DEPARTMENT OF INFORMATION ENGINEERING
UNIVERSITY OF PISA

Virtualization (LAB)

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Where are we?

- Virtualization
- Containerization and Docker
- **OpenStack**

Outline of the lecture

1) Cloud computing and its service models

2) The OpenStack Cloud Computing Platform
   - Overview of the framework
   - Core services
   - The CrossLab real-world use case

3) Software Defined Networks and Network Function Virtualization

4) OpenStack and NFV

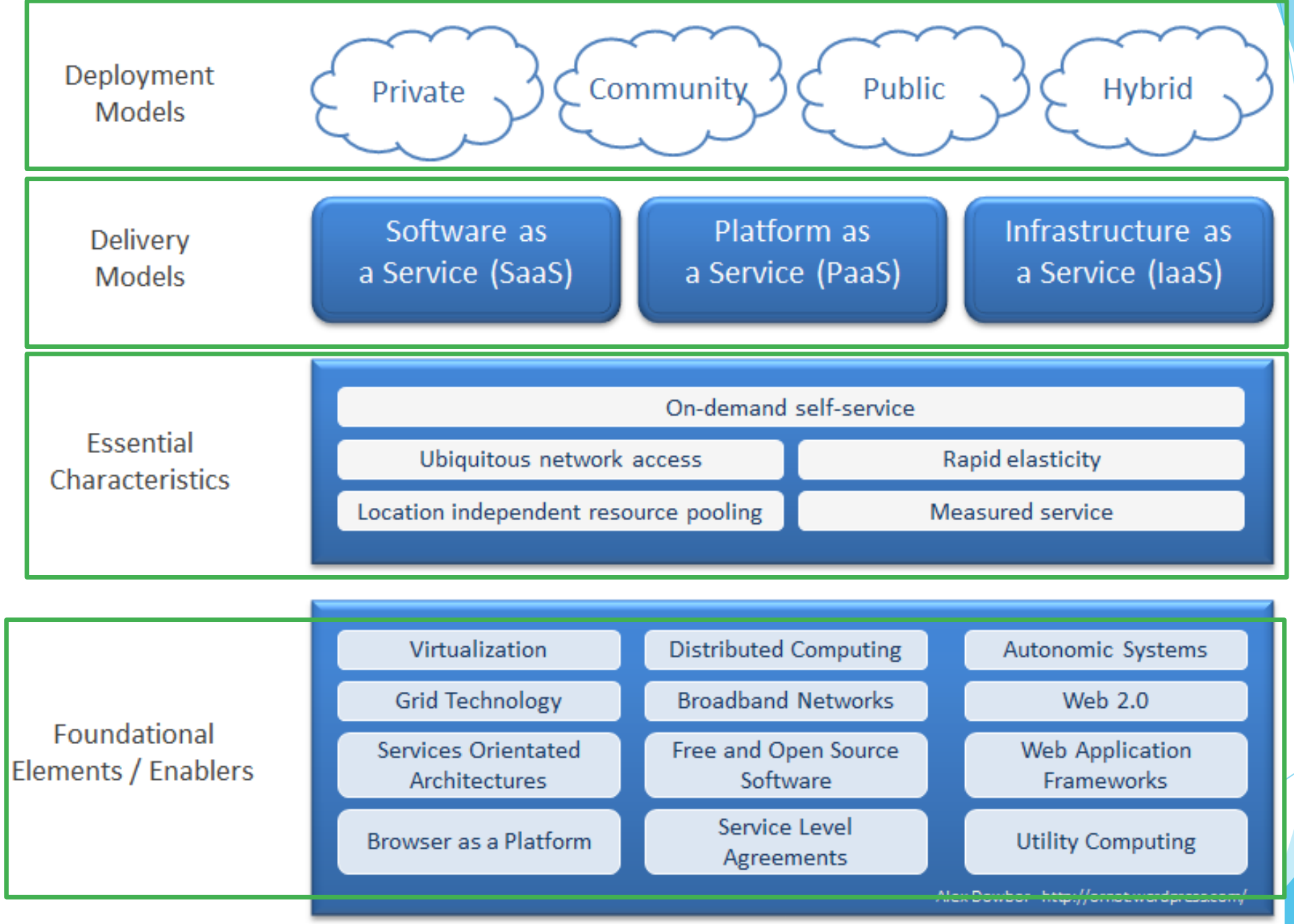
Cloud Computing

Cloud Computing

From the Official NIST definition:

- Model for enabling convenient, on-demand network access to a shared pool of configurable computing resources
- Computing resources
  - Networks
  - Servers
  - Storage
  - Applications
  - Services
- Resources can be rapidly provisioned and released with minimal management effort or service provider interaction

