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IFAC-PapersOnLine 48-29 (2015) 307–312

Networking Control Education by the use of Software Defined Networking Tools and Techniques

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Abstract: Software Defined Networking (SDN) is an emerging field of study within computer networks research area that will, in a near future, play an important role in the design and development of network infrastructures. The main idea behind SDN is to separate the control and the data planes that are nowadays coupled in the traditional network devices (routers, switches, etc). This separation of the control plane from the electronic that performs the actual packet switching tasks allows the former to be implemented in a physical different device and also permits to build the control strategies in a vendor and platform independent fashion, what helps to unify the different operating systems that today make it difficult to configure a complex network. The data plane (packet switching) is performed in physical devices but the control plane is implemented entirely by software, in devices that are called controllers. Controllers communicate control schemes to the packet switching devices by means of different protocols and APIs and can also communicate and interact with higher level applications that can be developed for different tasks: from easing the management of control schemas to monitoring the network status or, as is the case in this paper, for educational purposes. The aim of the work described in this paper is to show the possibilities of using software applications embedded in SDN controllers as an Internet-based educational tools in the field of computer network control.

Keywords: Internet-based education, learning environment, software-defined networking.

1. INTRODUCTION

Control of computer networks is a field with increasing demands over the last years, and a growing application domain for control engineers (Murray et. al., 2003). Complexity of computer networks and the need for flexibility and fast response has supposed an increase in this research area over the last years. The demands of experts in this area is also increasing in Internet service provider and hosting companies and so is the need for education in the field. While theoretical contents are important, there is a great deal of hands-on work needed in order to train a good professional in this area. This kind of training requires the use of networking laboratories and tools that are quite expensive. Simulation and virtualization techniques developed in the last years help to solve this problem. The joint use of these techniques along with the more recent Software Defined Networking (SDN) architectural paradigm allows building completely integrated and functional solutions for this kind of learning needs at a very low cost when compared with more traditional approaches based on the use of physical devices or expensive simulation environments. Moreover, the Internet-based nature of SDN eases the construction of distance learning tools.

Software Defined Networking (SDN) is a research area that emerged as an architecture that would permit the study and development of new network protocols (Casado and McKeown, 2005), (Feamster et. al. 2013). This initial work was soon perceived as a technology that could revolutionize the traditional architecture for the control of network interconnecting devices, easing their management and so allowing to cope with the increasing complexity of networks and the need for flexible architectures that can make configuration changes on a large amount of devices in a very fast way (Contreras et. al., 2014), (Hariki et. al., 2014).

The idea behind SDN is to separate the data switching capabilities of network devices from their control software, traditionally implemented in the form of integrated proprietary operating systems. This traditional implementation makes it difficult to manage a large set of devices, which are usually from different vendors and so have different operating systems and management tools. A change in the configuration of a large set of these kinds of devices is difficult and involves the need to connect with each of the devices and introduce the corresponding operating system commands in order to obtain the desired behaviour. Today, this kind of massive changes to the configuration of several devices is usual in order to cope with the increasing needs of Internet service providers and hosting companies.

The technologies underlying SDN allow the configuration of any number of devices in one single operation, centralizing the management in a single piece of software called "the controller" and with a unified set of control directives despite the manufacturer of the different switching devices.

10.1016/j.ifacol.2015.11.253

As well as centralizing and unifying the control plane for a set of network devices, the philosophy of the SDN approach encourages extensibility by allowing the programming of external applications that can work inside the controller performing any task that the user may think of. The usual kind of applications that one can find are those devoted to the management of the devices for administering, configuring and controlling a network, with a set of graphical tools that eases the programming skills that would be needed for the same task if these applications were not developed. But many other kind of applications can be build from different objectives: from monitoring of network variables to implementing higher level services like load balancers or quality of service provisioners. Among the possible set of applications that can be built in the controller, this paper proposes one that is devoted to education.

