Network Functions Virtualization

Christin Wilson
cwils28@clemson.edu

***Abstract*—Network service providers have been affected with an increase in the initial investment and the recurrent expenses that they have to spend due to the large diversity of network appliances. NFV or Network Function Virtualization was proposed to find a solution for this. NFV makes the network system provisioning better by making it more flexible and the time to market of new services is also considerably reduced. In NFV, the network functions are implemented as pure software instead of being on the hardware like in the traditional networks. It allows the centralized management of virtual network functions. NFVs are usually integrated with SDNs to provide efficient flow of traffic through the network while at the same time optimizing the network functions and resources. Service chaining is one of the most important application of NFV. In this survey we introduce the NFV and its architecture and also discuss some of the use cases and challenges that it faces. Being a relatively new technology we also survey the future research directions of NFV to overcome the existing challenges.**

I. Introduction

In traditional networks, The different network appliances being used are specifically built for a purpose. There exists a large variety of such devices and each of these have their own different usage. These propriety appliances increases the capital cost and the recurring running expense to the service providers. The main challenge is when these networks have to be updated to implement a new functionality. This will lead to a vast expense by the providers, thus preventing the network upgrades and addition of new services. A solution for this challenge was figured to be virtualization. By Virtualization, the software part of the network appliances is taken away from the specific hardware. In NFVs, the network functions that were previously infused with the hardware is now implemented as software. This will lead to every hardware being able to perform a certain network function using the software irrespective of the underlying hardware. NFV was proposed by the ETSI Industry Specification Group. The main use of this technology is that it removes the need of dedicated hardware and middleboxes and make commodity hardware able perform some functions.

Thus, NFV results in flexible provisioning of network functionalities without requiring dedicated hardware but just an optimal physical infrastructure.

The SDN technology was the technology introduced prior to NFV to further make the traditional networks efficient. With the introduction of NFV, researches suggested integrating NFVs with SDNs. This will result in multiple benefits to the network in terms of network control and management. Dynamic resource allocation is made possible by this integration. It is also possible to avoid the complex work and the installation of dedicated hardware for an upgrade in network functionality because of the ability to implement a virtual service environment dynamically using NFV and SDN. And the SDN helps in flexible traffic flow by considering all the forwarding devices as a whole.

NFV maximizes the utilization of network services while at the same time reducing the service providing cost. Also most of the work that is being performed manually currently are automated by making use of NFV. Some examples for this are network management, provisioning and configuration. This also helps in reducing the deployment time and thus bringing down the time to market for these services.

One of the most decorated use cases of NFVs integrated with SDNs is the service chaining functionality. In traditional networks, in order for service chaining, different dedicated hardware has to be installed on the system to provides various new functions like load balancers, Intrusion Detection Systems, etc. Installing a new hardware every time a new requirement comes up is a very expensive option. It also requires a lot of planning to be performed and space has to be allotted to accommodate this system. These can also lead to an error due to the manual installation of the new devices. On the other hand, by making use of NFV, the service chain provisioning and deployment are simple processes that are both fast and cheap.

While NFV does have these benefits, being a relatively new topic, there exists a lot of challenges that a NFV network will come across. Most of these are technical challenges faced while deploying virtual appliances in the network. Significant throughput is usually encountered. Also abnormal latency variations is usually seen along with virtualization.// The main challenge for NFV is to ensure that the performance of this network should be equal to or higher than the traditional networks that employed dedicated hardware for the different network functions. Also an efficient method for existing traditional networks to be migrated to NFVs must be developed. This is especially due to the large scale and tight coupling in the traditional networks. Also, the virtual appliances has to be efficiently placed.

Due to these challenges, significant research has to be performed on NFV to find solutions to these challenges.

II. Overview

This paper will give a brief survey of NFV. Section III will discuss the architecture of NFV networks. In addition,

the architecture when NFV is integrated with SDN is also discussed. The use cases of NFV will be discussed in section IV. Even though the NFV has several benefits, there does exist some drawbacks and challenges of an NFV network which will be discussed in section V. The future work and the research directions will be discussed in section VI. The paper will conclude with Section VII discussing the conclusion to the survey conducted.

