Throughput Performance Analysis between Juniper vMX and Brocade v5600 Virtual Router

Manas Parida

University of Alberta
MINT Capstone Project by: Manas Parida
Supervised by: Mr. Gurpreet Nanda

Contents:

Acknowledges:

I would like to say very special thanks to Mr. Gurpreet Nanda for supervising this project. His technical expertise, guidance and suggestion are very much helpful for deep driven of this work. Finally, my humble respect to Mr. Gurpreet Nanda for his valuable time and providing me expert opinion to complete this project work.

Mr. Nanda requested and arranged with the department for new upgraded server hardware for the projects. Mr. Nanda planned the SDN/NFV and VM lab environment and worked along with MINT student Eduardo to provision VMware Hypervisor on the new Dell Servers to allow for sharing of server resources. Without these efforts many (including mine) capstone projects would not have been possible. I would also like to thank Mr. Shahnawaz Mir in trying to maintain the lab environment.

Abstract:

Network function virtualization is a recent trend on Telecom and Data Center environment, which decouple network functions from hardware to software. It is applicable to any data and control plane functions and packet processing in networks.

List of network function devices such as switches, routers, firewalls, intrusion detection system and network management system.

In 2012 seven major telecommunication operator created group network function virtualization industry standard group (NFVISG) as part of European telecommunication standard institute. ISG group consists of multiple network equipment vendors, network technology companies and service providers.

This project work is to design, deploy and transformation virtual router of two network equipment vendors and will investigate end to end performance measurement on a virtualization environment.

Introduction:

NFV concept came from server virtualizations, which tends to replace physical network devices providing network functions on commercial-of-the-self (COTS) hardware.

Three key NFV principle **a. Service Chaining** where multiple function flow through multiple virtual network functions (VNF) to achieve desired functionality. **b. Management and Orchestration (MANO)** give deploying and managing the life cycle of VNF functions. **c. Distributed Architecture** in which multiple instances of VNF components can be deployed separately and distributed hosts to provide scalability and redundancy.

NFV framework consists of three domain operation. **a: Virtual Network Functions**, collection of VNFS implemented in software that runs over NFVI. **b: NFV Infrastructure** consists of computer hardware device, storage device, and network device. **c: NFV Management and Orchestration** which consists of Orchestration and life cycle management of physical software resources that support infrastructure virtualization and life cycle management.

With NFV deployment, it is huge reduction of operational expense **(OPEX)** as well capital expenses **(CAPEX)**. Some of these expenses as outlined. More efficiency for network operations and reduced complexity as with traditional network device hardware. Achieve more throughput, less latency while scaling-up and scaling-out of capacity. Potential software upgradation with zero down time can be achieved without any after hour change. It is comfortable for operators to deploy test and integration with reducing development cost. Energy consumption and work load of server reduced during low traffic.

Despite advantages, there are few challenges for implementation of network function virtualization. Virtual machine from different vendors should be compatibility with the hypervisor. As it is virtual network functions, but it still depends upon commodity server hardware to maintain efficiency and accuracy. Network stability is very important for large scale deployment with multi-vendor environment. Isolation of virtual machine system resources also important as it can be used by different user on same hypervisor. Security is key concern on NFV, as VNF is open in hypervisor anyone has access to hypervisor can temper VNFs without logging into the virtual machines. Therefore, VNFs need secure access. Critical interfaces and management interface needs to be secure between VNFs. Privilege level should be defining to access hypervisor, as there may be chance of multiple user can access same hypervisor for VNFs.

For cloud computing NFV solution gives easy deployment, vendor interoperability as well virtual network functions such as NAT, QOS and Load Balancing etc.

