Network Function Virtualization (NFV):
Conception, Present and Future

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TSSG

Telecommunications Software and Systems Group (TSSG)

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Outline

- Research Challenges
- State-of-the-art
- Relationship with SDN
- NFV Architecture
- Examples / Use cases
- Expected gains
- Concept / Definition
- NFV Timeline
- Motivation for NFV

Motivation for NFV

① **Continuously increasing user requirements:**

- rapidly changing service demands require short development cycles

- even more data,

Global IP Traffic Trend

Exabytes

2019

19. May 2015.

quipment

Motivation for NFV (2)

Increased competition among each other and from O-T-T providers

Limited possibility to raise subscription fees

Continuous reduction in ARPU, PROFITABILITY

13 Operators Call for Action

Network Functions Virtualisation – Introductory White Paper | Issue 1

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Network Functions Virtualisation

An Introduction, Benefits, Enablers, Challenges & Call for Action

at&t • BT • CHINA MOBILE • colt smarter / faster / further • CenturyLink • Deutsche Telekom • KDDI • TELECOM ITALIA • Telefónica • NTT • orange™ • T • verizon

A joint operator call for the Telecom and IT industry to take advantage of advances in virtualization to increase service agility, network flexibility and reduce CAPEX and OPEX

ETSI responds to Call

November 2012

- AT&T, BT, Deutsche Telekom, Orange, Telecom Italia, Telefonica and Verizon selected the European Telecommunications Standards Institute (ETSI) to be the home of the Industry Specification Group for NFV

- Now 270 individual companies including 38 of the world's major service providers as well as representatives from both telecoms and IT vendors

- 1st Phase of work ended at end of 2014, 11 documents: architectural framework, descriptions of the infrastructure, management and orchestration, security and trust, resilience and service quality metrics.
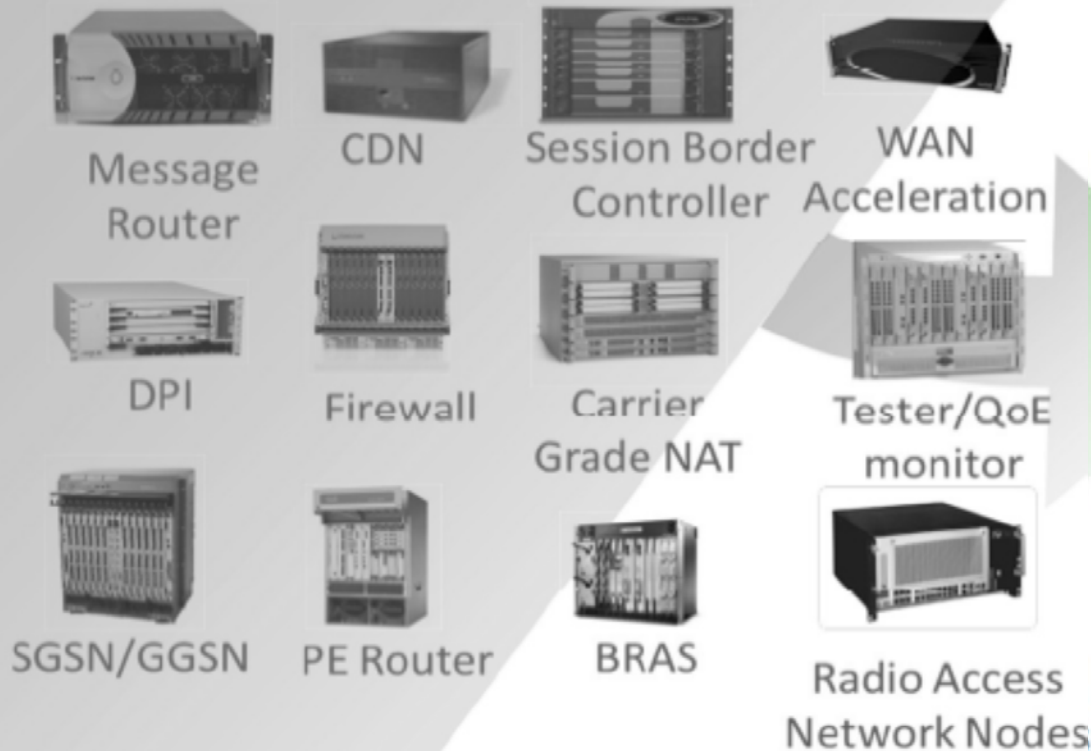
So, what is NFV ?

