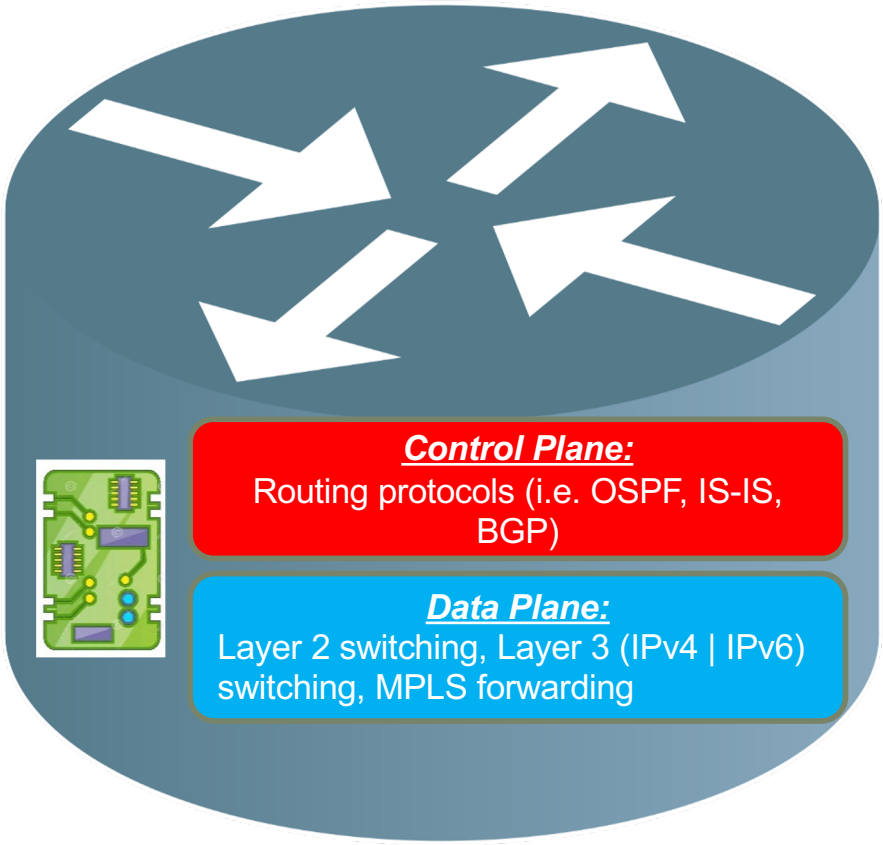
Network Function Virtualization

Antonio Virdis
Assistant Professor@ University of Pisa
antonio.virdis@unipi.it

Traditional Network Equipment

- A limited set of functionalities (just a little more than routing/forwarding) implemented in hardware
- Network is designed around the hardware and not viceversa
- Possible changes are limited
- New network services can not be created
- All is fine for the core of ISP networks

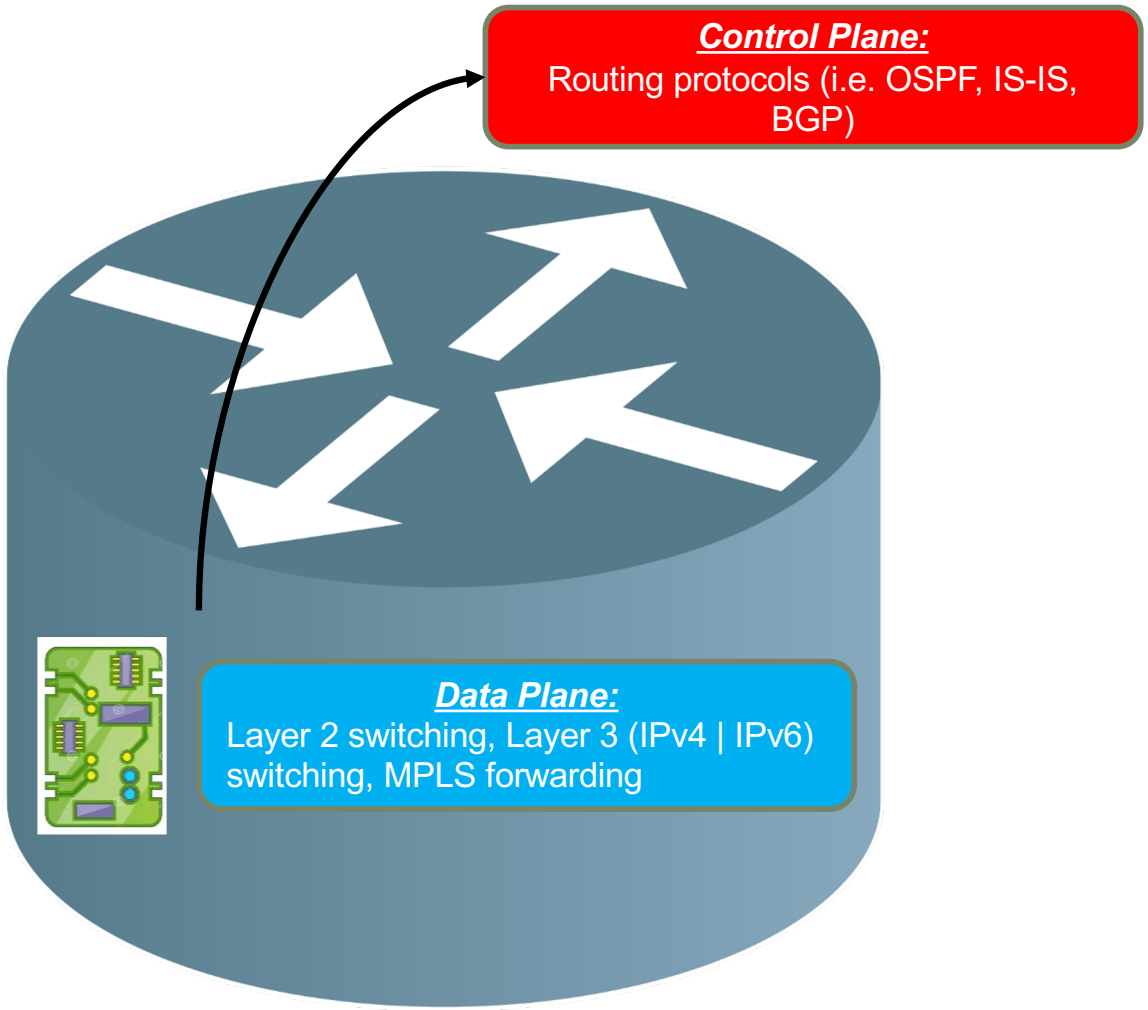


SDN Network Equipment

- SDN hardware is highly reconfigurable
- The set of SDN functionalities is small and implemented in hardware