III. ARCHITECTURE

A. NFV Architecture Framework

As we have seen in the Introduction, NFV offers the flexibility for the design. In existing traditional networks, there is a static architecture in which the various network devices are placed and connected in order to provide the various networking services. New schemes that are dynamic are added by NFVs to create and manage the functions of the network. The VNF forwarding graph is the key concept.The service chain provisioning is simplified by this. It also is responsible for adding new functions and upgrading the network by modifying , creating and removing service chains. We can either bring together various VNFs together to make the management better and easier. Or we can decompose a bigger VNF into smaller blocks which can be shared and would enable reusability. The response time can be made faster using this as well.

Three major differences are introduced in NFVs when compared to the traditional networks. These are:

Separation of software from hardware:

By decoupling the software from the hardware, it is possible to independently alter and modify the software side without affecting the underlying hardware of the network. At the same time the hardware can also be independently modified without affecting the software side.

Flexible Deployment of network functions:

The network functions can be deployed by the NFV automatically as software on a pool of hardware resources. It can be run on different locations at different times and it can also different functions as well.

Dynamic service provisioning:

The NFV performance can be scaled as per requirement to ensure that the resources are neither over used nor underused. A grow as you need approach is implemented which will alter the conditions depending on the current condition of the network. The architectural framework of NFV is illustrated in fig 1. There are four major parts in the NFV architectural framework. These are: orchestrator, virtualization layer, VNF manager and virtualized infrastructure manager.

The function of the orchestrator is to manage and orchestrate the different software and the virtualized hardware components in the network and ensure that the communication happens effectively and the network services are being carried out.

The NFV Infrastructure(NFVI) is the environment in which the Virtualized Network Functions are deployed. Its an environment made up by the combination of the hardware and the software resources in the network, The virtualization

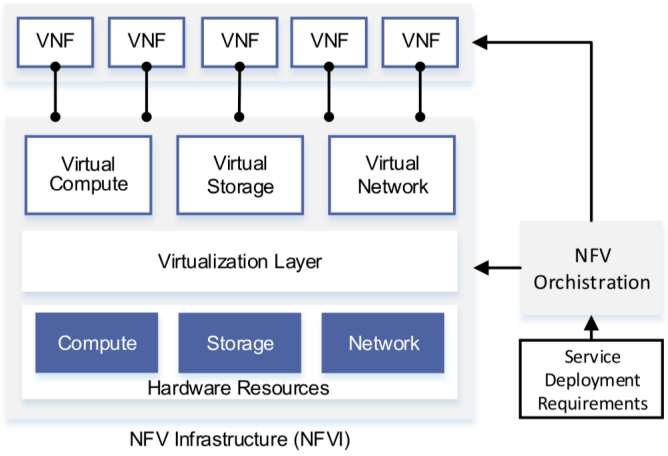

Fig. 1. Illustration of the NFV framework

layer abstracts the virtualized resources from the physical resources and decouples them. VMs are usually the computing and storage resources whiles the virtual links and nodes are represented by the virtual networks.

An implementation of a NF, which is a functional block in a network, on a virtual environment such as a VM is called the VNF. The VNF management and orchestration provisions these VNFS and configures them and the infrastructure in which they run on.

