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A Survey Paper on Comparison between NFV and SDN

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Abstract:
Network functions virtualization (NFV) offers a new way to design, deploy and manage networking services. NFV decouples the network functions, such as network address translation (NAT), firewalling, intrusion detection, and domain name service (DNS), and caching, to name a few, from proprietary hardware appliances it can run in software. Software-defined networking is an upcoming technology with lot of benefits in the networking. The basic definition of SDN is running the network using software simply, but there is a lot in this internally lets discuss about it now. Multiple software vendors who are researching on this technology architectures are providing interoperability between them. OpenFlow, Overlay and SDN APIs are the main of those architectures from the vendors.SDN contributes network automation that enables policy-based decisions to orchestrate which network traffic goes where, while NFV focuses on the services, and NV ensures the network's capabilities align with the virtualized environments they are supporting. This document mainly focuses on the SDN, NFV and differences between them.

Keywords:
SDN [5], NFV [9], TCP/IP [4], Open Flow [7].

Introduction:
Network is an inter-connection of computing devices with two or more components in it. In a networking architecture most important feature is using both hardware and software resources for sharing information. Hardware resource includes printers, scanners, hard disk and software's include operating system, technical tools and application development tools, this hardware and Software's can be shared across the network. Networking is defined as sharing data between multiple computers. There are three types of networks, LAN, MAN, WAN. Local Area Network is established in a defined geographical area like in a room or floor or building or campus. Metropolitan Area Network is a collection of LANs which are interconnected within range of a City. Wide Area Network is interconnected between LANs or WAN across the world without any size limitations. Internet is an example for WAN. This paper contains complete information about IP[1] Address, OSI Reference model and IP V6.

OSI Reference Model:
Networking concepts works based on operating systems compatibility, operation systems like windows and UNIX will have different commands and architecture for communicating between respective systems. But before 1977 it was not possible. Each vendor uses their own standard for making products. If there is no common standard between computers then one company computer cannot interconnect with another company computer. It was a big problem in those days. In 1977, one organization called ISO introduced and implemented a common standard for networks to communicate independently with Software and Hardware manufacturers. It was OSI Reference Model. In this model shows how the network has to be in software wise and hardware wise. OSI[3] Reference Model consists 7 layers which describes the working of different software and hardware in networks. Those layers are:
Layer 7: Application Layer
Layer 6: Presentation Layer
Layer 5: Session Layer
Layer 4: Transport Layer

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Layer 3: Network Layer
Layer 2: Data Link Layer
Layer 1: Physical Layer

Here each layer performs different tasks in network to communicate with another.

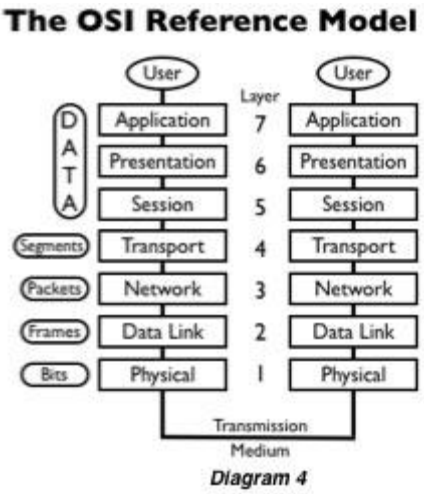

Diagram 4

The above image is taken from:
http://nsgn.net/osi_reference_model/the_osi_reference_model.htm
The above diagram describes how the data is forwarded from one computer to another computer using layers.

TCP/IP [4] Reference Model:

In addition to OSI[3] reference model another model was introduced at the same time that was DoD model. Department of Defense model is actually built based on the OSI[3] reference model only. But in this model the practical approach was given very clearly with all protocols. Number of layers also reduced to remove confusion in vendors. It contains only 4 Layers listed below.
Layer 4: Application or process Layer
Layer 3: Host to Host Layer
Layer 2: Internet Layer
Layer 1: Network Access Layer

All these four layers will perform the same operations like OSI reference model.

Network Access layer is combination of two layers in OSI [3], Physical and Data link. Internet layer is Network Layer. Host to Host Layer is Transport Layer and Application or process layer is combination of application, presentation, session layers.

Virtualization:

Virtualization [6] is the latest technology in computing, used to virtualize physical resources in to multiple logical resources. In this it allows the user to create multiple logical instances for the physical resources. Using this method can divide single physical computer in to multiple logical computers for optimum use of computer resources. Basically it allows user to run multiple operating systems in a single computer at a time. One is in Host Computer (Main Physical Computer) and others are in Guest Computers (Virtual Machines). Here all guest and host computers share the same physical resources. This technology is very useful where High Configuration Server computer resources are not used optimally.