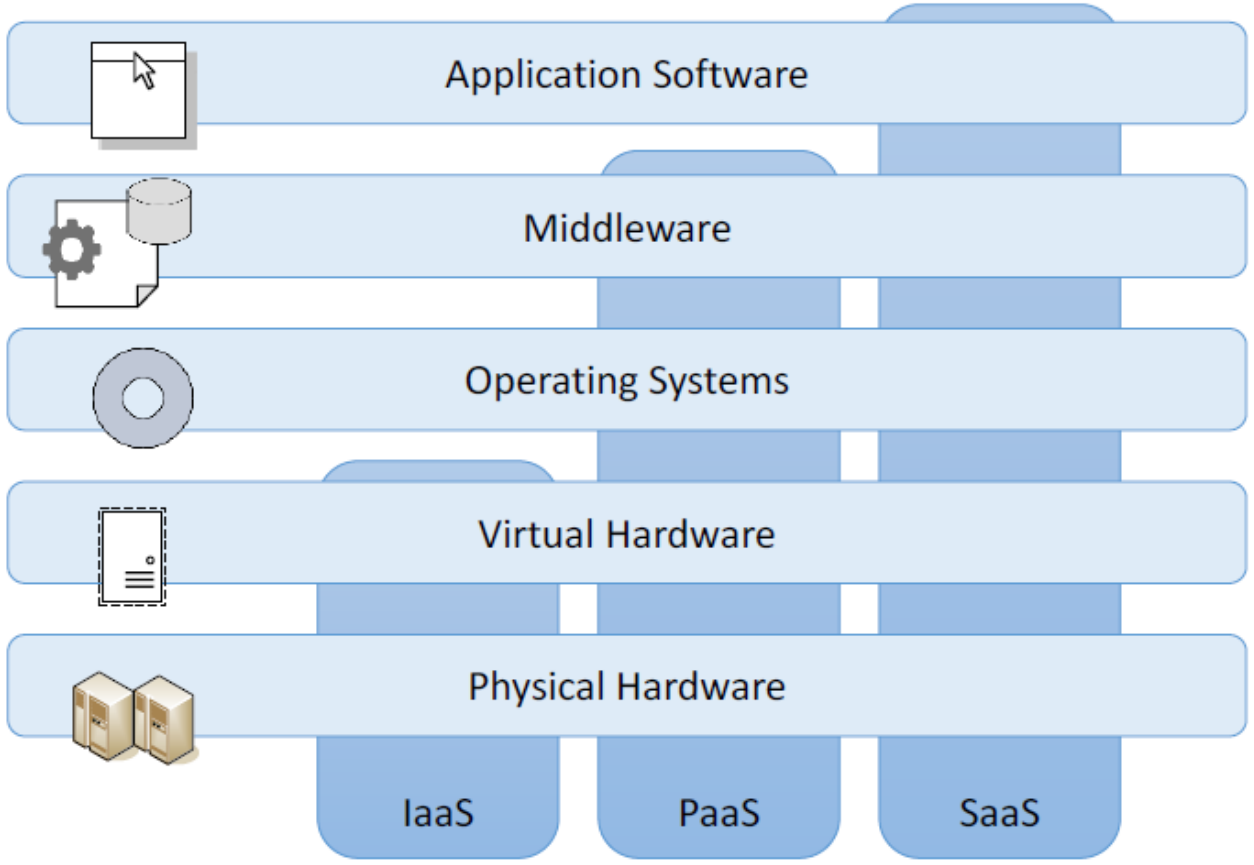
Bibliography:
https://csrc.nist.gov/publications/detail/sp/800-145/final



Bibliography:
https://csrc.nist.gov/projects/cloud-computing

Cloud Computing Service Models

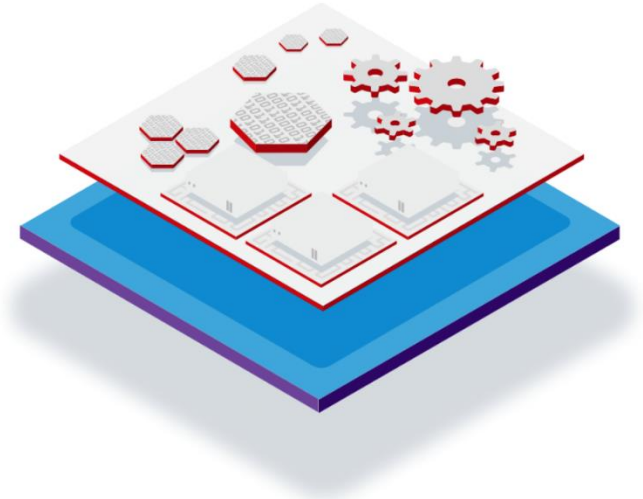
- Infrastructure as a Service (IaaS)
  - Virtual or physical hw accessible to customers (computing, storage and networking resources)
- Platform as a Service (PaaS)
  - An execution environment is offered to customers to deploy their apps
- Software as a Service (SaaS)
  - Applications directly available to users (e.g. email, web browing) through Graphical User Interface (GUI) or Application Program Interfaces (APIs)



The OpenStack Cloud Computing Platform

The Red Hat OpenStack Platform (RHOSP)

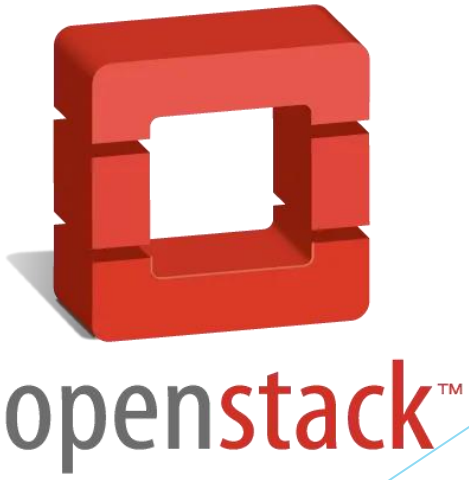
- Open source standard *cloud computing platform*
- Infrastructure-as-a-Service (IaaS)
- Build and manage *private*, *public* or *hybrid cloud platforms* from the available physical hardware
  - Virtual resources are made available to users through a common API abstraction layer



