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A Review of Network Virtualization (NV): A Brief Description of the Requirements, Objectives and Technology of Network Virtualization

Muthana Najim Abdulleh

Abstract*— In the past few years, network virtualization (NV) has been growing steadily among other network communities. NV offers an alternative advancement of the future internet by utilizing protocols and architectures through shared physical infrastructure and control architectures in the network. The frequent usage of NV demands new requirements that focus on the control and management of the given network. The existing process that combines software network resources and network functionality and hardware has even made NV more important in the network field (e.g., virtual networks have become important resources in information technology). Virtual network has taken the importance of NV from the original hardware while server virtualization supersedes virtual machines from the original server hardware. Therefore, the aim of the current paper is to provide a review of related studies on virtualization and NV concepts as well as aims or objectives and the requirements of such NV. It provides a brief description of technology and outlines its current and future applications. Finally, the study discusses the difficulties in implementing this technology.

***Index Terms*— Network Virtualization, virtualization, Software-Defined Networks, Virtual Private Network**

I. INTRODUCTION

Virtualization is defined as the separation of the infrastructural service from the operational physical resources [1][2]. Many authors have defined Network virtualization (NV) as a technology which simultaneously and independently makes the process of multiple logical systems possible on a physical platform [1] [2]. According to [3], NV is applicable through software and services which are meant for sharing storage, application and computing cycles. In other words, servers and services in the network are dealt with as a pool of accessible resources without considering the physical components. As pointed out by authors in [31], NV is often used to express properties like storage virtualization, network management and grid computing, and it supports the logical views such as virtual of the memory, platform and computing. Physical network is claimed to be multiple logical networks, thus, using the same multiple virtual network which consists of virtual nodes and virtual links and contains parts of the essential physical network assets. Such virtual networks coexist and they are isolated from one another at the same time [2] [3]. Historically, NV comprises five categories as: Virtual LAN (VLAN), Virtual Service Network (VSN), Virtual Private Network (VPN), Active and programmable Network as well as overlay Network [4][5].

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***** Correspondence Author (s)
Muthana Najim Abdulleh, Department of Information Technology, University of AL-Abar, College of Computer, AL-ANBAR. Iraq,

In general, the aim of NV is that virtual networks are designed to simultaneously live together on the same physical assets which can be apportioned into many smaller objectives. The objectives must be fulfilled in order to unveil the architectural plan as this objective spells out the principles to make the protocol for virtual networks [5].

II. THE OBJECTIVE OF NETWORK VIRTUALIZATION

NV has a number of objectives which are discussed here in details. First, it has the flexibility as the service provider can make a use of network topology, routing or forwarding. Secondly, NV is characterized by manageability in that the infrastructure is separated from the service provider to enhance the ability to manage by providing explanation at every level of networking. The third objective is scalability which refers to the ability to make a frequency of coexisting virtual networks possible without compromising the performance to enhance the utilization of the available resources. Fourthly, it has privacy and security in the sense that the isolation of resources to another coexisting virtual network will not affect others. The fifth objective of NV is programmability which assists the service in the implementation of customized protocols. Finally, legacy support is always critical when it comes to the deployment of any new technology. In view of the Internet as an additional virtual network, integration of NN becomes possible and easy. For example, the IPv6 will be faster when it is used on different virtual networks without having to deal with the preeminent IPv4 [5][6].

III. THE REQUIREMENTS OF THE INFRASTRUCTURE FOR NV

There are several requirements for the infrastructure of NV. The first requirement is the abstraction which allows users with high flexibility to investigate the operational goals divorced from the underlying physical infrastructure. The second requirement is the isolation which takes care of the mappings between the logical and physical contexts being separated from the rest in order to guarantee the security for improved performance. The third requirement is elasticity, known as the ability to stretch the allocation of the resources that construct the slice to get better and make the usages of resources as good as possible. The forth requirement is programmability which assists the resources to build the slice that could be put to enhance and facilitate the data process with the new communication protocol in the slice.

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The fifth requirement is the security referring to authentication, authorization and accounting for the resources to create the slice. In other words, it should be authenticated and authorized to insure secure operations of slices to prevent abuse and attacks [5][7].