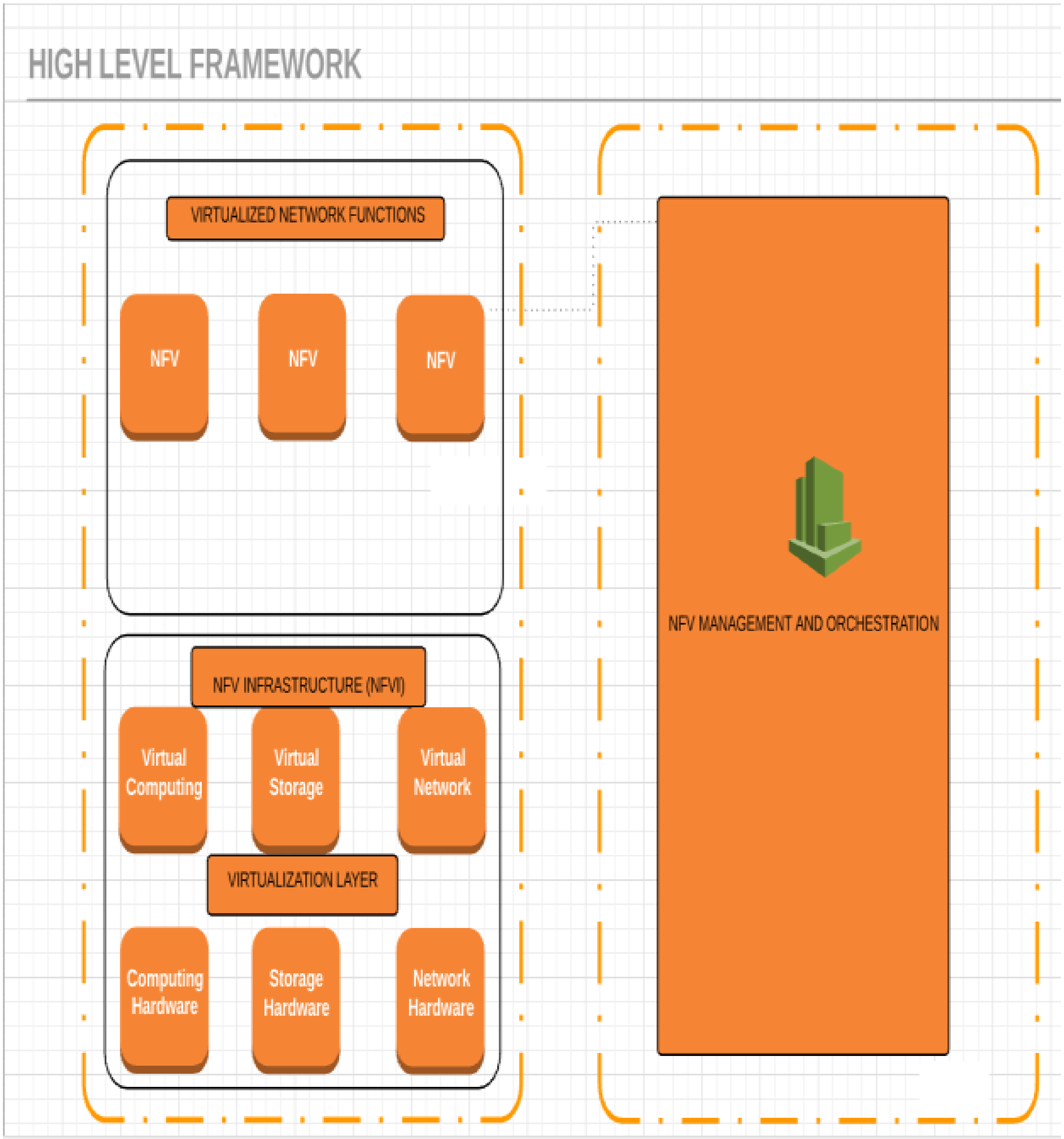

HIGH LEVEL FRAMEWORK
VIRTUALIZED NETWORK FUNCTIONS
NFV
NFV
NFV
NFV INFRASTRUCTURE (NFVI)
Virtual Computing
Virtual Storage
Virtual Network
VIRTUALIZATION LAYER
Computing Hardware
Storage Hardware
Network Hardware
NFV MANAGEMENT AND ORCHESTRATION

