Network Virtualization: Growing Technology and a Field of Research Challenges

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Abstract-Recently network virtualization has been pushed forward by its proponents as a long term solution to the gradual ossification problem faced by the existing Internet and proposed to be an integral part of the next-generation networking paradigm. By allowing multiple heterogeneous network architectures to cohabit on a shared physical substrate, network virtualization provides flexibility, promotes diversity, and promises security and increased manageability. However, many technical issues stand in the way toward its successful realization. This article investigates the past and the state of the art in network virtualization along with the future challenges that must be addressed to realize a viable network virtualization environment.

Keywords – Architecture, Link virtualization, Node virtualization

I. INTRODUCTION

For the past years, we have enjoyed a technological overhang as the personal computer has moved from being a rarity to a mainstay of lives around the world. Many positive effects have been observed, the fact remains that we expect more from technology than we frequently gets.

Now the next step in the field of technology is virtualization. The concept of virtualization steps in the business and consumer world as "the next big thing."

Virtualization means creating a virtual layer in a computer by hiding physical characteristics of computing resources from the way in which other systems, applications or end users interact with those resources. Hence, virtualization provides an abstraction between user and physical resources, so that the user gets the illusion of direct interaction with those physical resources. For example, when you get a Google map on your cell phone or when your PC automatically shop for the lowest price, you are using virtualization. The goal of virtualization is to centralize administrative tasks while improving scalability and overall hardware resource utilization.

II. OVERVIEW

Virtual Network fulfils the basic goal of providing different logical networks over a shared infrastructure, but suffers from a few limitations, among others:

- All virtual networks are based on the same technology and protocol stack, which precludes the coexistence of different networking solutions;
- A real isolation of virtual network resources is not possible, by default;
- A clean separation of the roles of infrastructure provider and VPN service provider is not possible and in practice they are played by the same entity.

Hence, Network virtualization is a technology that encapsulates computer network resources into a single platform appearing as a single network. In this form of virtualization all components of computer in the virtual network appear as a single collection of resource. There is another form of network virtualization in which logically isolated network partitions are created over the shared physical network infrastructure. This form of partitioning the results in co-existence of multiple heterogeneous virtual networks, simultaneously over the shared infrastructure is as shown in figure 1.

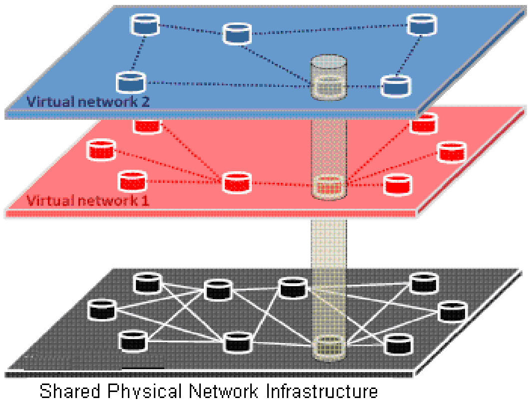

Figure 1 - Logical infrastructure of Network virtualization

Network virtualization is a technology to achieve better utilization of infrastructures in terms of reusing a single or multiple resources for multiple other network instances. These resources can be network components, for example routers, switches, hosts, virtual machines, etc. Hence, Network virtualization can reduce the total cost by utilizing network resources in a recycle fashion in better way.

III. KEY FEATURES

Some of the key features of network virtualization are given below:

a) Partitioning: It is possible to create logical network partitions with a programmable control plane so that users can use protocols, network topologies, and functions as per their requirements. The re-usability capability of Network virtualization make the logical partitions capable of easily and rapidly creating network topologies and reconfiguration according to user's requirements, the status of networks, policies of resource owners, etc.

b) Isolation: Once isolation has been done, then, among logical network partitions, there is no interference which may affect network performance. This includes the isolation to deterioration of the performance of a logical partition due to excess use of network resource logical partition.

c) Abstraction: Network abstraction allows hiding the underlying characteristics of network elements from the way in which other network elements, applications, or users interact with those network elements, separates instances and control frameworks of network virtualization.

d) Aggregation: Network virtualization makes it possible to provide high performance resources for users by logically aggregating multiple resources into single resource.

To illustrate some of the key features, we may take Server Virtualization as an example. Server virtualization software allows the user to run multiple guest computers on a single host computer with those guest computers believing that they are running on their own hardware. By this, user gain all the benefits of any type of virtualization such as portability of guest virtual machines, reduced operating costs, reduced administrative overhead, server consolidation, testing & training, and disaster recovery benefits.

IV. COMPONENTS OF VIRTUAL NETWORK

Here are some components offered by vendors for network virtualization either alone or in combination:

- Network hardware, such as switches and network adapters, also known as network interface cards (NICs);
- Network elements such as Firewalls, Load Balancers;
- Networks, such as (VLANs) and containers such as virtual machines (VMs) and Solaris Containers;
- Network storage devices;
- Network M2M element such as Telecommunications 4G HLR and SLR devices;
- Network Mobile elements such as Laptops, Tablets and Cell Phones;
- Network media, such as Ethernet and Fiber Channel.

Following is a survey of common network virtualization scenarios and examples.

External network virtualization: External network virtualization offered by some vendors, in which one or more local networks are combined or subdivided into virtual networks, with the goal of improving the efficiency of a large corporate network or data centre. The most important components of an external virtual network are the VLAN and the network switch. Using VLAN and switch technology, the system administrator can configure systems physically attached to the same local network into different virtual networks. Conversely, VLAN technology enables the system administrator to combine systems on separate local networks into a VLAN spanning the segments of a large corporate network.

