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An efficient latency monitoring scheme in software defined networks

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HIGHLIGHTS

- An SDN efficient latency monitoring solution is proposed.
- An optimization algorithm for detection period and time is proposed.
- Performance of monitoring SDN latency is improved.
- It allows for more accurate delay monitoring with smaller performance.

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ABSTRACT

The new architecture caught the attention of more and more scholars, called Software Defined Networks (SDN), separates the control plane from the data plan. Meanwhile, many applications which are sensitive to the QoS demand the network reach a certain latency constraint. The SDN brings new opportunity for measuring latency. However, with the expansion of network scale and the requirement of time-delay accuracy, the performance of the controller itself becomes the bottleneck of the requirements. This paper is based on the SDN latency monitoring solution to improve the efficiency and performance of the detection. Periodical triangular function is used in this paper to fit the available latent data so as to judge the variation period and more accurately fit the actual latency data. An optimization algorithm for detection period and time is proposed in this paper which can reduce the detection and time while ensuring the accurate latency monitoring. Compared to other method, the experimental results indicate that it allows for more accurate delay monitoring with smaller performance and network resources in the proposed algorithm.

1. Introduction

The architecture of the Internet has been designed more than 20 years ago. With the rapid expansion of the network scale and the application types, more and more problems have emerged. The expanding functions of network have lead the routers become bloated. Because of the lack of global scheduling, the network resource utilization rate is not high. The new architecture caught the attention of more and more scholars, called Software Defined Networks (SDN), separates the control plane from the data plan. The centralized control plane, called controller, communicates with network devices in the data plan to collect information from them and also to push configuration information to them. Thus, controller could have the information from all network switches. Controller also can build the network topology. Because of the centralized control plane, it is convenient to control the whole network. This new architecture is easy to provide global scheduling. The new type of network model simplifies network management, provides programmable characteristics through the network for network optimization, and improves quality and security of the network services.

To achieve global scheduling, network performance measurement, especially latency monitoring, must be conducted. Network latency is an important indicator of the network status. Many applications which are sensitive to the QoS demand the network reach a certain latency constraint. Monitoring the latency is also a common task in the traditional network management. There are two ways to measure the network latency: active or passive techniques. Active measurement obtains the network state by injecting probe packets into the network. In contrast to active measurement, passive measurement provides detailed information about the nodes being measured. Existing active and passive measurement approaches usually measure the latency for end-to-end paths, and this will bring additional data, which occupy the

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original network bandwidth. The SDN brings new opportunity for measuring latency. However, it is technically feasible to monitor latency based on a large amount of flow statistics information, as most existing passive measurement approaches do. The solution, which is based on sending a specially crafted packet through the link from the controller and back while measuring the amount of time, is more useful and feasible [1]. However, in this solution, all the detection and monitoring process are put on the controller, which adds to the burden of the controller. Therefore, it is an important scientific issue as to how to reduce the controller burden. One efficient algorithm targeting latent monitoring is designed in this paper which can reduce the controller burden to some degree based on accurate monitoring of network latency.

The main contribution of this paper is represented in following three aspects:

- Periodical triangular function is used in this paper to fit the available latent data so as to judge the variation period and more accurately fit the actual latency data.
- Based on the fitting function above, optimization algorithm for detection period and time is proposed in this paper which can reduce the detection and time while ensuring the accurate latency monitoring.
- The delay detection frequency of the whole network is considered comprehensively and more detailed detection is made for link with high delay variation frequency. The detection frequency can be reduced properly for the link with small change so as to optimize the controller performance from the overall perspective.

We discuss background and the related work in Section 2. Section 3 describes the efficient latency monitoring problem formally. We introduce how to build the efficient latency monitoring scheme in Section 4. The performance evaluation is shown in Section 5. Finally, we conclude this paper with Section 6.

2. Background and related works

In this section, we first briefly describe SDN networks and point out the key difference between SDN and today's TCP/IP networks. Subsequently we present an overview of latency monitoring in SDN. We also point out the primary problem of the related works and the goal of our solution.

