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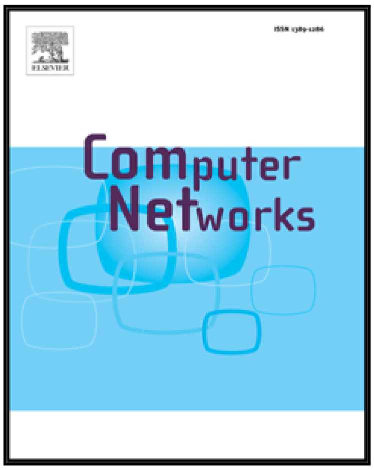

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Methodology, Measurement and Analysis of Flow Table Update Characteristics in Hardware OpenFlow Switches

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Abstract

Software-Defined Networking (SDN) and OpenFlow are actively being standardized and deployed. These deployments rely on switches that come from various vendors and differ in terms of performance and available features. Understanding these differences and performance characteristics is essential for ensuring successful and safe deployments.

We propose a systematic methodology for SDN switch performance analysis and devise a series of experiments based on this methodology. The methodology relies on sending a stream of rule updates, while relying on both observing the control plane view as reported by the switch and probing the data plane state to determine switch characteristics by comparing these views. We measure, report and explain the performance characteristics of flow table updates in six hardware OpenFlow switches. Our results describing rule update rates can help SDN designers make their controllers efficient. Further, we also highlight differences between the OpenFlow specification and its implementations, that if ignored, pose a serious threat to network security and correctness.

Keywords: Software-Defined Networking, switch, flow table updates, measurements

1. Introduction

Software-Defined Networking (SDN), and OpenFlow in particular are increasingly being standardized and deployed by many including the hyperscale companies like Google, Microsoft, Facebook, etc. that consider SDN to be the future of computer networks [1, 2, 3, 4]. This means that the number of SDN developers creating exciting new frameworks [5, 6, 7] as well as network administrators that are using a variety of SDN controllers is rapidly growing.

In OpenFlow, the control plane involves a controller communicating with OpenFlow agents running (as pat of the firmware) on the switch-local control plane to instruct them how to configure the data plane by sending flow modification commands that place rules in the forwarding tables. A single deployment can use one or more type of OpenFlow switches, and the developer typically assumes that if the switch conforms to a specification, it will perform as a well-behaved black box. SDN's transition from research to production means that real deployments are demanding new levels of reliability and performance requirements that are necessary for production environments. For example, consistent network update schemes [8, 9, 10] are trying to ensure that packets do not get lost while new forwarding rules are being installed. Schemes also exist for ensuring congestion-free updates [11] and for scheduling rule installations to minimize rule installation time [9, 12, 13, 14]. All of these assume quick rule installation latency, and many rely on update confirmations from the switch-local control plane before proceeding to the next step.

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