

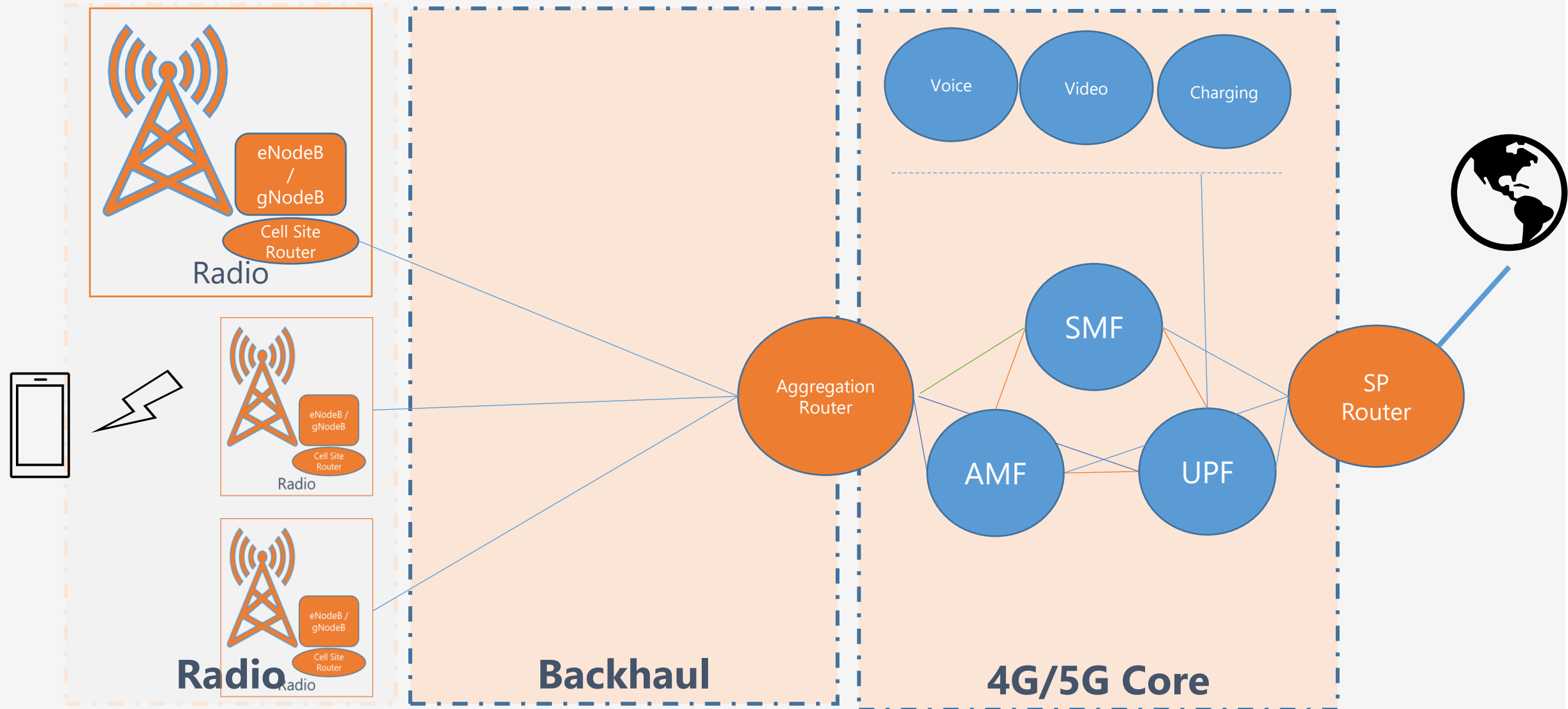
# Mobile Computing Architecture

UW Bothell, WA

Network Functions Virtualization (NFV)



# Network Functions



# Important Terms

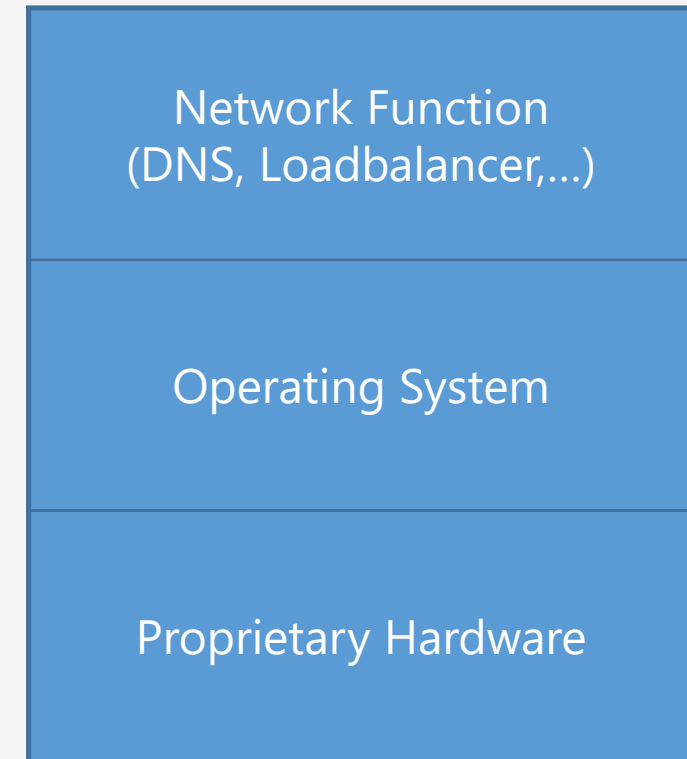
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- Agility - the ability to move a process quickly (in the business world), introduce new products and services with speed, adapt to changes in market demand and exceeding customer expectations.
- Time to Market - is the length of time it takes from a product and/or a service being conceived until its being available for monetization
- Time to Revenue – is the length of time from contract execution before the purchase begins to provide revenue or return on investment for the purchase. Sum of Capital Expenditure (CAPEX) and Operational Expense (OPEX).
- Total Cost of Ownership - an estimate of all the direct and indirect costs involved in acquiring and operating a product or system over its lifetime
- Business Continuity – planning for availability of services in case of disruption

# Classical Telecom – Physical Network Functions (PNFs)

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- Proprietary Hardware: manufactured specially for the applications.  
Typically expensive and long delivery and deployment cycles
- Operating systems typically UNIX, LINUX, BSD, etc. based but optimized for specific workloads by the Telecom OEMs. Expensive licensing schemes for support.
- Network Functions: Firewalls, Loadbalancers, Routers, Switches, Mobile Nodes (MME, Gateways, IMS, etc.) were designed to run only on proprietary hardware and operating systems
- Specialized competence required to operate the PNFs.



