ETSI GS NFV-EVE 005 V1.1.1 (2015-12)

Network Functions Virtualisation (NFV);
Ecosystem;
Report on SDN Usage in NFV Architectural Framework

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Foreword

This Group Specification (GS) has been produced by ETSI Industry Specification Group (ISG) Network Functions Virtualisation (NFV).

Modal verbs terminology

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1 Scope

The present document identifies the most common design patterns for using SDN in an NFV architectural framework. It also identifies potential recommendations to be fulfilled by the entities that perform the integration.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI GS NFV-INF 005 (V1.1.1) - (12-2014): "Network Functions Virtualisation (NFV); Infrastructure; Network Domain".

[i.2] ETSI GS NFV-MAN 001 (V1.1.1) - (12-2014): "Network Functions Virtualisation (NFV); Management and Orchestration".

[i.3] ETSI GS NFV 002 (V1.2.1) - (12-2014): "Network Functions Virtualisation (NFV); Architectural Framework".

[i.4] ETSI GS NFV 003 (V1.2.1) - (12-2014): "Network Functions Virtualisation (NFV); Terminology for Main Concepts in NFV".

[i.5] ETSI GS NFV-SWA 001: "Network Functions Virtualisation (NFV); Virtual Network Functions Architecture".

[i.6] Open Networking Foundation TR-502: "SDN Architecture", Issue 1.0, June 2014.

[i.7] Metro Ethernet Forum (V1.1) (February 2012): "Carrier Ethernet for Delivery of Private Cloud Services".

[i.8] Recommendation ITU-T Y.3300 (06-2014): "Framework of software-defined networking".

[i.9] IETF SFC Architecture.

NOTE: Available at http://tools.ietf.org/pdf/draft-ietf-sfc-architecture-07.pdf.

[i.10] IETF Service Function Chain Extension Architecture.

NOTE: Available at https://tools.ietf.org/pdf/draft-gu-sfc-extend-architecture-00.pdf.

[i.11] IETF I2NSF Interface to Network Security Functions.

NOTE: Available at http://datatracker.ietf.org/doc/charter-ietf-i2nsf/.

[i.12] Floodlight®: http://www.projectfloodlight.org/floodlight/.

[i.13] OpenDaylight®: http://www.opendaylight.org/.

[i.14] OpenContrail: http://www.opencontrail.org/.

[i.15] ONOS®: http://onosproject.org/.

[i.16] Ryu: http://osrg.github.io/ryu/.

[i.17] Midonet®: https://www.midonet.org/.

[i.18] IETF RFC 5493 (April 2009): "Requirements for the Conversion between Permanent Connections and Switched Connections in a Generalized Multiprotocol Label Switching (GPMLS) Network".

NOTE: Available at https://tools.ietf.org/html/rfc5493.

[i.19] IETF RFC 6830 (January 2013): "The Locator/ID Separation Protocol (LISP)".

[i.20] IETF RFC 7285 (September 2014): "Application-Layer Traffic Optimization (ALTO) Protocol".

[i.21] IETF RFC 7348: "Virtual eXtensible Local Area Network (VXLAN): A Framework for Overlaying Virtualized Layer 2 Networks over Layer 3 Networks".

NOTE: Available at http://www.rfc-editor.org/rfc/rfc7348.txt.

[i.22] IETF RFC 7426 (January 2015): "Software-Defined Networking (SDN): Layers and Architecture Terminology".

NOTE: Avaiable at http://www.rfc-editor.org/rfc/rfc7426.txt.

[i.23] IETF RFC 7432: "BGP MPLS-Based Ethernet VPN".

NOTE: Avaiable at https://tools.ietf.org/rfc/rfc7432.txt.

[i.24] ONOS® Developer's Guide.

NOTE: Available at https://wiki.onosproject.org/display/ONOS/Developer's+Guide.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in ETSI GS NFV 003 [i.4] and the following apply:

Openflow: trademark from the Open Networking Foundation (ONF) for an SDN standard protocol which enables remote programming of the forwarding plane

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI GS NFV 003 [i.4] and the following apply:

DC	Data Center
EM	Element Manager
ETSI	European Telecommunications Standards Institute
FIB	Forwarding Information Base (OSI Layer 3 forwarding table)

HSDN	Hierarchical SDN
ISG	Industry Standards Group
ITU-T	International Telecommunication Union-Standardization Sector
LFIB	Label Forwarding Information Base (MPLS forwarding table)
MPLS	Multi-Protocol Label Switching
OAM	Operation and Management
NCT	Network Connectivity Topology
NE	Network Element
NFP	Network Forwarding Path
POP	Point of Presence
SDN	Software Defined Networks
SFC	Service Function Chaining
SP	Service Provider
VTN	Virtual Tenant Network

