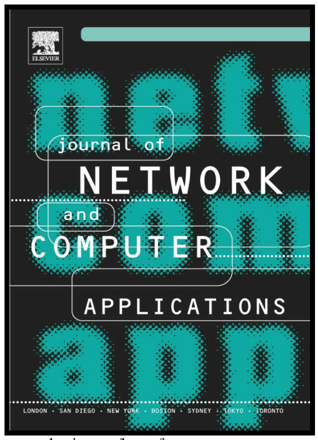


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# An Analytical Model for Delay Bound of OpenFlow Based SDN using Network Calculus

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Abstract

Software Defined Networking paves the way for simplifying network management. This is achieved through the separation of control plane and data plane in a network. In Software Defined Networks (SDN), the network control functions are removed from the data forwarding nodes and placed into a logically centralized controller. So, these functions can be updated with a cost of a simple software change and without any changes in the hardware modules. But an important question arises about the performance of SDNs. This question becomes more serious regarding the central control unit as a probable obstacle to the scalability of SDNs. To have a precise image of this problem, in this paper an analytical model is provided for SDNs implemented based on pure OpenFlow standard. This model which is based on the network calculus framework, computes the worst case delay bound of such SDNs. The delay bound is estimated according to the similarities between the caches and flow tables in OpenFlow switches. The results show the interaction of different parameters such as network size, flow table size, traffic characteristics and the delay of SDNs. This can be used to evaluate SDN prototypes in the early stages of the design phase. Also, it affirms the importance of proposing scalable architectures for SDNs, such as deploying distributed controllers. Additionally, some points about using distributed controllers are discussed based on the provided results.

Keywords

software-defiend-networking (SDN); OpenFlow; network calculus

## 1. Introduction

Software Defined Networking is a recently emerged concept which has made major impacts on computer networks [1, 2, 3]. Separating data plane and control plane forms the main idea of a Software Defined Network (SDN). In fact, hardware complexities and heterogeneities are abstracted from the management layer. This abstraction aims to ease the network administration and pave the way for rapid innovations in the network area [4, 5].

Many realizations of the SDN idea are based on the OpenFlow specifications [6]. The pure OpenFlow standard determines the way a SDN switch might be controlled by a controller [7]. An OpenFlow switch essentially consists of one or more flow tables and a channel for communicating with the controller. The header of an arriving packet is searched through the flow tables for a match. If a match occurs, the switch will act as specified in the action field of the matched entry. Otherwise, a copy of packet will be sent to the controller. In the controller, the packet will be processed and the outcome of network control functions determines the flow and its corresponding forwarding rule. This rule will be sent to all corresponding switches. Finally, these switches will update their flow table entries based on the controller decision. So, they can deal with the packets of this previously unknown flow.

Nowadays, the proportion of the market share accounted for SDN-related commercial products is rising [8], where many of these products are implemented based on OpenFlow. Due to the diverse use of these products in data centers and computer networks, it is necessary to study their performance characteristics. This gets more serious because SDN is defined based on a centralized controller which is a well-known potential performance bottleneck.

One of performance issues in the OpenFlow enabled devices, is the communication delay between the node and the controller. The added communication delay between OpenFlow switches and the controller can degrade the overall performance and limit the scalability of the system. Therefore, it is necessary to investigate this delay more accurately and find out how it impacts the scalability of the OpenFlow based SDNs. This issue is even more crucial for the SDNs implemented based on pure OpenFlow standard with a single central controller.

Although, simulations are the most popular tool for estimating the delay in a network, but they have some critical shortcomings such as high execution time and inability to consider all possible conditions. So, this paper utilizes network calculus to present an analytical model for SDNs implemented based on pure OpenFlow standard. In spite of the general model introduced in [9], the