APPLICATION LIFECYCLE
Murano Freezer
Solum Masakari
ORCHESTRATION
Heat Mistral Aodh
Senlin Zaqar Blazar
COMPUTE
VIRTUAL MACHINES
Nova
CONTAINERS
Zun
STORAGE
OBJECT
Swift
BLOCK
Cinder
FILE
Manila
NETWORKING
SDN
Neutron
LOAD BALANCING
Octavia
DNS
Designate
HARDWARE LIFECYCLE
BARE METAL
Ironic
ACCELERATORS
Cyborg
SHARED SERVICES
IDENTITY
Keystone
SCHEDULING
Placement
IMAGES
Glance
SECRETS
Barbican
OPERATIONS TOOLING
MONITORING SERVICES
Ceilometer
Monasca Panko
RESOURCE OPTIMIZATION
Watcher Vitrage
BILLING / BUSINESS LOGIC
Adjutant CloudKitty
TESTING / BENCHMARK
Tempest Patrole
Rally
LIFECYCLE MANAGEMENT
DEPLOYMENT / LIFECYCLE TOOLS
Kolla-Ansible OpenStack-Charms TripleO Bifrost Kayobe
OpenStack-Helm OpenStack-Ansible OpenStack-Chef
PACKAGING RECIPES FOR...
RPM Puppet
Containers (LOCI, Kolla)
Version 2021.02.01
openstack.

Shared Services

- Keystone
- Glance

Keystone: identity service

- Centralized service for authentication and authorization to all OpenStack services

Key aspects:

- Manages users, projects and roles
- Provides API client authentication, service discovery, and distributed multi-tenant authorization
- Supports multiple authentication mechanisms, including username and password credential and token-based systems

Full Documentation:
https://www.openstack.org/software/releases/ussuri/components/keystone

Glance: image service

- Stores resources such as VM images and volume snapshots
- Depends on Keystone

Key aspects:

- Acts as a registry service for virtual disk images
- Offers a RESTful API
- VM images can be stored in a variety of locations
  - Simple file systems
  - Object-storage systems (e.g. OpenStack Swift)

Full Documentation:
https://www.openstack.org/software/releases/ussuri/components/glance

Computing, Networking and Storage

- Nova
- Neutron
- Cinder
- Swift

Nova: compute service

- Manages and provisions VMs running on hypervisors nodes
- Depends on Neutron, Glance and Keystone

Key aspects:

- Provides virtual machines on demand and schedules them on a set of nodes
- Defines drivers to interact with the underlying virtualization mechanisms
- Exposes functionality to other OpenStack components

Full Documentation:
https://www.openstack.org/software/releases/ussuri/components/nova

Neutron: networking service

- Provides connectivity between the interfaces of OpenStack services
- Depends on Keystone

Key aspects:

- Handles creation and management of a virtual networking infrastructure in the OpenStack cloud
  - Infrastructure elements: networks, subnets, routers, …
- Advanced services can be deployed
  - Firewalls, Virtual Private Networks (VPNs)

Full Documentation:
https://www.openstack.org/software/releases/ussuri/components/neutron

Cinder: block storage service

- Manages persistent block storage volumes for VMs
- Depends on Keystone

Key aspects:

- Virtualizes the management of block storage devices
- End users can access the API to request/consume resources without knowing where the storage is actually deployed or on what kind of device

Full Documentation:
https://www.openstack.org/software/releases/ussuri/components/cinder

Swift: object storage service

- Stores and retrieves files and arbitrary data

Key aspects:

- Implements a distributed, scalable and consistent object/blob storage
  - Ideal for storing very large amount of data, including static entities such as videos, images, emails, files, VM images
- On the underlying file system, objects are stored as binaries along with metadata (file's attributes)

Full Documentation:
https://www.openstack.org/software/releases/ussuri/components/swift

Orchestration

- Heat

Heat: orchestration service

- Orchestrator engine based on templates
- Depends on Keystone

Key aspects:

