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Network Function Virtualisation

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ABSTRACT
This paper is written to give basic knowledge of Network function virtualisation in network system. In this paper the work on NFV done till now has been collaborated. It describes how the challenges faced by industry lead to NFV and what is meaning of NFV and NFV architecture model. It also explains NFV Infrastructure is managed and the forwarding path on which packets traverse in NFV. A relationship of NFV with SDN and current research ongoing on NFV policies is discussed.
Index Terms: NFV, SDN, Communications

I. INTRODUCTION

A. Motivation

Over the past decades the communication networks are growing at a rapid pace but to launch a new network service we require money to buy hardware, power to run them and space to keep these machines. These hardware reach to end of life early without much usage, this reduces innovation and revenue made by networking. NFV addresses this problem by using virtualization technology in servers, switches and storages [1]. It changes the network architecture by transferring hardware network functions to a software. By this way it reduces cost for equipment and power required to run it. NFV is portable on any data plane and control plane in fixed or mobile infrastructure [2]. More over NFV gives targeted service, based on different geography we can scale it up or down. This paper is divided into 6 sections. The first section describes how the challenges faced by industry lead to NFV and what is meaning of NFV. In second section NFV architecture model is defined. Third section talks about how NFV Infrastructure is managed and the forwarding path on which packets traverse in NFV. In fourth section mentions relationship of NFV with SDN, Further fifth section talks about use cases of NFV. In last section, we tell what current research ongoing on NFV policies is and work done till now.

B. Definition of NFV

”Network Functions Virtualization, or NFV, is a network architecture philosophy that utilizes virtualization technologies to manage core networking functions via software as opposed to having to rely on hardware to handle these functions” [2]. These functions imitate host functions and run on virtual machines. The NFV concept is based on building blocks of virtualized network functions, or VNFs, that can be combined to create full-scale networking communication services. NFV is designed to consolidate and deliver the networking components needed to support a fully virtualised infrastructure- including virtual infrastructure, servers, storage, and even other networks. It utilizes standard IT virtualisation technologies that run on high-volume service, switch and storage hardware to virtualise network functions. NFV is applicable to any data plane processing or control plane function in both wired and wireless network infrastructures.

C. Literature Review

Network Functions Virtualisation Industry specification group was founded under the European telecommunication standard institute. It is global organisation which gives open environment to progress this work. It is a platform to address the problems for NFV implementation and to encourage the growth of open ecosystem [3]. ETSI has made excellent progress and developed high level reference documents like NFV infrastructure, architecture, and use cases and NFV white papers. These documents give the information about ongoing progress on NFV and guides industry. SDX central has resources which gives information on NFV [4]. It says NFV offers a new way to design, deploy and manage networking services. It decouples network functions like network address translation, firewall, and intrusion detection from hardware appliances so that these functions can run on software. Alcatel-lucent offers complete NFV architecture that has NFV platform built to address demands of service providers and gives SDN technology that supports network automation and abstraction. TechTarget provides the sources for NFV, how it simplifies network chain provisioning, SDN and NFV relationship and various NFV strategies for mobile vendors [5].

II. NFV ARCHITECTURE

Virtual network functions run on a framework called Network Function Virtualisation Infrastructure. It includes diverse physical resources and how can they be virtualised [6].NFV architecture includes the functionality which is required to virtualise the network functions , then to run these functions on NFVI and manage them using NFV specific management and orchestration.

A. Virtualisation

Every network function is defined in form of functional block. It is implemented by configuring the host functional block. The interaction between these blocks is called interface. The functional block contains host function and Virtualised network function. The interface between two network function is divided.VNF is dependent on host function fig II.1. Specification of functional blocks include a transfer function which is a predefined transition matrix which mapped a specific tuple of input and current state to a specific value of next state and output. The functional block includes host private state, configured state and virtual dynamic state. These states allows virtual function to be defined in functional block.VNF is an abstract view of the host function. This configured VNF then can be installed on different VMs to perform virtual functions.