openstack™

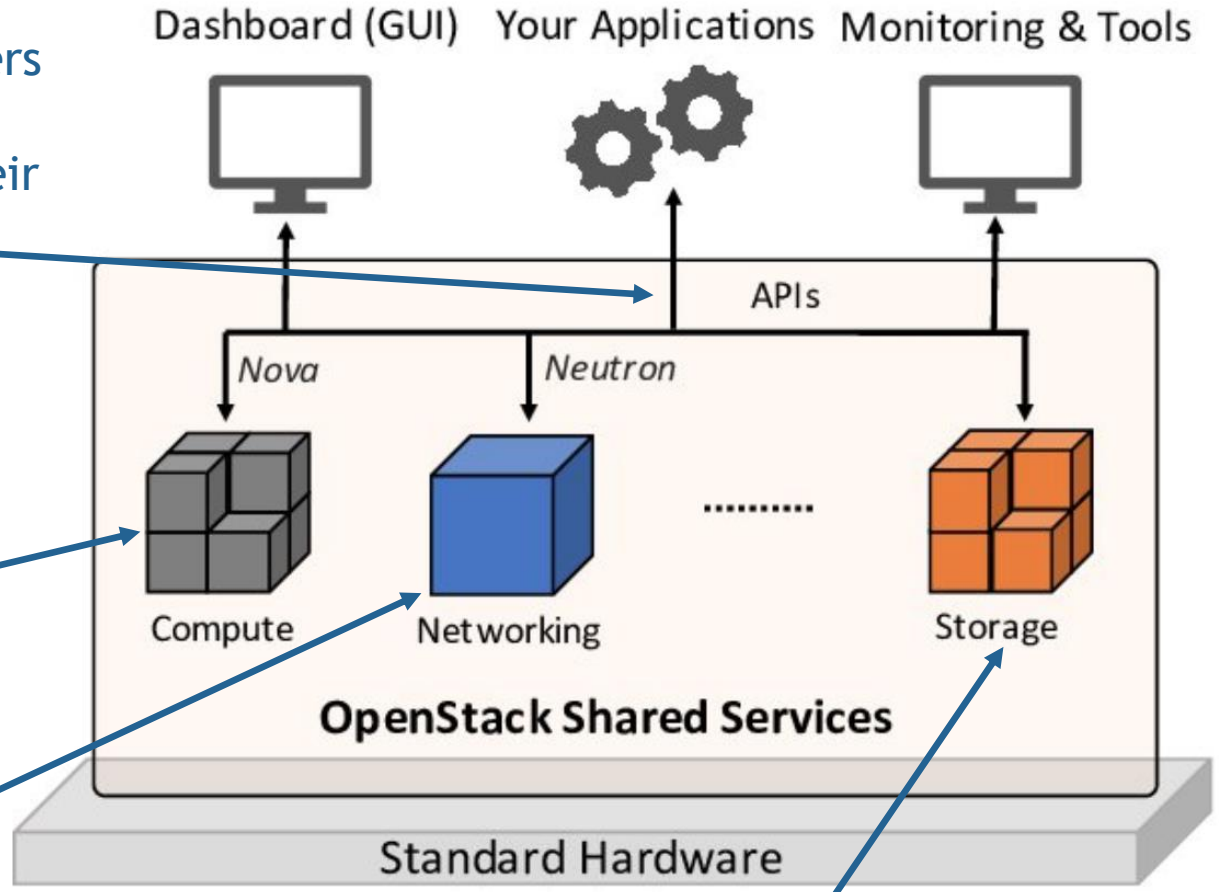
The Red Hat OpenStack Platform (RHOSP)

- 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



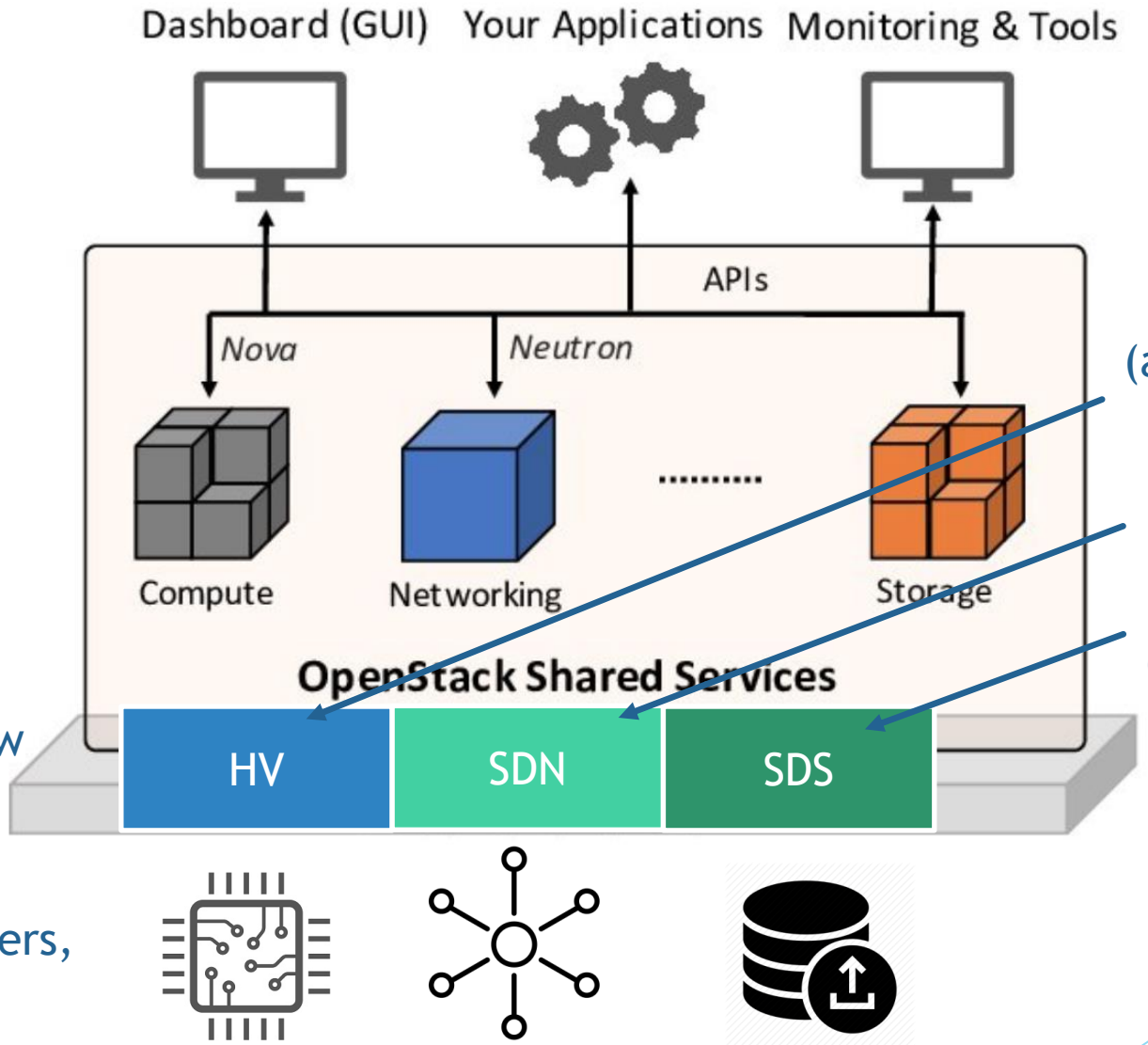
Nova Service
(manage computing resources)