4 Overview of SDN in the NFV architectural framework

4.1 Introduction

ETSI ISG NFV has defined an NFV architectural framework operating on the basis of the principle of separating network functions from the hardware they run on by using virtual hardware abstraction. The major components in this framework are (From ETSI GS NFV 002 [i.3]):

- Network Functions Virtualisation Infrastructure (NFVI): subsystem which encompasses Compute, Network and Storage resources, i.e. the totality of all hardware and software components that build up the environment in which VNFs are deployed.
- Management and Orchestration (MANO): subsystem which includes the Network Functions Virtualisation Orchestrator (NFVO), the Virtualised Infrastructure Manager (VIM) and Virtual Network Function Manager (VNFM).
- Virtual Network Functions (VNFs): deployed in the NFVI.

The present document provides an overview of SDN in relation to this ETSI NFV architectural framework as well as a summary of current industry work including a comparison of network controllers and PoCs including NFV and SDN.

4.2 SDN scope

Recommendation ITU-T Y.3300 [i.8] defines SDN as 'a set of techniques that enables to directly program, orchestrate, control and manage network resources, which facilitates the design, delivery and operation of network services in a dynamic and scalable manner'. Although this broad definition translates in many different ways in terms of specifications and implementations, most SDN-labelled solutions relocates the control of network resources to dedicated network elements, namely SDN controllers and might be mapped to the 3-layers reference model depicted in figure 1.

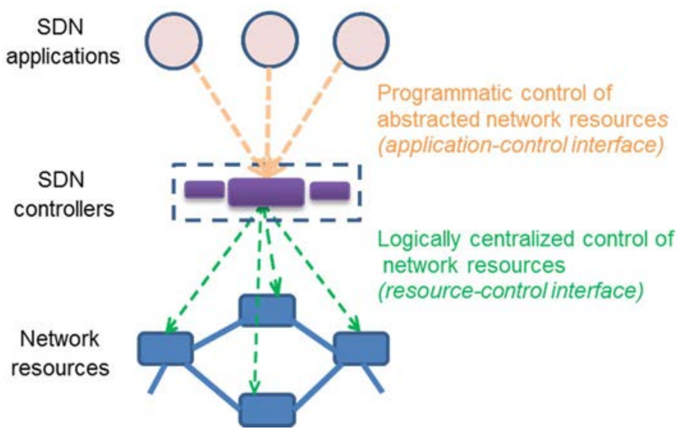

Figure 1: Concept of SDN (from Recommendation ITU-T Y. 3300 [i.8])

While there are other possible models, the present document focuses on the model described in figure 1.

Within the NFV architectural framework [i.3], SDN solutions might be used in the infrastructure domain, in the tenant domain or both.

When used in the infrastructure domain, the SDN controller acts as a Network Controller, as per ETSI GS NFV-MAN 001 [i.2]. In the present document SDN refers to software control of physical or virtual network resources that use standard interfaces (open APIs) to facilitate interoperability and evolution in a multi-vendor environment.

The SDN controller is not necessarily a stand-alone physical entity, e.g. a software component(s) of the VIM. Ideally, when the SDN technology is used in the infrastructure domain, the VIM, the SDN controller, and the Network Resources (physical or virtual) form a hierarchy for delivering connectivity services. In some cases, multiple SDN controllers form a hierarchy across management and resources, depending on the placement of the functionality. The SDN controller responsibility includes very specific control functions, interfacing with management agents responsible for control and management functions.

NOTE: SDN applications, SDN controllers and SDN resources come from one or different vendors, and are typically implemented in different VNF. The NFVO while on-boarding these VNFs would want to know that they are related and able to communicate with each other.

There is a large landscape of SDN architectures (NFV and non-NFV) and SDN controller functionality encompassing a variety of capabilities e.g. service negotiation, network element provisioning, and control of resources. This broader interpretation of SDN is beyond the scope of the present document.

4.3 SDN in the NFV architectural framework

4.3.1 General

As stated above, the focus of the present document lays on how network services and associated resources implemented, according to an SDN architecture, might be integrated with the NFV architectural framework by identifying possible design patterns and associated requirements. Many technical and non-technical issues need to be formulated and answered regarding all the functional entities that constitute this integrated architectural framework, such as:

- The position of the SDN resources.
- The position of the SDN controller.
- The softwarization & virtualisation of the various SDN entities.
- The interaction between the Element Managers, VNF Managers, SDN controllers and SDN applications that become enabled VNFs.
- The hierarchy of SDN networks.
- The position of the overlay SDN networks.
- Others.