Figure: 1

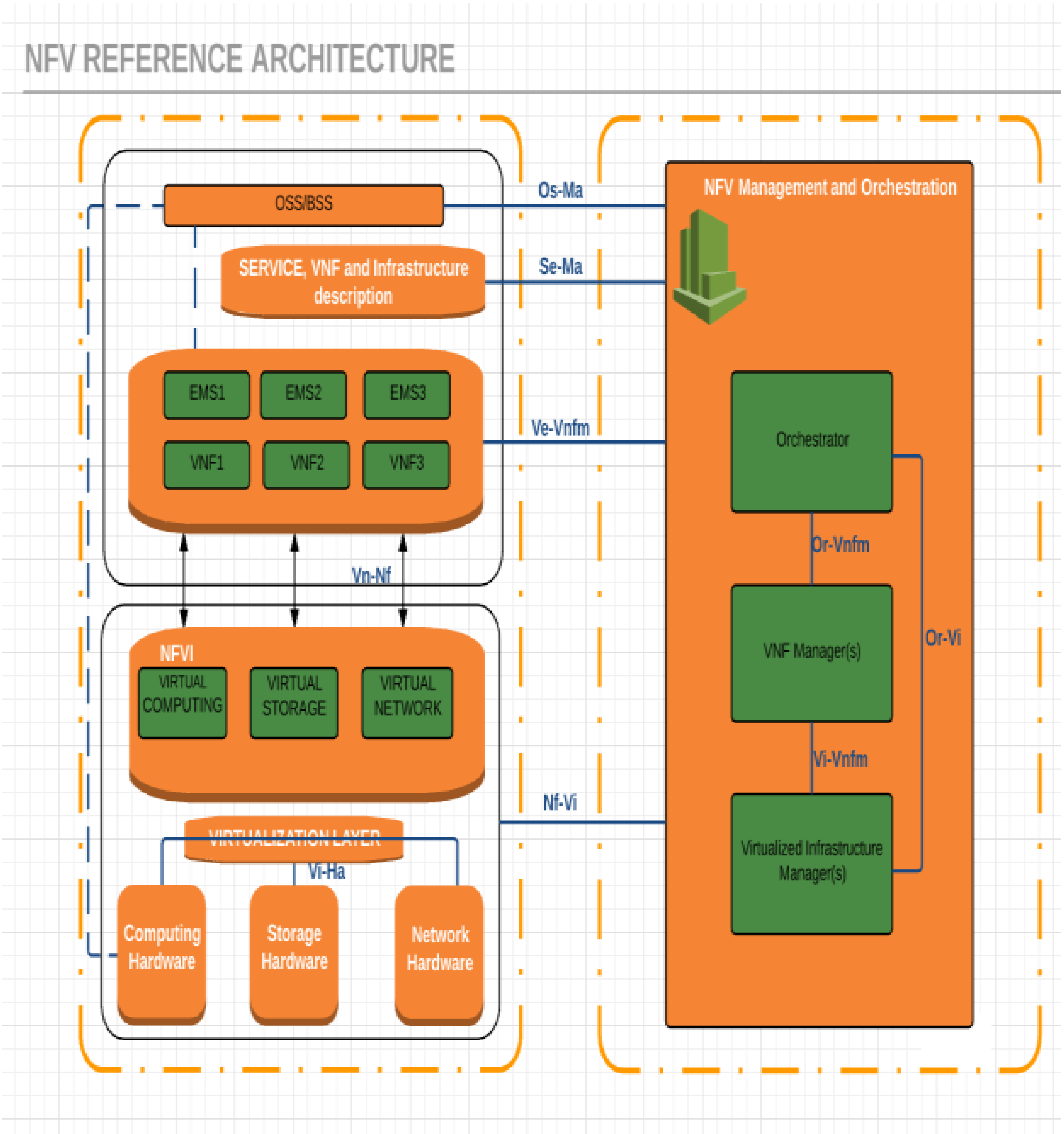

NFV REFERENCE ARCHITECTURE
OSS/BSS
SERVICE, VNF and Infrastructure description
EMS1
EMS2
EMS3
VNF1
VNF2
VNF3
Vn-Nf
NFVI
VIRTUAL COMPUTING
VIRTUAL STORAGE
VIRTUAL NETWORK
VIRTUALIZATION LAYER
Vi-Ha
Computing Hardware
Storage Hardware
Network Hardware
Os-Ma
Se-Ma
Ve-Vnfm
Nf-Vi
NFV Management and Orchestration
Orchestrator
Or-Vnfm
VNF Manager(s)
Or-Vi
Vi-Vnfm
Virtualized Infrastructure Manager(s)

Figure: 2

There are nine use cases defined by ISGNFV based on architectural and service oriented use cases.

Architectural use case a: **Network function virtualization as a service which provide infrastrutcher as a service** and network as a service on cloud computing environment. **b: Virtual Network function as a service (VNFaas) c: Virtual Network Platform as a service (VNPaas**). **d: VNF forwarding** graphs for building end to end service.

This project work is concentrating on architectural use cases and will determine throughput measurement on multivendor environment.

Related Works:

There are few works on virtual router performance of multiple hypervisor like ESXi, Xen and openVz. Where they tested about processor, memory and hard disk performance with different hypervisor.

Performance evaluation of virtual router in a paravartual environment, where they tested with single virtual router to multiple hardware routers and their analysis shows throughput will decrease in case of use one virtual router to multiple hardware routers

Some research work on virtualization at the network edge and performance evaluation using different benchmark tool.

Deployment Challenges:

NFV solution is critical in nature; some of the challenges like virtual router installation, configuration and architectural design; I have faced during these virtualization deployments.

During first phase of installation vMX router, FPC slot was not coming online and no WAN interface appeared on virtual router, after subsequent troubleshoot and observed that vMX router has separate instance of forward plane vFPC which needs to be add vNIC interface. After adding enough vNIC interfaces then FPC slot came online and Gigabit interface appeared on control plane vCP.

Other challenges with the virtual router WAN interfaces and their configuration with VSwitch. vNIC interface should be added, where first vNIC goes to fist Gigabit Interface with subsequently order. Otherwise routing will not appear as designed. So carefully attention needed for Gigabit Interface assign.

In addition, there was issue with routing protocol, first design goal is to implement ISIS as routing protocol to this structure but later found that v5600 virtual router does not support ISIS. OSPF configured between vMX and v5600 to avoid this issue.

Deployment Details:

Hardware and software used for deployment, server Dell power edge R430, 20x2.197 GHz, Intel Xeon R CPU ES-2630, Memory 64 GB, 1TB hard disk. ESXi 6.0 as hypervisor, Juniper vMX router and Brocade V5600 router used.