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)

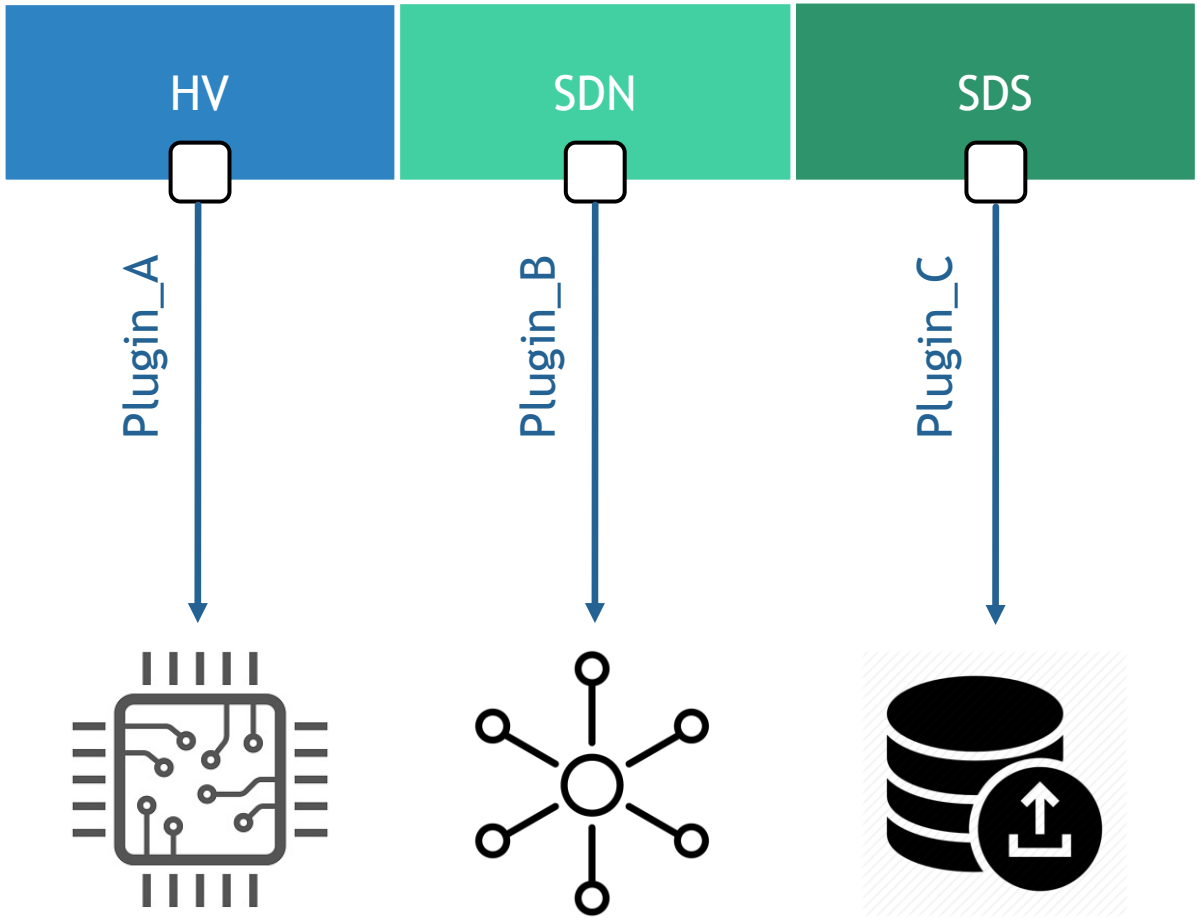
Software Defined Storage
(abstract storage resources)

Infrastructure below the framework

Physical layer (servers, network, storage)