B. Software Defined NFV Architecture

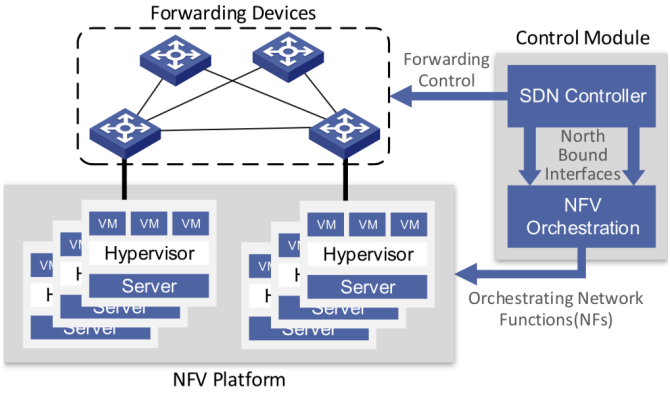

Fig. 2. Software-defined NFV system

This architecture consists of a control module, forwarding devices from the SDN network and NFV platform in the network as well. The architecture is shown in Fig 2. The SDN controller handles the packet forwarding through the use of protocols like OpenFlow. There are two separate planes, the data plane and the controller plane like the usual SDN. The NFV platform implements NFs in the network to perform

various functions at low cost.The firewalls, load balancers, middleboxes, IDSs all exist as software within the VMS that implement the NFs.
The logic module in this architecture is composed of the SDN controller and the NFV orchestration system. The functions are handled by the NFV while SDN controller handles the flow of traffic between the devices in the network namely the VMs and the forwarding devices.

IV. Use cases

A. Service chaining

Integrating SDN and NFV together lets monitoring and controlling the traffic through the network much more efficient and thus decreasing the operational cost. By using NFV the network functions are moved from the dedicated hardware to software over commodity hardware. By using SDN, the control functions of the network are moved from the independent switches to a common controller. Thus, it is possible to control, configure and update the service chains in the controller itself. This will also reduce the operation errors in the network due to the availability of the global view for the controller in the network. It also removes the need for dedicated middleboxes in the network. Figure 3 illustrates an example of the service chaining process.

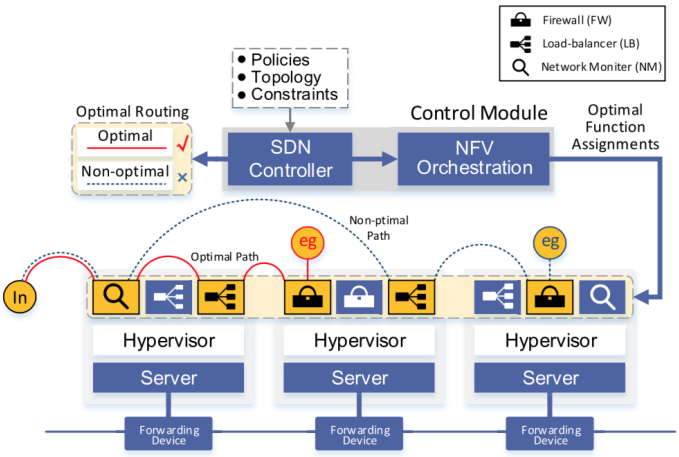

Fig. 3. Service chaining in the software-defined NFV architecture

B. Cloud computing

Just like cloud computing enables the distributed allocation of computing power to end users and availability of services to end users with very low latency. This is made possible by partitioning or replicating the resources and distributing across various global locations. NFV also provides dynamic service provisioning. A software image can be updated inorder to add new functions and this does not require waiting for the installation of dedicated hardware to bring about this update. Users can also be served better by the service providers by dynamically modifying the service provided to the users based on their requirements since this is not a difficult task and can be brought about in software itself.

C. Enterprise network

There will be a huge demand for NFV in enterprise. This is mainly because of the conflicting requirements of the network managers and the service providers. With NFV, the virtual network services required by the enterprises can be dynamically provisioned to them in very less time. It is not feasible to redesign the architecture of the enterprise architecture each time a new update has to be made.

D. Home network

NFVs are also beneficial for home networks since it will reduce the overall operating cost since the maintenance and updating costs can be made rid of. It also provides a very larger amount of services to the users. Unlimited access to the services is provided. Also the sharing quality management is monitored and new services are shared to the users more smoothly and without the trouble of having to install new hardware dedicated for it.

V. Issues and challenges

A. Function virtualization

Performance requirements must be met by the virtualized functions.The packet processing must be performed at a relatively good rate. The Vms and the hypervisors used in NFV are not optimized like the middleboxes and thus it is difficult to obtain high performance for function virtualization. Also multi tenancy should be supported by the NFV hardware and software components since different operators concurrently run them.