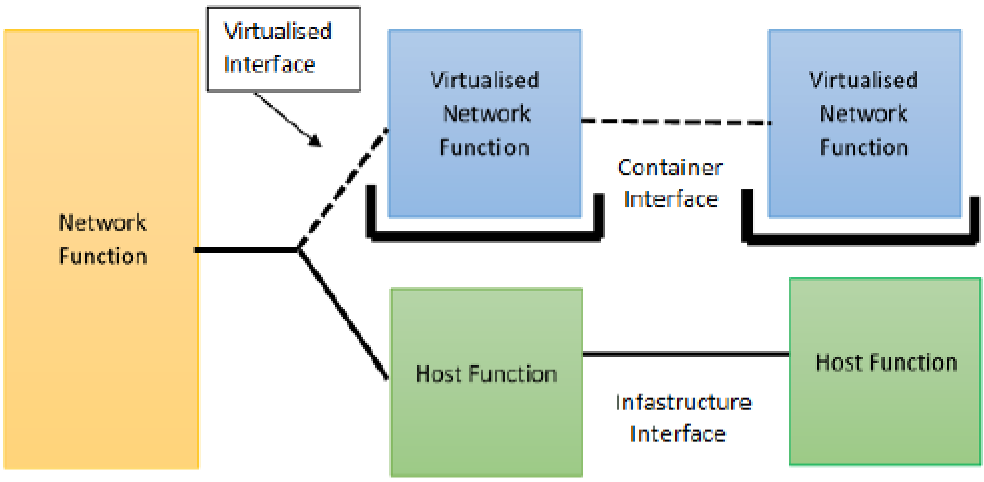

Fig. II.1. Virtualisation [6].

B. NFV Infrastructure

"NFV architectural framework includes functional blocks and reference points in NFV framework" [7]. NFVI is total hardware and software component on which VNFs can be deployed, managed and executed [7]. This infrastructure can span around the locations by using NFVI-Pops. The network connectivity between these locations are part of NFV infrastructure. The owner decides which functions should be virtualised. Physical hardware resources include computing, storage and network that provide processing, storage and connectivity to virtual network functions through virtualisation layer. A software called hypervisor is installed on these physical resources which creates them as virtual machines. This creates virtualisation layer on which virtual network functions are executed. In order to manage the complexity and scalability of infrastructure it NFVI is partitioned into three separate domains. The interfaces between them are reasonable. NFVI supports continued open supply between these domains. Three primary domains are as follows:

1) Compute Domain: It consists of high volume storages and servers. It provides the COTS computational and storage. It reduces the hardware equipment cost and reduce power consumption. Storage in compute includes CPU register, CPU cache, volatile RAM and non-volatile block storage [8]. In this domain processor instruction set is executed by compute node which is a functional entity capable of executing instruction set in such a way that execution time is less. It accelerate packet forwarding, switching and encryption.

2) Hypervisor Domain: It mediates the computer resources to the virtual machines. It can emulate every single piece of hardware. For example it emulates CPU such that CPU instruction set believes that it is running on completely different CPU. Sometimes there can be performance hit in these cases. To improve this CPU core is exclusively allocated to VMs, direct memory mapped polled drivers are used for VMs and v Switch is implemented to provide connectivity between VMs [9]. NFV hypervisor architecture is used to improve performance and provide orchestration and management.

3) Infrastructure Network Domain: It consists of Consists of high volume switches interconnected into a network which can be configured to supply infrastructure network services. It provides communication channel between different VNFs, VNF and orchestration and management and components of NFVI [10]. It also gives mean to remotely deploy VNFCs. It basically gives connectivity services. It will provide addressing scheme and help in bandwidth allocation process. Figure II.2 illustrates the application of principle domains to NFV and how particularly it works in NFVI. The three domains are maintained as separate domain in NFVI. Management and orchestration functions are hosted in NFVI as VMs and are placed on container interface. In figure 2.2 Container interfaces 1 are provided by VNFI to host VNFs. VNF interconnect interfaces 2 connect Virtual network functions with each other. VNF Management and Orchestration Interface 3 connects VNF to management services. Interface between existing networks 4 and infrastructure domain is lower layers of protocol.

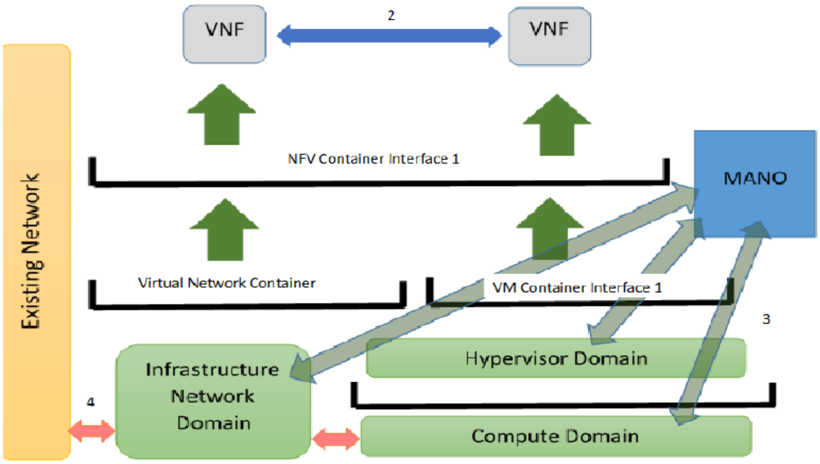

Fig. II.2. NFV Infrastructure with it's domains [7].