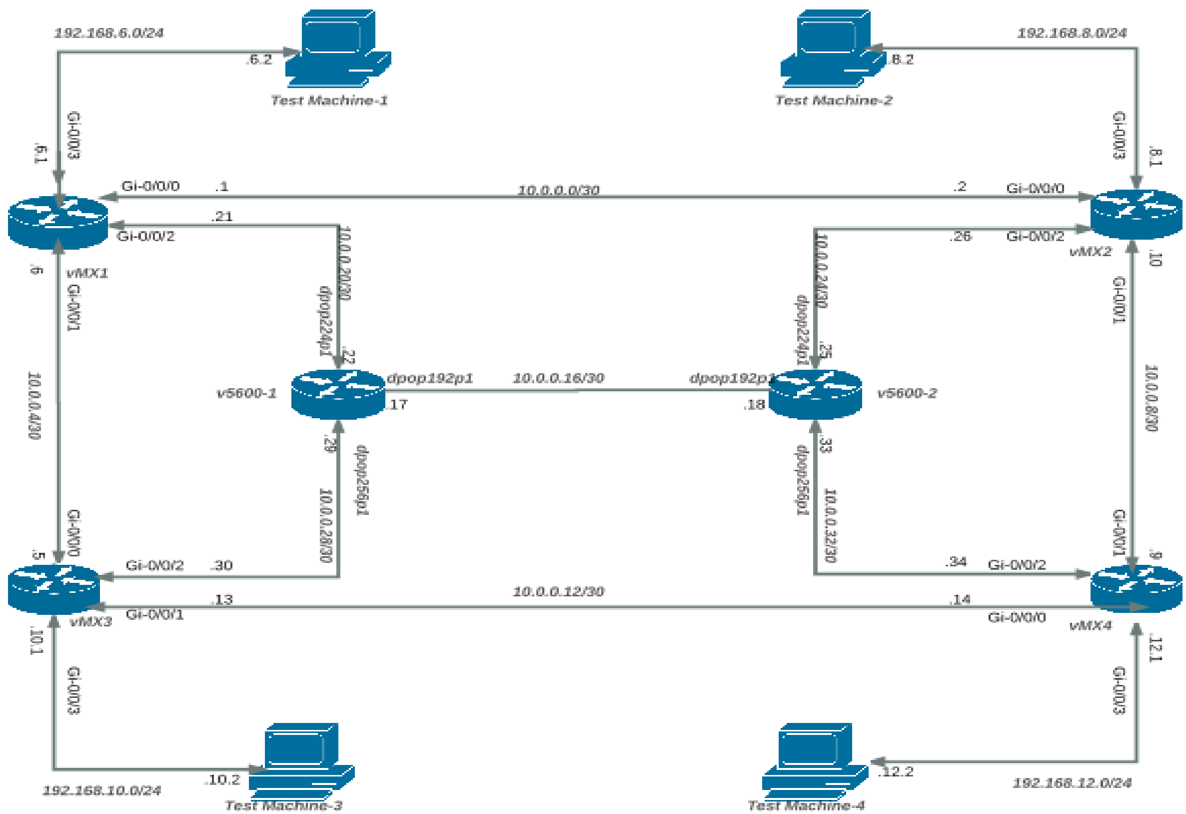
Each Juniper vMX router control plane assigned with 8 vCPU and 4 GB Ram, forward plane assigned with 12 vCPU and 8 GB Ram. And each Brocade V5600 router assigned with 4 vCPU and 8 GB Ram.

Four instance of Juniper vMX router and two instance of Brocade V5600 router configured on ESXi 6.0 hypervisor. All routers connected each other with vSwitch with isolated VLAN.

Four Juniper vMX routers connected each other with ISIS routing protocol and vMX to v5600 router configure with OSPF routing protocol.

Four test machine with Windows 10 operating system connected with each vMX router. Each test machine installed with iperf3 as throughput measurement tool. Test machine 4 configured as iperf3 server and Test machine 1, 2, 3 configured as client.

Deployment Diagram:



THROUGHPUT PERFORMANCE TEST BETWEEN JUNIPER vMX AND BROCADE V5600 VIRTUAL ROUTER NFV SOLUTION

Diagram: 1

NFV Design Details:

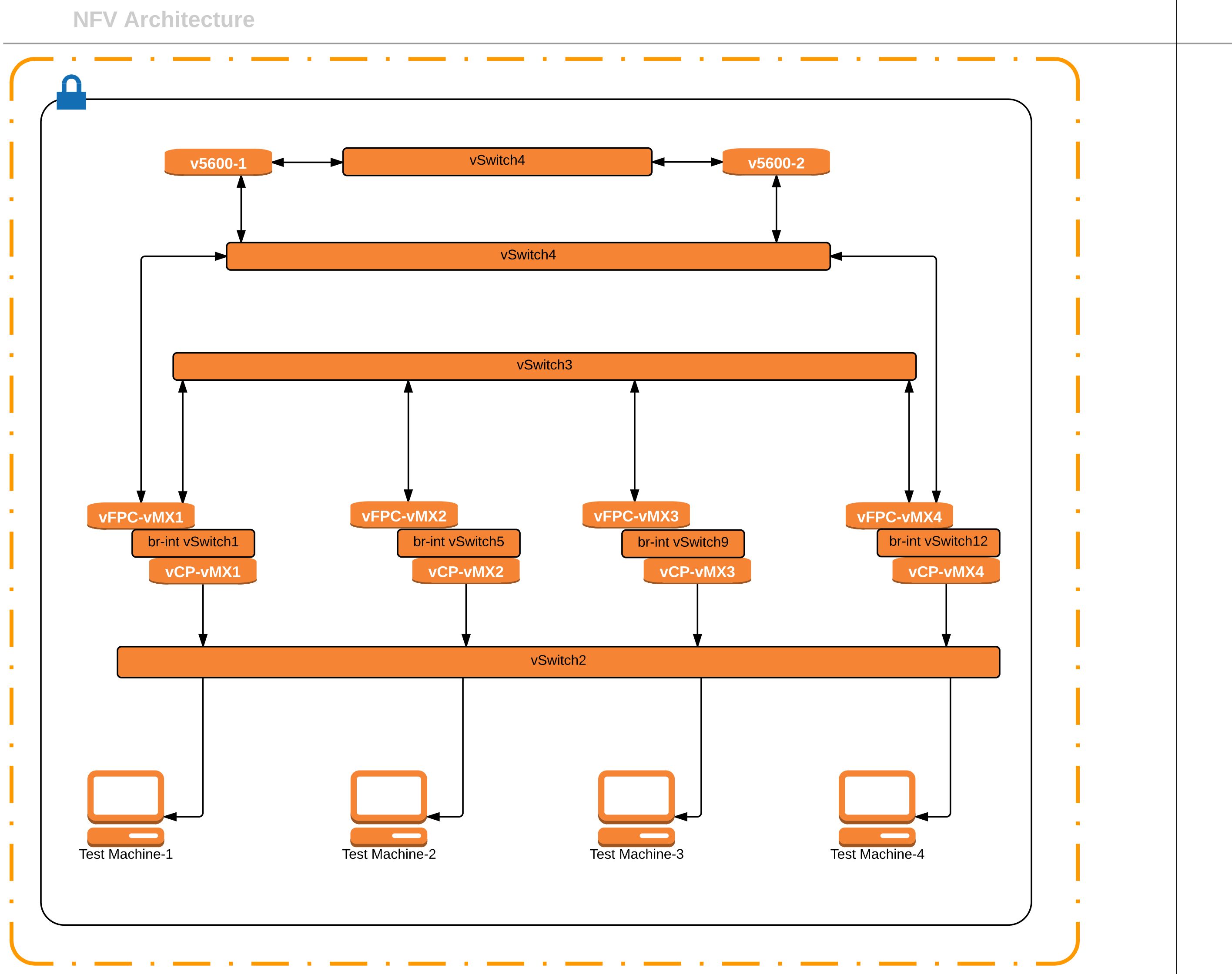


Diagram: 2

Throughput Measurement:

Throughput is and equal to total number of TCP receive window size with the ratio of round trip time. Total time taken for end to end communication. This L3 forwarding test followed RFC 2544 standard.

Throughput = RWIN TCP Window size/RTT, I have used iperf3 as throughput measurement toll which gives end to end communication as client and server relationship.

Test machine -4 configured as server and Test machine-1 and 2 as client. With iperf3, there are series of test conducted with varying TCP Packet size. As per the observation throughput is almost stable, performance consistency with increase packet size on a virtualization environment. Which gives optimize solution for NFV deployment with minimal latency and test results represented below.

Considering result of VMX1-v5600-V5600-VMX2, where tool transferred TCP packet 32.4 Mbytes with throughput achieved 27.2 Mbits/sec unidirectional.

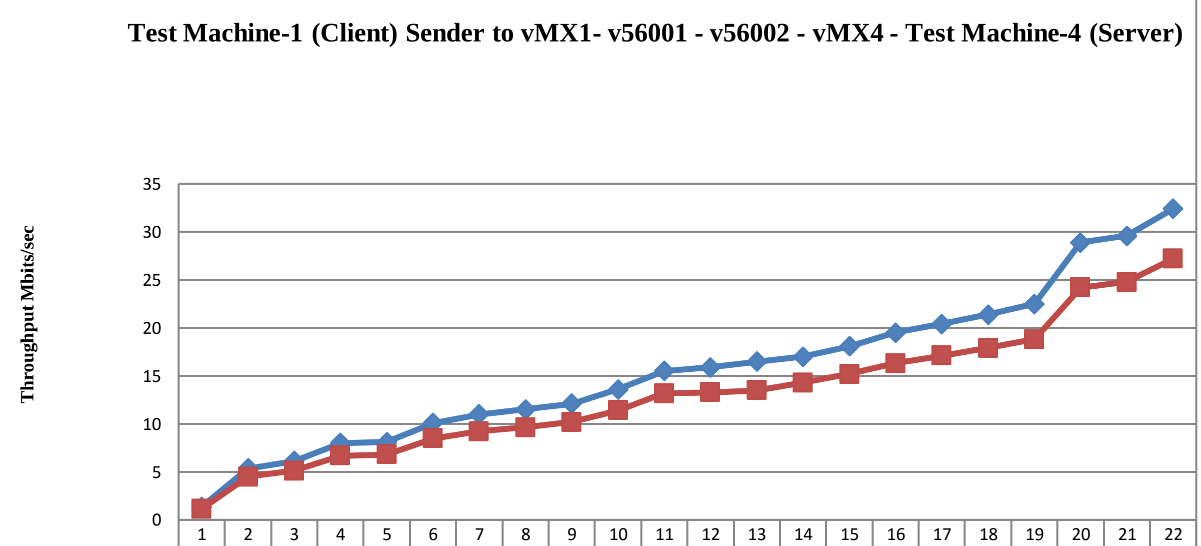
Considering another result of VMX2-V5600-VMX4 where tool transferred TCP packet size 27.1 Mbytes with throughput achieved 22.7 Mbits/sec unidirectional.

According to manufacture performance test, this virtual router supports up to 160 Gbps unidirectional and 80 Gbps bi directional throughput, which they claimed as true carrier class router.

As per the manufacture suggestion, with the help of tool, I have tested with fixed bandwidth 160 Gbps = 163840 Mbits/s. and throughput achieved 12.9 and 12.4 Mbits/sec per TCP packet size 15.4 and 14.8 Mbytes respectively.

