Software Defined Network: The Revolution of Modern Networks

A Literature Review on Software Defined Network

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Abstract

Software defined network (SDN) is an emerging architecture of network which draws many leading corporations' interest. In this article, we examine several papers mainly from IEEE journals on this topic during the recent 5 years, and try to explain what software defined network is, and briefly introduce some background information about it followed by specific use case of SDN, in particular, the role it plays in network management, data center network and virtualization of cloud computing. We also have evaluation and conclusion of the current states of SDN related research nowadays.

Key words: *software defined network, network management, network virtualization*

Introduction

In the past, people tend to use simple network devices, but as user demand expanding with the technology development everyday, engineers add more and more sophisticated functions to routers, switches and many other network devices resulting in that they become super complicated [1]. Under this circumstance, SDN was first presented by a research group called clean slate in Stanford University. It uses a core technique of decoupling the data plane and control plane to implement the flexible network management, providing a better platform for network and application innovation.

As it was created a few years ago, SDN remains in development. Many APIs provided for higher level applications are still not standardized in spite of the southbound APIs (used to manipulate lower level hardware) have reached a commonly admitted standard—OpenFlow which originates from the same place where SDN was proposed at Stanford University [2]. Now OpenFlow is commonly used globally and is the major approach to implement an SDN.

SDN can improve the performance of the network in various aspects. In the latest 10 years, it has made a great deal of contribution to network routing, network management, and network virtualization. For its conceptually innovative idea and significant acceleration to the modern network progress, it is called “the revolution of modern networks”.

Review Scope and Method

In this review report, basically we illustrate what SDN and OpenFlow are, how it works, and its special features, however, we focus more on the use of SDN in different cases and some useful models and prototypes built based on SDN. Network virtualization, data center network, network routing and network management and some other fields that SDN can perform well in are included. Finally the evaluation will be appended.

Most papers are chosen from IEEE Explorer through Monash Online Library, and we use “software defined network” as the key words when searching the relative articles. Since the main target is to have a rough idea of what SDN can be applied, we focus more on the various field that SDN can be used in, and engineering articles are preferred rather than those about theoretical research.

Body of Review

What is Software Defined Network & OpenFlow

There are various types of definition of SDN. Kim and Feamster [3] thought software defined network is a new paradiam in networking which decouples the control plane and data plane in routers and switches making them simply transfer data packets and leaving a cetralized programmable controller to control how and where to send those packets.

With the appearance of SDN, recent work has introduced the notion of southbound and northbound interfaces. The southbound interface refers to one kind of interfaces and protocols that connects programmable switches and the software controller, while the northbound interfaces determines how to express operational tasks and network policies, and also how to translate them into the form that the controller can understand [3].

OpenFlow which is a standard set up by many famous vendors like HP, NEC, IBM and so on is one of the most common southbound SDN interfaces. Nowadays, making switches and routers OpenFlow enabled has become the trend among the manufacturers.

Why Does SDN Become So Special

The modern network is facing two major problems, one is the complexity, and the other is the flexibility. The key challenges of network architecture are how to adapt the rapid change of business with less complexity which can be addressed by one approach—SDN [4].

Basically Jain and Paul [2] conclude that SDN has 4 innovative features:

1. ***Separation of the control and data plane***. The control logic of forwarding data packets is separated and implemented in an independent controller which can be programmed individually, so it reduces both the complexity and the cost of the infrastructure devices significantly.
2. ***Centralization of the control plane***. In the past decades, experts in IT preferred distribution much more than centralization, and they thought centralization was a terrible thing until a few years ago. Centralization came back to people's view and more and more systems are designed centralized due to its good performance when a structural change occurs in spite of its scaling issues. The efficiency of adjusting control policy makes it a better choice than distributed network management system.
3. ***Programmability of the control plane***. This is the key factor that makes SDN has a easier and more efficient reaction to the network modification and network event, because altering a centralized and programmable controller can provide quick and accurate responses and it is much easier compared to the legacy network with very complicated devices[1].
4. ***Standardization of application programming interfaces***. What we want to point out is OpenFlow—the most commonly used southbound API which has been standardized by the Open Network Foundation.

What Can Software Defined Network Do

SDN can be applied in many fields, such as network management, network virtualization, and network service, also, in data center network and routing system you can find SDN easily as well. Here are some examples which show how SDN facilitates the development of modern network engineering.