IV. NV TECHNOLOGIES

NV is a wide range of technologies so this review focuses on the whole spectrum of technologies, perspectives and practices to identify the common features. Specifically, the review concentrates on technologies in relation to devices, links and networks so as to give a detailed explanation of their gradual development together and the influence they exert on each other [5][6].

A. Network Device Virtualization:

• Software-Enabled NIC Virtualization: VMware, Microsoft, Citrix Systems (providing Xen), and Oracle are among the main commercial providers of the operating system (OS) virtualization solutions.

• Router Virtualization: "Rrouter" is used as a general term to refer to a network device that performs routing or switching operations [6][8].

B. Link Virtualization:

• Physical Channel Multiplexing: The first issue to consider in an attempt to explain link virtualization is to look at what exactly a 'link' is made up of. It is conclusive that the link virtualization might be similar to multiplexing in condition that the link is a physical medium.

• Bandwidth Virtualization: In this context, link virtualization refers to technologies that combine the bandwidth of the individual channels together to form virtual links.

• Data Path Virtualization: Data path virtualization refers to the technologies that do not manipulate the channel itself, but rather the data (packets) carried on this channel[6][8].

C. Virtual Networks:

• Overlay Networks: It is mainly the use of tunneling and encapsulation technologies to build a network on an already existing network [32].

• Virtual Private Networks: A virtual private network (VPN), refers to private networks that are separated from each other but are connected to each other [4][5].

• Virtual Sharing Network: Virtual sharing network (VSN) refers to technologies which encourage the sharing of physical resources among multiple network instances and provide clear delineation among these instances[5][6][8].

V. CURRENT AND FUTURE APPLICATION

A. Military Application

The military process achievement depends heavily on the advantage of information technologies particularly on the network technology. While protocol of TCP/IP has played an important role in military communication network for two decades, this network protocol based on an end to- end path is actually unsuitable for military communication network. The common features of military communication are high error rates, being significantly heterogeneous, variable and long delay [32].The implementation of TCP/IP network depended on the assumptions of low error rates, lower transition delays and existence of the end to end path, thus, without any doubt contradicting the key characteristics of military communication network [10]. The NV technology which is used to design the military communication network is called the Disruption Tolerant Network (DTN). This is achieved when the DTN concept is combined with the NV architecture as well as the Military Network Virtualization Environment (MVNE). The MVNE can significantly assist the military tactical network with a particular attention on the relatively new concept of VN. It is, however, feasible to achieve such MVNE with the improvement in networking technology. In future work, the first conceptual design of MVN (Military Virtualization Network) will be simulated and analyzed with much attention on the routing and MLS [10].

B. Application in Virtualized Environment:

The future implementation of near-optimal resource provision in enhanced virtualized data centers will depend on the predictability of performance of a virtualized application at a given allocation level of resources that can be partitioned and and watched, and the stages of competition in resources that cannot be partitioned. The next significant step is the online model refinement which takes into consideration the behavioral changes and makes the channel of future research available. High-performance virtualized data centers depend on the ability to predict a virtualized application performance at a given allocation level of an observed competition level of non-partitionable resources and partitionable resources. There are several challenges which need to be addressed for developing such a solution. The first challenge is concerned with identifying the techniques for either observing or controlling these parameters in a virtualized environment. The second challenge is the identification of the parameters of a virtualized system that can affect the performance of a virtualized application at the right level of abstraction and which are sufficient to predict a given application behavior with a high level of accuracy. The third challenge is related to building a performance model for a virtualized application based on the above parameters that can accommodate the complexity of both intra- Virtual machine monitor and inter-Virtual machine monitor resource usage dynamics [11].