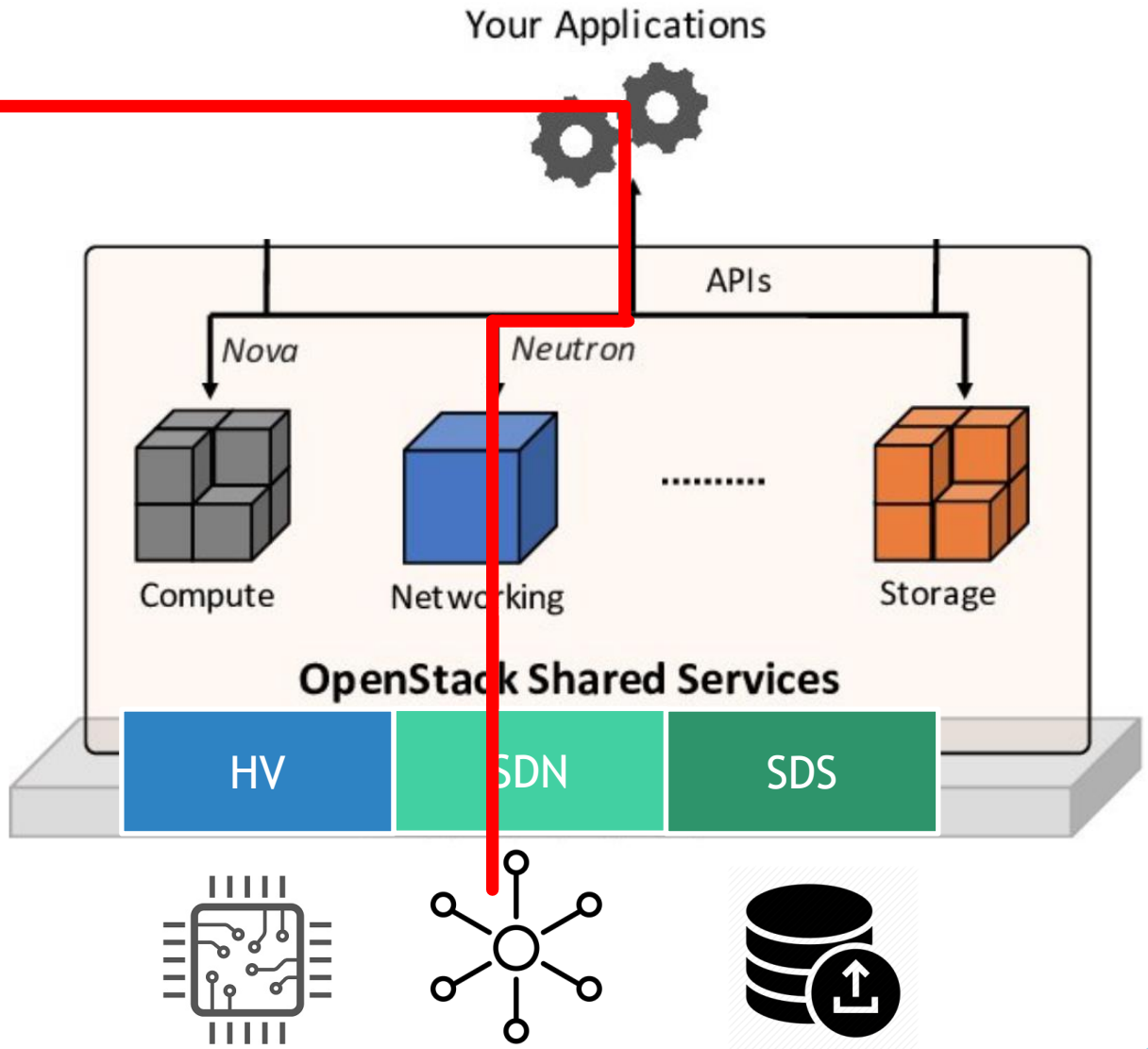
OpenStack Framework Overview (3/3)

Plugin or drivers interface with the physical resources



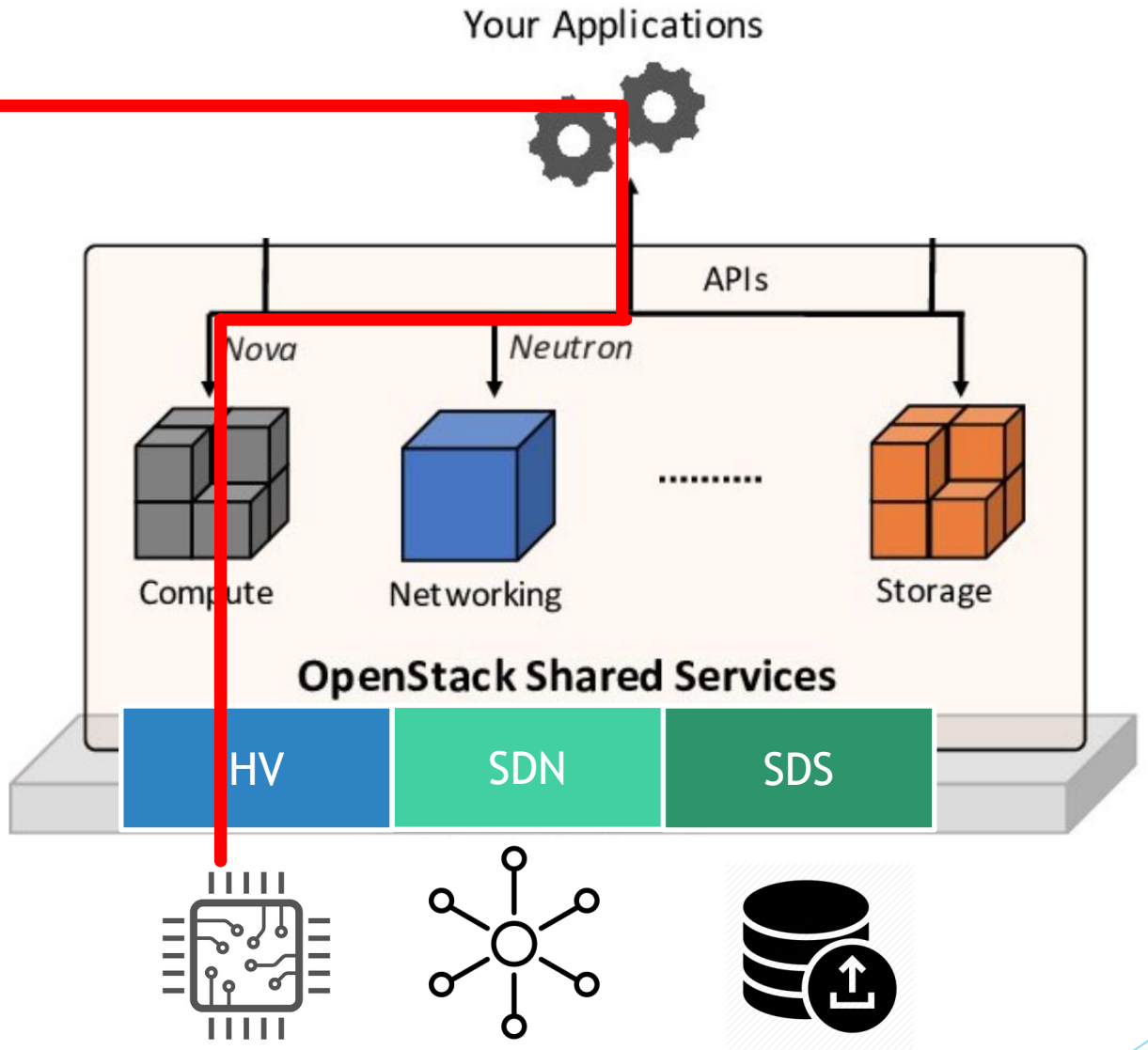
OpenStack Framework Overview: example

create_network()