Traditional Networking:

Traditional Networking uses standard devices like hub, switch, and router for maintaining network functionality. A dedicated hardware is presented on all networking appliances called ASIC (Application Specific Integrated Circuit). The following are the major characteristics of this mechanism for developing networking devices.

- Network functionality for hardware's designed on specific architecture standard (ASIC) are slow.
- These ASICs operations or functionality is controlled by the vendor of that device.
- These are proprietary based appliances.
- User need to configure them manually and individually.
- Some of the tasks in change management are very time taking processes and most leads to errors.

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- Provisioning and De-Provisioning also take much time and leads to more errors.

To increase efficiency in traditional approach on networking is big task for networking organizations. Now a day's virtualization is more popular technology in using the resources. As it is increasing, it is also looking for efficient network. Most of these problems are found on Server Virtualization. In server virtualization, there is a feature called dynamic migration of servers from one physical machine to another. If it is happening in the same network then there is no problem. But if it is migrating from one network to another then it takes so much of time for reconfiguring the networks again. Server movement will takes seconds of time for migration but network changing is the major issue here. Server virtualization requires network also to be rebuild with in very less time. That is a major requirement here, but traditional networking is not giving that feature.The final point is that traditional network evolves slowly and it is limited in functionality and this limitation is based on the vendors of the ASICs hardware. SDN is promising on this to overcome these issues in traditional networking.

Network Virtualization:

Network virtualization is a concept in network which divides the physical network infrastructure into virtual. Basically it is not a new technology. In networking already there are concepts called VLAN, VRF and VPNs. Virtual LAN is the concept in switching where a single physical LAN is divided into virtual LANs. In a Large scale networks VLANs helps administrator to maintain efficiently. Virtual routing and forwarding is a concept for enabling routing functionalities without using physical router. Virtual Private Network is a network which creates a virtual private LAN over public network. In Network Virtualization, like VMs there are virtual network devices used as physical network devices. vRouter, vSwitch like the devices used in Network Virtualization. The following diagram explains the concepts of Virtualization of Computers and Networks.

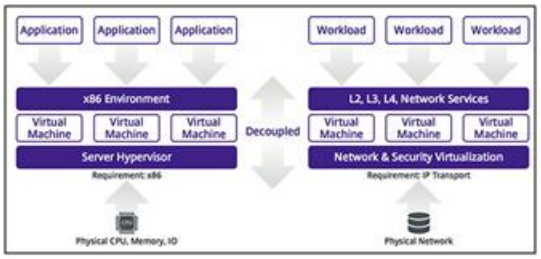

Figure: Virtual Computers and Networks, Source: www.vmware.com

Cloud Computing:

Cloud computing technology is under usage from many years and it uses internet and some set of servers to maintain, manage or serve data and applications (IBM Cloud Computing, n.d.). Cloud Computing allows normal users, customers or businesses to access their applications and data without installing on their computers with internet connection. Users need to connect to their computers and access their personal data and applications from anywhere. This technology increases the efficiency in storing data, using processing abilities and bandwidth.

Advantages of Cloud Computing:

The following are the different advantages in using of Cloud Computing.

- Flexibility
- Disaster Recovery
- Automatic Software updates
- Capital-expenditure free
- Work from anywhere
- Collaboration
- Security
- Environment friendly and more.

Before learning about cloud computing and anomalies in it, it is best to know basic concepts involved in it.

Network Functions Virtualization:

NFV was born in October of 2012 when AT&T, BT, China Mobile, Deutsche Telekom and many other Telco's introduced the NFV Call to Action document.

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In order to increase velocity, a new committee was set up under the ETSI the European Telecommunications Standards Institute. This committee will work on creating the NFV standard. Network functions virtualization (NFV) [9] is a network architecture concept that uses the technologies of IT virtualization to virtualize entire classes of network node functions into building blocks that may connect, or chain together, to create communication services. The following diagram shows the basic working of NFV [9] managed router service.

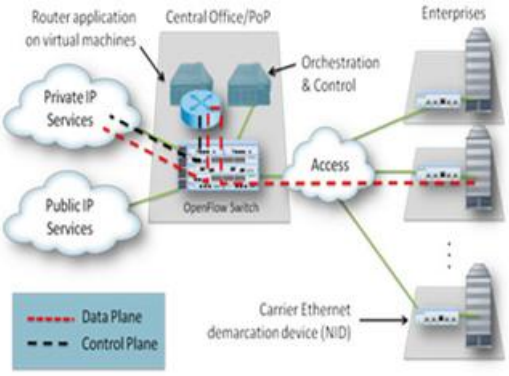

Figure: Example for Working of NFV, Source: https://www.sdxcentral.com/nfv/definitions/whats-network-functions-virtualization-nfv/

Refer to above image which gives overview of future networks and devices control in the network. Here all physical devices are replaced with software in servers which reduces the cost and power usage.