4.3.2 SDN management plane

IETF RFC 7426 [i.22] discusses the distinction between control and management plane in an SDN environment. In brief the control plane is mostly responsible for making decisions on how packets are forwarded by one or more network resources and pushing such decisions down to the network resources for execution, whilst the management plane is mostly responsible for monitoring, configuring, and maintaining network devices, e.g. making decisions regarding the state of a network resources.

IETF RFC 7426 [i.22] also discusses the differentiation between these two planes by identifying their characteristics. It does so by showcasing four characteristics: (1) timescale, i.e. how often and how fast resources are configured and state persistence; (2) longevity of the state; (3) locality, i.e. centralized or distributed; (4) insights from the CAP theorem, e.g. the control plane is available, whilst the management plane is consistent.

Actually the CAP theorem (https://en.wikipedia.org/wiki/CAP_theorem) states that it is impossible for a distributed computer system to simultaneously provide consistency, availability and partition tolerance.

NOTE: The distinction between the control and management plane has become somewhat muddled due to the logical centralization of the control plane which is more of the domain of the management plane.

4.3.3 Position of SDN resources in an NFV architectural framework

The first entities to be considered are the SDN resources. Multiple scenarios might be envisaged for their actual location or for their images:

- Case a: physical switch or router
- Case b: virtual switch or router
- Case c: e-switch, software based SDN enabled switch in a server NIC
- Case d: switch or router as a VNF

In case d the resource might be logically part of the NFVI or belong to an independent tenant's domain. An example of case d is illustrated in NFV PoC#14 (clause B.5). This PoC has demonstrated the usage of SDN in an NFV environment by splitting the Service Gateway (SGW) and Packet Gateway (PGW) of the Long Term Evolution (LTE) architecture into a control and data plane for each, using an open interface, in this case IETF's ForCES. PoC#14 demonstrates that the data plane functionality might be deployed as VNF and controlled as a network resource.

Figure 2 shows the functional entities in the NFV architectural framework [i.3] for the scenarios identified above.

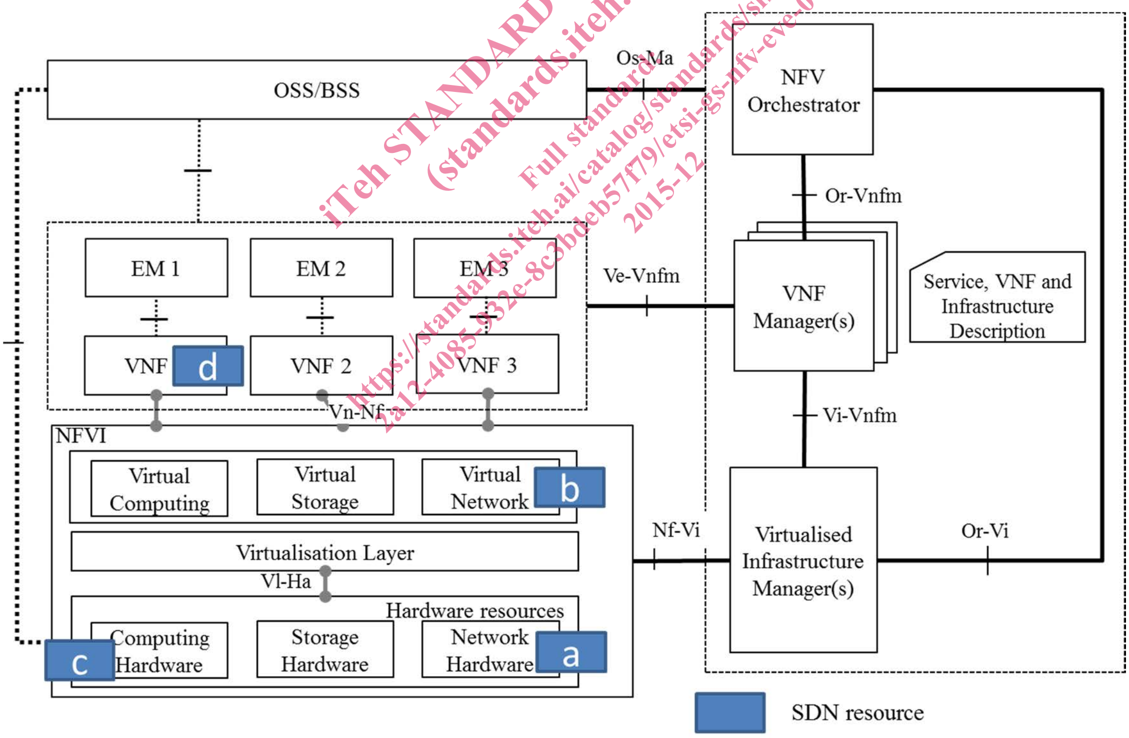

Figure 2: Possible SDN Resource Locations in the NFV Architectural Framework (adaptation from [i.3])