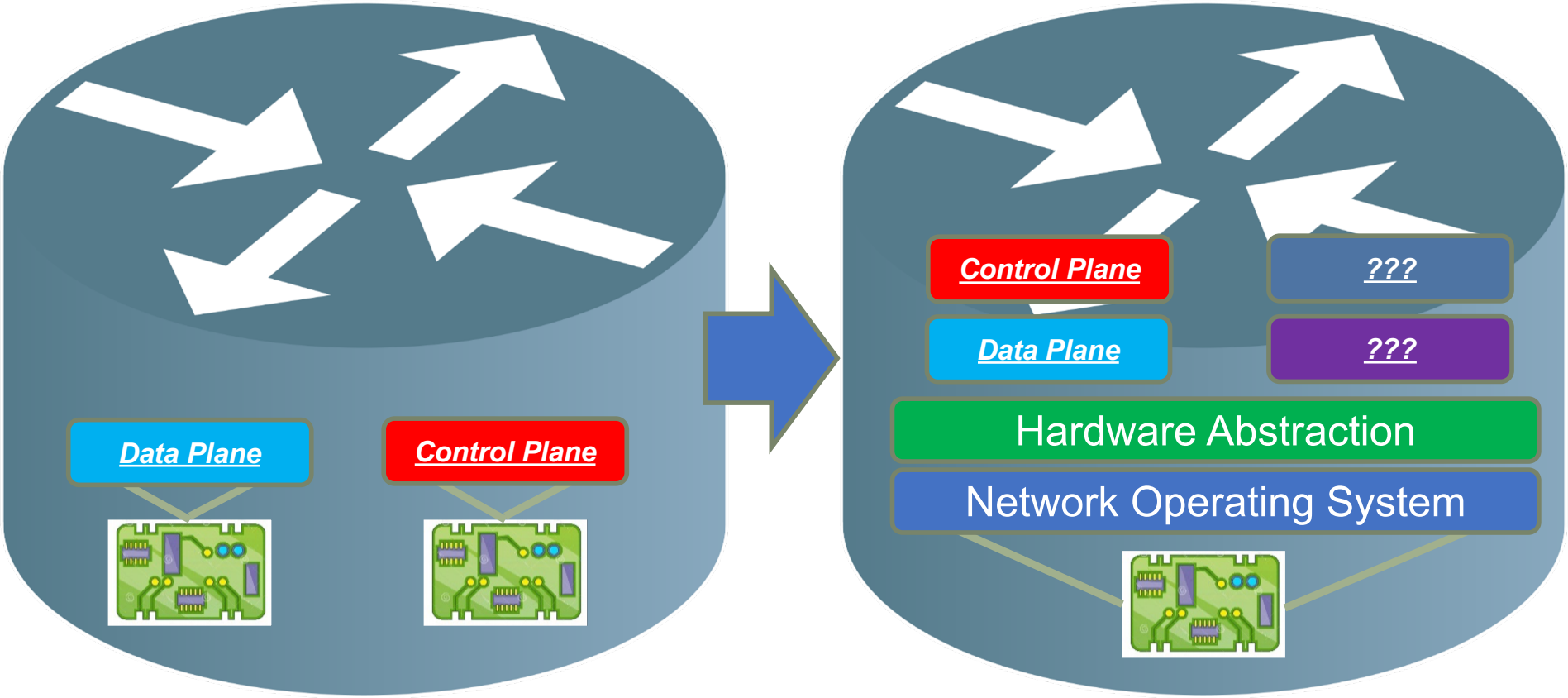
- Again, possible changes are limited
- Again, new network services can not be created if not already there

- All is fine at the core of the datacenter where re-configurability is all

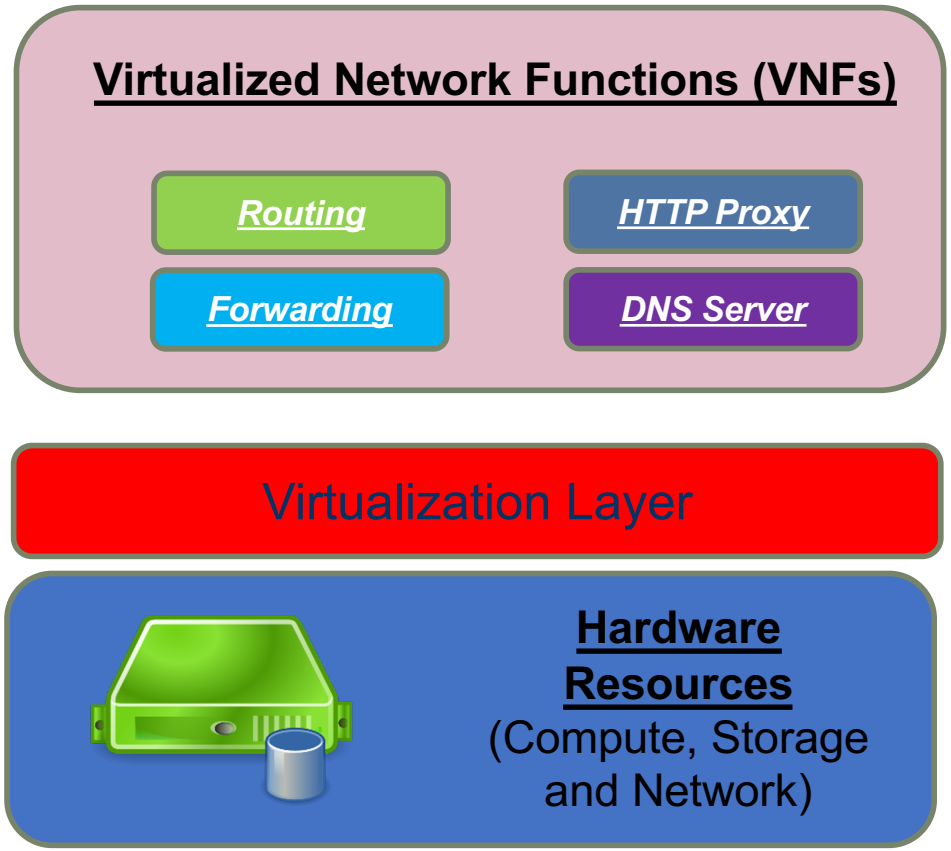


Network Function Virtualization

Motivation: Lack of flexibility / Creation of new services is difficult
Solution: Apply the same virtualization paradigm exploited for computing to networking: virtualize the functions of the network; **implement the functions as software-only entities that are designed to be independent from the hardware**