1. ***Meet the requirement of data center network***. When legacy ethernet is still struggling to meet the performance and scalability requirement of data centers, SDN can handle this issue at a very low cost due to its separation between controllers and traditional routers and switches. SDN technique can be employed in some loss-free multipathing solution for data center network to reduce overhead and accelerate update [5]. Since SDN has centralized data controller to dispatch all the flow in the system, thus the data packets can carry less control information so that data sources can react more rapidly to the bad network condition such as congestion.
2. ***Save the cost of Internet equipment***. Hares and White [4] believes that as the exponentially increasing amount of information travelling arount the Internet, the cost scale is getting higher and higher, so network operators are looking for ways to reduce expensive cost of maintainance of network. Removing redundant equipment makes OpenFlow enabled switches much simpler than traditional ones which results in the relative lower cost happens to cut down the expense perfectly.
3. ***Serve as the infrastructure of network service***. Rubio-Loyola et al. [6] published one article to describe the architectural model and validation results of the European Union Autonomic Internet (AutoI) project which was built on SDN and enables fast and scalable composition of services in an efficient manner.According to Banikazemi et al. [7] , they worked out an SDN controller platform called Meridian which supports service-level application among clouds.
4. ***Provide interfaces to the routing system***. The IETF's Interface to the Routing System (I2RS) protocol can utilize software defined network. I2RS is designed to provide the flexibility that network operators expect from SDN as well as the network-layer control plane[4]. Google used to set up an internal network connecting its data centers with an SDN-based network with OpenFlow enabled

switches, and tested for 2-3 years. During the testing, Google investigated the new interface to the routing system.

5. ***Apply to optical transport layer network architecture***. SDN control paradigm can be applied to optical networks that supports various types of transport and switching technologies[8]. In 2012 IEEE Image and Signal Processing and Analysis (ISPA) conferences, service providers and equipment providers discussed the efficiency gains that a SDN approach could have and the result is, theoretically increased from 60 to 98-99 percent[4].
6. ***Network virtualization in cloud computing***. It is widely accepted that virtualization is the key to the cloud computing, and SDN is expected to make the networks more programmable, partitionable, and virtualizable. Furthermore, current SDN-based technologies mostly focus on Layer 3 or lower, it may extend to manage Layer 3 or above, for example, OpenADN which is based on the standardized model of data plane proposed by SDN may be one of the solution[2].
7. ***Improve network management***. Network is challenging nowadays. Network operators need to maintain, operate, and secure a network with very tedious low-level vendor-specific configurations by implementing various types of high-level network policies, and it's even harder when dealing with the rapid network change and network event because today's networks have an extremely big scale with little or no mechanism responding to the wide range of changes or events may occur[3]. However, with the help of SDN due to its centralized control plane principle, it becomes much easier than ever before. Only the forwarding controller need to be altered not like before that all the distributed devices are in the change list, in which way increase the efficiency of network management significantly.

Evaluation and Conclusion

SDN is the very state-of-the-art network technology at this moment. By virtue of its original and novel idea of separating control plane and data plane of network device to decouple forwarding logic and data transportation, it attracted a lot of interest of IT industry in a very short time. Until now there are still many huge corporations and research institutes working on this topic. Yet there have been a few achievements and SDN has been applied to many aspects in IT industry as listed above. However, software defined network is still in its infancy, there are some drawbacks need to be handled. As all the other products with a centralized structure, it has an inherent defect—lack of scalability. The simplicity of a logical centralized controller may come at the cost of control plane scalability which may become a key bottleneck as the modern network scales up rapidly in both the numbers of switches and the number of end hosts unfortunately. Besides, SDN has a relatively unified southbound API which is known as OpenFlow, but northbound interfaces remain a mess. Different specifications established by various vendors coexist and even contend with each other. Security is another problem to address. Because the controller is abstracted, it becomes vulnerable and once it is attacked the whole network communication will be down as a result. Aiming at these unmature aspects we think more research need to be conducted. So, in conclusion, software defined network is totally new invention full of inspiring ideas, it has a potential power to put the development of network a big step forward, but on the other side, there is room for its development and expansion. Generally speaking, we believe that SDN has a very promising future.

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