The rest of the paper is organized as follows. Section 2 gives a more detailed overview of the SDN architecture, showing some of the more important practical applications. Section 3 describes the architecture of the proposed educational application and its main functionalities. Finally, some conclusion and future work are presented in section 4.

2. SOFTWARE DEFINED NETWORKING ARCHITECTURE

This section gives an overview of SDN, its architecture and main components, as well as the possibilities of new simulation tools that ease the research and development tasks, as well as offer good possibilities for building educational tools. Subection 2.1 is devoted to show the main idea of separating the control and data planes found in traditional network devices. Subsection 2.2 presents how both of these planes are implemented in the SDN paradigm and how new applications may benefit from their separation. In subsection 2.3 the Mininet tool is introduced as a new and flexible network simulation environment which is compatible with SDN functionality.

2.1 SDN Overview

Figure 1 shows the traditional and the SDN-based disposition of networking devices and their control planes. Traditional approach (a) consist in the encapsulation of both the data (packet switching) and control planes in the same hardware device. In order to administer the whole network, a connection must be made to each of the devices and a set of vendor specific operating system commands must be executed for configuring them, what difficults the stablishment of a new configuration or topology that may be necessary. The SDN approach (b) separates the control and the data planes, unifying and concentrating the control of the whole set of switching devices in a single place: the controller, a piece of software that may be placed in a dedicated piece of hardware.

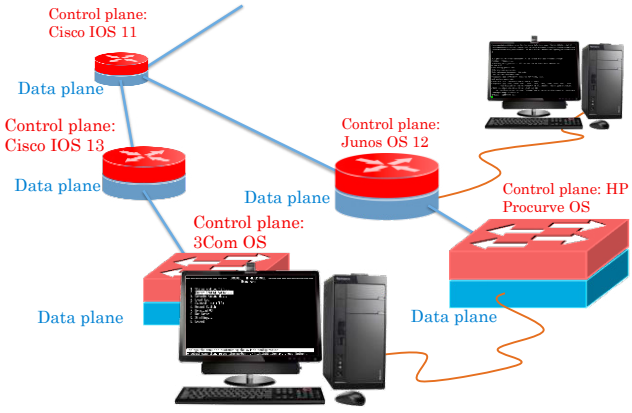

Figure 1 (a) traditional networking device control architecture

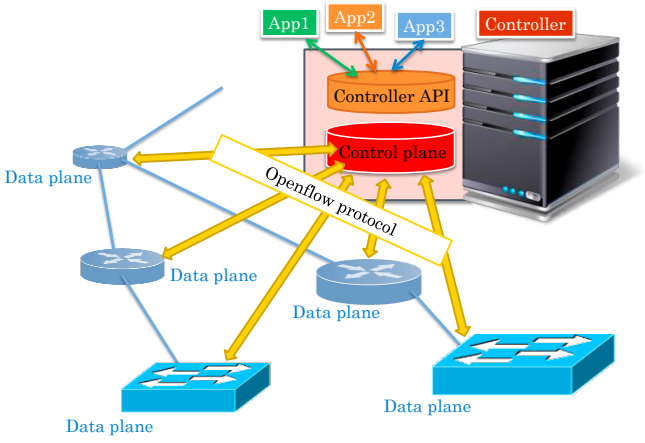

Figure 1 (b) SDN networking device control architecture

Typical application scenarios for SDN are:

- Internet Service Provider companies that need to provision links for their traffic according to the demands of the users in a real time fashion. This usually involves a great number of changes in the configuration of many devices in order to accomplish the required configuration, as is the in the video on demand systems (Georgopoulos et. al., 2015) With SDN, different networking configuration scenarios can be pre-stored and transferred to the devices in a bulk operation, thus allowing the fast adaptation of the network to the new situations.
- Hosting or platform and infrastructure-as-a-service companies can configure links and networks in their data centers for adapting to the demands of their different customers when they increase their traffic (whether occasionally or permanently) or have special needs (Wu et. al., 2013), (Koerner and Kao, 2014).