C. Multiple Applications in NV:

The Parallel Selection Algorithm is adopted for many-to-many Applications in Network Virtualization. This algorithm is based on the modified Kuhn-Munkres algorithm applying to multiple applications which come from user level at the same time in NV. The parallel selection algorithm is included in the Netlet Selection where there is no available netlet that can match the application requirements, and therefore, the "Netlet Creator" will instantiate one. The "Netlet Creator" instantiates the Netlets by using a Netlet repository [29][12]. The parallel selection algorithm focuses on the performance of the integration systems rather than the algorithms which only consider the individual optimum. Then, this parallel selection algorithm energetically and forcefully selects the suitable network architectures for multiple applications [12].

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D. Application of Desktop Virtualization Technology

The four advantages that the application of desktop virtualization technology can boast of include mobile computing, security, easier management and lower costs. There are indications from these advantages that the application of desktop virtualization technology can easily acquire the support and approval of both vendors and users. Desktop virtualization has provided a way out for the consolidation of information and technology for high-end data mining like cloud computing which is convenient, fast and safe to be used by the individual desktops for the consumers. Invariably, the more the remote login protocol and virtualization technology are enhanced without interruption, then the faster and better developed will be the desktop virtualization technology. Such desktop virtualization is to make the desktop virtual allow users or let them to log in to get their personal desktops through the network with any devices at any place and any time [13].

VI. ISSUES AND DIFFICULTIES

Any group that intends to have a rapid development of NV functions should be able to address some of the difficulties for the implementation of NV functions.

A. Portability/interoperability:

This refers to the ability to operate and load virtual machines in a unified data center under different conditions by different sellers for various workers. The challenges define a unified interface which clearly separates the issues of software from hardware which are represented by the virtual machines and the devices that control them. Apart from the significance of interoperability, each ecosystem depends on the other because it makes different types of ecosystems for virtual devices and data center sellers. Furthermore, the portability permits the operator to grant them freedom to enhance the site and the resources required from virtual machines without much restrictions [9].

B. Performance trade-off:

The default approach has considered functions based on industrial standard hardware to avoid accelerated engines that have the tendency to decrease in performance. The challenging issue is how to use a right control device and a contemporary software technology to keep up the performance by checking the minimize effect of latency, productivity and overhead processing. It is appropriate that the performance for the underlying platform was marked out clearly in order to inform virtual machines that expect from the devices.The authors believe that selecting and using the right technology will allow the virtualization not only the network control functions [9].

C. Co-existence and Migration for legacy and correspondence with present platforms:

There should be co-existence between the NV Functions and network equipment for implementation to correspond with the elements of Management Systems, OSS and BSS, Network Managing System as well as the IT Synchronization System if the IT orchestrations are to be integrated. Furthermore, the migrating track must be maintained by the NV function from a proprietary physical network device to clear standards based on the virtual network device. The infrastructure of the NV Functions should maintain the migrating track from a proprietary physical network device to more opening standards according to the solutions of the virtual network device [9].

D. Automation:

The NV Functions can be measured if there is automation in the functions because the major success depends on the automation processes [9].

E. Resilience and Security:

When virtualized network functions are inserted, the network operators need certain resilience and security as well as the availability of networks in order to avoid damages. NV functions permit the access of network functions on demand after it fails by improving the available network device. When the infrastructure, the hypervisor and the configuration are secured, then a virtual device must be protected as a physical device. The network operators will search for devices that will be able to control and verify the configurations of hypervisor [9].

VII. CURRENT RESEARCH FOCUS

NV has become the focus of the network researcher. We can see that NV is considered by the majority of previous network researchers as the basis for finding a new generation of network architectures. Hence, this section outlines the focus of research of contemporary researchers for the past three years:-

- **Management of Virtual Networks**: The procedure of managing such virtual networks will be more flexible because every virtual network has its management system and its own control. Moreover, the isolation offered in NV environments can decrease the impact of security threats. Thus, managing virtual network places much emphasis on managing NV as well as identifying research the areas as opportunities for important solutions [23].
- **NV federation:** This refers to the proposed methodology for joining several NV platforms by creating and managing slices. Moreover, the NV federation is important because it supports many tenants with controller applications and raises scalability challenges and various topologies. The implementation of the proposed methodology was based on two NV platforms, and federation of joining two homogeneous areas of interest in achieving the desired result was made clear. Federation performance was also measured and there are difficulties in implementing several issues on functional restrictions as reported by previous research [32].
- **Data Center in NV:** More recently, the attention has focused on data centers (DCs) as a cost efficient infrastructure to contain a large number of data as well as large scale service applications. For instance, Amazon, Google, Facebook and Yahoo have been used as examples of companies which utilize these DCs to store information. DCs have promised efficiency and infrastructure purposely to support the storage of data as a result of the increase in data and a large number of internet applications. As such, DCs provide the necessary platform for the effective utilization of different network services and applications like video streaming and cloud computing [29].