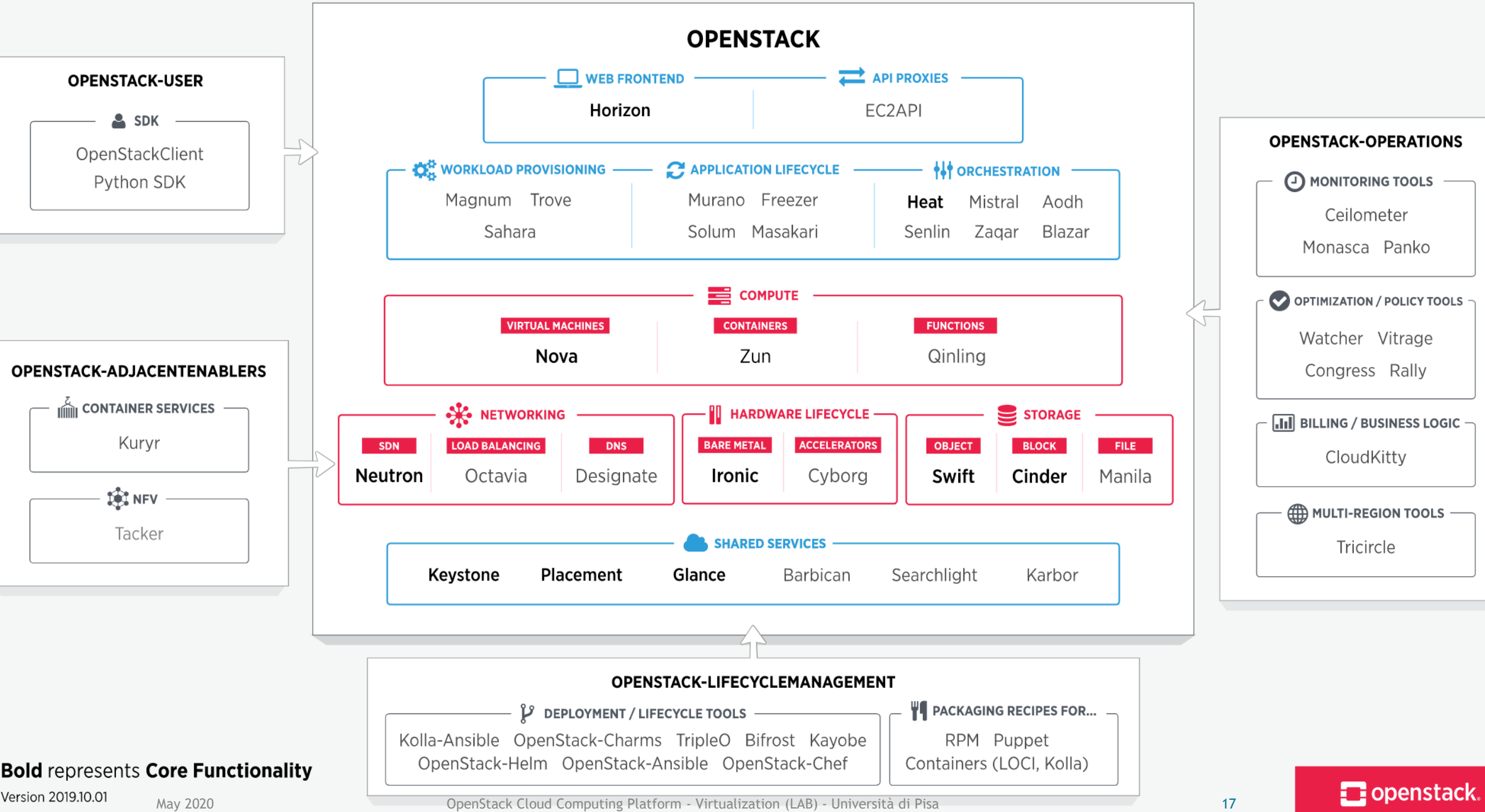
OpenStack Framework Overview: example

create_VM()



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



Bold represents **Core Functionality**

Version 2019.10.01

May 2020

Shared Services

- Keystone
- Glance

Keystone: identity service

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

- 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

Glance: image service

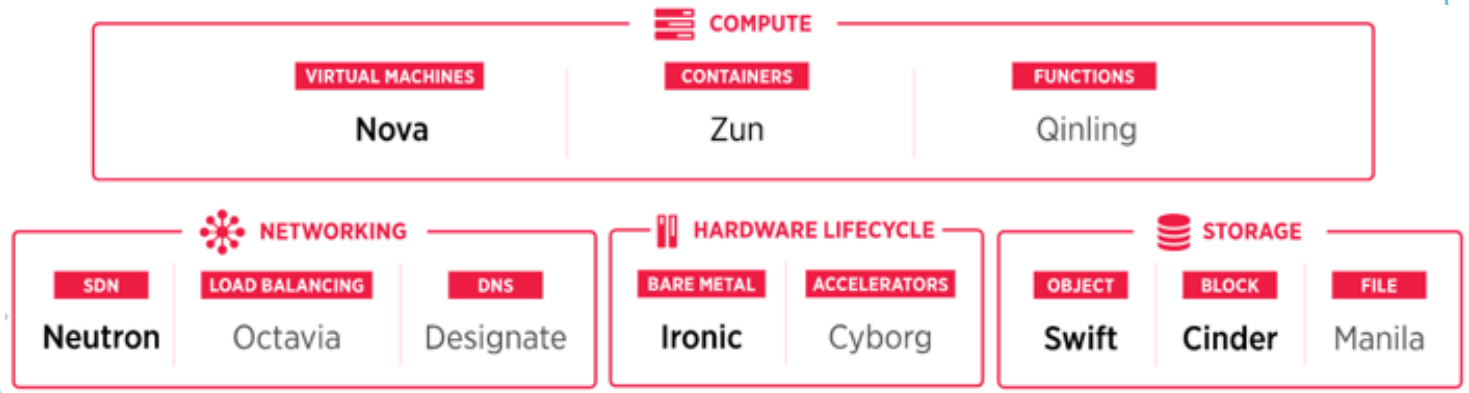
Full Documentation:
https://www.openstack.org/software/releases/ussuri/components/glance