B. Portability

The VNFs should be able to be executed and moved across a variety of environments even though they might all be standard servers. This property is defined as portability.VNF does not abide by this portability goal. The VNFs must be independent and be decoupled from the OS layer underneath.

C. Standard interfaces

To ensure that the NFV is rightly integrated with the other layers existing in the system like the underlying computing platform, the interfaces should be standardized. function deployment. This will make the network flexible and manageable. A major research challenge is to decide how the communications between the NFV and the upper and lower layer happens and how an AP that is both flexible and efficient should be designed.

D. Function deployment

During deployment of the functions, there exists many challenges for eg, the resources have to be allotted including both network and function process resources. Also the placement of the VNF must also be automatically identified.

E. Traffic steering

Even though the traffic steering in SDN and middle box networks have been made efficient and automated, the Software defined NFV architecture requires more optimization in this area due to the larger number variables and the clutter in the system due to these additions.New algorithms should be designed to reduce the complexity of computing in these networks

VI. Future work and research

A. network performance of VNF

For a network with virtual appliances, it is difficult to obtain a network performance like the ones that are obtained on networks with dedicated hardware devices for specific purposes.

B. placement of virtual appliances

In traditional networks, the middleboxes are placed on the path connecting the sender and the receiver but in NFV, the functions are virtualized and are placed in some datacenter which may not be in the direct path. This can lead to a delay in receiving the packet. Therefore the placement of the VMS must be given utmost thought and planning to reduce this latency.

C. vnf outsourcing

The types of VNFs that can be outsourced to third parties must identified. Research must also be performed to study how this can be done efficiently

D. Energy efficiency

Theoretically NFV are supposed to be energy efficient due to the property of being able to increase and decrease resources as per requirement. But since the NFV makes use of a datacenter, the energy needs of the datacenter must be considered and a study must be conducted to identify whether the claim that NFV is energy efficient is true or not.

E. Resource allocation

The current research allocation algorithm being used in NFVs are found to be inefficient and results in sub optimal placement and allocation of resources which is not expected from NFV.Studies must be conducted to come up with an efficient algorithm to determine the physical resources that are being used and to move the functions between different servers.

F. security privacy and trust

Users might fear the security of their data. Concerns regarding privacy and trust arises in every implementation of cloud since the information is being stored in a data center that might not be owned by the service provider. The details regarding who has access to the information and where the information is actually located is hard to know. The privacy and security statements released by data centers cannot be fully trusted as well. Therefore research must be done in this direction for NFV

VII. Conclusion

In this paper, we have discussed comprehensively about the Network Function Virtualization. NFVs covert the functionality earlier brought about through dedicated hardware appliances to software. We have discussed how the NFV can be integrated with SDNs. We discuss the architecture of the standalone NFV framework as well as the NFV integrated with SDN architecture. There are various benefits of using NFVs when compared to the traditional networks. But the topic being relatively new, there are also a lot of challenges and research directions that are present for NFVs at this point of time.

References

[1] Li, Y., & Chen, M. (2015). Software-defined network function virtualization: A survey. IEEE Access, 3, 2542-2553.

[2] Han, B., Gopalakrishnan, V., Ji, L., & Lee, S. (2015). Network function virtualization: Challenges and opportunities for innovations. IEEE Communications Magazine, 53(2), 90-97.

[3] Mijumbi, R., Serrat, J., Gorricho, J. L., Bouten, N., De Turck, F., & Boutaba, R. (2016). Network function virtualization: State-of-the-art and research challenges. IEEE Communications Surveys Tutorials, 18(1), 236-262.

[4] Yi, B., Wang, X., Li, K., & Huang, M. (2018). A comprehensive survey of network function virtualization. Computer Networks, 133, 212-262.

[5] Herrera, J. G., & Botero, J. F. (2016). Resource allocation in NFV: A comprehensive survey. IEEE Transactions on Network and Service Management, 13(3), 518-532.