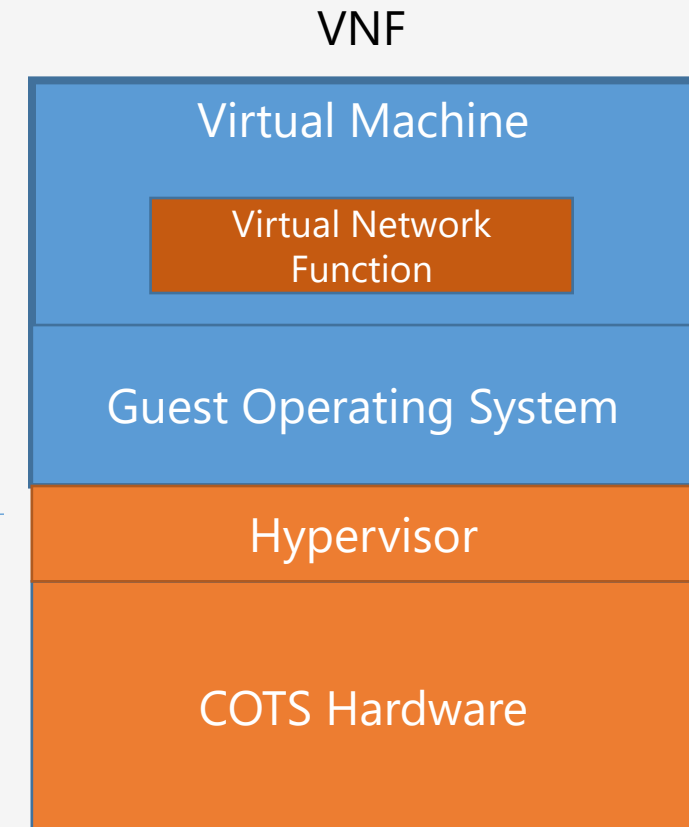
# Network functions virtualization (NFV)

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- Network functions virtualization (NFV) is the process of **decoupling network functions from (proprietary) hardware** and running them on COTS hardware
- NFV began when service providers attempted to **speed up deployment of new network services** in order to advance their revenue and growth plans
- Developers found that proprietary hardware-based appliances limited their ability to achieve these goals. They looked to **standard IT virtualization technologies** and found that virtualizing network functions accelerated service dynamics and provisioning
- With this, several providers banded together and **created the NFV ISG under the European Telecommunications Standards Institute (ETSI)**. The creation of ETSI NFV ISG resulted in the foundation of **NFV's basic requirements and architecture**
- **NFV primarily focuses on optimizing the network services themselves. It is a key part of cloud computing, 5G development, data center networking, SD-WAN, and many others**

# Virtual Network Functions (VNFs) – First Phase

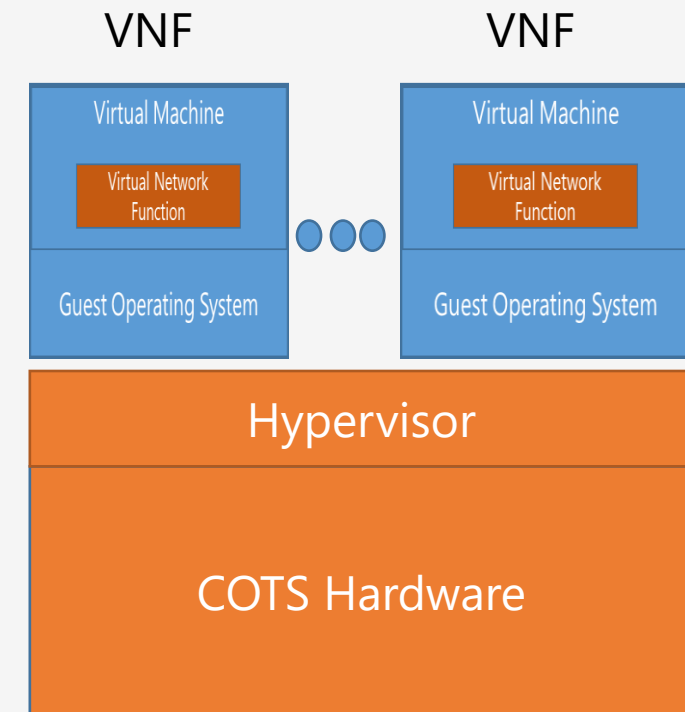
- Off the Shelf Hardware: Intel, AMD, etc . Cheaper than proprietary hardware, commonly available, faster delivery and deployment cycles
- Hypervisors solved the problem of OEM operating systems. Typically, KVM, VmWare, Xen, etc.
- Virtualized Network Functions: vFirewalls, vLoadbalancers, vRouters, vSwitches, Mobile Nodes (vMME, vGateways, vIMS, etc.) in Virtual machines
- Broad market competence available to setup IaaS and PaaS.



