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Survey Paper

Software defined networking: State of the art and research challenges

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ABSTRACT

Network usage and demands are growing at a rapid pace, while the network administrators are facing difficulties in tracking the frequent users' access of the network. Consequently, managing the infrastructure supporting these demands has become a complicated and time-consuming task. Networks are also in a flux state, they are not only expanding but require reconfigurations to meet the business needs. Software defined networking (SDN) and network function virtualization (NFV) technologies have emerged as promising solutions that change the cost profile and agility of internet protocol (IP) networks. Conceptually, SDN separates the network control logic from its underlying hardware, enabling network administrators to exert more control over network functioning and providing a unified global view of the network. However, SDN and NFV can be merged and have the potential to mitigate the challenges of legacy networks. In this paper, our aim is to describe the benefits of using SDN in a multitude of environments such as in data centers, data center networks, and Network as Service offerings. We also present the various challenges facing SDN, from scalability to reliability and security concerns, and discuss existing solutions to these challenges.

1. Introduction

Today's Internet applications require the underlying networks to be fast, carry large amounts of traffic, and to deploy a number of distinct, dynamic applications and services. Adoption of the concepts of "inter-connected data centers" and "server virtualization" has increased network demand tremendously. In addition to various proprietary network hardware, distributed protocols, and software components, legacy networks are inundated with switching devices that decide on the route taken by each packet individually; moreover, the data paths and the decision-making processes for switching or routing are collocated on the same device. This situation is elucidated in Fig. 1. The decision-making capability or network intelligence is distributed across the various network hardware components. This makes the introduction of any new network device or service a tedious job because it requires reconfiguration of each of the numerous network nodes.

Legacy networks have become difficult to automate [1,2]. Networks today depend on IP addresses to identify and locate servers and applications. This approach works fine for static networks where each physical device is recognizable by an IP address, but is extremely laborious for large virtual networks. Managing such complex environments using traditional networks is time-consuming and expensive, especially in the case of virtual machine (VM) migration and network configuration. To simplify the task of

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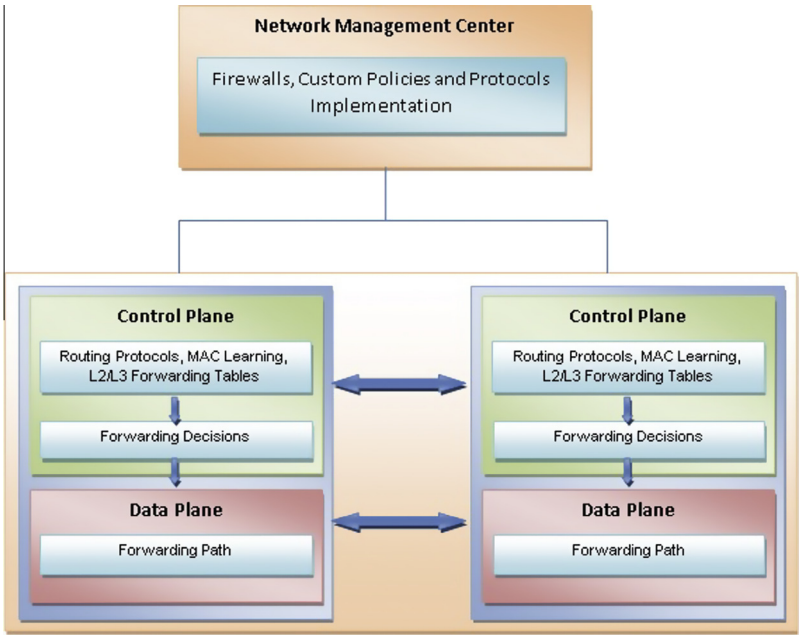

Fig. 1. Inflexible legacy infrastructure.

managing large virtualized networks, administrators must resolve the physical infrastructure concerns that increase management complexity. In addition, most modern-day vendors use control-plane software to optimize data flow to achieve high performance and competitive advantage [2]. This switch-based control-plane paradigm gives network administrators very little opportunity to increase data-flow efficiency across the network as a whole. The rigid structure of legacy networks prohibits programmability to meet the variety of client requirements, sometimes forcing vendors into deploying complex and fragile programmable management systems. In addition, vast teams of network administrators are employed to make thousands of changes manually to network components [2,3].

The demand for services and network usage is growing rapidly. Although growth drivers such as video traffic, big data, and mobile usage augment revenues, they pose significant challenges for network operators [4]. Mobile and Telco operators are encountering spectrum congestion, the shift to internet protocol (IP), and increased mobile users. Concurrently, data-center operators are facing tremendous growth in the number of servers and virtual machines, increasing server-to-server communication traffic. In order to tackle these challenges, operators require a network that is efficient, flexible, agile, and scalable.

Inspired by the words of Marc Andreesen, "software is eating the world", software-defined networking (SDN) and virtualization are poised to be the solutions that overcome the challenges described above. SDN operates on an aggregated and centralized control plane that might be a promising solution for network management and control problems. The main idea behind SDN is to separate the forwarding/data plane from the control plane while providing programmability on the control plane, as illustrated in Fig. 2.

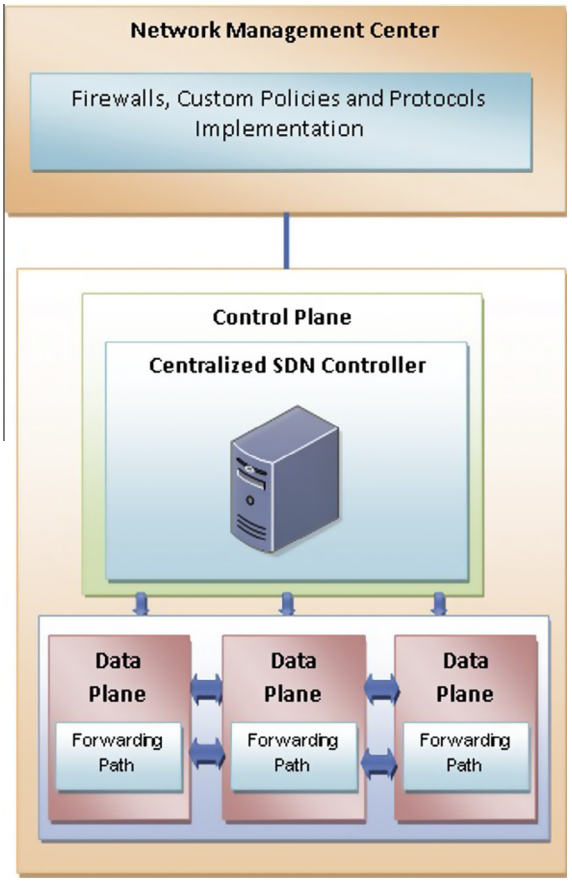

Fig. 2. SDN architecture.