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A Multi-objective Software Defined Network Traffic Measurement

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Abstract: Software Defined Networking (SDN) with defining characteristics, such as "separation of data and control plane" and "centralizing network control with decision making", has significantly simplified network management. However, active monitoring techniques used to dynamically measure network traffic introduce additional overheads in the network, while a passive approach lacks accuracy in terms of traffic measurement. As a result, various efforts have been devoted to designing per-flow based network measurement system to address both accuracy and overhead challenges. Existing measurement techniques lack a multi-objective network measurement mechanism to overcome various overheads, like communication cost, controller computation, and accuracy in a real-time environment. Therefore, this paper presents a novel and practical solution to enable accurate real-time traffic matrix for the traffic measurement system in SDN. The solution is proposed to measure fine-grained monitoring task with less controller communication and computational cost with high accuracy. The solution is based on two measurement designs, namely: fixed and elastic schemas. Our experiments demonstrate that both fixed and elastic schemas achieve significant overhead reduction without compromising on accuracy.

Keywords: Software Defined Measurement, Software Defined Networking, Network Monitoring

1 Introduction

Network monitoring and measurement are crucial to Network Management Systems (NMS). For example, large data center networks (DCN) require accurate measurements of traffic flows to effective monitor the traffic volume in real-time. Similarly, a per-flow traffic measurement system can be used to monitor the micro-details of every flow in different network layers. Such system is also known as a fine-grained monitoring system. The fine-grained traffic measurement system, in turn, needs necessary tasks to have insight into the network traffic, including Traffic Matrix (TM) estimation, elephant flow detection, and link utilization. These measurement tasks are utilized in a wide range of applications, such as network planning, billing, anomaly detection, load-balancing, traffic engineering, security and various others [1]; thus, it is important to ensure Quality of Service (QoS). Traditional flow-based measurement systems, such as NetFlow [2] and sFlow [3], often employ too much resources (e.g. bandwidth, and CPU) and require significant investments in hardware deployment to satisfy the fine-grained measurement requirements. However, traditional flow-based measurement systems have either a low accuracy or a high deployment cost and consume more resources [4]. An example of the latter is the deployment of NetFlow, which requires setting up of collectors, analyzers and other related services. However, enabling NetFlow in the routers may degrade the packet forwarding performance [5]. Furthermore, NetFlow and similar tools such as Sflow, Jflow, IPFIX, and PRTG are hardware based feature and need to be configured to be set for each interface on the physical device (switch/router).

Unlike traditional network architecture, in the relatively recent Software Define Networking (SDN) architecture, the control plane is separated from the data plane [6]. This enables efficient network management by controlling the entire network through logically centralized controller. The network management is then facilitated through network programmable application which executes through the controller to operate the network devices. Despite the benefits (e.g. capability to provide customizable traffic measurement, and flexible and fine-grain visibility of the network traffic), SDN deployment complicates network measurement systems by introducing a new measurement strategy which may impact efficiency and performance of both data and control plane resources, for example imposing overhead in controller and network infrastructure.

Network measurement methods are broadly categorized into active and passive measurement [7]. In active measurement, a probe packet is continuously sent over network path as a request to monitor flows and packet/byte