Next generation Network Equipment



- Run the network software entities on top of off-the-shelf compute and storage elements, using the same **virtualization and cloud technologies** of recent IT infrastructures
- VNF are implemented as a **Virtual Machine** or a **Container**
- Network functions can be deployed at runtime as needed

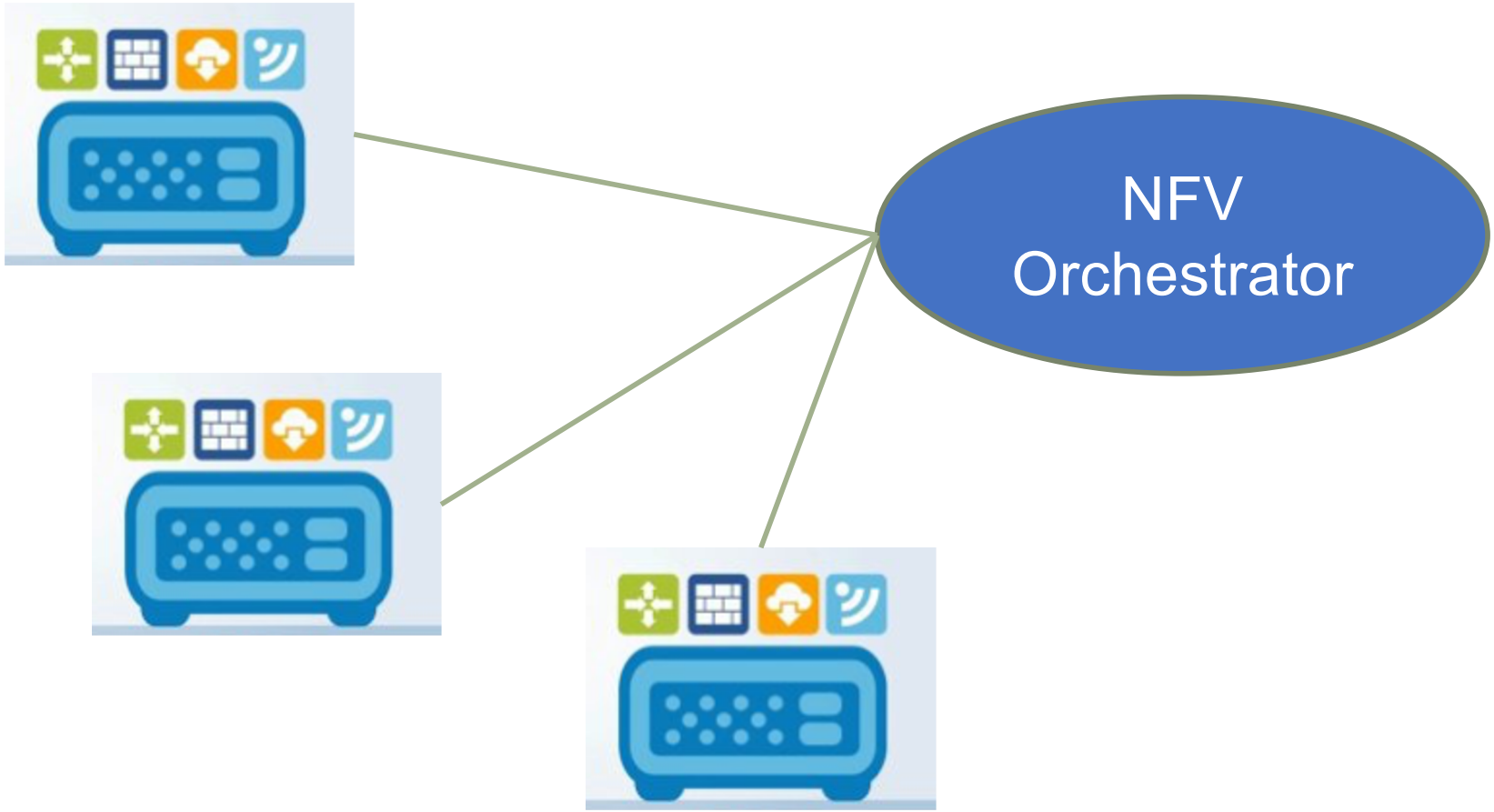
Definition and history

- Originally presented in 2012 through the paper
  "*Network Functions Virtualisation; an introduction, benefits, enablers, challenges & call for action*"

- NFV aims to transform the way that network-operators architect networks by evolving standard IT virtualisation technology to consolidate many network equipment types onto industry standard high-volume servers
- It involves the implementation of network functions in software that can run on a range of industry standard server hardware
- NFs can be moved to, or instantiated in, various locations in the network as required, without the need for installation of new equipment.

NFV Orchestrator

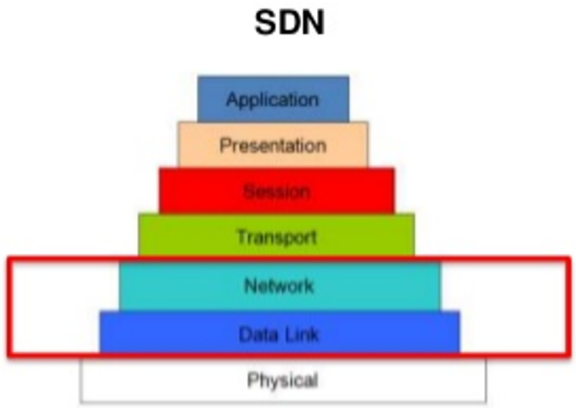
Softwarization allows to control all the components of each virtualized network equipment by a centralized entity, called **NFV Orchestrator**, *which controls the services to be instantiated on each device*



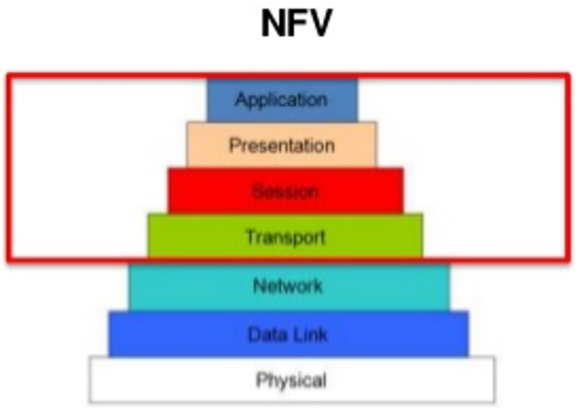
SDN vs NFV

SDN and NFV are not in contrast and can coexist

- SDN, more focused on optimizing network infrastructure
- NFV, more focused on optimizing the network functions