III. NFV SERVICE CHAIN AND MANO

A. Service chain

A Service chain is made up of network services like application delivery controller, firewalls. These services are interconnected to support an application. Service chain can made shorter and simpler when implemented with SDN and NFV. In the past, building a service chain to support a new application took a great deal of time and effort. It meant acquiring network devices and cabling them together in the required sequence. Each service required a specialized hardware device, and each device had to be individually configured with its own command syntax."The chance for error was high, and a problem in one component could disrupt the entire network" [11]. however two recent development SDN and NFV, now enable network managers to quickly and inexpensively create, modify and remove service chains

B. NFV Management and Orchestration

NFV orchestration has unique requirements based on the need to automate the highly dynamic delivery of virtualized network services based on service intent, compared to traditional orchestration for services on physical appliances. The requirements for NFV orchestration include rapid configuration, provisioning, and chaining of virtual network functions in addition to other resources required for the service [12]. The ability to chain VNFs together is an important and differentiating feature to create innovative and customized services. Second, intelligent service placement, Selection of an optimal physical location and platform on which to place the virtual network functions, depending on various business and network parameters such as cost, performance, and user experience, is a benefit. A Virtual network function can be placed on various devices in the network e.g. in a data center, network node, or on the customer premises. Third, dynamic scaling that involves the orchestration process maps the instantiation of virtual network functions against real-time demand. The capability of dynamically scaling, frees up physical capacity to be used for other services. Service providers use their infrastructure more efficiently. They can also achieve a more optimized return on investment by deploying additional network services without additional equipment costs.

Lastly, full lifecycle management of the VNFs: This management includes the creation, instantiation, and monitoring of the VNF until it is decommissioned. Their are certain management challenges associated with the decoupling of a VNF from the hardware resources. ”Such challenges include allocating and scaling hardware resources to VNFs, keeping track of VNF instances location, etc. such decoupling also presents challenges in determining faults and correlating them for recovery over the network. In order to perform its task, the NFV management and orchestration should work with existing management systems such as OSS/BSS, hardware resourcemanagement system” [13]. NFV Infrastructure include compute: that has host or bare metal machines, virtual Machines as resources that comprises CPU and Memory. It also include volumes of storage at file system level . Networking component include Ports, addresses and forwarding rules, that ensures intra- and inter- VNF connectivity. ”Aspects of VNF include traditional FCAPS that is Fault management, configuration, accounting, performance and security It Instantiates network service by creating a network service using NS on-board artefacts. It creates, deletes, query, and update of VNF forwarding graphs associated to Network Service and terminate them. Other Management and orchestration aspects include Fault and performance management, Policy Management, Testing aspects of Network Services. MANO that is, Management and orchestration function that manages the overall functionality of virtual network functions includes NFV Orchestrator (NFVO),VNF Manager (VNFM),Virtualized Infrastructure Manager (VIM), and a group of repositories .The traditional Element Management (EM) and OSS/BSS. The latter two blocks are not directly part of the MANO, they exchange information with MANO [13].

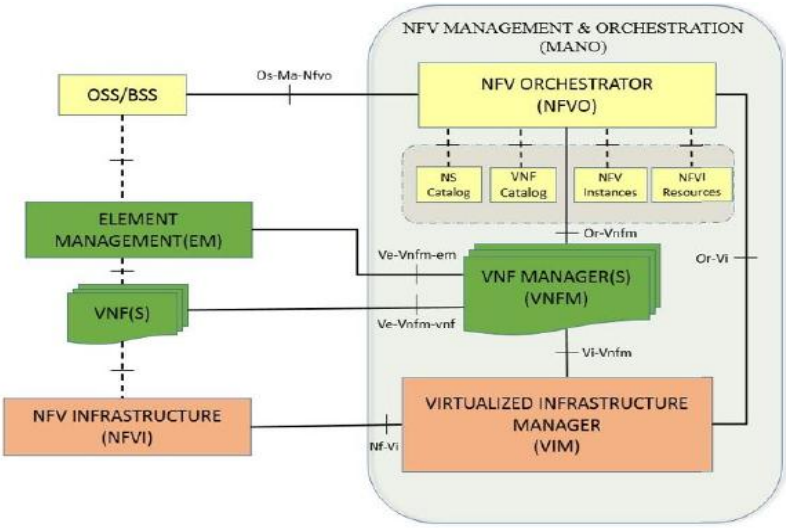

Fig. III.1. VNF Management and Orchestration [13].