- Keeps blueprints/templates of the infrastructure topology
- Orchestrates infrastructure resources for a cloud application
- Supports automatic creation of resource stacks (collections of resources)
- Offers a RESTful API

Full Documentation:
https://www.openstack.org/software/releases/ussuri/components/heat

Dashboard

- Horizon

Horizon: dashboard service

- Web browser-based platform to manage OpenStack services
- Depends on Keystone

Key aspects:

- Graphical User Interface accessible for users and administrators
  - Create and launch instances, manage networking, and set access control
- Default dashboards: Project, Admin, Settings
- Modular design
  - Can be extended with other products (e.g. monitoring, other management tools)

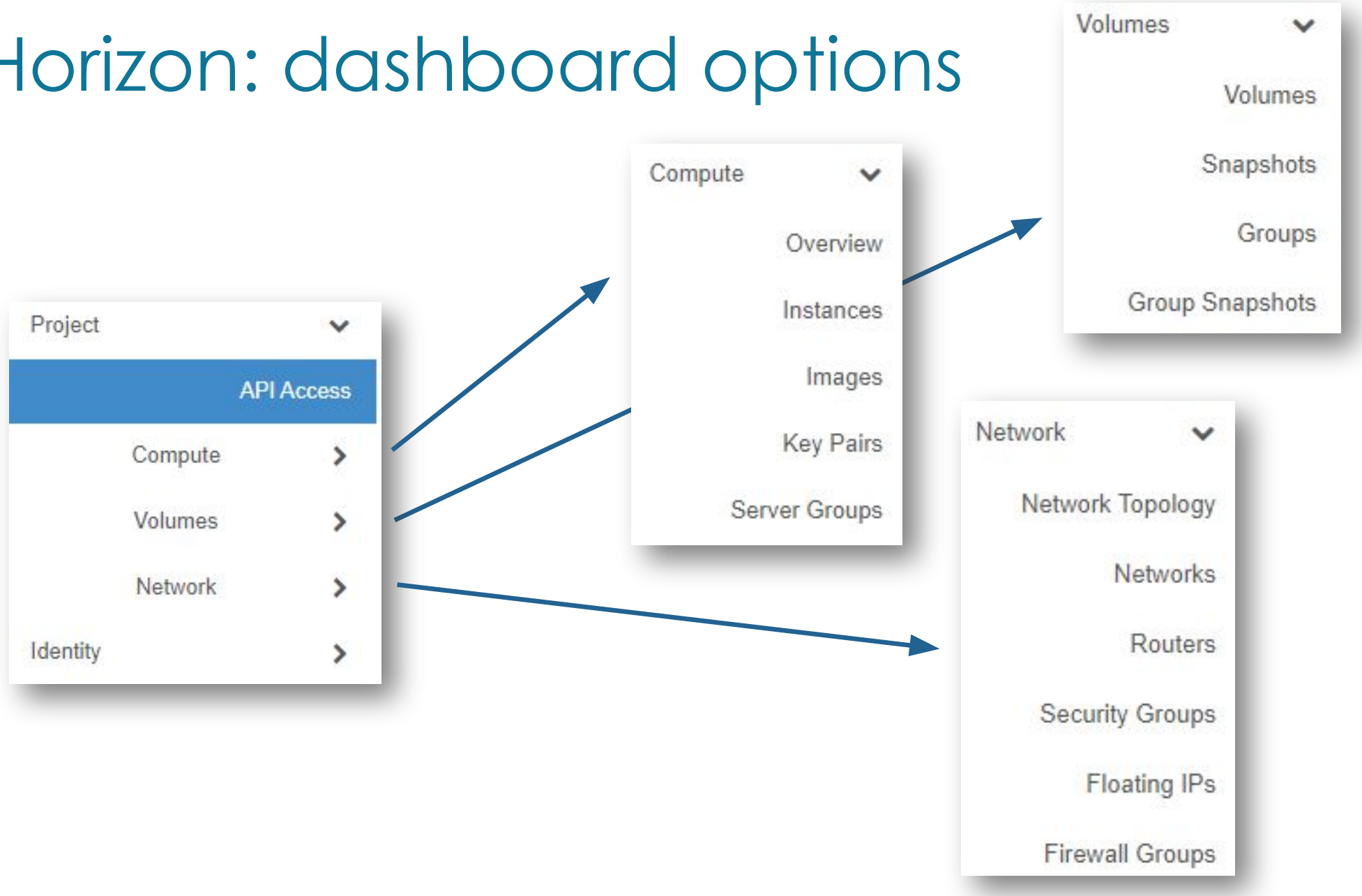
Full Documentation:
https://www.openstack.org/software/releases/ussuri/components/horizon