- Optimize network infrastructure such as Ethernet switches, routers and wireless access points
- OSI Layer 2-3

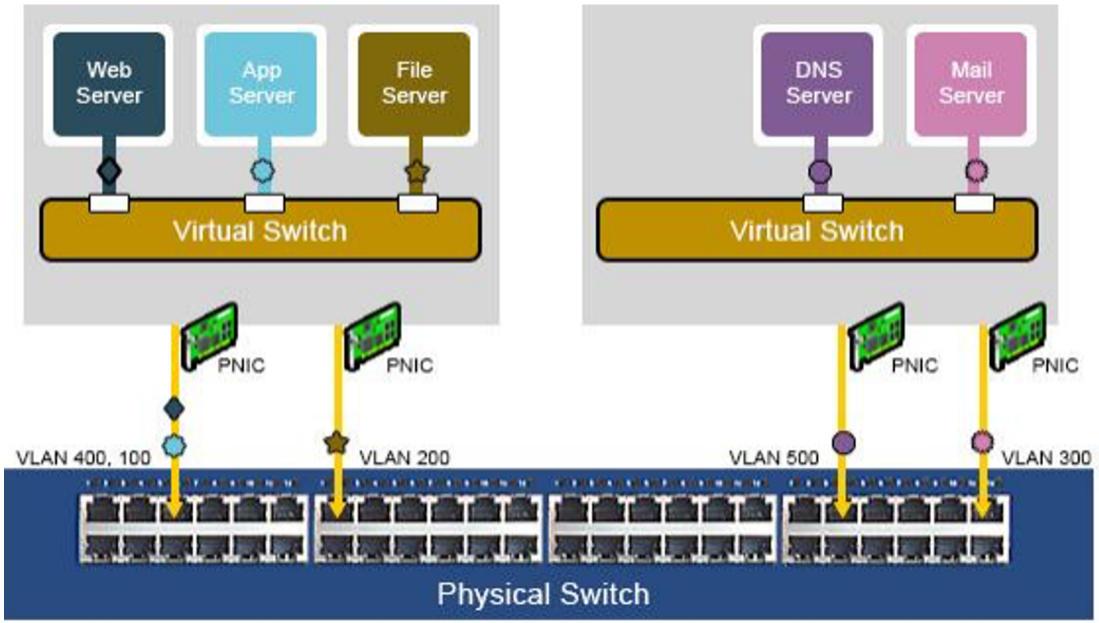


- Optimize deployment of network functions such as: load balancer, firewall, WAN optimization controller, deep packet inspection etc.
- OSI Layer 4-7

Use cases

Network Functions Virtualisation (NFV); Use Cases
ETSI GR NFV 001 [from V1.1.1 to V1.2.1]

Use Cases (i)

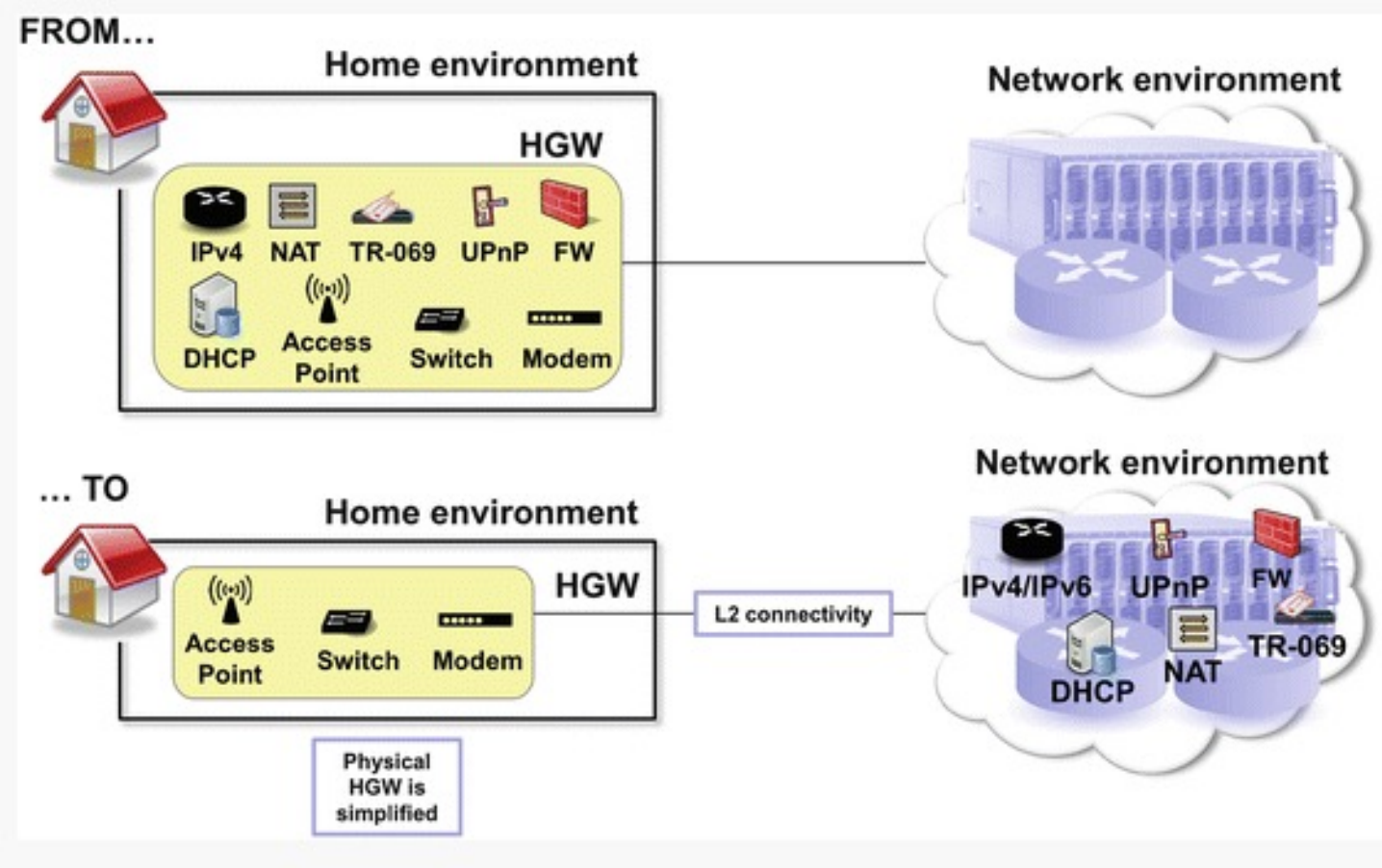


New networks and virtual network services can be instantiated as VMs are created or destroyed

Virtual Networks inside Cloud Computing platforms:
Network functions are virtualized by definitions as they are implemented on top of the cloud virtual infrastructure

The cloud orchestrator (the software controlling the instantiation of VMs) is already a NFV orchestrator

Use Cases (ii)



Customer network equipment can be virtualized.