1) NFV Orchestrator (NFVO): The NFV Orchestrator has major responsibilities of Orchestrating the NFV infrastructure(NFVI) resources across multiple VIMs, fulfilling the resource Orchestration. Secondly, lifecycle management of network services thus fulfilling the network service orchestration functions. Resource orchestration:NFVO coordinates, authorizes, releases and engages NFVI resources among different PoPs (point of presence) or within one PoP. It engages with the VIMs directly through their north bound APIs instead of engaging with the NFVI resources, directly. Resource orchestration function of the NFVO is responsible for global view of the network characteristics of the various logical links. Service Orchestration: Service Orchestration overcomes the challenge of creation of an end to end service among different virtual network functions. It coordinates with the respective VNFMs so it does not need to talk to VNFs directly. E.g. would be creating a service between the base station VNFs of one vendor and core node VNFs of another vendor. Service Orchestration can instantiate VNFMs on requirement. It does the topology management of the network services instances (VNF Forwarding Graphs) i.e. creation, updation, query, and deletion of VNF Forwarding Graphs. NFVO acts like a glue in NFV that binds together different network functions and creates an end to end service and resource coordination in an otherwise dispersed NFV environment.

2) Virtualised Network function manager-VNFM(s): VNF manager is responsible for lifecycle management of VNF instances of instantiation, updation, scaling, and termination. A VNF Manager can assigned the management of a particular VNF instance, or also management of multiple VNF instances. Most of the VNF Manager functions are assumed to be common functions applicable to any type of VNF but other functionalities also includes VNF instantiation, of VNF configuration if required by the VNF deployment template.VNF instance software updating or upgradation, VNF instance modification, like scaling up/down of virtual instance. Coordination of VIM and the Element manager is responsibility of VNFM. A VNF Manager maintains overall coordination and adaptation for event reporting.

3) Virtualised infrastructure manager (VIM): VIM manages NFVI resources in one domain that is there may be multiple VIMs in an NFV architecture, each managing its respective NFV Infrastructure (NFVI) domain. NFVI is the NFV Infrastructure that includes physical (server, storage etc.), virtual resources (Virtual Machines) and software resources (hypervisor) in an NFV environment). A VIM may handle different types of NFVI resource like compute, storage and network, or may be capable of managing multiple types of NFV Infrastructures like storage, networking resources etc.VIM is responsible for Orchestrating the allocation, upgradation, release of NFVI resources. It manages life cycle of virtual resources in an NFVI domain. That is, it creates, maintains and tears down virtual machines (VMs) from physical resources in an NFVI domain. It keeps north bound APIs and thus exposes physical and virtual resources to other management systems. It also provides northbound interface to the higher layers like NFVO and VNF Manager. Virtual Infrastructure manager is responsible for the inventory information and management of NFVI hardware resources like compute, storage and software resources e.g. hypervisors. From NFVs point of view, VIM comprises the functionalities that controls and manages the network function with computing, storage and network resources and their virtualisation.

4) Repositories: Repositories are like files or lists that holds different information in NFV MANO. There are four types of repositories VNF Catalog is a catalog of all usable VNF descriptors. "A VNF Descriptor (VNFD) is a deployment template which describes a VNF in terms of its deployment and operational behavior requirements. It is primarily used by VNFM in the process of VNF instantiation and lifecycle management of a VNF instance. The information provided in the VNFD is used by the NFVO to manage and orchestrate Network Services and virtualized resources on NFVI" [13]. Network Services (NS) Catalog of the usable Network services services. A deployment template for a network service in terms of VNFs and description of their connectivity through virtual links is stored in NS Catalog for future use. NFV Instances list holds all details about Network Services instances and related VNF Instances. NFVI Resources repository holds list of NFVI resources utilized for the purpose of establishing NFV services. The Element manager and OSS management systems are not part of NFV MANO but they exchange information with NFVO MANO functional Blocks. Element Management (EM is available, if it needs to coordinate with VNFM. it is responsible for the FCAPS (Fault, Configuration, Accounting, Performance and Security management) of VNF. VNFM does the same job, but EM does it through proprietary interface with the VNF in contrast to VNFM. EM exchanges information with VNFM through open reference point (Ve-Vnfm-em). OSS/BSS include collection of systems-applications that a service provider uses to operate its business. The existing OSS/BBS, however, can value add the NFV MANO by offering additional functions if, are not supported by a certain implementation of NFV MANO. It is done via an open reference point (Or-Ma-NFVO) between NFV MANO and OSS-BSS.