Example: real-world use case

The Cloud Computing Platform of the DII CrossLab

If you want to know more about the CrossLab projects of the DII, Università di Pisa:
https://crosslab.dii.unipi.it/

Horizon: dashboard options



Project / Compute / Overview

Overview

Limit Summary

Compute

Instances

Used 1 of 10

VCPUs

Used 8 of 20

RAM

Used 15.8GB of 50GB

Volume

Volumes

Used 1 of 10

Volume Snapshots

Used 0 of 10

Volume Storage

Used 10GB of 1000GB

Network

Floating IPs

Allocated 0 of 0

Security Groups

Used 1 of 10

Security Group Rules

Used 4 of 100

Networks

Used 0 of 10

Ports

Used 1 of 50

Routers

Used 0 of 0

Usage Summary

Select a period of time to query its usage:

The date should be in YYYY-MM-DD format.

2020-05-19 to 2020-05-20 Submit

Images

Click here for filters or full text search. + Create Image Delete Images

Displaying 14 items

Name	Type	Status	Visibility	Protected	Disk Format	Size	
Centos 7 centos/centos	Snapshot	Active	Public	No	QCOW2	911.06 MB	Launch
CentOS 7 KEY AUTH	Image	Active	Public	No	QCOW2	898.75 MB	Launch
Cirros cirros/gocubsgo	Image	Active	Public	No	QCOW2	12.13 MB	Launch
Contiki OS	Snapshot	Active	Public	No	QCOW2	5.80 GB	Launch
Debian 10 debian/debian	Snapshot	Active	Public	No	QCOW2	1.36 GB	Launch
Debian 10 KEY AUTH	Image	Active	Public	No	QCOW2	540.19 MB	Launch
IPfire	Image	Active	Public	No	QCOW2	1.65 GB	Launch
OpenWRT	Image	Active	Public	No	QCOW2	52.50 MB	Launch
Ubuntu 16.04 Server 32-bit KEY AUTH	Image	Active	Public	No	QCOW2	281.50 MB	Launch
Ubuntu Server 18.04 GPU ubuntu/ubuntu	Snapshot	Active	Public	No	QCOW2	10.93 GB	Launch
Ubuntu Server 18.04 KEY AUTH	Image	Active	Public	No	QCOW2	328.56 MB	Launch
Ubuntu Server 18.04 ubuntu/ubuntu	Snapshot	Active	Public	No	QCOW2	1.04 GB	Launch

Project / Network / Network Topology

Network Topology

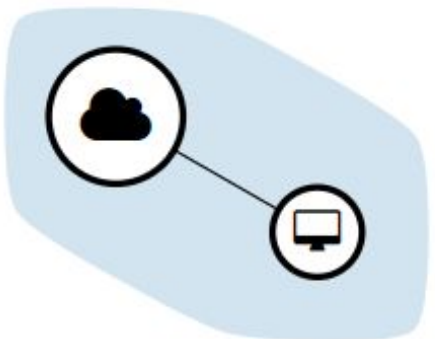
Topology | Graph

Resize the canvas by scrolling up/down with your mouse/trackpad on the topology. Pan around the canvas by clicking and dragging the space behind the topology.