# Virtual Network Functions (VNFs) – Second Phase

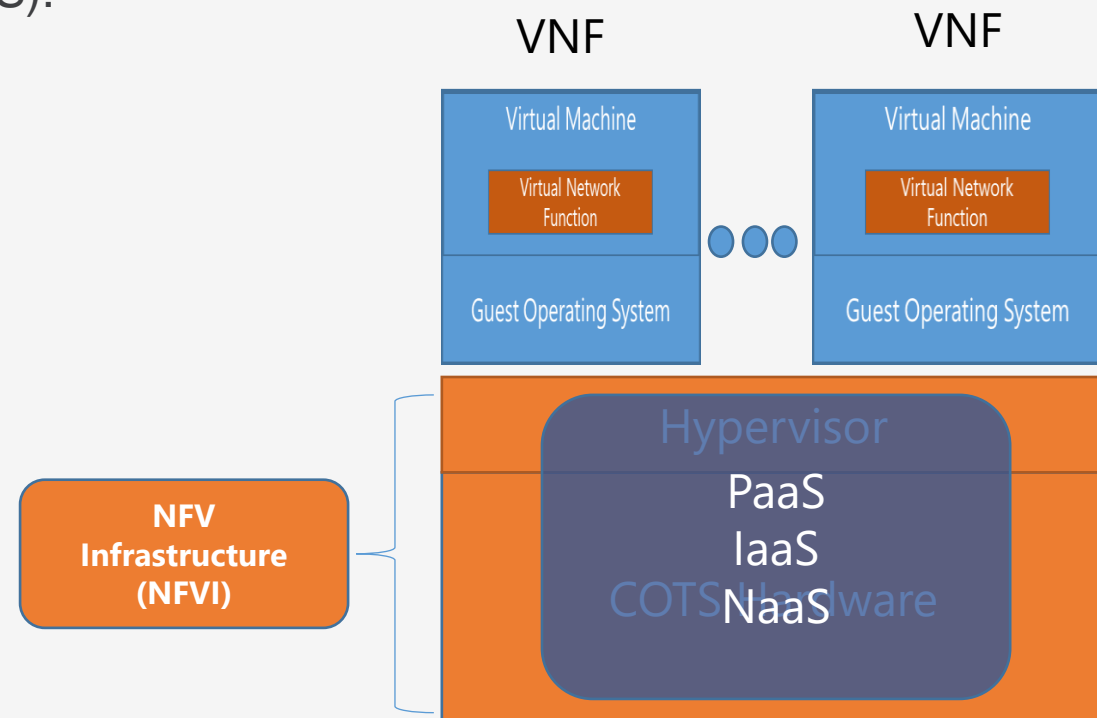
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- The first phase was about running a single network function on virtualized infrastructure. Same vendor
- The second phase was about running multiple networks functions on the same virtualized infrastructure. Same vendor
- Cost efficiencies, speed to deployment



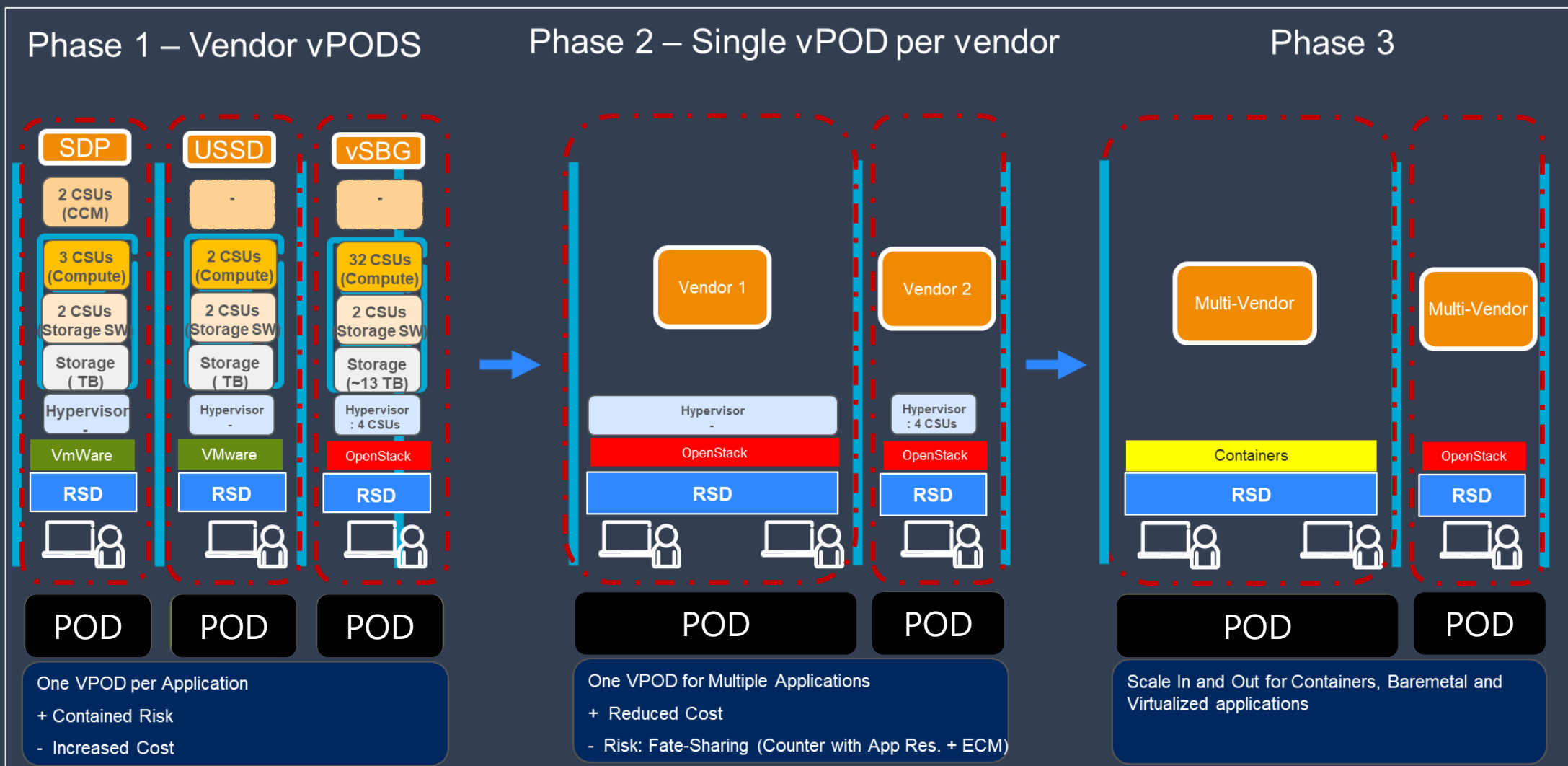
# Virtual Network Functions (VNFs) – Current Deployments

- The current trend is to run multiple network functions, from different vendors, on the same (PaaS/IaaS/NaaS).
- Cost efficiencies and speed of deployment
- Critical Shift: Risk versus Ownership
  - Who owns the risk?
  - Who is accountable for Business Continuity?