C. VNF Instantiation flow

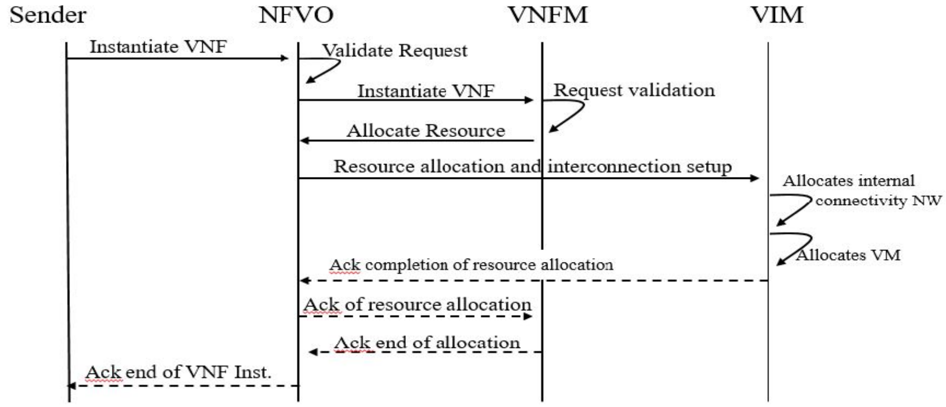

Fig. III.2. Instantiation flow [13].

Figure III.2 provides a high level picture of a VNF instance instantiation request by an application. ”NFVO receives a request to instantiate a new VNF. This request might come from an OSS, commissioning of a new VNF or part of an order for a Network Service instantiation, or might come from the VNF Manager when the need to instantiate a new VNF is detected by the VNF Manager itself or by the EM. Thus the Sender in the diagram can be the OSS or an application. NFVO receives a request to instantiate a new VNF using VNF lifecycle management interface. it validates the request and calls VNF manager to instantiate the VNF. The VNF Manager validates the requests and processes it further requesting NFVO for resource allocation. NFVO requests allocation of resources to the VIM, needed for virtualization deployment. VIM allocates the internal connectivity network and allocates the needed VMs and storage resources and attaches instantiated VMs to internal connectivity network. Acknowledgement of completion of resource allocation is sent back to NFVO. NFVO then acknowledges the completion of resource allocation back to VNF manager”[13]. The NFVO acknowledges the completion of VNF instantiation.

IV. RELATIONSHIP OF SDN AND NFV

As shown in figure IV.1, NFV is highly complementary to SDN, but not dependent on it (or vice-versa). Virtualisation of Network functions can be implemented without SDN being required, although the two concepts and solutions can be combined Network Functions [14]. Virtualisation goals can be achieved using non-SDN mechanisms, relying on the techniques currently in use in many datacentres. But approaches relying on the separation of the control and data forwarding planes as proposed by SDN can enhance performance, simplifying compatibility with existing deployments, and facilitating operation and maintenance procedures. NFV can support infrastructure on which SDN software can run.

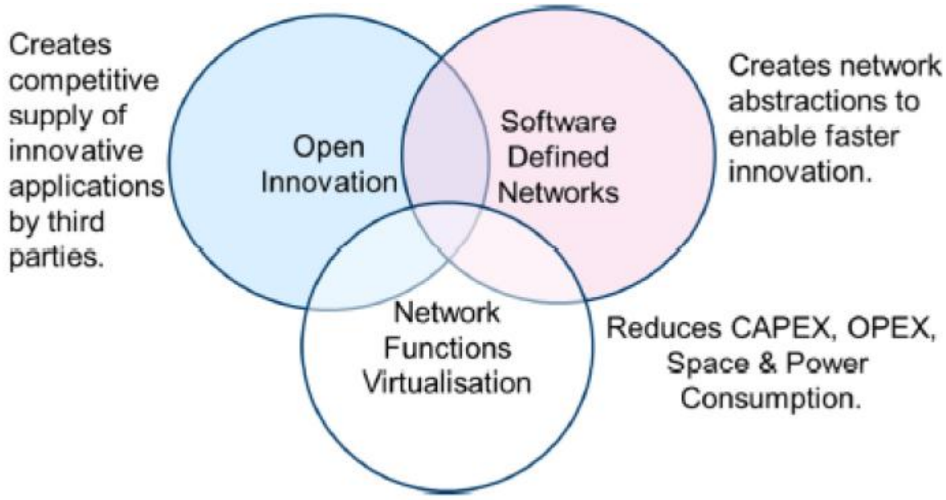

Fig. IV.1. Relashionship of SDN, NFV and Open Inovation [14]

A. Collaborating SDN and NFV

ESTI gives out some ways by which NFV and SDN can complement each other. According to them SDN controller resembles NFV controller. SDN help in orchestration of NFV resources by providing functions like provisioning, configuration of network connectivity, bandwidth allocation, automation of operations, monitoring, security, and policy control. SDN controller can implement forwarding graphs by providing automatic provisioning of service chain and ensure security [15]. SDN controller overall can run as virtual network function and become a part of service chain for example all services and application of SDN controller can be virtualised and implemented as a separate VNF.

