Research Report
Software Defined Networking

April 2017

Jin Tae Kim(1485971), Computing Department, Unitec

Abstract---Information Technology (IT) has been evolving rapidly in the past two years. With the emergence of cloud services, most organizations are modifying their data centers to take advantages of the services provided by virtualization technology. With this type of technology, efficiency and security are very important [1]. The network administrators, operators and service providers needs a solution that will increase the efficiency of their network to meet the rapid changing and increasing demands of this network architecture. Software Defined networking (SDN) has emerged as a solution for all the above requirements due to its efficient nature and ability to support dynamic applications [2]. In addition to being intelligent, the SDN has also promised to offer efficient operations at low cost. This report will revolve around the question of how to implement a grade network with Software Defined Networking. The specific focus will be placed on the security, scalability, interoperability and potential solutions to the challenges [2].

1. BACKGROUND

Software Defined Networking (SDN) refers to a new architecture offering programmable controls over the network [3]. It has been the hottest topic in network discussions in the last two years. Its ability to offer controls over the network has enabled many computing devices and their applications to be accessible of the network infrastructure [4]. This architecture abstracts networked applications and services creating a virtual/logical entity. Software Defined Networks came into existence as a result of trying to solve some limitations associated with the Traditional Data Network.

1.1 Traditional Data Network

As opposed to the Software Defined Networks, Traditional Data Networks had functionalities implemented on the specific appliance; e.g. router, application controllers, and switch [1]. In addition to that, most functionalities were implemented in hardware dedicated appliances i.e. Application Specific Integrated Circuit (ASIC).

Below are some of the characteristics of Traditional Data Network when developing network appliances:

i. Network functionality is provided by Application Specific Integrated Circuits that evolves slowly.

ii. Provider of the appliance controls how the ASIC functionalities evolve.

iii. Appliances are proprietary.

iv. Individual configuration of appliances.

v. Most tasks are error prone; for example change management.

Most networking organization are rapidly growing and hence their need for efficiency cannot be meet by the traditional networking approach. These organizations has adopted the current technology of server virtualization and that becomes one of the reasons of demanding a newer networking approach (SDN) to traditional networks [4]. Server virtualization comes with another factor of speed. Virtual Machines involved in server virtualization has to keep on moving from one server to another in a matter of seconds. If by any chance the Virtual Machine moves past the boundary of Layer 3, it may take weeks or months to reconfigure the network to support its movement in the new location [2].

The key points to note about the traditional network approach are, it has limited functionality i.e. it only supports functionalities defined by the vendors, it evolves slowly, and it is static in nature and has high operational expenditure (OPEX) level [5]. To overcome all these limitations, organizations are migrating to the new networking architecture brought by SDN.

1.2 Software Defined Networking

Software Defined Network architectures are dynamic, cost-effective, adaptable and manageable networking approach for high bandwidth and supports dynamic applications. The approach is developed and standardized by Open Networking Foundation (ONF) group [6]. In this approach of networking, network control and forwarding functions are decoupled making the infrastructure to be abstracted for both applications and network services. It encompasses OpenFlowTM protocol as its foundational element.

Software Defined Networks have got centralized controllers where the Network intelligence software is installed. It is through these controllers that SDN is able to view and control the overall network architecture [7]. Having a single control point makes SND architectures to be perceived as single logical/virtual switch. This is due to abstraction of network applications and services offered by the network. The centralized controllers also make organizations that have adopted the SDN to be independent of vendors control over the network since the SDN is a programmable network, unlike the Traditional network.

The centralized controllers or single point of control makes this type of network to use very few devices. This is because the controller interprets all the instructions of the network which would have else required thousands of devices to do the same.

When it comes to reconfiguring the network, SDN requires only a few lines of codes to reconfigure the controllers. Configuring Traditional network required the network operators and administrators to write millions of code since every device was configured individually [8].

2. CRITICAL EVALUATION A SPECIFIC SDN APPLICATION

In this report, I would like to discuss storage applications. From the past two decades, organizations have been working with storage systems that embed SDN network switches on their platform. They have been manipulating the ternary content-addressable memory (TCAM) forwarding tables directly though the chipset APIs and OpenFlow [8].