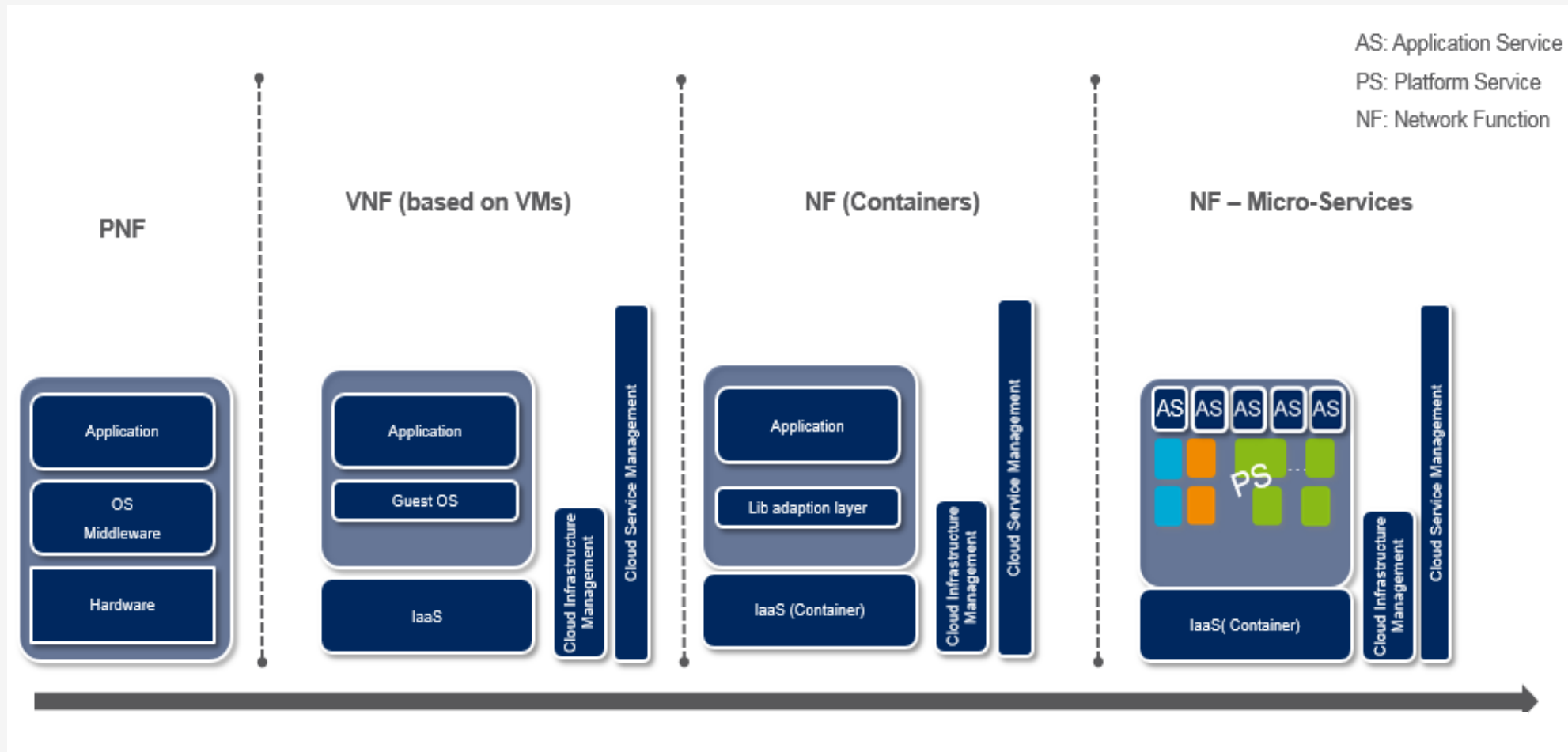




# Evolution to Cloud Native Functions



# Virtual Network Functions (VNFs) – Evolution to Cloud Native Functions



# TTM, How?

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Question: what is the purpose of all this effort if we can not deploy the services fast and shorten the TTM?

# Automation and Orchestration

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## What is automation?