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- **NV and Software-Defined Networks (SDN):** Virtualizing SDN is known as a SDN hypervisor that extracts the potential physical SDN into multiple logically disconnected virtual Software-Defined Networks (vSDNs), each with its own controller [30]. The tools for achieving such virtualization have been provided by SDNs. SDN is recognized as a natural platform for NV because it gives a standard connection between controller applications and switch-forwarding tables [30].
- **Virtualization-based cloud computing platforms:** With the advanced network technology the popularization in providing new additions to improvement, utilization, and delivery model for network software application (NetApp) over the Internet, the focus becomes on the server virtualization technology [31].
- **NV technology in military applications:** Military uses NV technology to design their communication network which is described as Disruption Tolerant Network (DTN) [32].
- **The network architecture (DRIVE):** This refers to data-wise routing in virtualization environment with so many levels of security for planned network. Moreover, on the basis of the level of security data, the NV technology is used to come out with a unique advantageous network routing concept which is meant for military communication [33].
- **Adopting new algorithm of virtual network:** Taking new algorithms of virtual network is based on the relationship existing between the node mapping and the link mapping, thus based on the node resource. Considering the relationship between the node mapping and link mapping shows that such properties result into distributed propagation. Selecting a time window model, the new algorithms widens the problem. In this sense, the performance of algorithms is improved by the minimum node stress and adjacent principle [34].
- **Wireless NV:** The wireless NV constitutes up three paradigms which include universal, cross-infrastructure and limited intra-infrastructure. There are variations to some degree in these virtualization paradigms where the infrastructure sharing includes both infrastructure sharing and spectrum sharing [31].
- **Re-imaging Cloud Hardware to get full Virtualization:** This refers to the alterations in the structure to overcome certain growth limitations and the difficulties involved in calculation. The infinite growth of social network and mobile computing will be accepted based on the emergence of hardware and software algorithms [32].
- **Router Virtualization:** The router virtualization improves the IP-level Resilience which is a common characteristic in the current IP devices meant to enhance the level of protection provided by LFA. The existing operator facilitates integrating infrastructure into modern multiservice MPLS/LDP in a way that will not interfere with the normal operation of the network, or the network topology itself [32].
- **MDR for NV:** The MDR for NV is a solution for Minimum Disclosure Routing (MDR) which is problematic to the SP overlaid on top of so many InPs to minimize the disclosure of its virtual network routing information to the underlying InPs [23].
- **SVNE for NV:** The SVNE for NV formulates the survivable virtual network embedding (SVNE) to be able to withstand problem in order to incorporate the single substrate link failures in VNE and also propose an efficient heuristic solution for it [30].
- **Virtualization Technologies:** Virtualization technologies integrate Hadoop and virtualization technologies to study the effects of virtualization technologies accompanied with Hadoop [17].
- **Future Mobile Carrier Networks**: Sharing standardized functionality is followed by an overview of the Radio Access Network (RAN) where sharing enhancements is currently being discussed in the 3GPP RSE and study item based on emerging business models. How this relates the networks to sharing has been partially exploited and easier to implement. active the network to share a sustainable decrease in the network expenses in order to ensure that the future operators are of cost competitiveness and also increase the importance of enabling this substantially [16].
- **NV Solution:** NV solution is the use of an Intent-based approach which offers a novel intent-based on virtual network abstraction whereby network blueprints are created to determine the verifiable specification of network functionality [15].
- **Nested Virtualization Environments:** Nested virtualization environments mean enhancing services running on virtual machines in IaaS clouds. In order to be able to build secure and reliable services in the cloud, the recommendable useful concepts are intrusion detection systems and honeypots. Intrusion detection is commendable because it enables the system to take immediate counter measures in a case of attach. The honeypots are also recommendable because such new emerging technology provides information about the actions of attackers and in that way, it assists in protecting the production system against such actions. Nested virtualization is a promising generic approach that allows cloud users to enhance the dependability of their cloud-based applications and security, without being tied to dependability mechanisms offered and specific security by the cloud provider [14].