2.1 Raid Storage

In the past two years, vendors used aggregated RAID techniques which involved putting spinning disks together in a big box. These box were used as file systems which were abstracted on the network. The spinning disks are arranged into array of disks having the same redundancy and performance. This provides improved and balanced performance for the servers [9].

Raid implemented using Utra320 can offer a throughput of 165 MB/s when accessed sequentially [7]. This means that read/write operation can be performed on a 300 GB hard disk within an hour.

As organisations continues to grow each and every day, their data continues to increase. This means that, in order for an organisation to maintain its performance, it must virtualize its storage systems. Virtualizing RAID will mean adding very many numbers of drives in the volume group [10]. The rebuild operation can be very expensive and time consuming. Organisations therefore requires a solution that will yield to the same or improved performance at low cost.

2.2 Flash Storage

On the other hand, we have flash storage which has also been a sudden problem. It is also a form of hardware storage that has been in existence for more than five years. Initially, this type of storage was very expensive and unreliable [7]. They offered great Random I/O access and performed the same functions as hard disks. That was exactly what qualified them to be used as storage systems. With the emergence of this technology, vendors started to replace some spinning hard disks with SSDs and used them as a cache. The SSDs and disks shared SATA bus which serve very slow and aggregated to only 10 GB connection.

The emergence of PCI-e-based flash hardware changed everything. They eliminated the use of storage buses and now shares the same high-speed interconnection offered by the NIC [7] [6]. The aggregated 10 GB connection can now be saturated by a single PCI e-flash card.

The storage came to solve the problem of low-performance disks aggregated in a single box. Despite solving the problem, it brought another problem exposing the enterprise performance capabilities as a result of having solid state memories in their distributed system of the organization network. This approach requires a lot of logic when addressing the PCI e-flash devices that connected to an SDN switch.

2.3 How SDN Solves Storage Problem

In this part, am trying to address the virtualized NFS-based environment as the initial customer environment for storage. VMware is configured to only use one shared server but is deployable across many hosts. We, therefore, need to come up with a way to take advantage of the SDN to enable sharing of this expensive PCI e-flash across all servers. This will end up solving the problem of bottleneck effect in the enterprise network.

2.3.1 SDN solves the problem of single IP Endpoint

First, we need to understand that we cannot change the client software stack on another deployed software. Therefore, performance and scalability have to be implemented in such a way that they will support legacy protocols. Storages based on IP protocols like NFS works on the assumptions that each server is associated with only one IP address [2]. In our case, we are looking at effective distributed TCP stack on NFS server implementation. Setting a new connection on a single configured IP address will trigger an OpenFlow exception that gives us an option to assign it to the connection to the least loaded node in that system. It should also allow connections to migrate from heavily loaded node to nodes that have light or no connections. This will enable the switch to control redirection of flow of resources across the storage. With that, we can be able to provide the client with the full width of connectivity to the storage resources through the switch. We can also implement the same by using OpenFlow to balance the loads as it can place the connections and migrations in an effective way based on its own understanding.

This scalability problem is solved by SDN which decouples the client connections from its storage controller. In SDN, the stored data is viewed as a fluid resource. The client connection and underlying data can be moved together in response to their access and load pattern.

2.3.2 SDN solves the problem of High-performance multi-tenant isolation

SDN extends the sharing of virtual machines that are isolated in networks. The isolated network resources can now be shared through the support of the entire distributed system which is now managed as a single unit. The VMs will connect the virtual networks together with their resources including storage and data allowing them to be shared between the networks.

2.4 BENEFITS OF SDN AS COMPARED TO

TRADITIONAL NETWORKING; THE SDN IS,

Directly programmable: this is because its network controls are decoupled from their forwarding functions.

Agile: network administrators and operators can dynamically adjust network traffic as per requirement. This becomes possible since the network controls are decoupled from their forwarding function.

Centrally managed: the network is managed from a central point where the Network intelligence software is installed. I.e. in the SDN controllers.

Pragmatically configured: SDN network managers can write their own programs to control the network functionalities. E.g. security, optimize network dynamic resources quickly. The managers have these privileges since the programs are independent from proprietary software [11].