B. Joint Deployment

Open Networking foundation purposes a model for jointly deploying multiple SDN and NFV domains which requires explicit SDN-NFV domain manager. SDN needs to know functionality of available VNF and how to connect them to data plane services and access them for control. Some parts of NFVI may be dedicated to NFV domain while other may

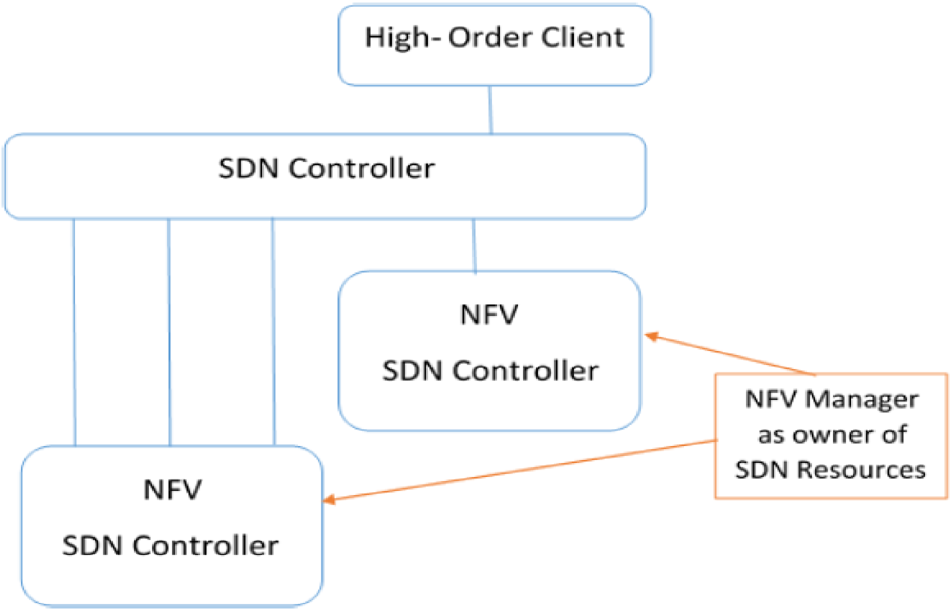

Fig. IV.2. Deploying SDN and NFV Controllers [15].

be particularly for SDN. NFV and SDN must coordinate their claim to shared resources or dynamically on packet by packet basis. Figure IV.2 illustrates how this might work. SDN controllers may be both servers and clients to NFV domain [16]. At the top of the figure, high order clients request network services from SDN controller. SDN controller satisfies this service request by provisioning service-specific attributes into its available resources for example NFV network services. SDN controller can and should invoke operations from the NFV discipline to create or scale the necessary resources. In this figure resource request push through the SDN do-main. It is equally possible these requests can be set to NFV manager at first and it instantiate VNFs which invokes SDN controller.

V. USE CASES NFV

aims to transfer the way how network operator architects network and virtualise network functions and nodes. It can be used in service models and applied to meet few challenges of network. NFV gives the way of rapid innovation through software-based deployment and operational network functions.The following are use cases of NFV as given by ETSI [17].

Use case	**Description**
NFV IaaS *(Infrastructure as a Service)*	Computing, Storage and network as a Service for end users
NFV SaaS *(Virtual Network function as a Service)*	Software as a service for end users
NFV PaaS *(Virtual network platform as a Service)*	Platform as a service for end users
Virtual Network Forwarding	NFV internetworking: defining the logical connectivity paths between virtual appliances
Virtualization of Mobile Base Station	Baseband radio processing using IT virtualization techniques for signal processing capacity aggregation and centralization
Virtualization of Home Environment	Replacement of customer premises set-top boxes with virtual services in a network
Virtualization of CDNs	Replace content delivery network nodes a virtual appliances on operator infrastructure
Fixed Access Network function Virtualization	Applying virtualization to reduce the complexity of access nodes, links and network services

Fig. V.1. Use Cases of NFV [17].

A. Use Case1: NFV IaaS

NFV infrastructure as service functions similarly as cloud Iaas does. It can orchestrate virtual functions that compose virtual and physical network and performs storage and compute functionality. NFV IaaS is built on ETSI NFV standard interfaces unlike traditional IaaS. NFV IaaS would also compose of an information model and network and network services interfaces that will allow NFV Infrastructure to span the administrative domains of multiple service providers.

B. Use Case2: Virtual CPE

Internet service providers spend huge sum of money to procure and install consumer premises equipments or access point routers. NFV allows ISP to replace existing proprietary CPE with a virtualization platform running on commercial of the shelf servers that can be configured from a central console and that can dynamically add and run new services. Onpremises virtual access points will increase new sales opportunities in competition to market competitors and will drastically reduce capital and operational expenditure. NFV management and orchestration gives the ability for CPE platform to run and manage multiple number of virtual network functions. However, accessing VNFs remotely would require significant bandwidth and in densely populated residential areas would require massive processing power and need for development of methodology in which multiple VNFs could share a single virtual machine.