VIII. Conclusion

In conclusion, NV has become the focus of research on network. Based on the above discussion, it is evident that NV is considered by the majority of network researchers as the basis to find a new generation of network architectures. Virtualization can be defined as the separation of the infrastructural service from the operational physical resources. However, this should have several requirements of the infrastructure for NV. This paper introduced the most important concepts related to NV, the requirements and objectives of NV. It also provided a brief description of technology and outlined its current and future applications. Finally, the study discusses the difficulties in implementing this technology.

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REFERENCES

[1] Web site (2013) "Virtualization –basic " retrieved from http://www .vmware. com/virtualization/what-is-virtualization.html / accessed on August 9.

[2] Rouskas , G.N. (2012). "Network Virtualization: A Tutorial" , Optical Fiber communication conference and exposition (OFC/NFOEC), 2012 and national Fiber Optic Engineers Conference , pp. 1-15 , IEEE conference Publications.

[3] Website (2013). "Network Virtualization", retrieved from http://www.Baselinemag.com/c/a/Projects-Networks-and-Storage/Network-Virtualization-A-Primer/ accessed on August 9.

[4] N. M. Mosharaf Kabir Chowdhury & Raouf Boutaba (2009). University of Waterloo , "Network Virtualization: State of the Art and Research Challenges" , IEEE Communications Magazine ,pp. 20-26, July.

[5] N.M. Mosharaf Kabir Chowdhury & Raouf Boutaba (2008). "A Survey of Network Virtualization" , University of Waterloo, Computer Science dep., Technical Report:pp.1-22.

[6] Jorge Carapinha & Javier Jiménez (2009). "Network Virtualization – a View from the Bottom" , conferences.sigcomm.org/sigcomm , pp73.

[7] Network Virtualization Study Group (NVSG) White Paper "Advanced Network Virtualization: Definition, Benefits, Applications, and Technical Challenges" ,pp.1-35, Version 1.0 , January 2012.

[8] Anjing Wang, "Network Virtualization: Technologies, Perspectives, and Frontiers ", journal of light wave technology, vol. 31, no. 4, February 15, 2013.

[9] Margaret Chiosi,"Network Functions Virtualization" , at the "SDN and OpenFlow World Congress", Darmstadt-Germany, pp. 1-16 , October 22-24, 2012

[10] Jiradett Kerdsri, Komwut Wipusitwarkun ,"Network Virtualization for Military Application: Review and Initial development of conceptual design", Defense Technology Institute, Thailand, 2012.

[11] Kundu , Raju Rangaswami Kaushik Dutta,and Ming Zhao, "Application Performance Modeling in a Virtualized Environment", College of Business Administration Florida International University , 2009 .

[12] Mao Yang, Yong Li, Lieguang Zeng, Depeng Jin, Li Su , "Parallel Selection Algorithm for Multiple Applications in Network Virtualization " , Tsinghua National Laboratory for Information Science and Technology , 2011.

[13] Li Yan , "Development and Application of Desktop Virtualization Technology " , Computer Studies Department,Anhui University , 2011.

[14] Michael Beham, Marius Vlad, Hans P. Reiser, "Intrusion Detection and Honeypots in Nested Virtualization Environments" , University of Passau, Germany, 2013.

[15] Rami Co Renato Recio and Vinit Jain hen , "An Intent-based Approach for Network Virtualization ", IBM Austin, USA , IFIP, 2013.

[16] Xavier Costa-Pérez and Joerg Swetina, , "Radio Access Network Virtualization for Future Mobile Carrier Networks "IEEE Communications Magazine , July 2013.