Leverage advances in virtualization to decouple network functions from Hardware

Classical Network Appliance Approach

Message Router
CDN
Session Border Controller
WAN Acceleration
DPI
Firewall
Carrier Grade NAT
Tester/QoE monitor
SGSN/GGSN
PE Router
BRAS
Radio Access Network Nodes

- Fragmented non-commodity hardware.
- Physical install per appliance per site.
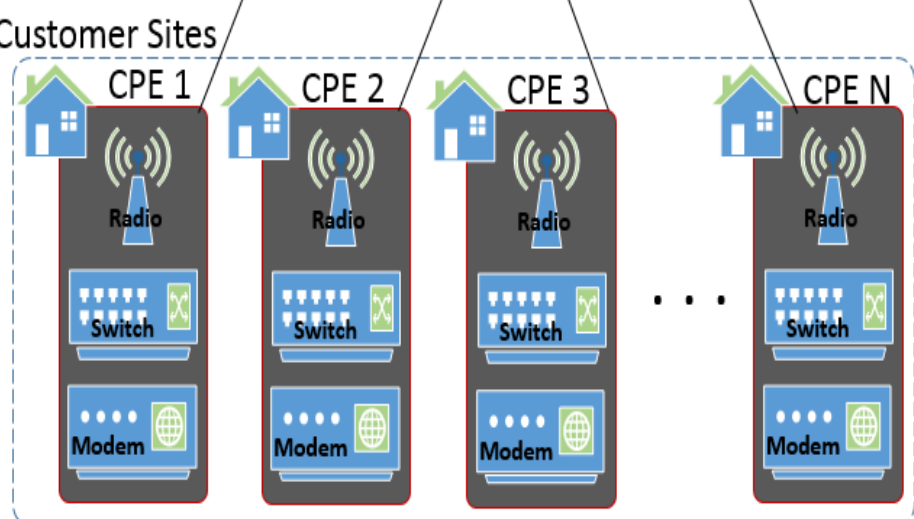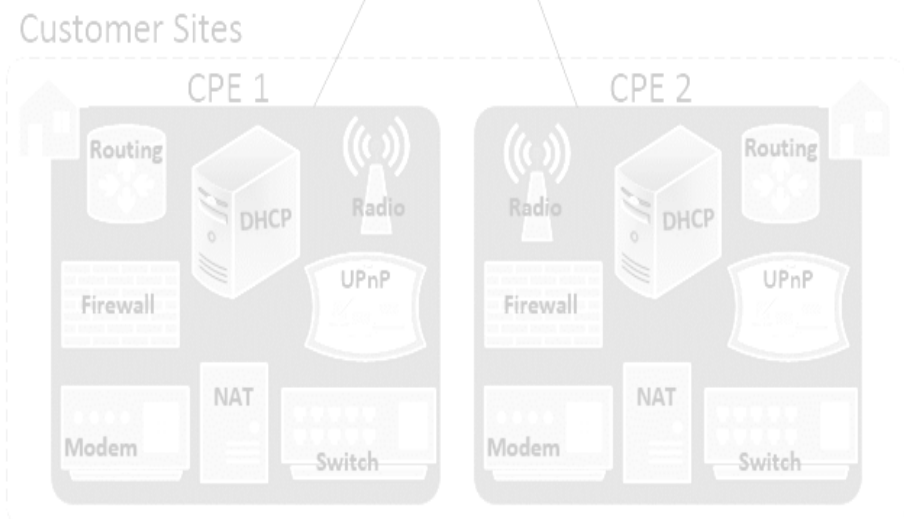- Hardware development large barrier to entry for new vendors, constraining innovation & competition.

Independent Software Vendors

Virtual Appliance
Virtual Appliance
Virtual Appliance
Virtual Appliance
Virtual Appliance
Virtual Appliance
Virtual Appliance

Orchestrated, automatic & remote install.