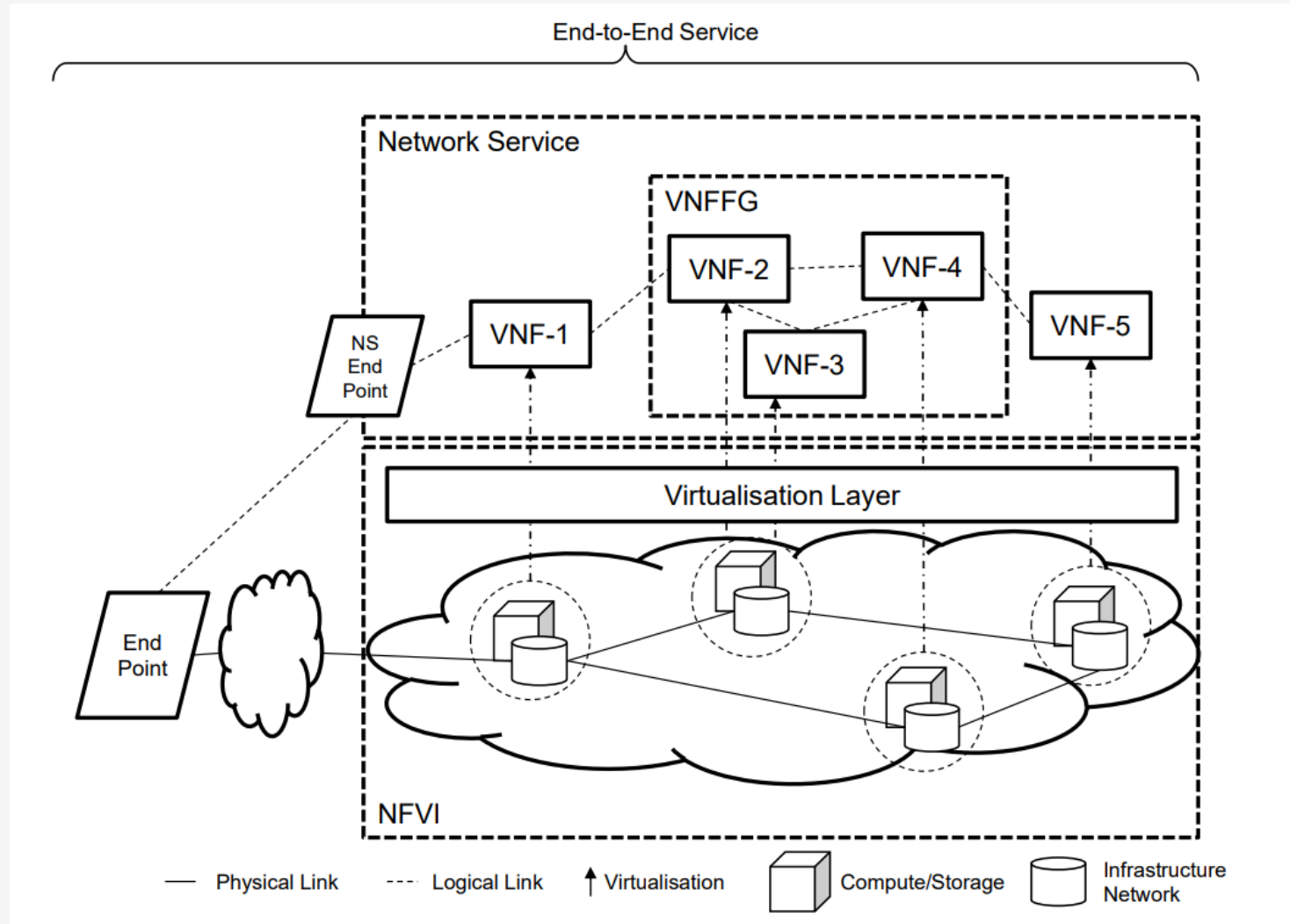
Typically, setting up a single task to run on its own—automating one task. This single task can be anything launching a web server, stopping a service, integrating a web app, etc.

## What is orchestration?

Orchestration is automating many tasks together. It's automation not of a single task but an entire IT-driven process. Orchestrating a process, then, is automating a series of individual tasks to work together. Referred to as **workflow**. Orchestrating a process requires the understanding of the *workflow*:

- Knowing and understanding the many steps involved
- Tracking each step across a variety of environments: applications, mobile devices, and databases, for instance.

# Typical Network End to End (E2E) Service



How do we automate/orchestrate this E2E service?

# NFV – MANO

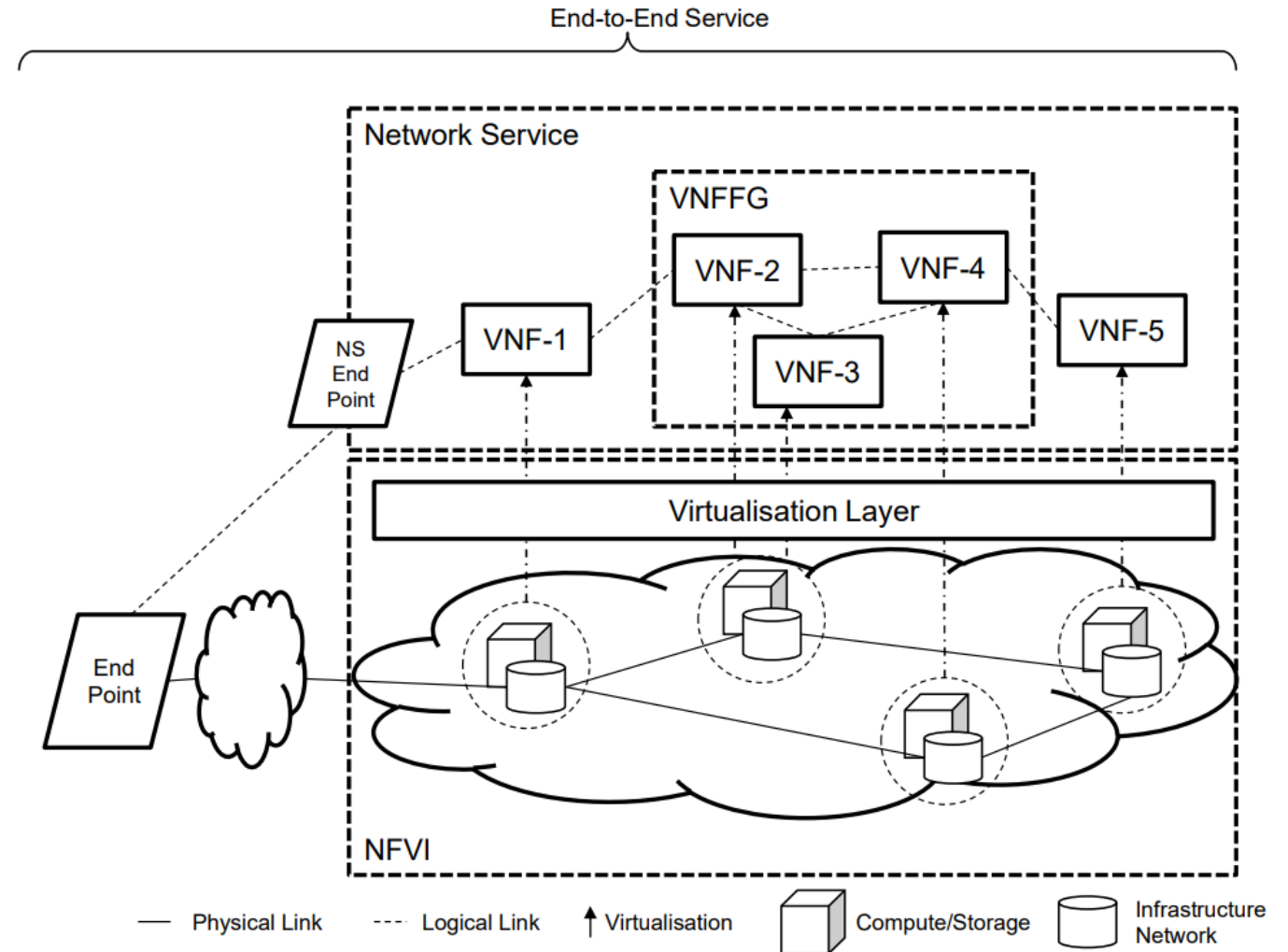
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MANO: Network Functions Virtualization (NFV) **Management and Orchestration**