Internal network virtualization: Internal network virtualization offered by other vendors is single system configured with containers, such as the Xen domain, combined with hypervisor control programs or pseudo-interfaces such as the VNIC, to create a "network in a box." This solution improves overall efficiency of a single system by isolating applications to separate containers and pseudo interfaces.

V. ARCHITECTURE OF NETWORK VIRTUALIZATION

Network virtualization is required to be capable of providing multiple partition of network appearing to be isolated from each other.

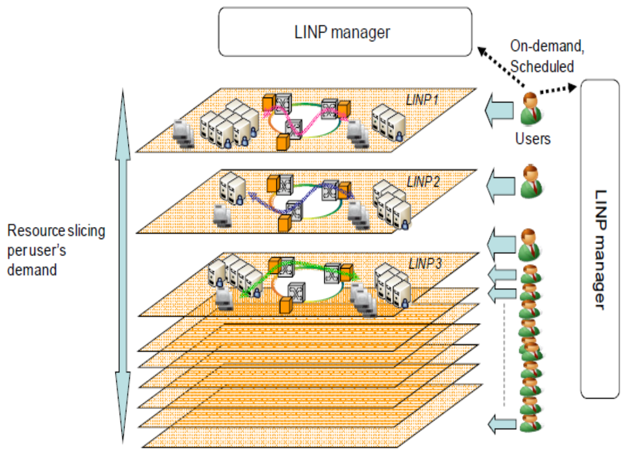

Figure 2 - Network virtualization

These partitions, also referred to as Logically Isolated Network Partitions (LINP), may be created over the single physical infrastructure. Figure 2 shows multiple LINPs created in a network virtualization framework. Each LINP is isolated from each other and is programmable to satisfy the user's demand on the functionality and amount. Users' demand is conveyed to an entity known as LINP manager which coordinates infrastructures resource so that appropriate LINP is provided to the user as per the user's demand.

VI. EXAMPLE

Virtualization at application level: Figure 3 shows an example of relation between applications and LINPs. Each application accesses the LINP to control the functionality of the LINP, such as routing. Multiple applications may access the same LINP.

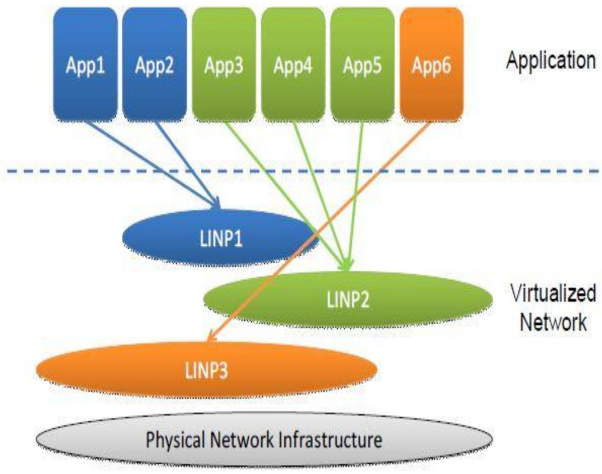

Figure 3: Relationship between application and LINP

VII. BENEFITS OF NETWORK VIRTUALIZATION

At the device level network virtualization reduces the number of physical network devices, or when done at the network level, by creating multiple logical networks, enables full utilization of one physical network.

In brief, following are some of the benefits of network virtualization:

- It helps in de-ossifying the current network architectures.
- It allows multiple virtual networks to coexist over a shared physical infrastructure.
- It provides paths to the future networks approaches.
- It allows the deployment of new business roles and players.
- It reduces/shares cost of ownership.
- It optimizes the resource (network infrastructure) usage.

VIII. AREAS OF RESEARCH AND CHALLENGES

Following are some of the issues or challenges which need attention to avail the benefits of network virtualization. They are as:

a) Isolation: It is quite difficult to provide secure isolation among the network services. The isolation involves many aspects as performance isolation, management isolation, and many more. For example, as multiple network services coexist over shared physical infrastructures, performance problems in a service may spread out over the whole network and may cause performance degradation of other services. Hence, it is to be ensured that Network virtualization provides complete isolation of any LINP from all others, minimizes the impact of behaviour of LINPs to other networks, and supports diversity of application, service and architectures.

b) Flexibility: In network virtualization, it should be convenient for users to use arbitrary network topologies, forwarding or routing functions, and protocols.

c) Management: Since each and every virtual network is independent of other virtual networks, it has to be managed and handled independently from other virtual networks. At the same time, the management system for the virtual network has to collaborate with the management system of physical infrastructure. It is therefore mandatory for users to carefully define which part of management can be done by the management system of the virtual network, and how to align it with that of physical infrastructure. Moreover, if the isolation is not perfect, alignment with the management systems of other virtual networks also becomes necessary.

d) Security: Network virtualization should ensure user that each and every complete isolated virtual layers among logical network partitions are not prone to threat. Thus the failure or malfunction or security problem in one service or in one of the logical network is independent of other logical networks and should not affect the other virtual layer.

CONCLUSION

Network virtualization has been accepted as a key technology for the future and has been recognized as a powerful way to bring significant benefits for the enterprises that deploy it. For network operators, it brings new business scenario where they can sell infrastructure to third parties, diversify infrastructure for private purposes, minimize the cost of ownership, and provide network infrastructure as a managed service.

However, implementation and deployment of the network virtualization needs to satisfy its requirements, characteristics and design goals such as manageability, scalability, reliability, isolation, security, etc.

This paper is focused on the impact of virtualization on the network infrastructure and tries to provide a broad overview of the main challenges ahead. Several topics have been briefly discussed and should be further developed in the future. Another issue that should deserve further attention is the co-existence of several crucial, but to some extent conflicting, goals for infrastructure providers: scalability, flexibility, strict VN isolation.

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