2.1. Software defined network

IP network has been widely used, however, It is difficult to manage the traditional IP networks because of the complexity of TCP/IP architecture. Considering the complexity of configuration, it is difficult to adapt the network environment to the load changing. Automatic reconfiguration and response mechanisms in IP network are almost impossible. Network traffic handling and data transmission are bundled inside the networking devices, reducing the flexibility of the networking infrastructure [2] .

Software Defined Networking is more and more used in networking , especially for cloud and enterprise infrastructures, and envisioned for mesh and potentially, deployed networks. SDN is an emerging networking paradigm that gives hope to change the limitations of current network infrastructures. First, it breaks the vertical integration by separating the network's control logic (the control layer) from the underlying routers and switches that forward the traffic (the infrastructure layer). Second, with the separation of the control and data planes, network switches become simple forwarding devices and the control Please, leave two blank lines between successive sections as here. Logic is implemented in a logically centralized controller (or network operating system1), simplifying policy enforcement and network (re)configuration and evolution [3]. A simplified view of this architecture is shown in Fig. 1. It is important to emphasize that a logically centralized programmatic model does not postulate a physically centralized system [4]. In fact, the need to guarantee adequate levels of performance, scalability, and reliability would preclude such a solution. Instead, production-level SDN network designs resort to physically distributed control planes [5,6].

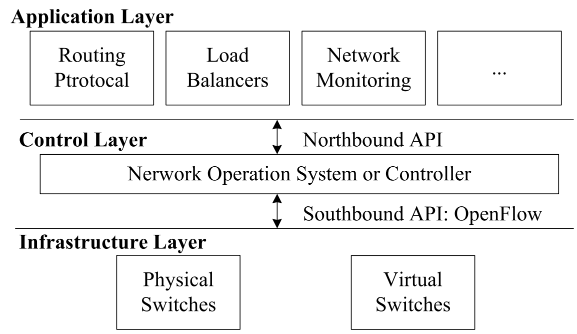

Fig. 1. Architecture of SDN.

2.2. Latency monitoring in SDN

Latency monitoring has been a field of interest for years in the computer networks. Latency is a crucial metric to consider in the operation of a network, especially if it is used to transmit data from applications sensitive to delay or jitter. Measuring link properties in the traditional network is a difficult task because the network devices (routers and switches) do not provide enough supports. However, SDN design architecture provides a centralized controller which can manage all flow decisions and handle many roles in one node without the need for any third-part nodes. The OpenFlow [7] protocol is capable of not only controlling the data plane, but also to monitor the link properties within the network.

A NetFlow [8] enabled equipment periodically sends information to a NetFlow Collector, a server which can be queried to access these information. Additionally, standalone NetFlow probes can be deployed into the network to collect information by tapping into a link. sFlow [9] works similarly and has the advantage to let the agents "push" their counters. This means that fewer packets are needed to obtain the relevant data as there is no request. Other initiatives such as OpenSAFE [10] use traffic duplication to monitor the network adding a very high overhead while FlowSense [11] use a push mechanism to analyze link utilization passively, it is an efficient method but not to determine latency [12].

In [1], a solution of monitoring latency with OpenFlow was proposed. The solution to perform latency monitoring is to use the SDN controller to pilot a network of OpenFlow switches. The solution is based on sending a specially crafted packet through the link from the controller and back while measuring the amount of time. This solution detailed in the next section is the basis of the scheme in our paper. This solution increases detection accuracy by increasing detection frequency [13]. However, there is a problem with this solution. With the expansion of network scale and the requirement of time-delay accuracy [14], the performance of the controller itself becomes the bottleneck of the above requirements. Therefore, our paper is based on this solution to improve the efficiency and performance of the detection.

3. Problem description

In this section, we first describe the solution of monitoring latency with OpenFlow in [1]. And then we describe and formalize the problem that we are going to solve.

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