3. RESEARCH GAP IN THE STATE OF THE ART

The main gap is how the SDN should be able to handle client movement without losing access to current resources. It should be able to tunnel resources in the virtualized network so that the client would not be limited to resources from one server each time. It should be efficient in tunneling resources in a way that client should not be aware or the change in connections. When client changes from one connection to another, the connection should also go hand in hand with the resources. I.e. the access should not be terminated. The client should not necessary know where the resources are located though he/she should perceive the network as a whole or a single unit. This should be done virtualizing a network with many flash resources in a network. This PCI e-flash should then be defined by the OpenFlow which will then create tunnels to each end system. Through this, the client will be able to access resources from any network which to him will be a single virtual network. It will also give the client the advantage of getting resources for expensive and high-performance storage. In traditional networks, this could only be done through an intermediary between the client and the resources, which increased the risk of the bottleneck in the network performance [12]

4. CHALLENGES

Despite the SDN being essential for providing solutions for enterprises and cloud providers, it faces some challenges that affect its implementation and performance. Some of the challenges include: Scalability, Scalability, Interoperability, and Performance [6].

4.1 Security

Since most of the very important work in SDN architecture is performed on the control panel, the security strategy must ensure no an authorized applications should access the control panel. It should protect it and authenticate applications that want the control panel. New and an authorized service risks the SDN security as they may introduce harmful codes which may extend to countless network segments each carrying its own risk.

4.2 Scalability

Since SDN architecture allows for interfacing with other panels, there are chances that bottleneck may occur in the network controllers. Large organization networks with very high traffic can overwhelm the network controllers. Network performance continues to degrade as the network continues to growth.

Scalability of the network can be improved by implementing a splinted or fully distributed panels. The above solutions can bring some obstacles to the network in form of convergence, and demand for very many control instances that needs to be managed.

4.3 Interoperability

It's straightforward for new networks to implement SDN since all devices are ready. Creating an SDN network by inheriting a traditional network is a story as since the traditional network may fail to support new devices added to its network. Most network environment and Organizations that have to change to SDN requires a period interoperability test with the new SDN infrastructures.

The legacy network should use appropriate the protocol that supports communications between the legacy network nodes and SDN. This will help in reducing disruption of services, risks, and cost that may be incurred while moving to SDN.

4.4 Performance

This is the essential part of all networks regardless of how secure, scalable, robust and interoperable they are. Adding new controls or data plan architectures to the network can lead to an unnecessary delay which ends up degrading the network performance.

The solution to this is to add more intelligence data plans or control panels architectures of some types. This will tend to shift the SDN network to traditional network and hence balance will be needed to maintain virtualization without introducing points of failure or degrading performance.

5. DISCUSSION AND FUTURE WORK

The future of SDN will be an implementation of full programmable networks that will allow organizations roll out new products offered to customers by linking services together and launch in days instead of weeks, months or years.

To clarify this, OpenFlow is an open protocol responsible for taking elements in the network. Though most networking professional claims that you can't do SDN without using OpenFlow there are still other alternatives that provide similar functionality and even extends elements of a legacy network to provide programmability i.e., NETCONF. Venders' solutions are built on the leading SDN open source solution (OpenDaylight) [13].

6. CONCLUSION AND SUMMARY

Having done all my research on SDN, I have no doubt saying that SDN has shown a great and significant impact on network enterprises and in the roles played by IT professionals. Due to server virtualization and user mobility in the changing business environments, SDN needs to be rapidly evolved to respond to these changes and demands in an efficient way [4].

SDN is a dynamic network that has been transformed from the traditional network to provide broad and services and solutions that are limited in the traditional network. The SDN which is OpenFlow architecture is able to provide solutions for traditional network issues by decoupling network forwarding and controls. The OpenFlow SDN is also programmable and has manageable scales and hence network organizations using it becomes independent of their vendors. Having a common approach to tool set in SDN network visualization, IT operators and administrators are able to manage applications, servers, and storages very easily.

Adoption of SDN network improves scalability, manageability, and agility in any networking environment i.e. either enterprise or carrier environment. The Open Networking Foundation group develops and manages standards for SDN infrastructures ranging from software developers to hardware manufacturers. OpenFlow switching has now been integrated into various architecture designs such as SDN controller software and on both physical and virtual designs to enhance efficient communications between them. The future of SDN is mainly based on software that will increase the rate of innovations for networks due to the presence of legacy computing and storage domains.