- 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)

Computing, Networking and Storage



- Nova
- Neutron
- Cinder
- Swift

Nova: compute service

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

- 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

Neutron: networking service

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

- 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)

Cinder: block storage service

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

- 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

Swift: object storage service

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

- 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)

Orchestration

- Heat

Heat: orchestration service

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

- 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

Dashboard

- Horizon

Horizon: dashboard service

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

- Web browser-based platform to manage Open-Stack services
- Depends on Keystone

Key aspects:

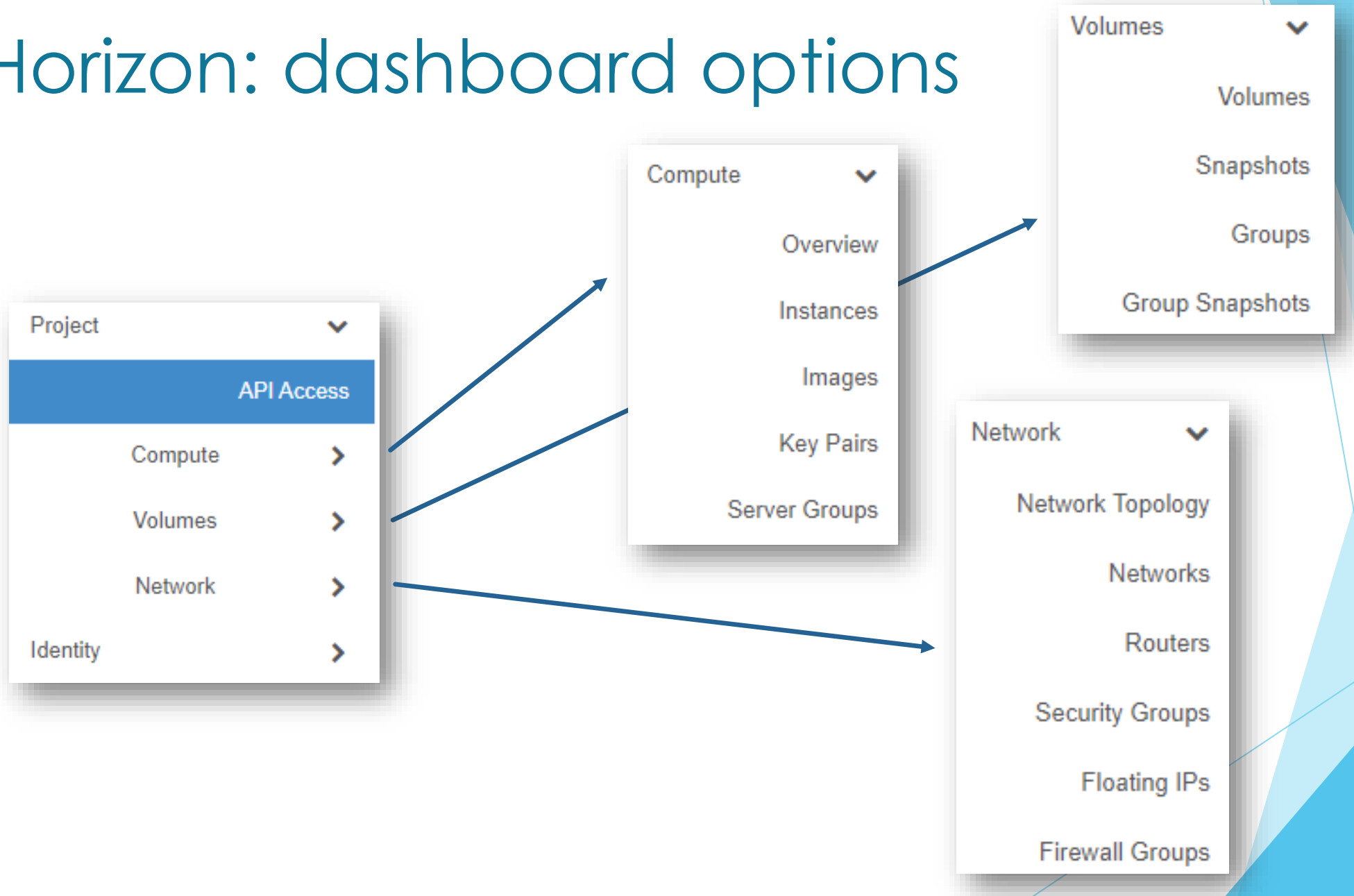
- Graphycal User Interface accessible for users and administrators
  - Create and launch instances, manage networking, and set access control
- Default dashboards: Project, Admin, Settings
- Modular design
  - Can be extended with other products (e.g. monitoring, additional management tools)

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



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

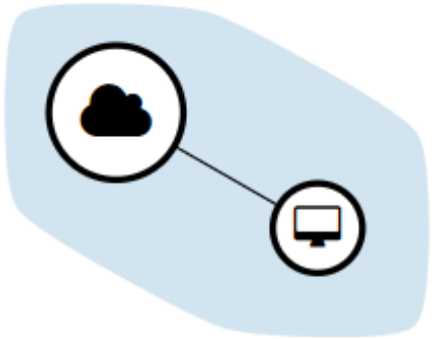
Topology | Graph

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

Software Defined Networks and Network Function Virtualization

SDN

Replace distributed static network protocols with centralized, flexible, software network applications

- Centralized control plane
- Network flexibility and programmability
- New functionalities can be deployed, relocated and upgraded depending on the needs in nearly no time

NFV

Use generic hardware to run software solutions instead of using specialized non-programmable network devices

- Hardware becomes cheaper (COTS)
- Network functionalities can be easily relocated, optimizing network performance such as latency and capacity

SDN and NFV are often use in conjunction!