This allows the deployment of new services in the customer's network as the customer requires (and pay) them. New services (unknown at the time of device installation) can be created and deployed anytime.

Use Cases (iii)

The core network of wireless operator is a complex infrastructure. Wireless protocols rapidly changes over time (e.g. UMTS -> LTE -> LTE Advanced -> 5G)

The virtualization of the core network can allow:
(i) Network reconfiguration and protocol update using the same hardware
(ii) Rapid deployment of virtualized network services to create Virtual Network Service Operators

Evolved Packet Core Networks (EPC) of Wireless Providers

NFV - Advantages

- It enables new opportunities and more innovation
  - The same hardware can be used to create new services, unknown at design time
- High flexibility
- Faster time to market for new services
- Improved business processes
- Reduce Capex/Opex

NFV - Principles

- **Service Chaining**: selecting the set of VNFs the traffic flow will traverse
- **Management and Orchestration (MANO)**: managing the whole lifecycle of VNF istances
- **Distributed Architecture**: a VNF may be made up of one or more VNF components, each one possibly deployed on different hosts

NFV - Requirements

- Portability/interoperability
- Performance trade-off
- Migration and coexistence w.r.t. legacy equipment.
- Automation
- Security and resilience
- Network stability

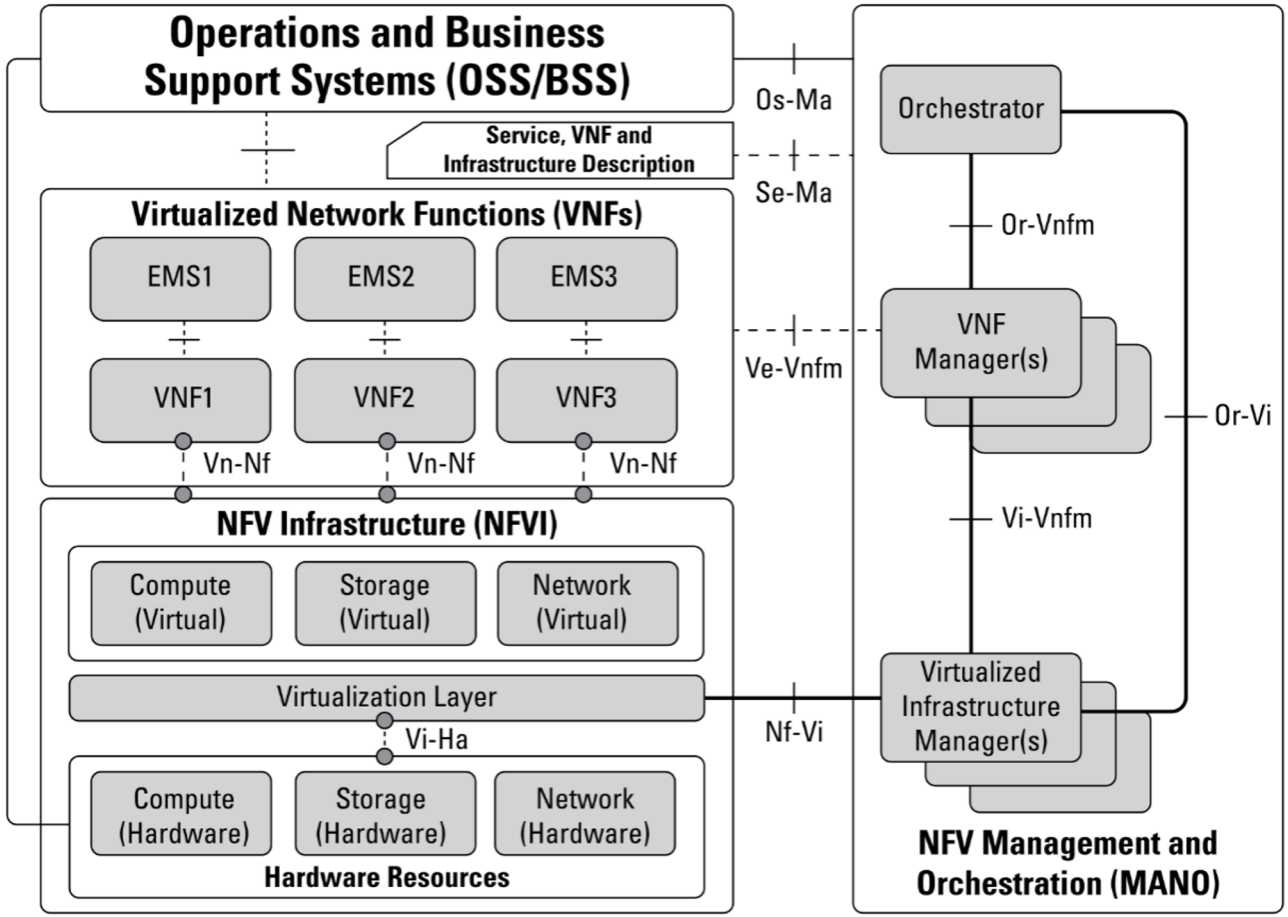
NV vs NFV

Network Virtualization ≠ Network Function Virtualization

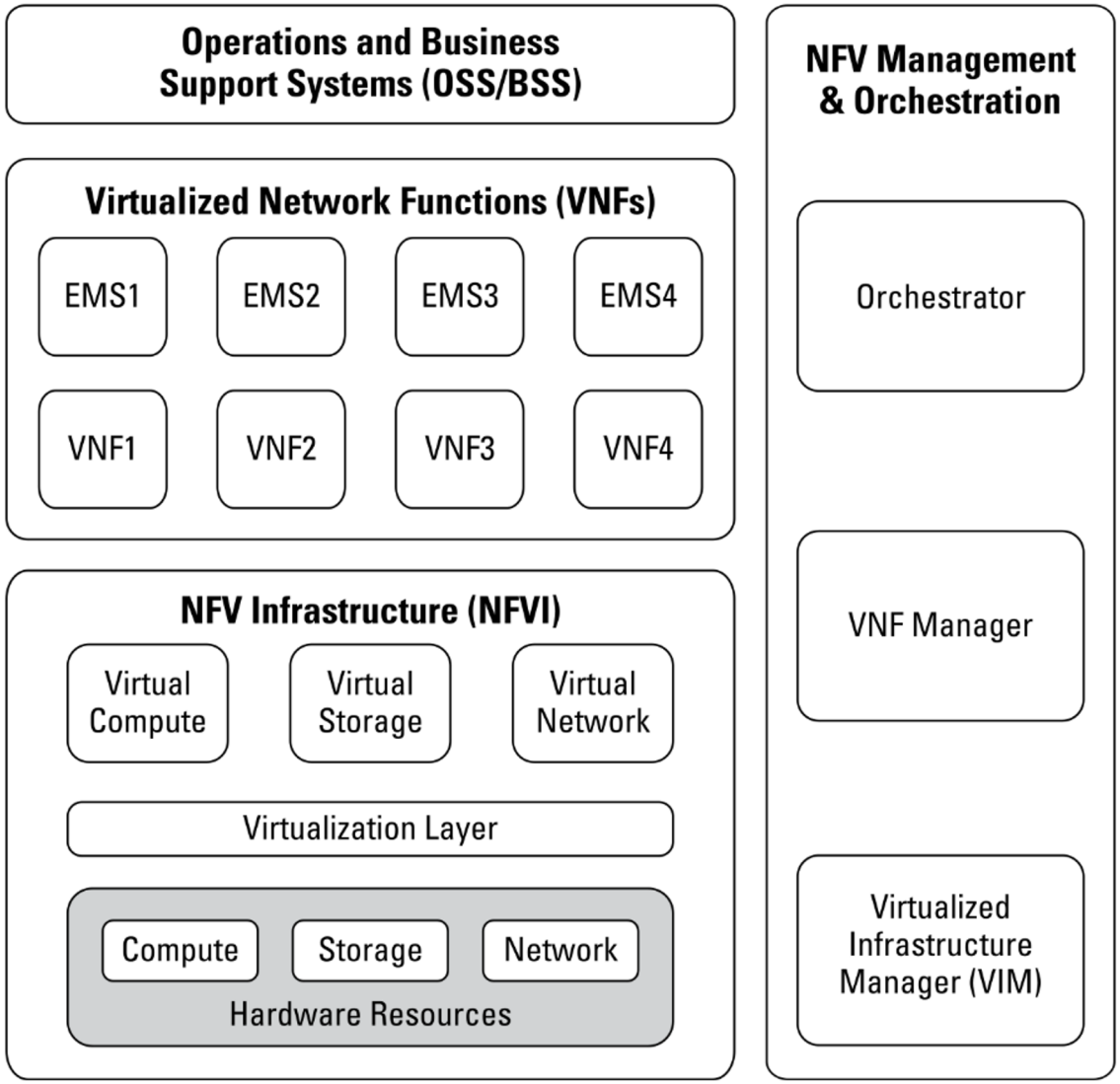
- NV creates an overlay of the physical network to *virtually interconnect* possibly remote networks
- *NFV* virtualize network functions

Standard Architecture

The ETSI NFV Industry Specification Group in its working group MANO has defined a high-level functional architectural framework for NFV



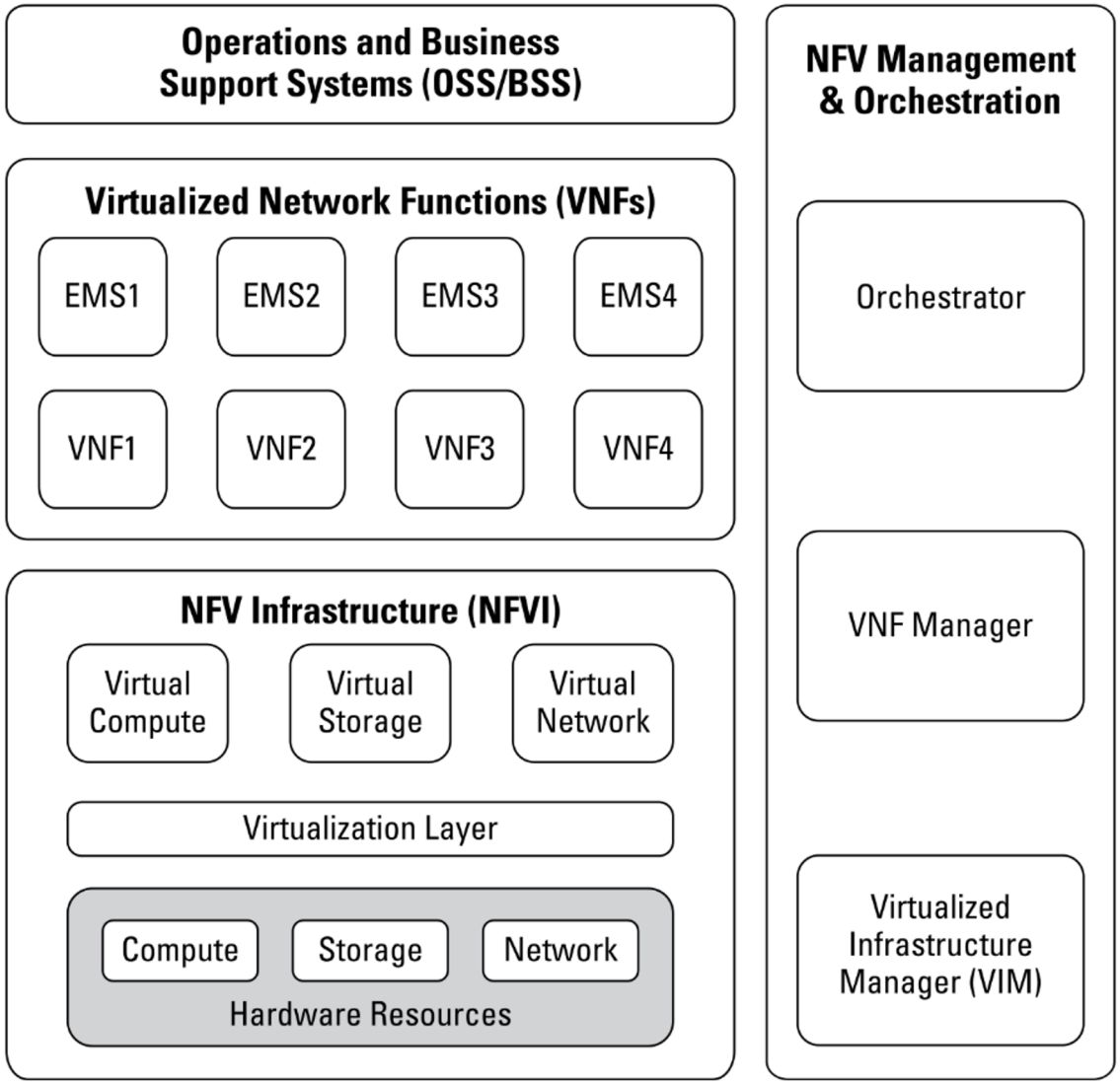
Components



Network Functions Virtualization Infrastructure (NFVI):
A subsystem that consists of all the hardware and software components *on top of which VNFs are deployed*.