Toggle Labels | Toggle Network Collapse | Center Topology

External network

Internal network



My Virtual Machine

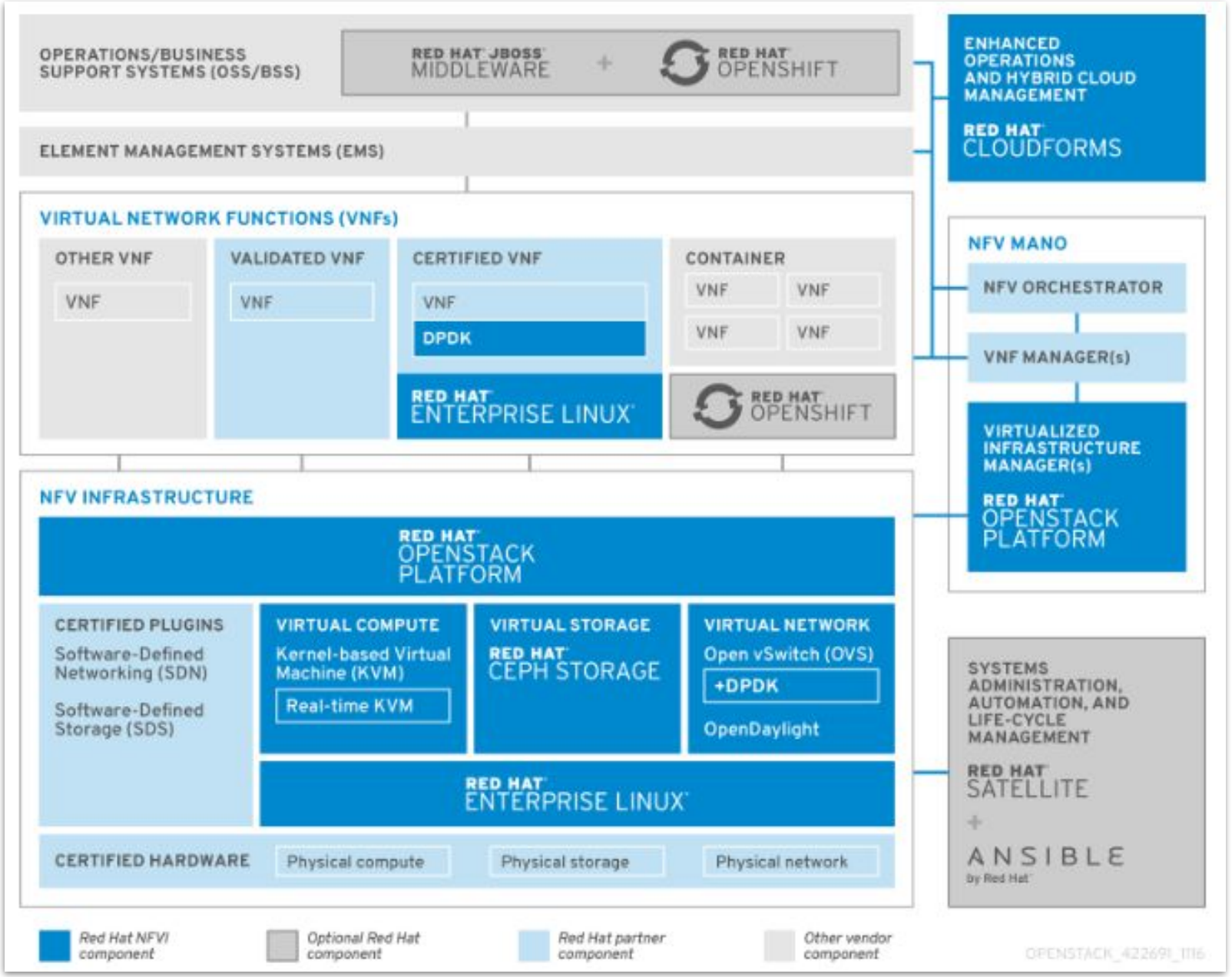
OpenStack and NFV

ETSI NFV architecture

- European Telecommunications Standards Institute (ETSI)
  - ICT standardization group in Europe
- Sets the requirements, reference architecture and infrastructure specifications necessary to ensure support to virtualized functions