NFV: benefits and promises

- Equipment costs (CAPEX) and operational costs (OPEX) are reduced
  - Reduced energy consumption and space, improved network monitoring
- Time to market speed is increased
  - Software-oriented innovation to rapid prototype and test
  - Development of new services is encouraged
  - New revenue streams are generated
- Multi-version and multi-tenant network appliances
  - Single platform can support different applications, users and tenants
- Flexibility
  - Rapid and dynamic provisioning and instantiation of new services in various locations

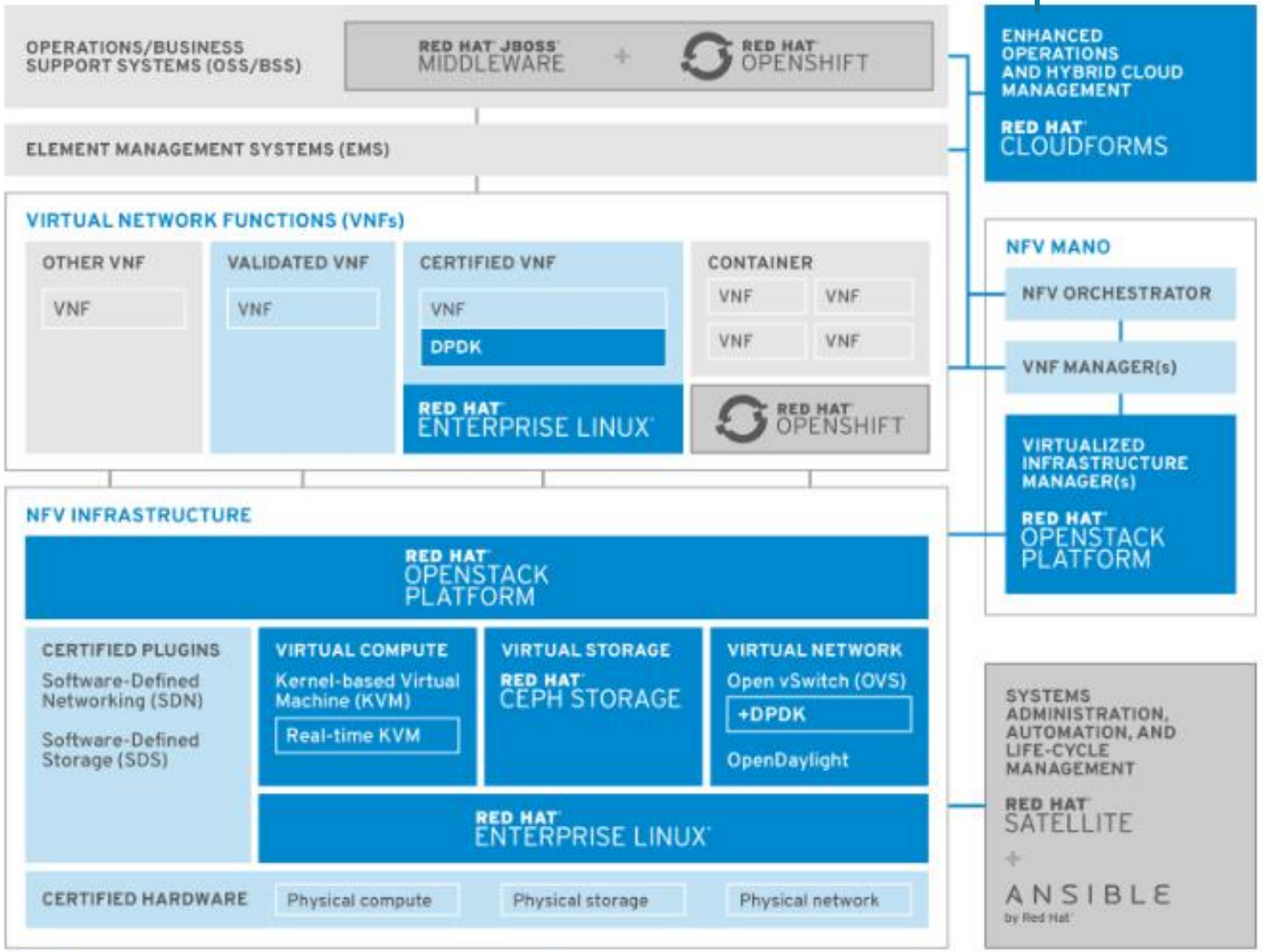
OpenStack and NFV

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 (SR-IOV)
  - Open vSwitch with Data Plane Development Kit (OVS-DPDK)

NFV ETSI Architecture and Components



General components of NFV platform

- **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

- **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

- Cloud Service Models
  - https://www.ibm.com/cloud/learn/iaas-paas-saas
- NIST Cloud Computing program
  - https://csrc.nist.gov/projects/cloud-computing
- 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
- Understanding OpenStack
  - https://www.redhat.com/en/topics/openstack
- 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
  - Ubuntu 19.10 Eoan Ermine
    - http://archive.ubuntu.com/ubuntu/dists/eoan/main/installer-amd64/current/images/netboot/mini.iso

Useful references

- OpenStack and NFV
  - https://access.redhat.com/documentation/en-us/red_hat_openstack_platform/16.0/html/network_functions_virtualization_product_guide/pr01
- 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
- ETSI NFV architecture and RedHat NFV components
  - https://access.redhat.com/documentation/en-us/red_hat_openstack_platform/16.0/html/network_functions_virtualization_product_guide/ch-nfv_software