Standard High Volume Servers

Standard High Volume Storage

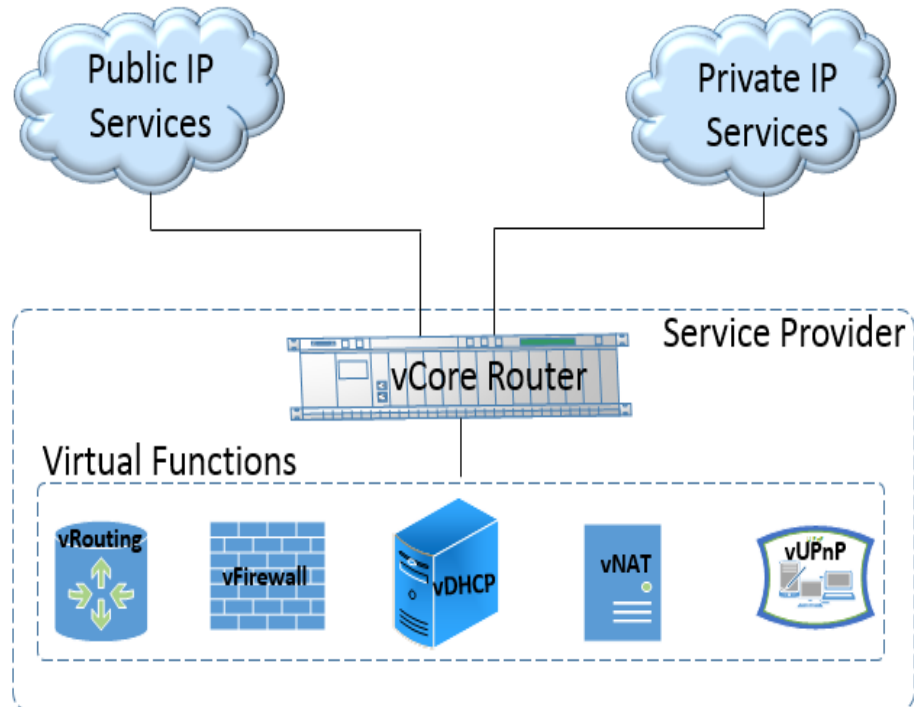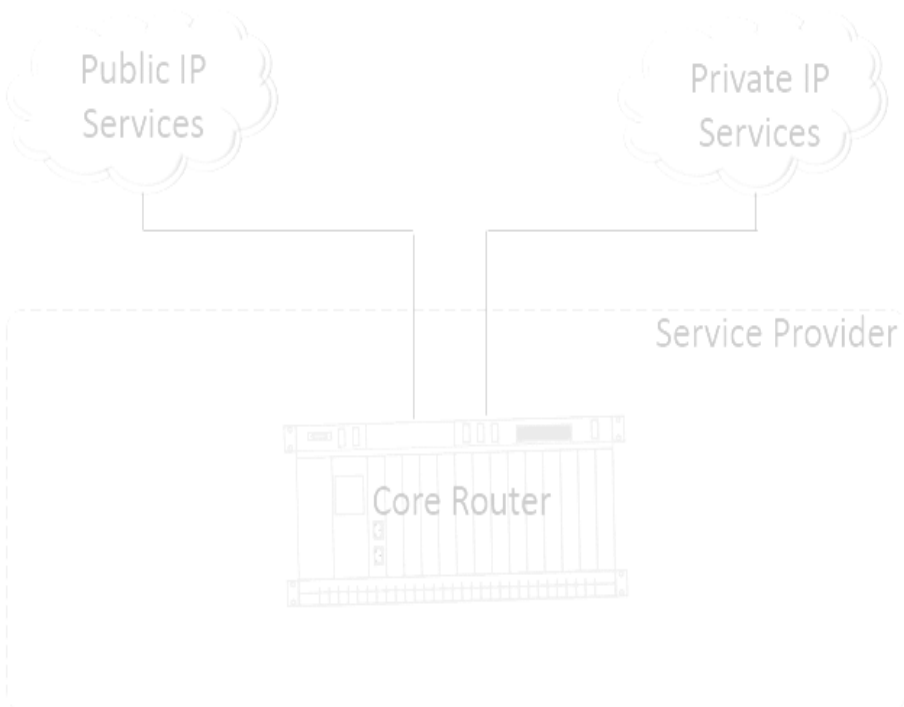Standard High Volume Ethernet Switches