- Red Hat adds NFV features to OpenStack and offers integration with other products to implement full NFV support
  - Single root I/O virtualization and sharing (SR-IOV)
    - virtualize a single PCIe Ethernet controller to appear as multiple PCIe devices
  - Open vSwitch (also accelerated with Data Plane Development Kit (OVS-DPDK))
    - open source software switch (used as a virtual switch in a virtualized server)

NFV ETSI Architecture and Components



General components of NFV platform (recap)

- **Virtualized Network Functions (VNFs)**
  - Software implementation of network functions (e.g. routers, firewalls, mobile packet processors, load balancers)

- **NFV infrastructure (NFVi)**
  - Comprehends physical resources (compute, network, storage) and the virtualization layer that make up the infrastructure
  - Foundation for the NFV layer
  - Managed by the **Virtual Infrastructure Manager (VIM)**

General components of NFV platform (recap)

- **NFV Management and Orchestration (MANO)**
  - Provides service management and orchestration required throughout the network function life-cycle
  - Service definition, monitoring and life-cycle management are decoupled from the physical infrastructure
  - Two interacting entities: **Virtual Network Function Manager (VNFM)** and **Orchestrator (NFVO)**
    - NFVO interacts with databases and business function applications (e.g. billing, support) and can create new services for a customer
    - VNFM triggers the instantiation of a new virtualized function (this may result in multiple virtual machine instances) when NFVO asks for a new service

RedHat NFV components

Range of products that can act as the different components of the NFV framework in the ETSI model

- **OpenStack Platform**
  - Supports IT and NFV workloads
- **Enterprise Linux**
  - Creates VMs and containers as VNFs
- **Ceph Storage**
  - Unified elastic and high-performance storage layer for the service provider workloads

RedHat NFV components

Range of products that can act as the different components of the NFV framework in the ETSI model

- **JBoss Middleware** and **OpenShift Enterprise**
  - Improve the operation and business support systems
- **CloudForms**
  - Provides a VNF manager and presents data from multiple sources, such as the VIM and NFVi in a unified view
- **Satellite** and **Ansible**
  - Provide enhanced systems administration, automation and life-cycle management

Useful references

Useful references

- Understanding OpenStack
  - https://www.redhat.com/en/topics/openstack
- Red Hat OpenStack Platform 16.0 Product Guide
  - https://access.redhat.com/documentation/en-us/red_hat_openstack_platform/16.0/html/product_guide/index
- OpenStack components in detail
  - https://access.redhat.com/documentation/en-us/red_hat_openstack_platform/16.0/html/product_guide/ch-rhosp-software#sect-components
- A word about OpenStack and the general OpenStack projects architecture
  - https://www.mirantis.com/blog/confusing-openstack-with-infrastructure/

Useful references

- Horizon: The OpenStack Dashboard Project
  - https://docs.openstack.org/horizon/latest/index.html
- Horizon Administration Guide
  - https://docs.openstack.org/horizon/latest/admin/index.html
- OpenStack Virtual Machine Image Guide
  - https://docs.openstack.org/image-guide/index.html

Advanced topic:

- Create images manually (Ubuntu example)
  - https://docs.openstack.org/image-guide/create-images-manually.html
  - https://docs.openstack.org/image-guide/ubuntu-image.html

Useful references

- Advantages of NFV
  - https://access.redhat.com/documentation/en-us/red_hat_openstack_platform/16.0/html/network_functions_virtualization_product_guide/ch-understanding_red_hat_nfv
- OpenStack and NFV: ETSI NFV architecture and components
  - https://access.redhat.com/documentation/en-us/red_hat_openstack_platform/16.0/html/network_functions_virtualization_product_guide/ch-nfv_software
- NFV data plane connectivity and fast data path options
  - https://access.redhat.com/documentation/en-us/red_hat_openstack_platform/16.0/html/network_functions_virtualization_product_guide/ch-datapath_supportability_matrix
- Single root I/O virtualization and sharing (SR-IOV)
  - https://docs.openstack.org/neutron/wallaby/admin/config-sriov.html