- Standard: **ETSI GS NFV-MAN 001** ([LINK](#))
- The standard is about the management and orchestration framework required for the provisioning of **virtualized network functions (VNF)**, and the related operations, such as the configuration of the virtualized network functions and the infrastructure these functions run on.
- The standard covers architecture framework for:
  - management and orchestration of NFV
  - information elements, interfaces, provisioning, configuration, and operational management, including interworking with existing operations and management systems

# Typical Network Service

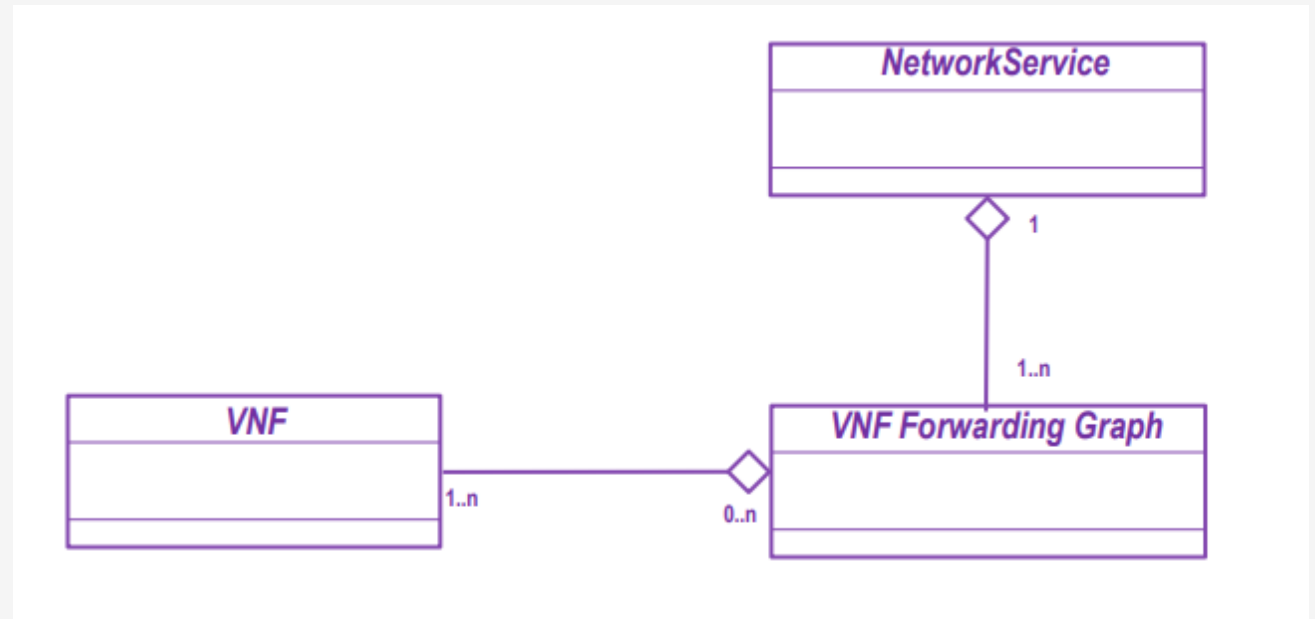
- **VNF**: described by its descriptor file, instantiated by the VNF Manager, – covers VNF components (VNFC) each mapped to a VM described with the Virtual Deployment Unit descriptor.
- **Network Service (NS)**: – described by its descriptor file, may cover one or more VNF Graphs, VNFs and PNFs.
- **VNF Forwarding Graph (VNF-FG)**: described by its descriptor file, orchestrated by NFVO, may cover VNFs and NFs, and other VNF-FG's



# NFV – MANO

## Architecture – Functional Blocks

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- **VNF Forwarding Graph (VNF-FG)**: described by its descriptor file, orchestrated by NFVO, – may cover VNF-FGs, VNFs and NFs