[17] Yang Yang, Xiang Long, Xiaoqiang Dou, Chengjian Wen, "Impacts of Virtualization Technologies on Hadoop ",Third International Conference on Intelligent System Design and Engineering Applications, 2013.

[18] Blenk, A., Basta, A., Reisslein, M., & Kellerer, W. (2015). Survey on Network Virtualization Hypervisors for Software Defined Networking. arXiv preprint arXiv:1506.07275.

[19] Websit (2013), What is Network Virtualization from http://bradhedlund.com/2013/05/28/what-is-network-virtualization.

[20] K. Fall, "A delay-tolerant network architecture for challenged internets," in Proceedings of the 2003 conference on Applications, 2003.

[21] L. V¨olker, D. Martin, I. E. Khayat, C. Werle, and M. Zitterbart, "ANode Architecture for 1000 Future Networks", in Proceedings of the International Workshop on the Network of the Future 2009. Dresden,Germany: IEEE, Jun. 2009.

[22] Muntasir Raihan Rahman and Raouf Boutaba, "SVNE: Survivable Virtual Network Embedding Algorithms for Network Virtualization " , IEEE transactions on network and service management, vol. 10, no. 2, June 2013.

[23] Masaki Fukushima, Kohei Sugiyama, Teruyuki Hasegawa, Toru Hasegawa ,"Minimum Disclosure Routing for Network Virtualization and Its Experimental Evaluation" , article, IEEE, 2013.

[24] J´anos Tapolcai, G´abor R´etv´ari , "Router Virtualization for Improving IP-level Resilience " , Proceedings IEEE infocom, 2013.

[25] Rafael Pereira Esteves and Lisandro Zambenedetti Granville, Federal University of Rio Grande do Sul Raouf Boutaba, University of Waterloo "On the Management of Virtual Networks" , IEEE Communications Magazine • July 2013.

[26] Yasusi Kanada and Toshiaki Tarui, Kei Shiraishi, "Federation-less-federation of Network-virtualization Platforms" Hitachi, Ltd., Central Research Laboratory Yokohama, Japan , 2013.

[27] Md. Faizul Bari, Raouf Boutaba, Rafael Esteves, Lisandro Zambenedetti Granville, Maxim Podlesny, Md Golam Rabbani, Qi Zhang, and Mohamed Faten Zhani "Data Center Network Virtualization: A Survey" , IEEE communications surveys & tutorials, vol. 15, no. 2, second quarter 2013.

[28] Dmitry Drutskoy, "Scalable Network Virtualization in Software-Defined Networks " , IEEE internet computing, 2013.

[29] Lu Liu, Osama Masfary Jianxin Li, "Evaluation of Server Virtualization Technologies for Green IT ",Proceedings of The 6th IEEE International Symposium on Service Oriented System Engineering (SOSE 2011).

[30] Jiradett Kerdsri, Komwut Wipusitwarkun "Network Virtualization for Military Application Review and Initial development of conceptual design" , Sirindhorn International Institute of Technology, Thailand, ICACT, 2012.

[31] Jiradett Kerdsri, Komwut Wipusitwarkun , "Data-wise Routing in Virtualization Environment (DRIVE) with multiple level of security for tactical network , IEEE/SICE International Symposium on System Integration (SII) , 2012.

[32] Hongyan Cui, Fangjie Kong, Yunjie Liu , "A new algorithm of virtual network embedding based on minimum node stress and adjacent principle "The 4th IEEE International Workshop on Management of Emerging Networks and Services, 2012.

[33] Xin Wang, Prashant Krishnamurthy, and David Tipper , "Wireless Network Virtualization "International Conference on Computing, Networking and Communications, Invited Position Papers , 2013.

[34] Mike Redford,"Full Virtualization by Re-imaging Cloud Hardware "University of Fairfax, Vienna, Virginia. USA , 2011.

Muthana Najim Abdulleh, was born in Iraq. He obtained his Bachelors In Information System from Iraq. He is complete his study in Master of Information Technology from Universiti Tenaga Nasional (UNITEN), Kram, Selangor, Malaysia..

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