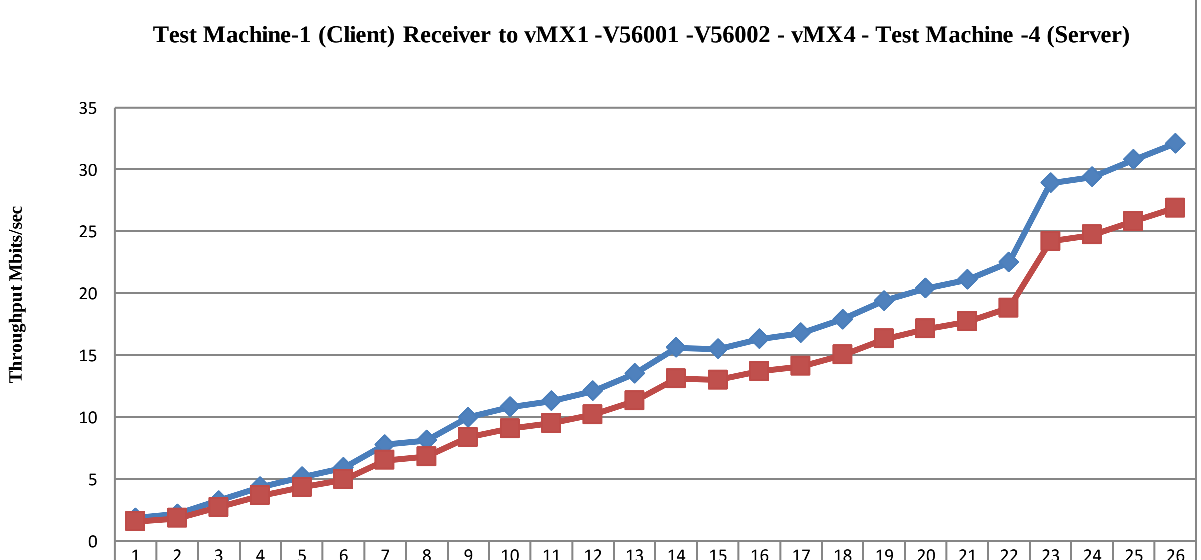
```
C:\iperf-3.1.3-win64>iperf3 -c 192.168.8.2 -b 163840
Connecting to host 192.168.8.2, port 5201
[  4] local 192.168.6.2 port 49847 connected to 192.168.8.2 port 5201
[ ID] Interval           Transfer     Bandwidth
[  4]   0.00-1.01   sec  1.50 MBytes  12.5 Mbits/sec
[  4]   1.01-2.00   sec  1.50 MBytes  12.7 Mbits/sec
[  4]   2.00-3.02   sec  1.62 MBytes  13.4 Mbits/sec
[  4]   3.02-4.01   sec  1.62 MBytes  13.6 Mbits/sec
[  4]   4.01-5.01   sec  1.50 MBytes  12.7 Mbits/sec
[  4]   5.01-6.01   sec  1.38 MBytes  11.5 Mbits/sec
[  4]   6.01-7.01   sec  1.50 MBytes  12.6 Mbits/sec
[  4]   7.01-8.01   sec  1.62 MBytes  13.6 Mbits/sec
[  4]   8.01-9.01   sec  1.62 MBytes  13.6 Mbits/sec
[  4]   9.01-10.01  sec  1.50 MBytes  12.5 Mbits/sec
- - - - - - - - - - - - - - - - - - - - - - - - -
[ ID] Interval           Transfer     Bandwidth
[  4]   0.00-10.01  sec  15.4 MBytes  12.9 Mbits/sec                  sender
[  4]   0.00-10.01  sec  15.3 MBytes  12.8 Mbits/sec                  receiver

iperf Done.

C:\iperf-3.1.3-win64>iperf3 -c 192.168.8.2 -b 163840
Connecting to host 192.168.8.2, port 5201
[  4] local 192.168.6.2 port 49849 connected to 192.168.8.2 port 5201
[ ID] Interval           Transfer     Bandwidth
[  4]   0.00-1.01   sec  1.62 MBytes  13.5 Mbits/sec
[  4]   1.01-2.01   sec  1.38 MBytes  11.5 Mbits/sec
[  4]   2.01-3.00   sec  1.38 MBytes  11.6 Mbits/sec
[  4]   3.00-4.01   sec  1.50 MBytes  12.5 Mbits/sec
[  4]   4.01-5.01   sec  1.38 MBytes  11.5 Mbits/sec
[  4]   5.01-6.00   sec  1.50 MBytes  12.7 Mbits/sec
[  4]   6.00-7.02   sec  1.75 MBytes  14.5 Mbits/sec
[  4]   7.02-8.01   sec  1.50 MBytes  12.7 Mbits/sec
[  4]   8.01-9.01   sec  1.38 MBytes  11.5 Mbits/sec
[  4]   9.01-10.01  sec  1.38 MBytes  11.5 Mbits/sec
- - - - - - - - - - - - - - - - - - - - - - - - -
[ ID] Interval           Transfer     Bandwidth
[  4]   0.00-10.01  sec  14.8 MBytes  12.4 Mbits/sec                  sender
[  4]   0.00-10.01  sec  14.7 MBytes  12.3 Mbits/sec                  receiver

iperf Done.
```

