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Framework for optimized multimedia routing over software defined networks

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ABSTRACT

The increase of data traffic moving in the Internet is particularly concentrated in multimedia content. However, the rigidity of the typical Internet architecture based on best-effort oriented IP network has limited the development of innovative network services. The new post-PC multimedia services require networks with high levels of flexibility and customization in order to provide efficient security, mobility, availability and QoS. In this context, software defined networking (SDN) is a novel paradigm that decouples the data and control plane in network devices and opens the programming capabilities of the network behavior. SDN opens the possibility to customize the network behavior in function of the different users requirements.

In this paper, we describe the SDN architecture and analyze the opportunities to provide new multimedia services. Moreover, a SDN framework is also presented to provide QoS for different multimedia services. This framework uses OpenFlow, Network Virtualization and establishes functional boxes and interfaces to test different routing algorithms. Then, the modules of "Network Performance" and "QoS Routing Algorithm" are implemented to demonstrate the effectiveness of the framework. The experiments with video streaming information show a quality optimization (PSNR, SSIM, MOS) in comparison with the best effort engine. Finally, the challenges of SDN and the future lines of work are presented.

1. Introduction

Typical network architecture was originally designed to transmit information and provide connectivity through the best-effort paradigm. The information, indistinct of the type of data, has the same treatment at the network layer. The upper layers have the task of reading the information and classifying the different services (e-mail, http, ftp). In this context, the route between source and destination is established in a distributed system, where an individual and not a global view of the network is used. Each network device uses a routing protocol to establish the network topology and the routing algorithm computes the next hop. This structure has worked properly for data transmission and facilitated the expansion of Internet in new areas of human activity.

However, the exponential growth of devices connected to the Internet and the development of new post-PC services (VoIP, video streaming, Internet of Things, cloud computing) brought with it unexpected challenges to the rigid network architecture of today. For example, real time streaming information is more sensitive to delays than e-mail services and the network equipment should categorize this different data types in lower layers. In the current networks, these

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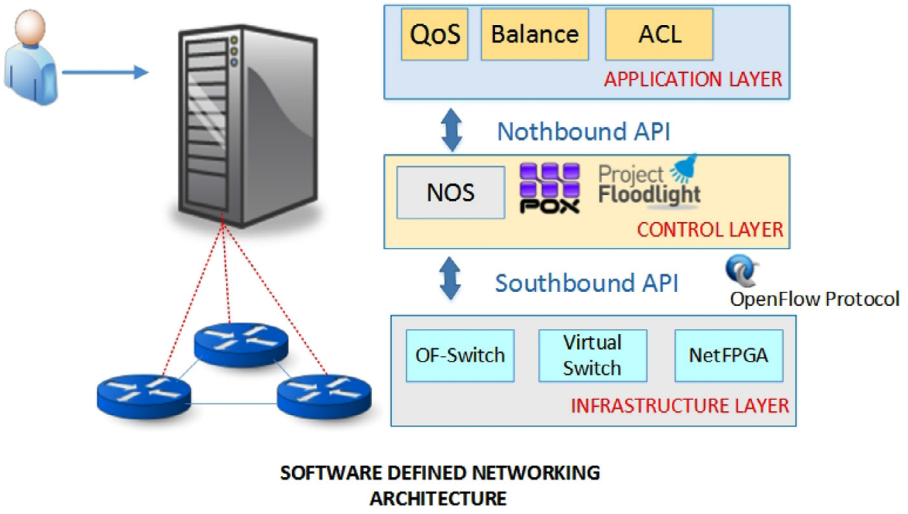

Fig. 1. Software defined networking architecture.

services have been progressively integrated in the network core through protocols (currently about 7000 RFCs) or proprietary technology. However, the updates increase the complexity of the network devices in terms of memory, CPU resources and energy consumption. Moreover, some of the new services require the redesign of the network or the change of equipment due to the rigid union between hardware and software. In addition, the administrator has limited access to the network configuration (change parameters using command line interface CLI). These limitations have also brought another requirement to provide better network services, namely the flexibility and customization of the network behavior. In other words, it is necessary that the network can be adapted to the specific needs of a particular institution, campus or group of users.

Software defined networking (SDN) is a novel paradigm that proposes the separation between data and control planes in network devices and centralizes the control of the network. SDN opens the possibility to remotely controlling the network behavior through a software program in an external server. The possibility of developing "network programs" has also given rise to the concept of Network Operating System NOS, following the evolution of operating systems OS in computer science. In this piece of work, we describe the software defined networking architecture and OpenFlow [1] as one of the main SDN protocols. This advance has been tested in different fields, such as security, home networking, data center, virtualization, Internet of Things, amongst others [2,3]. Special attention is given to the development of multimedia services, such as quality of service. In this context, the network administrator can dynamically implement different algorithms without waiting for the publication in a protocol or software/hardware update of the network device. This paper also describes the first initiatives of multimedia applications using a SDN/OpenFlow approach. Furthermore, we present a SDN framework to evaluate different QoS Routing Algorithms. We use virtualization, the OpenFlow protocol and the per-flow engine to propose functional boxes to provide different multimedia services. Moreover, we implement and propose an algorithm to monitor the network performance and select the path between source and destination. Finally, we present the results and describe the challenges and future work.

The rest of this paper is organized as follows: the software defined networking architecture together with OpenFlow protocol is presented in Section 2. Section 3 presents the related work of the first multimedia applications with SDN. The framework to evaluate QoS Routing Algorithms is presented in Section 4. Section 5 describes the network performance and QoS Routing Algorithm functions and our experiences in the implementation of the framework. Section 6 presents an application scenario, test and results. Finally, Section 7 describes the conclusions and Section 8 the future work.

2. Software defined networking

The software defined networking SDN architecture takes advantages of previous advances in network technologies. Active Networks [4] in mid 90s proposed a network interface or API to open the network resources and enabling the individual programming of the node. The administrator can program the treatment of information based on the header of the incoming packet. This approach helps researchers to test new network architectures, models and algorithms [5,6]. However, their implementation in network productions was unfeasible due to limitations in performance and safety. Another important advance in network technologies is the separation between control and data planes [7,8], enabling their independent evolution. Thus, the data plane is responsible for the packet forwarding engine (transmission of packets) and the control plane is in charge of the network management (routing engine, QoS, load balancing). However, the first implementations of this systems were difficult due to the need for custom switches based on Linux, OpenWrt or NetFPGA.

Software defined networking proposes a separation between control and data planes in network devices, a centralized control of the network and establishes open interfaces between them [9]. The SDN architecture is shown in Fig. 1. The network devices or infrastructure layer are in charge of