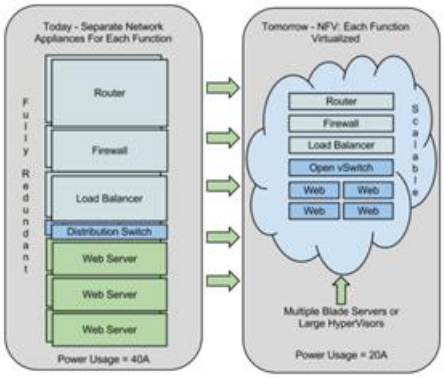

Figure: Example of NFV, Source: http://wikibon.org/wiki/v/Network_Function_Virtualization_or_NFV_Explained

Cloud computing offers more features with NFV. Many service providers offer cloud computing services in addition to network services. Infrastructure as a service is the main platform where NFV plays key role. Cloud computing provides cloud networks with NFV now. There is no need of physical network devices. Using servers and software NFV creates networks virtually in servers. Infrastructure as a service is a service in cloud computing used for providing cloud solutions for hardware of the computers (Services in Cloud Computing, n.d.). It provides Storage disks, Data Centers, Virtual Servers, and more. It reduces the investment and time for building own hardware. Up gradations in the hardware also can be done in very less time. Need to pay per use basis. Very beneficial for startup companies without purchasing and managing their own infrastructure in server side. The following are different companies providing these type of services.

- Amazon
- Rackspace
- Flexiscale

NFV Orchestration and Management Architecture:

NFV Management and Organization (MANO) is divided in to three parts and those are follows.

NFV Orchestrator:

Responsible for on-boarding of new network services (NS) and Virtual Network Function (VNF) packages; NS lifecycle management; global resource management; validation and authorization of network functions virtualization infrastructure (NFVI) resource requests

VNF Manager:

Oversees lifecycle management of VNF instances; coordination and adaptation role for configuration and event reporting between NFVI and E/NMS

Virtualized Infrastructure Manager (VIM):

Controls and manages the NFVI compute, storage, and network resources. The below image shows the architecture of NFV.

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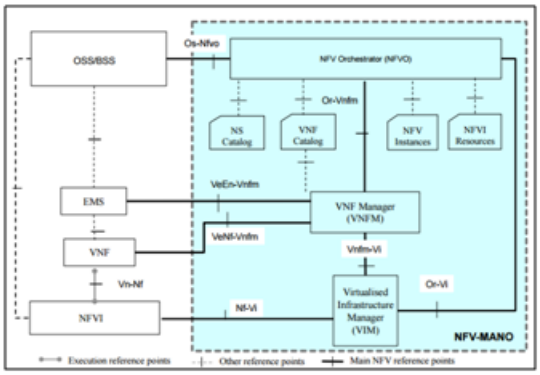

Figure: Architecture of NFV, Source: https://www.sdxcentral.com/nfv/definitions/nfv-mano/

Software Defined Network [5]

As explained, the traditional network is mostly based on hardware components. In the last few years there were some changes in networking which was the adoption of virtualization in networks but it is not enough to solve issues in traditional networks. First software based network functionality is started with SDDC (Software Defined Data Center). It is having the functionality of WOC and ADCs. Here WOC means WAN Optimization Controller and ADC means Application Delivery Controllers. WOC and ADC hardware appliances are there for controlling the function of encryption, decryption and processing of data flow in TCP format and more.

These all are controlled by WOC and ADC Hardware controllers. Now that functionality is added to SDDC. It can be installed in normal server computer and can be run on Virtual Machine. The advantage of using software here is it is not limited to controlling functionality of that device, it can also be able to control entire data center. It can virtualize entire data center network and it can deliver all as a service. Policy based management system feature is also included in the SDDCto control the applications of data center automatically.

Category	SDN	NFV
Reason for Being	Separation of control and data, centralization of control and programmability of network	Relocation of network functions from dedicated appliances to generic servers
Target Location	Campus, data centre / cloud	Service provider network
Target Devices	Commodity servers and switches	Commodity servers and switches
Initial Applications	Cloud orchestration and networking	Routers, firewalls, gateways, CDN, WAN accelerators, SLA assurance
New Protocols	Open Flow	None yet
Formalization	Open Networking Forum (ONF)	ETSI NFV Working Group

Advantages of SDN

The following are different advantages with SDN [5].