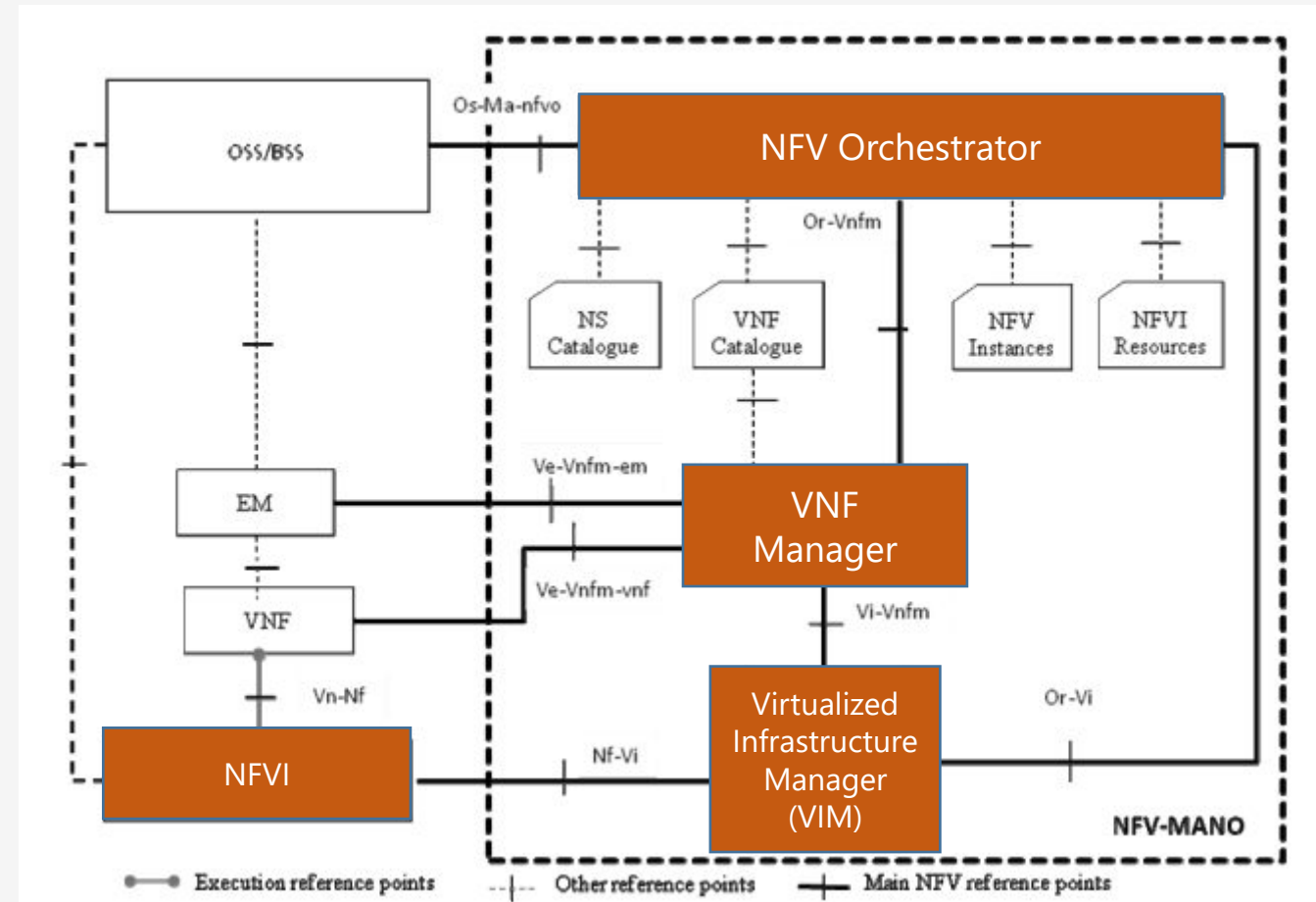




# NFV – MANO

## Architecture – Functional Blocks

- **NFV Orchestrator:** on-boarding of new Network Service (NS), VNF-FG and VNF Packages
  - NS lifecycle management including instantiation, scale-out/in, performance measurements, event correlation, termination
  - global resource management, validation and authorization of NFVI resource requests
  - policy management for NS instances
- **VNF Manager**
  - lifecycle management of VNF instances
  - overall coordination and adaptation role for configuration and event
  - reporting between NFVI and the E/NMS
- **Virtualized Infrastructure Manager (VIM)**
  - controlling and managing the NFVI compute, storage and network
  - resources, within one operator's infrastructure sub-domain
  - collection and forwarding of performance measurements and events



# NFV – MANO

## Architecture – Functional Blocks

NFV-MANO identifies the following data repositories:

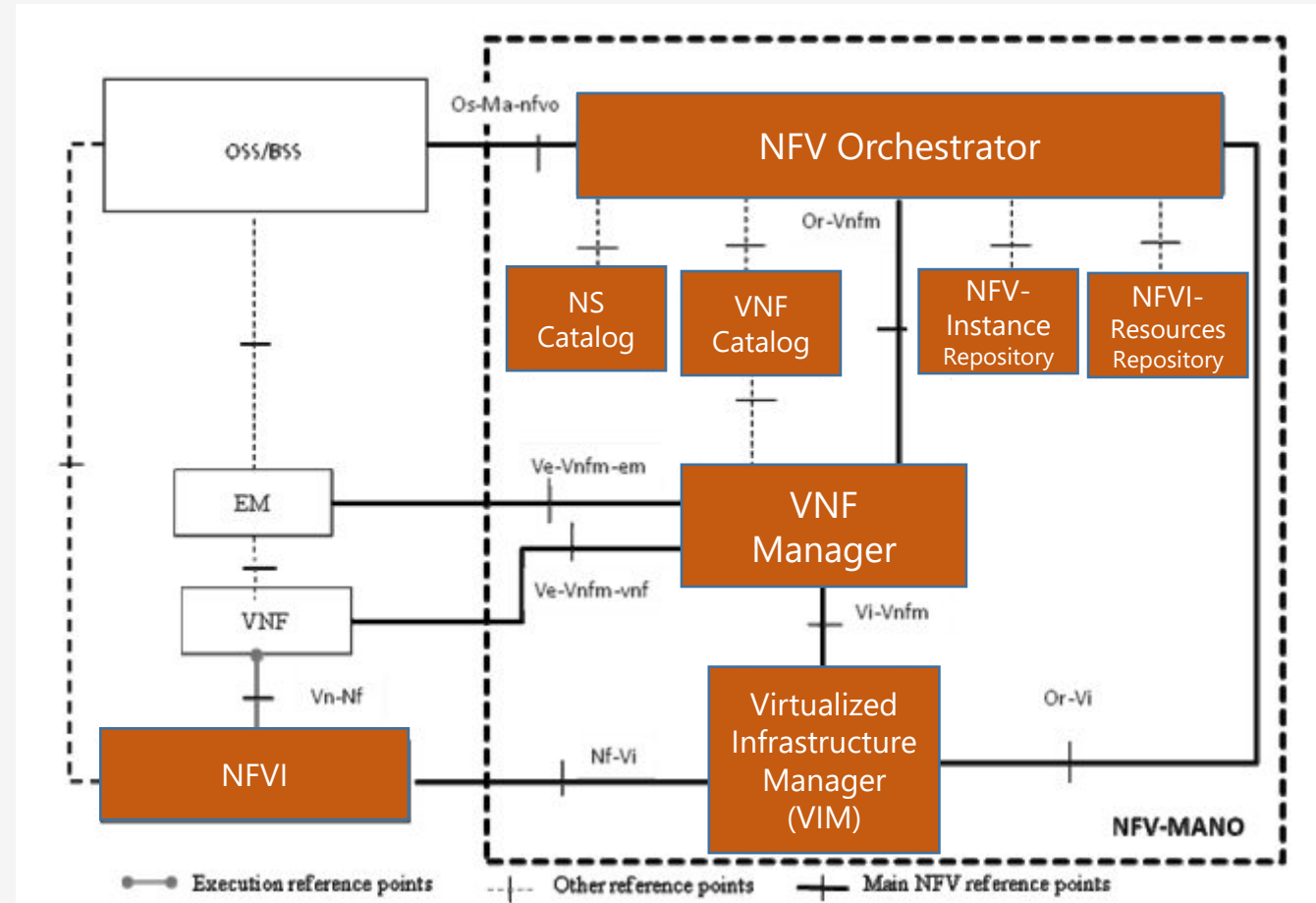
- *Network Services Catalog*
- *VNF Catalog*
- *NFV Instances repository*
- *NFVI Resources repository*