NFV Concept
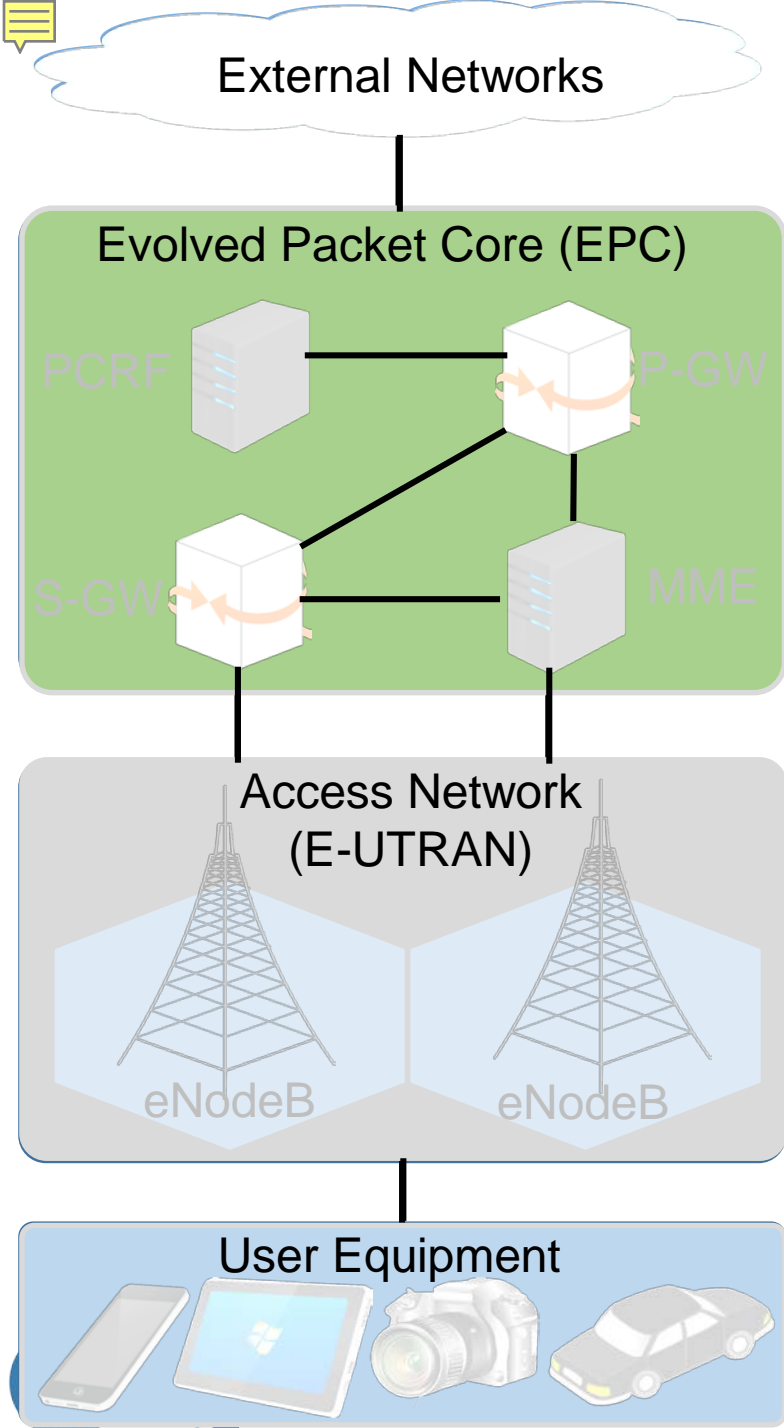
Anticipated Benefits

1 **Reduced capital expenses (CAPEX)**

- Due to economies of scale and more efficient use of resources (scale up/down),

2 **Reduced operation expenses (OPEX)**

- Power/energy, space, update/upgrade/maintenance

3 **Flexible, faster deployment, reducing time to market**

- Minimizing typical operator innovation cycle. Automated, standard deployment

Some examples: Customer Premises Equipment

External Networks

Evolved Packet Core (EPC)