- Dynamic migration is supported here.
- Replication between different virtual appliances
- Easy Administration of QoS and Security.
- Easy of deployment and scalable functionality of the network.
- Controlling of entire network traffic.
- Better utilization of network resources.
- Application can request and access network services dynamically
- More efficiency.
- Reduced complexity

Practical Implementation of Software-Defined Networking Open Networking Foundation (ONF) is the group working for implementing the standards for Software Defined Networking. According to ONF, SDN is an architecture that enables network to dynamic, manageable, cost-less, reduced maintenance and offers high bandwidth.

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The SDN architecture divides the network control and its forwarding functionalities which helps to program directly and can be used with applications and network services. Open Flow is one of the protocols implemented for SDN solutions. According to ONF, the SDN is having following benefits.

Directly Programmable

- Abstract control.
- Centralized control.
- Open standards which makes neutral in vendors.

The following diagram explains the architecture of the SDN

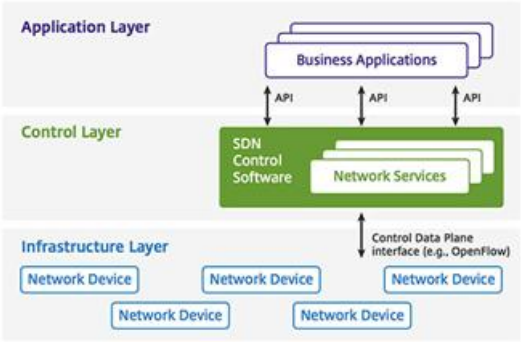
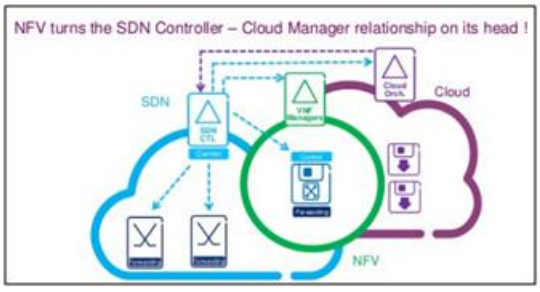


Figure: SDN Architecture taken from www.opennetworking.org

Relation between SDN, NFV and Cloud:

In cloud computing SDN and NFV plays main roles in cloud networks. Generally cloud networks contain physical devices which are virtualized and hosted to different customers. But with SDN and NFV, those networks are completely changed. Without physical devices NFV creates and manages like software for physical devices and SDN will be used for maintaining, controlling or administering that network structure.



Major Differences between SDN and NFV:

Network Functions Virtualization is highly complementary to Software Defined Networking (SDN), but not dependent on it (or vice-versa). Network Functions Virtualization can be implemented without a SDN being required, although the two concepts and solutions can be combined and potentially greater value accrued.

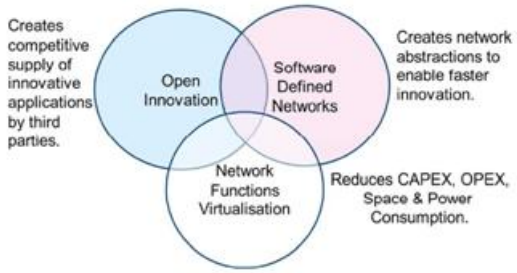


Figure: SDN vs NFV source: www.sdxcentral.com

Network Functions Virtualization goals can be achieved using non-SDN mechanisms, relying on the techniques currently in use in many datacenters. But approaches relying on the separation of the control and data forwarding planes as proposed by SDN can enhance performance, simplify compatibility with existing deployments, and facilitate operation and maintenance procedures. Network Functions Virtualization is able to support SDN by providing the infrastructure upon which the SDN software can be run. Furthermore, Network Functions Virtualization aligns closely with the SDN objectives to use commodity servers and switches.

Conclusion:

NFV, Network Functions Virtualization and SDN, Software Defined Networking are new concepts in network. Network Operators' networks are populated with a large and increasing variety of proprietary hardware appliances. Installing new network architecture and allow it to function has become a difficult task because of space availability and accommodating hardware. Compounded by the increasing costs of energy, capital investment challenges and the rarity of skills necessary to design integrate and operate increasingly complex hardware-based appliances.

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Moreover, hardware-based appliances rapidly reach end of life, requiring much of the procure-design-integrate-deploy cycle to be repeated with little or no revenue benefit. All these problems are resolved by SDN [5] and NFV [9].

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