C. Use Case3: VNPaaS

”The Service provider can make available a suite of infrastructure and applications as a platform on which the Enterprise can deploy their network applications” [17]. In this form consumer deploy his own application using this platform. It controls this deployed application not underlining network. VNFPaas provides a large scale service to enterprise for examples it gives away whole virtual network. It gives capability to consumer to make their own VNF instances. Services like firewall or a whole business communication can be deployed on these virtual platforms. Basically service provider will give out capabilities which gives ability to instantiate, configure selected VFN and develop applications on virtual machines.

D. Use Case4: VNF Forwarding Graph

VNF forwarding graph provides logical connectivity between virtual appliances. VNF FG can also interconnect with physical network functions to provide network service. These forwarding graphs provides efficiency, Resiliency and Flexibility when used to connect physical appliances. Figure V.2 gives example of VNF FG that service provider can use. In this example, a network service is established between two physical network function that has VNF. In network services, many packets traverse through VNF FG. Logical VNF FG maps physical elements and their relationships. The service provided will be able to judge the expected nature of endend services and then understand effect of abstract network functions in physical infrastructure.

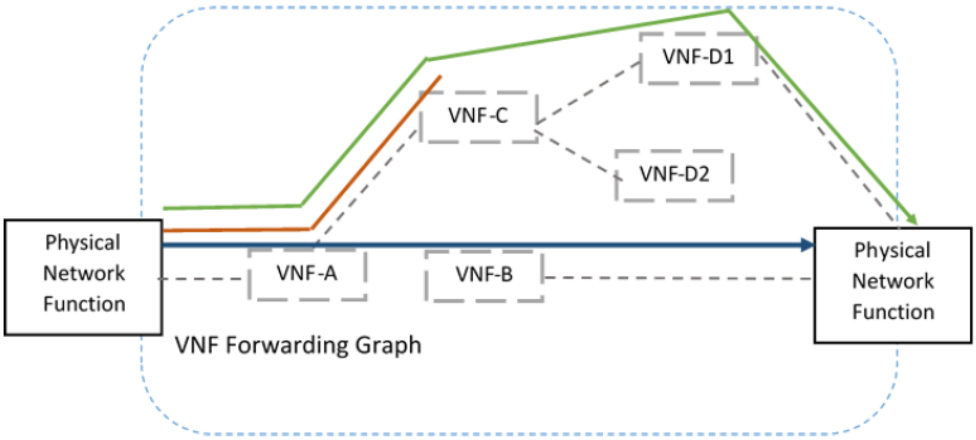

Fig. V.2. Deployemnt of different Forwarding graphs by service provide [17].

E. Use Case5: Virtualisation of Mobile Core Network

Mobile networks uses many hardware appliances. Network function virtualisation aims at reducing cost of these hardware, complexity and increasing network operational efficiency. By virtualisation, network topology can be changed to optimise performances and increase elasticity of network. Evolved Packet Core of cellular network architecture has network functions like MME,S/P-GW. This use case aims at virtualising EPC, IP Multimedia subsystem, HSS , PRF etc. VNFs can be scaled independently based on requirements.

F. Use Case6: Virtualisation of Mobile Base Station

Mobile network traffic is significantly increasing. In this scenario radio access part of Evolved packet system has to fulfil requirements of high peak data rate, ensure short round trip frequency flexibility in radio access network. RAN nodes in mobile network significantly accounts for operational cost and energy consumption. Virtualising mobile base station will transfer functions of RAN on servers and switches which in return will lead to dynamic resource allocation by sharing multiple logical RAN nodes and traffic load balancing. This will reduce power consumption.

G. Use Case7: Virtualisation of home environment

NFV approach can be considered in home environment. Currently CPE devices are provided in house by service provider. These include residential gateways, VOIP services and Setup box. NFV technology facilitates virtualisation of all these home devices to NFV cloud. It will make virtualised replica of original device for example vRGW, vSTB etc. This in return will reduce cost of equipment, eliminate the work of maintaining CPE and improve quality of experience.

H. Use Case8: Virtualization of CDNs

Delivery of the content especially video has become a major challenge today. On another hand requirement of improving quality of video is required too. Content delivery networks are used to manage the video services and to address traffic. CDN is combination of CDN controller and cache nodes. Usually CDN cache nodes are dedicated physical appliances. This leads to disruption in services at peak hours or wastage of some resources during non-peak time hence reduction in resiliency of CDN. Deploying CDN cache nodes as virtual appliances on standardised appliances will overcome most of the challenges like dynamic allocation of resources, operational process of resources can be harmonised and as appliances these software can be replaced easily.

I. Use Case9: Fixed Access Network Functions Virtualisation

Access network functions are the one that add to network operational cost. These functions like FTTcab/VDSL2 and and FTTdp/G which electronic systems to be deployed in remote nodes located in the street or in multiple-occupancy buildings. These equipment must be efficient and consume less power. However if access network functions are virtualised the complexity can be reduced and low power stand by modes can be used. Virtualization can also support militancy, improve deployment economies and reduce overall energy consumption.