PCRF

P-GW

S-GW

MME

Access Network (E-UTRAN)

eNodeB

eNodeB

User Equipment

External Networks

Data Centers

VNFs

P-GW

PCRF

MME

S-GW

Access Network (E-UTRAN)

eNodeB

eNodeB

User Equipment

Evolved Packet Core
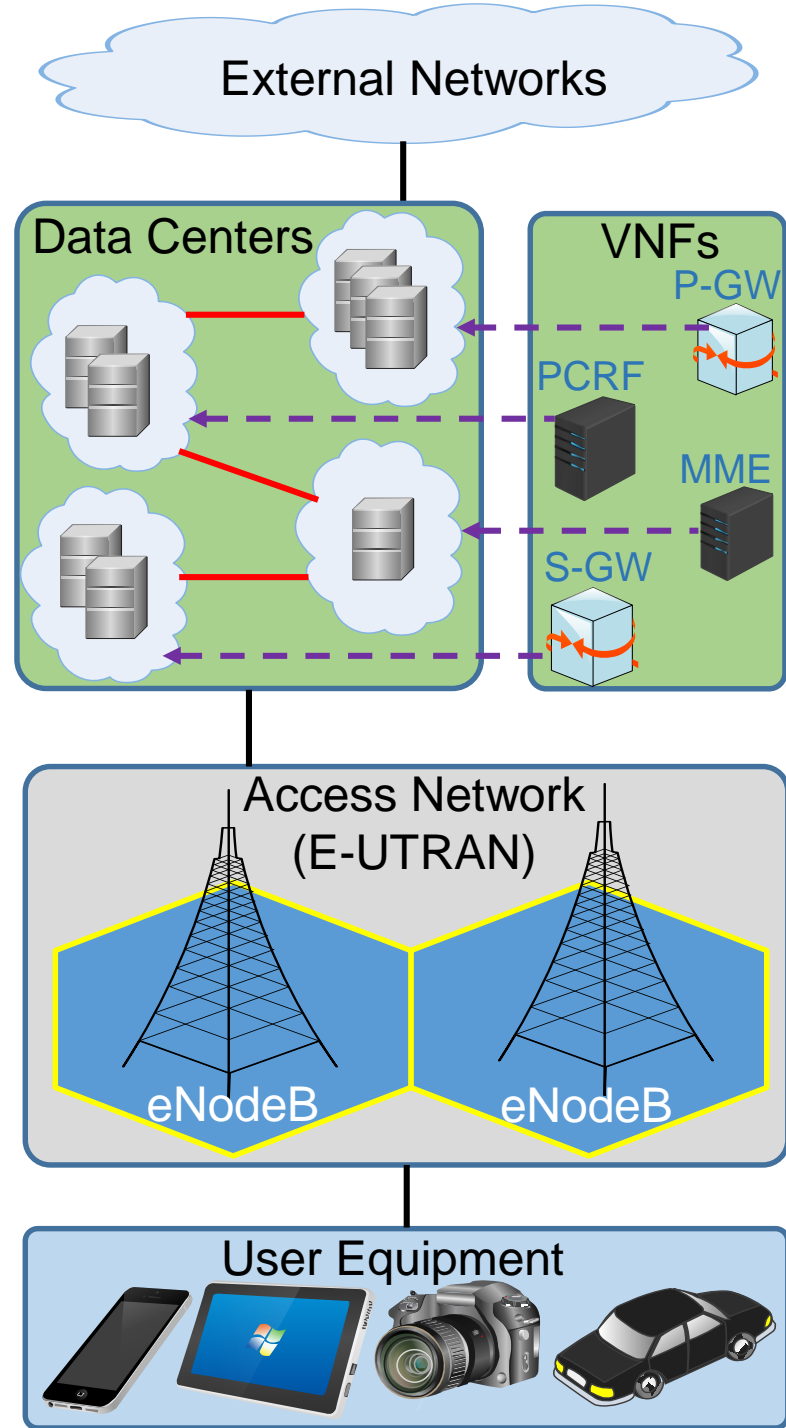
NFV Reference Architecture

2 Virtual Network Functions

VNF 1

VNF 2

VNF 3

. . .