Result: 1



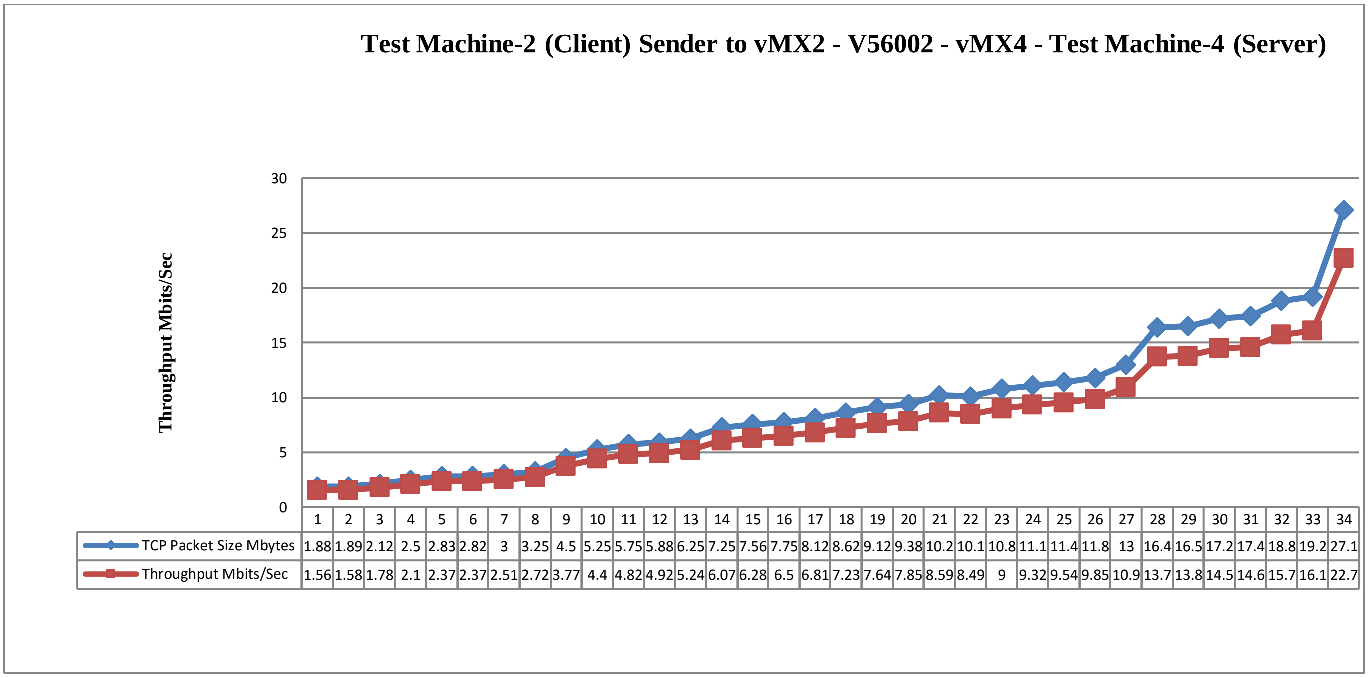
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
TCP Packet size Mbytes	1.38	5.38	6.12	8	8.12	10.1	11	11.5	12.1	13.6	15.5	15.9	16.5	17	18.1	19.5	20.4	21.4	22.5	28.9	29.6	32.4
Throughput Mbits/Sec	1.15	4.5	5.13	6.7	6.81	8.48	9.22	9.63	10.2	11.4	13.2	13.3	13.5	14.3	15.2	16.3	17.1	17.9	18.8	24.2	24.8	27.2

<u>Graph: 1</u>



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
TCP Packet size Mbytes	1.86	2.17	3.24	4.35	5.16	5.91	7.77	8.12	9.99	10.8	11.3	12.1	13.5	15.6	15.5	16.3	16.8	17.9	19.4	20.4	21.1	22.5	28.9	29.4	30.8	32.1
Throughput Mbits/Sec	1.56	1.82	2.71	3.64	4.32	4.95	6.51	6.81	8.37	9.07	9.5	10.2	11.3	13.1	13	13.7	14.1	15	16.3	17.1	17.7	18.8	24.2	24.7	25.8	26.9