VI. CURRENT WORK AND FUTURE SCOPE

Over the past decades, the scale of communications networks has been growing rapidly with the emergence of more and more network based services. However, network operators are experiencing a decline in profitability. Responding to such a challenge and paradox, the concept of network function virtualization (NFV) has been introduced with the aim of efficiently enabling network based services by deploying standardized and programmable hardware systems and by virtualizing network functions with software.

A. Current Scenario of NFV

”Compared to the current approaches to network and service deployment, which are based on a large variety of propriety equipment, NFV opens up many opportunities to the telecommunications industry. By reducing the cost of equipment and increasing the revenue with virtualized services, NFV has the potential to revolutionize the entire telecommunication industry” [18]. Despite the potential of NFV, there are many challenging issues to be addressed like how to design the network equipment with programmability to efficiently enable services; How to manage and orchestrate NFV-based systems; what is the trade-off between system performance and equipment cost?To understand and solve these problems, there is attempt for research and development on NFV, from both academia and industry.

1) Research on NFV policies: In the paper ’High Performance Evolved Packet Core Signaling and Bearer Processing on General Purpose Processors’, [19] the authors demonstrate the performance of an NFV system using general purpose X86 processors. In their study, they develop a prototype for the evolved packet core (EPC), which is a key component of Long Term Evolution (LTE) systems. Experiment results show that, with a certain number of processors, the NFV prototype can handle control and data traffic from 50,000 subscribers, with 10Gbps downlink traffic and 4.8Gbps uplink traffic. To enhance the performance of virtual network functions (VNFs) in the NFV infrastructure (NFVI), hardware acceleration (HWA) can be applied. In Uniform Handling and Abstraction of NFV Hardware Accelerators, [20]the authors investigate this topic. Specifically, the authors explain the background of HWA and the performance requirements of NFV. Paper also elaborates on more details of HWA for NFV, including some proof-of-concept (PoC) demonstrations for both network intensive acceleration and computing intensive acceleration.

2) Policies for integrating SDN and NFV: NFV and software-defined networks (SDN) are closely related as well as emerging technologies, and hence the integration of SDN and NFV is attracting significant attention. An Open Service Chain as a Service Platform towards the Integration of SDN and NFV [21], the authors consider that service chain policy is important to service providers, so they propose a service platform for integration of SDN and NFV. In this platform, the service chain can be realized as a service; SDN is used to improve the flexibility; NFV is applied to enhance the adaptability; and encapsulating the service chain can help guarantee scalability. Recently, with the successful deployment and operation of the fourth-generation (4G) cellular system, the fifth-generation (5G) cellular system has become a hot topic. As a result, researchers are interested in integrating NFV into the design of 5G. In Integrating Network Function Virtualization with SDR and SDN for 4G/5G Networks [22] the authors propose to integrate NFV with SDN, as well as software-defined radio (SDR), for 4G and 5G networks. The authors explain the background of these technologies, in particular existing standards. And also elaborate necessary extensions facilitating the integration and present open issues in this direction [18].

B. Future of NFV

Overall it is believed that NFV will help to reduce operational cost of networking. Its software service capabilities will enhance customer experience through content rich offering and reduced cost [23].As result new customers can be brought into network quickly. In this way NFV is creating renewed interest in the networking business. NFV will make the world more cloud-centric in future. NFV will encourage the innovation in networking by increasing transparency in network functions. Presently, leading carriers like ETSI and ONF are already working to achieve its realistic accomplishment and mitigate challenges associated with NFV. It is believed in future, Existing IP networks will be more elastic, programmable and dynamically managed on cloud platforms [24].

VII. CONCLUSION NFV

NFV had a huge surge in popularity especially to telecom service providers as it provides immediate gains in converting the network appliances into virtual machines providing same functionality as dedicated proprietary appliance currently being used. Network function virtualization can provide service providers with significant gains in automation, thus saving costs, computing power and electricity. SDN is a key enabler for NFV. SDN and NFV are complimentary approaches and both offer new way to design and deploy the network with white box hardware. Despite offering reduced capital expenditure and operational costs, SDN and NFV together aim in advancing software based networking approach which offers agile and scalable networks. The benefits of NFV for the consumers would include latest telecom technology deployment, newer services to subscribers. Furthermore, the use cases document as released by ETSI [17] gives comparatively a clear picture of the commercial and the technical context that could benefit from implementing NFV. Major telecom operators have set up teams to study the aspects of incorporating NFV. In the near future majority telecom service operators and internet service providers will shift their physical networks and infrastructure to virtual state eventually benefitting businesses and consumers.

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