One or more VNFs are instantiated to implement a **Network Service (NS)** to implement a specific network functionality.

ETSI MANO

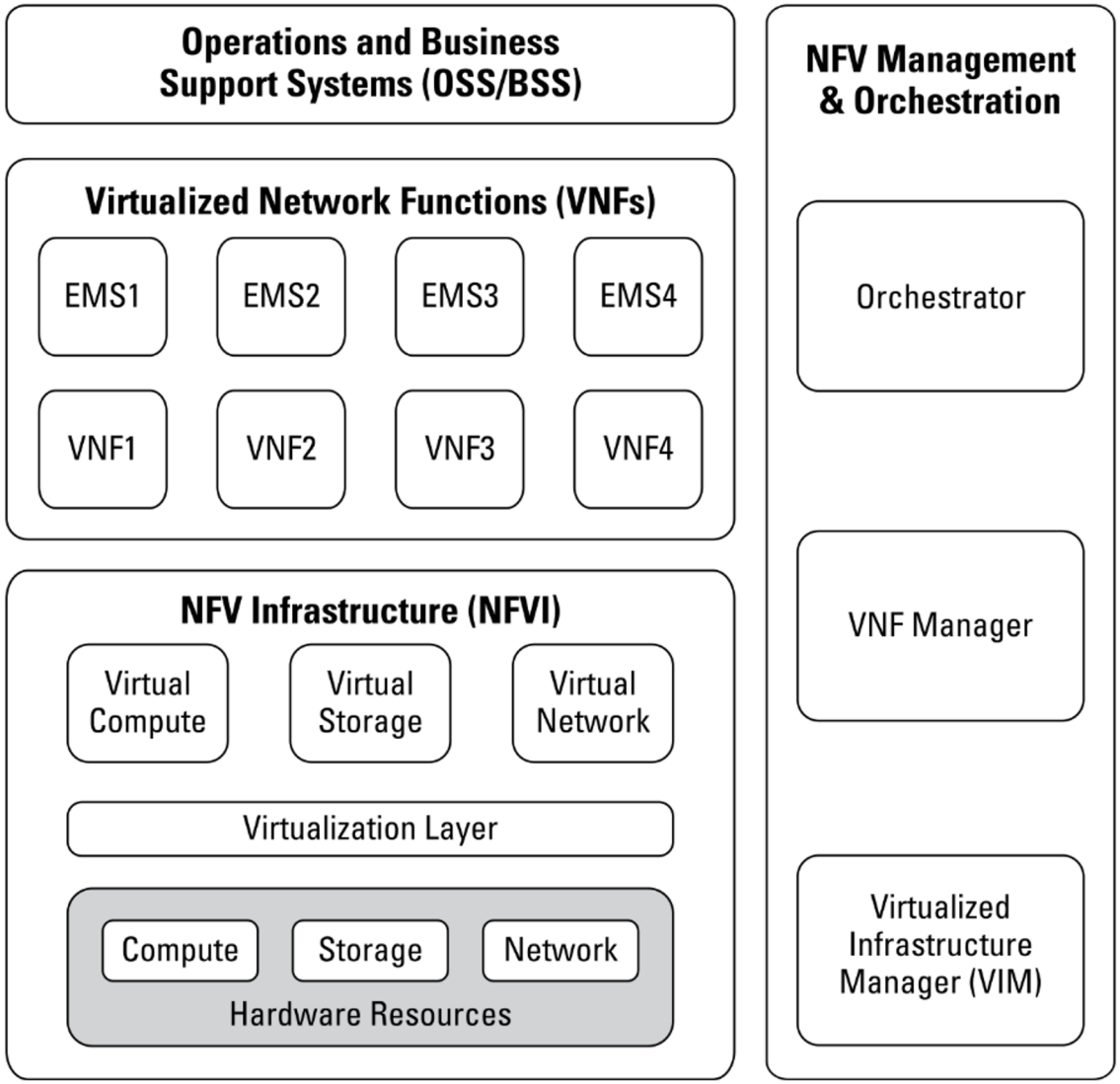


Management and Orchestration (MANO):
A subsystem that includes the **Network Functions Virtualization Orchestrator** (NFVO), the **Virtualized Infrastructure Manager** (VIM), and the **Virtual Network Functions Manager** (VNFM).

VNFM: is responsible for the management and operation of individual VNFs

NFVO: is responsible for managing network services (NS) that span multiple VNFs

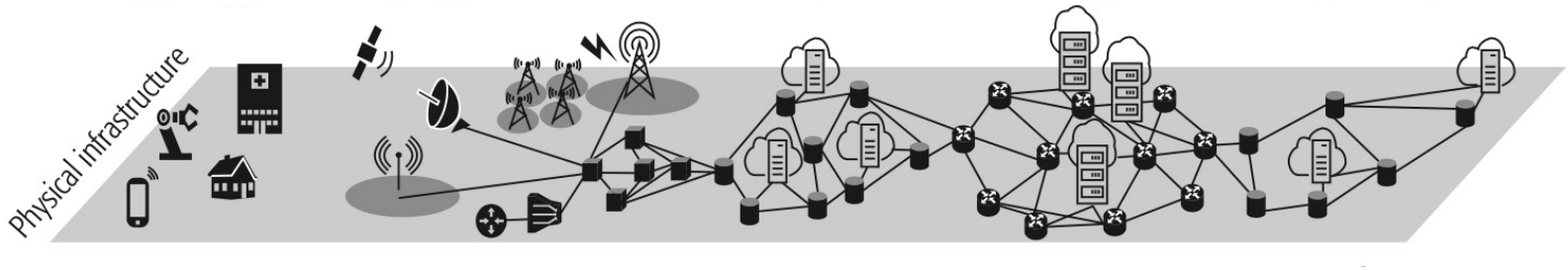
ETSI MANO



VIM: is responsible for managing the physical and virtual resources. It interfaces with the NFV Infrastructure (possibly across different hosts).