VNF N

3 NFV Management & Orchestration (NFV MANO)

Network Function Virtualization Infrastructure

Virtual Resources

Computing, Storage, Network Resources

1

Physical Resources

Computing, Storage, Network Resources

Software Defined Networking

Network/Business Applications

Load Balancing — Routing . . . MAC Learning

Application Layer — APIs

Network Services

SDN Controller

Control Layer — Interface e.g. Openflow

Forwarding Switches

Infrastructure Layer

Distributed Control and Middleboxes
(e.g. Firewall, Intrusion Detection, etc.) in Traditional Networks
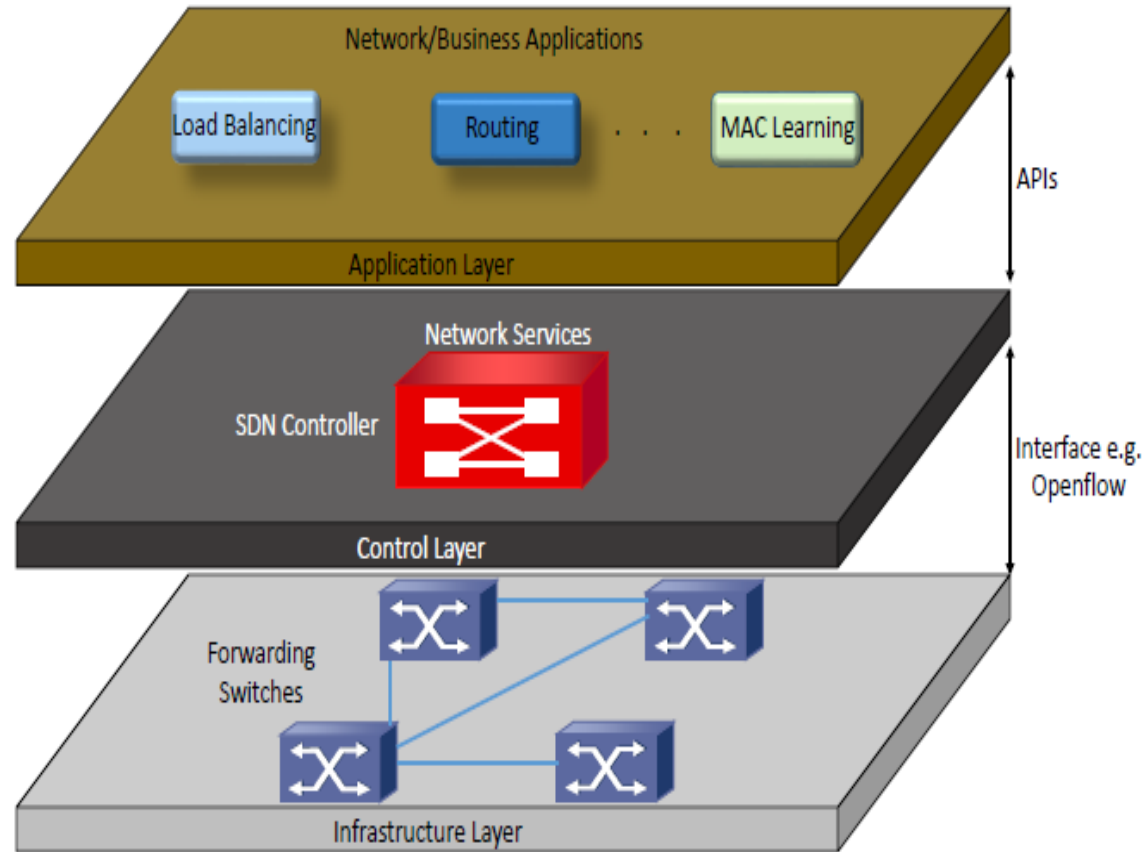
Logical Layers in a Software Defined Network

Relationship between SDN and NFV

Decouples functions from hardware to reduce network operator CAPEX and OPEX, and increase service agility