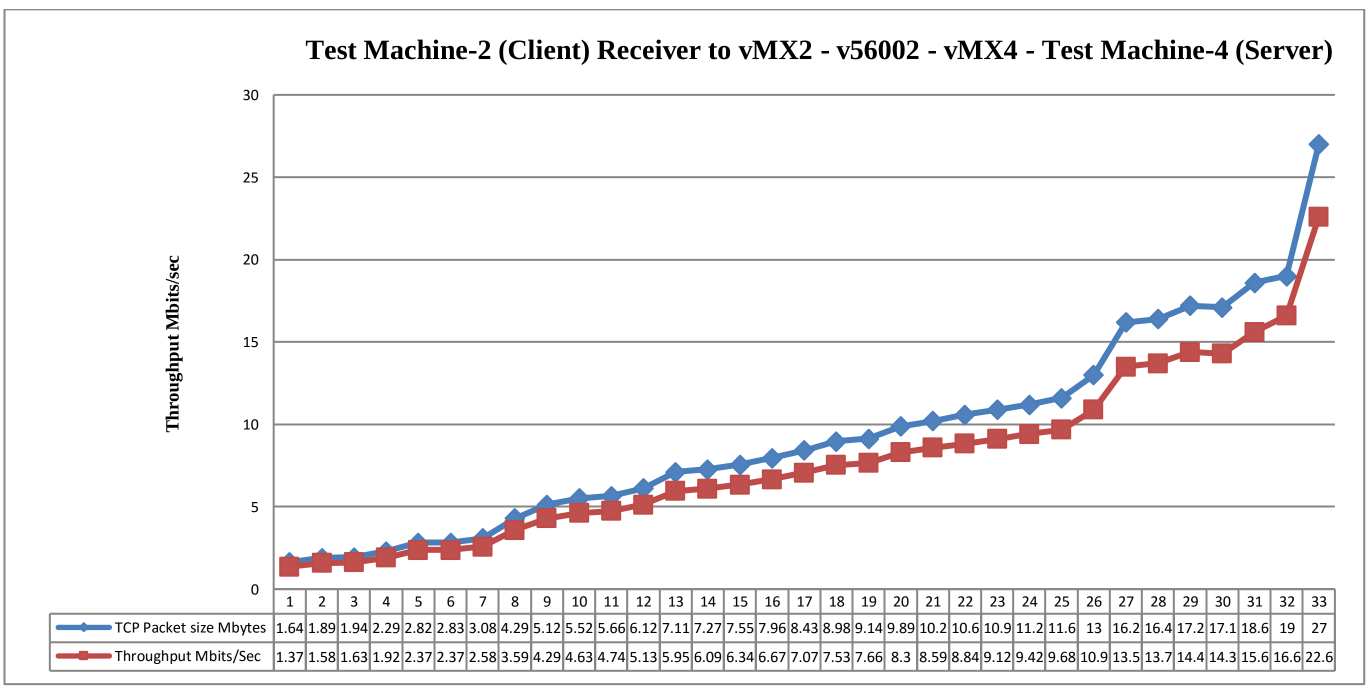
<u>Graph: 2</u>



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
TCP Packet Size Mbytes	1.88	1.89	2.12	2.5	2.83	2.82	3	3.25	4.5	5.25	5.75	5.88	6.25	7.25	7.56	7.75	8.12
Throughput Mbits/Sec	1.56	1.58	1.78	2.1	2.37	2.37	2.51	2.72	3.77	4.4	4.82	4.92	5.24	6.07	6.28	6.5	6.81

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
TCP Packet Size Mbytes	8.62	9.12	9.38	10.2	10.1	10.8	11.1	11.4	11.8	13	16.4	16.5	17.2	17.4	18.8	19.2	27.1
Throughput Mbits/Sec	7.23	7.64	7.85	8.59	8.49	9	9.32	9.54	9.85	10.9	13.7	13.8	14.5	14.6	15.7	16.1	22.7

<u>Graph: 3</u>



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
TCP Packet size Mbytes	1.64	1.89	1.94	2.29	2.82	2.83	3.08	4.29	5.12	5.52	5.66	6.12	7.11	7.27	7.55	7.96	8.43
Throughput Mbits/Sec	1.37	1.58	1.63	1.92	2.37	2.37	2.58	3.59	4.29	4.63	4.74	5.13	5.95	6.09	6.34	6.67	7.07

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
TCP Packet size Mbytes	8.98	9.14	9.89	10.2	10.6	10.9	11.2	11.6	13	16.2	16.4	17.2	17.1	18.6	19	27
Throughput Mbits/Sec	7.53	7.66	8.3	8.59	8.84	9.12	9.42	9.68	10.9	13.5	13.7	14.4	14.3	15.6	16.6	22.6

<u>Graph: 4</u>

There are number of factors related to server hardware can affect NFV performance like CPU architecture, Processor speed, core and cache, available Memory size, bandwidth, Memory cache, I/O bandwidth etc. Hardware enhancement with Intel platform can increase efficiency and subsequently NFV performance.

There are several other factors also affected the performance, these are categorized as a. **Data plane Work Load** for end to end communication such as session initiation and termination, data transmission and reception, removing moving headers, flow session accounting, encryption technique etc. which cause an extra load on CPU resources. **b. Control Plane Work load** which can affect between NFs such management traffic, routing and authentication. **c. Signal processing workload** and **d. Storage workload**.

Performance also depends upon hypervisor, using proper hypervisor can increase throughput, reducing latency and process overhead. In this case ESXi is a great hypervisor for NFV solution, which gives appropriate result on a multivendor environment.

Conclusion:

In this report, I have measured and tested end to end throughput in different scenarios two, three and four hop. To demonstrate this, I did series of test with iperf3 as bandwidth network measurement tool. As per the investigation, in four hop throughput is less as compare with three and two hop. In addition, it was observed throughput will decrease as increases the packet size. In comparison with two network equipment vendor, iperf3 gives consistency result and measured throughput accurately by increasing packet size which shows vendor inoperability. For performance point of view both Juniper vMX and Brocade v5600 virtual router has excellent capability of L3 forwarding and better throughput achieved. In addition, throughput is more stable and zero latency in a virtual infrastrutcher as with traditional hardware devices.

Reference:

http://www.etsi.org/deliver/etsi_gs/NFV-PER/001_099/001/01.01.01_60/gs_nfv-per001v010101p.pdf

http://portal.etsi.org/NFV/NFV_White_Paper.pdf

www.juniper.net/us/en/products-services/routing/mx-series/vmx

https://networkbuilders.intel.com/.../Vyatta_5600_Performance_Test_Full_Report.pdf

Network Functions Virtualization (NFV) with a Touch of SDN, By: Rajendra Chayapathi; Syed Farrukh Hassan; Paresh Shah, Web ISBN-13: 978-0-13-446431-2

Network Function Virtualization, By: Ken Gray; Thomas D. Nadeau, Web ISBN-13: 978-0-12-802343-3

Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud, By: William Stallings, Web ISBN-13: 978-0-13-417547-8