NFV-MANO has the following functional blocks that share reference points with NFV-MANO:

- *Element Management (EM)*
- *Virtualized Network Function (VNF)*
- *Operation System Support (OSS) and Business System Support functions (BSS)*
- *NFV Infrastructure (NFVI)*

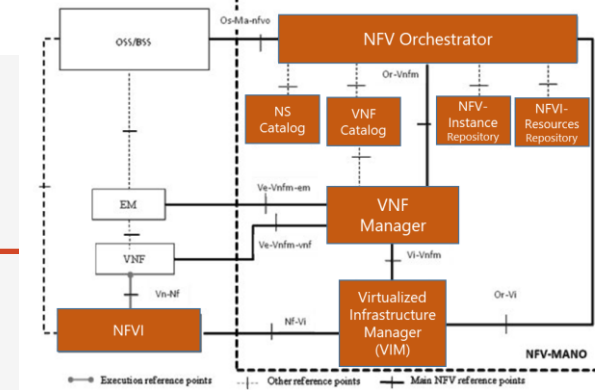
The NFV-MANO architectural framework identifies the following main reference points:

- *Os-Ma-nfvo*, between OSS/BSS and NFVO
- *Ve-Vnfm-em*, between EM and VNFM
- *Ve-Vnfm-vnf*, between VNF and VNFM
- *Nf-Vi*, between NFVI and VIM
- *Or-Vnfm*, between NFVO and VNFM
- *Or-Vi*, a between NFVO and VIM
- *Vi-Vnfm*, between VIM and VNFM



# NFV – MANO

## VNF-Orchestrator

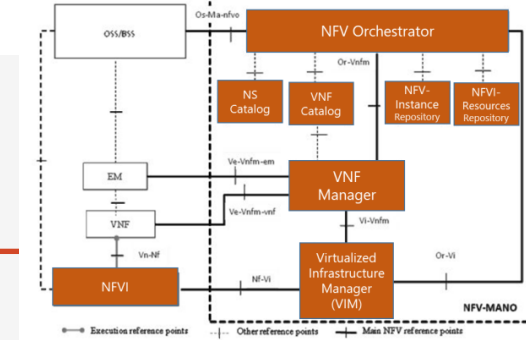


- Validation and authorization of NFVI resource requests from VNF Manager(s)
- NFVI resource management across operator's Infrastructure Domains including the distribution, reservation and allocation of NFVI resources to Network Service instances and VNF instances by using an NFVI resources repository, as well as locating and/or accessing one or more VIMs as needed and providing the location of the appropriate VIM to the VNFM, when required
- Supporting the management of the relationship between the VNF instances and the NFVI resources allocated to those VNF instances by using NFVI Resources repository and information received from the VIMs
- Policy management and enforcement for the Network Service instances and VNF instances (e.g. NFVI resources access control, reservation and/or allocation policies, placement optimization based on affinity and/or anti-affinity rules as well as geography and/or regulatory rules, resource usage, etc.)
- Collect usage information of NFVI resources by VNF instances or groups of VNF instances, for example, by collecting information about the quantity of NFVI resources consumed via NFVI interfaces and then correlating NFVI usage records to VNF instances.

# NFV – MANO

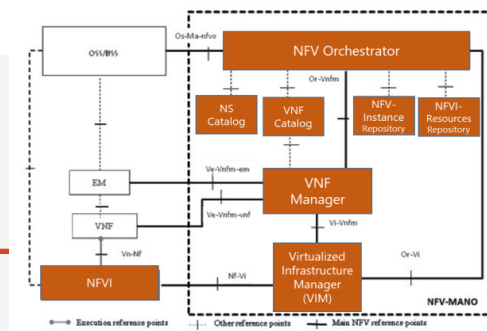
## VNF-Manager

- VNF instantiation, including VNF configuration
- VNF instantiation
- VNF instance software update/upgrade
- VNF instance modification
- VNF instance **scaling out/in and up/down**
- VNF instance-related collection of NFVI performance measurement results and faults/events information, and correlation to VNF instance-related events/faults
- VNF instance assisted or automated healing
- VNF instance termination
- VNF lifecycle management change notification
- Overall coordination and adaptation role for configuration and event reporting between the VIM and the EM



# NFV – MANO

## VIM



- Orchestrating the allocation/upgrade/release/reclamation of NFVI resources including the optimization of such resource's usage, and managing the association of the virtualized resources to the physical compute, storage, networking resources. Therefore, the VIM keeps an inventory of the allocation of virtual resources to physical resources, e.g. to a server pool
- Supporting the management of VNF Forwarding Graphs (create, query, update, delete), e.g. by creating and maintaining Virtual Links, virtual networks, sub-nets, and ports, as well as the management of security group policies to ensure network/traffic access control
- Managing in a repository inventory related information of NFVI hardware resources (compute, storage, networking) and software resources (e.g. hypervisors), and discovery of the capabilities and features (e.g. related to usage optimization) of such resources
- Management of the virtualized resource capacity e.g. density of virtualized resources to physical resources, and forwarding of information related to NFVI resources capacity and usage reporting

# TTM Improvement – Real World Example

|                         | PO reception to order delivery on site | Site work: Node installation & Power up | Software Installation, Configuration & Integration | Acceptance Testing |
|-------------------------|--|---|--|--------------------|
| MME Hardware Deployment | 56 days                                | 30 days                                 | 14 days  | 7 days             |
| vMME on Cots Platform   | 1 day                                  |   | 14 days  | 7 days             |
| vMME fully automated    | 1 day                                  |   | 1 hour   | 1 day              |

TTM Improvement: From 3-4 months to 2 days!