Decouples control plane from data plane to enable faster innovation, network flexibility and holistic management

Service/Function Abstraction

Networking Abstraction

Automation

Isolation

Agility

ETSI
World Class Standards

NFV

Mainly Telecom service providers

Multiple Control Protocols (e.g NETCONF, SNMP)

SDN

ONF
OPEN NETWORKING FOUNDATION

Mainly networking software and hardware vendors

OpenFlow de-facto standard

NFV and SDN are highly related and complimentary, combining them may lead to greater value. BUT they are **not** dependent on each other

State-of-the-art (1): Standardization Activities

Description	Focus Area	Description of NFV-Related Work
Industry-led ETSI Standards		NFV architectural framework, infrastructure description, MANO

❑ There is sufficient involvement of standards bodies in NFV activities.

❑ While many of them work in liaison with the ETSI, some of them such as ATIS and 3GPP SA5 have identified and are working on specific aspects of NFV that have not yet been sufficiently developed by the ETSI.

❑ What remains to be seen is whether the output in terms of standards will match with the speed at which vendors and TSPs propose NFV solutions.

| BB Forum | Industry-led consortium that develops broadband network specifications | NFV in Broadband Networks | Collaborating with the ETSI to achieve a consistent approach and common architecture for the infrastructure needed to support VNFs. |

State-of-the-art (2): Collaborative Projects

	Project Type	Leader and/or Funding	Focus Areas	Main Objective
ZOOM	Association of SPs	TM Forum	NFV	Enable more rapid deployment of services by automating the provisioning process and modernizing OSS/BSS models.
OPNFV	Collaborative Project	Linux Foundation	NFV	Build an open source reference platform to advance the evolution of NFV.
OpenMANO	Vendor Project	Telefonica	SDN, NFV	Implementation of ETSI's MANO framework.

❑ It is interesting to observe that all the three industrial projects (ZOOM, OPNFV and OpenMANO) are focused on MANO. This underlines the importance of MANO in NFV.

❑ MANO is a critical aspect towards ensuring the correct operation of the NFVI as well as the VNFs.

❑ Like the decoupled functions, NFV demands a shift from network management models that are device driven to those that are aware of the orchestration needs of networks with both legacy equipment and VNFs.

Functionality

Platform   Driving Standards

❑ Although NFV is gaining momentum, it is still an emerging technology and solutions based on final specifications, and widespread deployments for end-users may take a few years to appear.

❑ Many organizations/vendors/operators are investing in and are willing to test NFV-based solutions.

❑ It can be observed from these early implementations and platforms, that two aspects re-appear in a big number of them:
    (1) the high focus on open source, and
    (2) the ability of current SDN and cloud technologies to support NFV.

Overture vSE	activation and assurance, Decrease inventory and management costs, Optimize service flexibility, Eliminate trucks rolls	OSA [24], OpenStack

A lot of progress, yet many challenges and questions open for research . . .

❑ **Management and Orchestration**

Management of SDN
Inter-operability

❑ Performance

❑ Efficient resource allocation

❑ Energy efficiency

❑ Efficient Resource Allocation

❑ Architectural design

❑ Information and data modeling

❑ Standardization

References

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[2]   Rashid Mijumbi, Joan Serrat, Juan-Luis Gorricho, Niels Bouten, Filip De Turck, Steven Davy, "Design and Evaluation of Algorithms for Mapping and Scheduling of Virtual Network Functions", IEEE Conference on Network Softwarization (NetSoft). University College London. 13-17 April 2015

[3]   Rashid Mijumbi, Joan Serrat, Juan-Luis Gorricho, "Self-managed Resources in Network Virtualization Environments", IFIP/IEEE International Symposium on Integrated Network Management (IM), Ottawa Canada, May 2015. Dissertation Digest Paper.

[4]   Rashid Mijumbi, Joan Serrat, Juan-Luis Gorricho, Javier Rubio-Loyola and Steven Davy, "Server Placement and Assignment in Virtualized Radio Access Networks", IEEE/IFIP CNSM, International Workshop on Management of SDN and NFV Systems, Barcelona, Spain. Accepted September 2015