It manages the resources based on the input from the VNFM and NFVO

Towards 5G? Network Slicing



J. Ordonez-Lucena, P. Ameigeiras, D. Lopez, J. J. Ramos-Munoz, J. Lorca and J. Folgueira, "Network Slicing for 5G with SDN/NFV: Concepts, Architectures, and Challenges," in IEEE Communications Magazine

Network Slice

- Multiple definitions of Network Slice do exist

"end-to-end (E2E) logical networks running on a common underlying (physical or virtual) network, mutually isolated, with independent control and management, which can be created on demand"

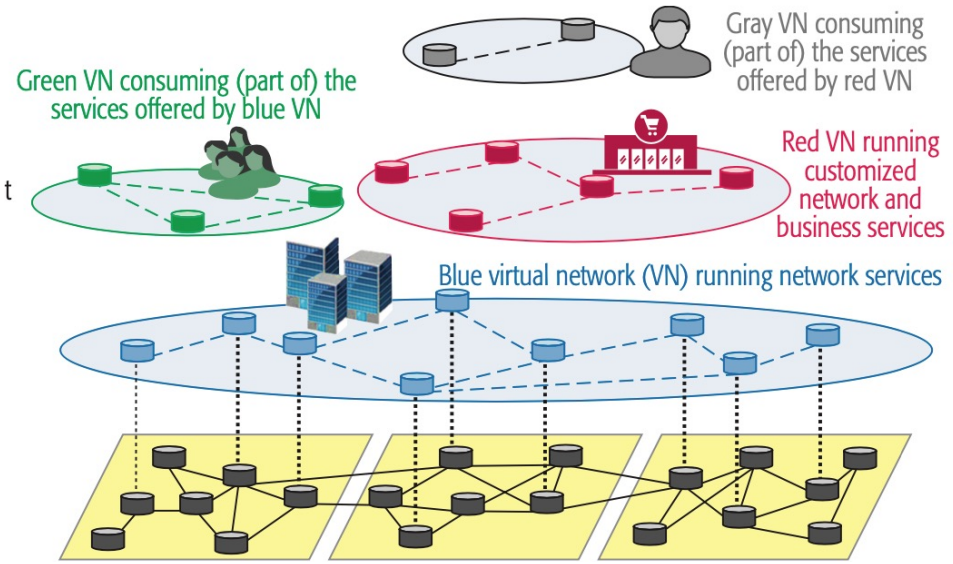
Main components of a Network Slice

- Resources.
  - Network Functions
  - Infrastructure resources

- Virtualization

Actors

- Infrastructure Provider
- Tenant
- End User

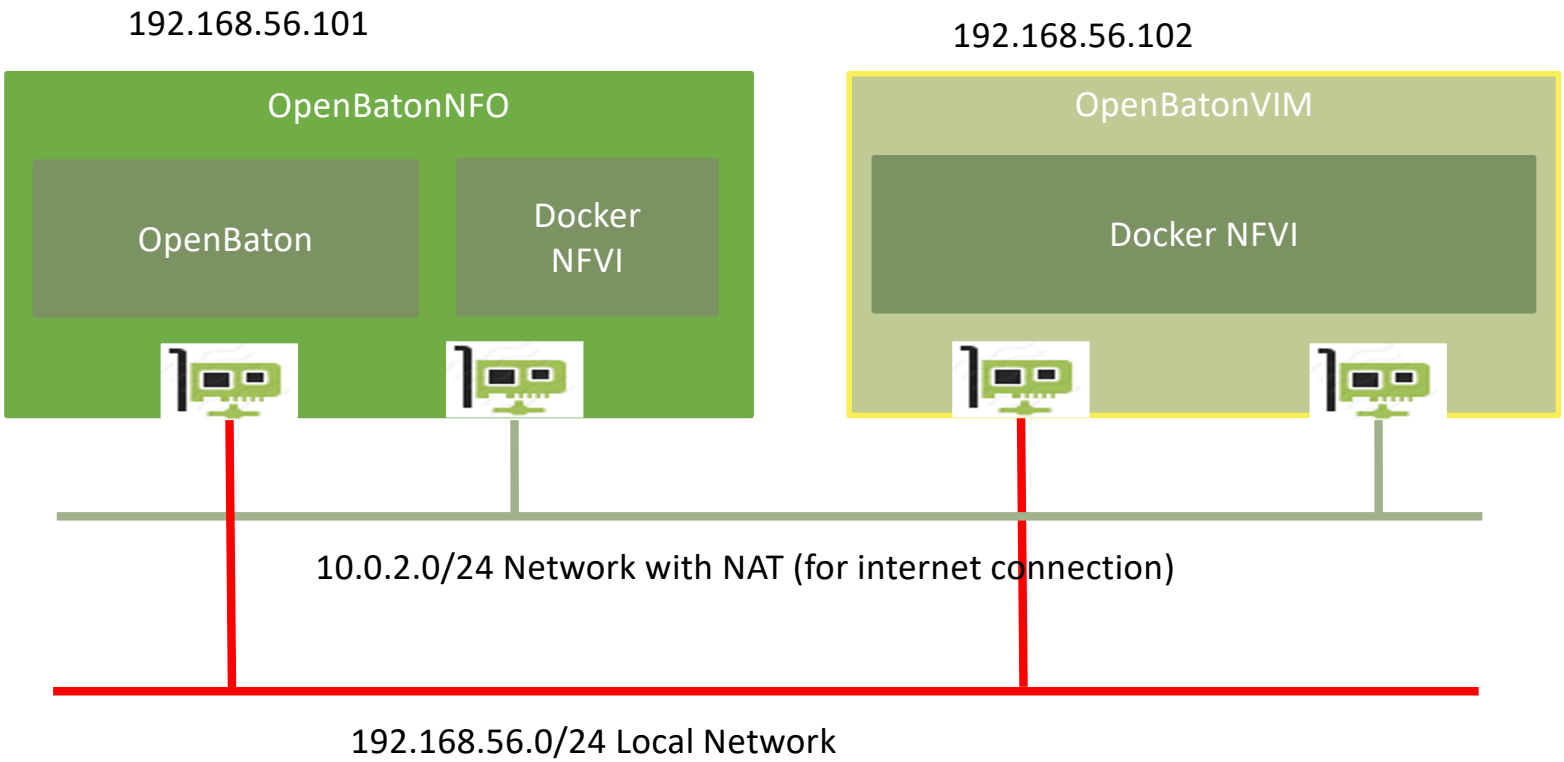


Orchestration

- Definition
  - orchestration can be defined as the art of both bringing together and coordinating disparate things into a coherent whole.

- Logically centralized – implemented distributedtly
  - In a slicing environment, where the players involved are so diverse, an orchestrator is needed to coordinate seemingly disparate network processes for creating, managing, and delivering services.

Next Steps: lab session



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