4.3.4 Position of the SDN controller in an NFV architectural framework

The second entity in this context is the SDN controller, which interfaces with SDN network resources via the Resource Control Interface. One SDN controller might interface with multiple SDN network resources.

Multiple scenarios exist to illustrate the possible locations of an SDN Controller in the context of an NFV framework:

- Case 1: the SDN controller is merged with the Virtualised Infrastructure Manager functionality.

- Case 2: the SDN controller is Virtualised as a VNF.
- Case 3: the SDN controller is part of the NFVI and is not a VNF.
- Case 4: the SDN controller is part of the OSS/BSS.
- Case 5: the SDN controller is a PNF.

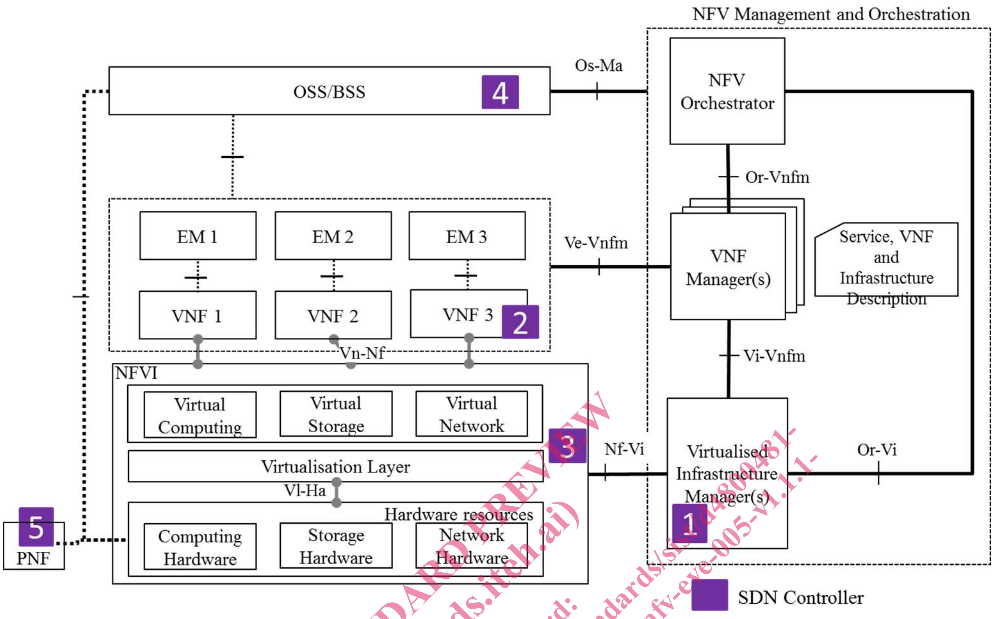

Figure 3: Possible SDN Controller Locations in the NFV Architectural Framework

Case 1: SDN controller functionality merged with the VIM functionality, in such case the two functions are not distinguishable.

Case 2: SDN controller as a VNF is typically the case of an SDN controller Virtualised as a VNF itself, or being part of a VNF. This VNF might be logically part of the NFVI and therefore belong to a special infrastructure tenant or belong to an independent tenant.

Case 3: SDN controller in the NFVI is a classic case of SDN controller for the network connectivity in the NFVI, where the SDN controller is not implemented as a VNF.

Case 4: SDN controller part of the OSS, is illustrated in clause 5.7, figures 27 and 28 as the tenant SDN controller.

Case 5: SDN controller as a PNF - while this case exists, it has not been studied in the rest of the present document.

4.3.5 Position of SDN applications in an NFV architectural framework

The third entity to be considered is the SDN application which interfaces with the SDN controller. An SDN application might interface with multiple SDN controllers. Multiple case scenarios might be envisioned, for the position of the SDN applications in the NFV architectural framework, such as:

- Case i: as part of a PNF
- Case ii: as part of the VIM
- Case iii: Virtualised as a VNF
- Case iv: as part of an EM
- Case v: as part of the OSS/BSS