SDN promises to provide solutions to the static traditional networks by providing a flexible, programmable and intelligent network that can allocate resources dynamically [5]. This will scale to support large networking organizations that need efficient virtualization due to the enormous data involved [7]. Having given the many advantages of SDN over traditional networks and its great impacts in enterprises, SDN, therefore becomes the new norm for today's networks.

Reference

[1] G. Ferro, "Analyst Report: Evolving SDN: Tackling challenges for web-scale deployments," GIGAOM, 2013. [Online]. Available: https://gigaom.com/report/evolving-sdn-tackling-challenges-for-web-scale-deployments/.

[2] S. Sezer, S. Scott-Hayward, P. K. Chouhan, B. Fraser, D. Lake, J. Finnegan and N. Viljoen, "Are we ready for SDN? Implementation challenges for software-defined networks," IEEE Communications Magazine, 2013. [Online]. Available: http://ieeexplore.ieee.org/document/6553676/.

[3] A. Shapochka, "4 Challenges Lying in the Wait of SDN," nojitter, 2015. [Online]. Available: http://www.nojitter.com/post/240169834/4-challenges-lying-in-the-wait-of-sdn.

[4] sdxcentral, "What's Software Defined Networking (SDN)? Definition," sdxcentral, [Online]. Available: https://www.sdxcentral.com/sdn/definitions/what-the-definition-of-software-defined-networking-sdn/.

[5] citrix.dk, "SDN 101: An introduction to software-defined networking," citrix.dk, [Online]. Available: https://www.citrix.dk/products/netscaler-adc/resources/sdn-101.html.

[6] T. Lin, J.-M. Kang, H. Bannazadeh and A. Leon-Garcia, "Enabling SDN applications on Software-Defined Infrastructure," Network Operations and Management Symposium (NOMS), 2014. [Online]. Available: http://ieeexplore.ieee.org/document/6838226/.

[7] A. Warfield, "Data, Storage, and SDN: An Application Example," cohodata, 2014. [Online]. Available: http://www.cohodata.com/blog/2014/01/22/data-storage-and-sdn-an-application-example/.

[8] A. M. Dr. Jin Metzler, "The 2013 Guide to Network Visualization and SDN," AVAYA, 2013. [Online]. Available: https://www.avaya.com/en/documents/the_2013_guide_to_network_virtualization_and_sdn.pdf.

[9] V. Beal, "RAID - redundant array of independent disks," webopedia, [Online]. Available: http://www.webopedia.com/TERM/R/RAID.html.

[10] G. Crump, "Five ways to control RAID rebuild times," TechTarget, [Online]. Available: http://searchsmbstorage.techtarget.com/tip/Five-ways-to-control-RAID-rebuild-times.

[11] I. M. J. A. L. A. S. S. Veeramani Shamugam, "Software Defined Networking challenges and future direction: A case study of implementing SDN features on OpenStack private cloud," IOP Publishing , 2015. [Online]. Available: http://iopscience.iop.org/article/10.1088/1757-899X/121/1/012003/pdf.

[12] A. G. P. B. D. C. S. G. T. Akram Hakiri, "Software-defined Networking: Challenges and Research Opportunities for Future Internet," Vanderbilt , 2014. [Online]. Available: http://www.dre.vanderbilt.edu/~gokhale/WWW/papers/COMNET14_SDN.pdf.

[13] S. Rao, "OpenFlow: What is the future of SDN?," Quora, 2014. [Online]. Available: https://www.quora.com/OpenFlow-What-is-the-future-of-SDN.

[14] A. Manzalini, "5G Network Softwarization," ieee-sdn.blogspot, 2017. [Online]. Available: http://ieee-sdn.blogspot.co.nz/.

[15] H. Marks, "RAID Redefined," networkcomputing, 2014. [Online]. Available: http://www.networkcomputing.com/storage/raid-redefined/1994513662.

[16] ONF, "Software-Defined Networking: The New Norm for Networks," Open Networking Foundation, 2012. [Online]. Available: https://www.opennetworking.org/images/stories/downloads/sdn-resources/white-papers/wp-sdn-newnorm.pdf.