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FlowTrace: measuring round-trip time and tracing path in software-defined networking with low communication overhead

Key words: Software-defined networking, Network monitoring, Traceroute

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Motivation

- Tracing paths and measuring congestion is important for network operators to diagnose network troubles. However, it is hard to trace path and measure congestion in SDN networks.
- First, traditional troubleshooting tools, such as ‘traceroute’ and ‘ping’, are not supported by OpenFlow-based switches.
- Second, load balancing and multi-queue technologies make it is hard to measure congestion without knowing the paths of flows.
- Although several studies on this topic exist (Agarwa *et al.*, *2014*; Zhang *et al., 2*014), they generally solve tracing path and measurement issues separately. Through our investigation , by jointly considering tracing path and measurement, the measurement accuracy can be further improved.

Main idea

- Inspired by the observations that tracing path is needed before measuring congestion, we introduce FlowTrace, a network tracing path and latency measurement mechanism in SDN.

- FlowTrace can quickly trace flow paths with zero control plan overhand, and can also accurately measure path latencies.

Method

1. Tracing Path

   (1) FlowTrace passively monitors FLOW_MOD and FLOW_REMOVED messages between controller and switches. Thus, FlowTrace collects flow entries with zero control plan overhead;

   (2) FlowTrace finds relations between flow entries. Then, Flow Trace can quickly trace path according to the relations.

2. Measure Latency

   (1) FlowTrace traces the forwarding path of a flow, which guarantees the measurement results of FlowTrace is not affected by load balancing mechanisms.

   (2) FlowTrace inserts measurement rules into switches and sends probe packets that have the same packet header as measured flows. This enables FlowTrace can accurately measure the queuing delays that the measured flows experience.

Major results

- FlowTrace can trace paths with near zero overheads.

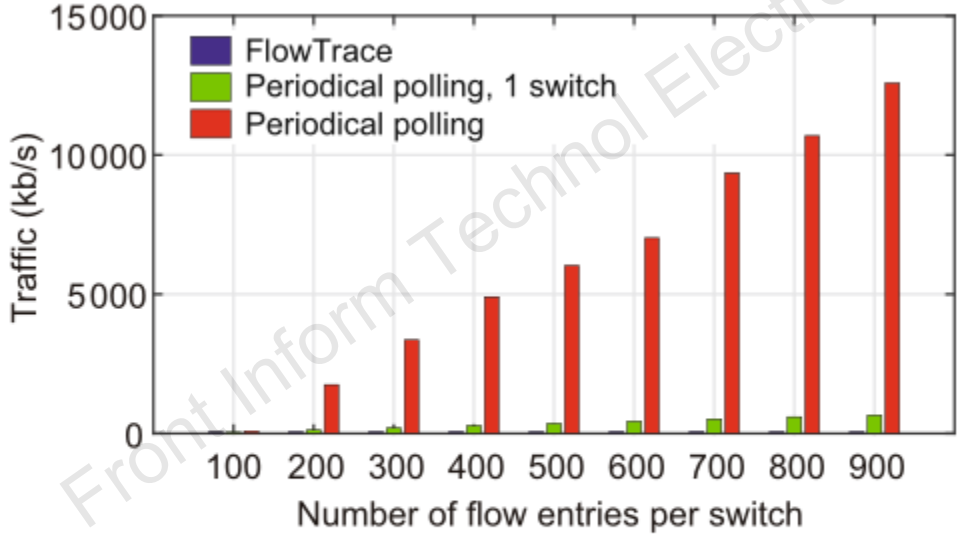

Fig. 5 Control plane traffic by varying the number of flow entries in each switch

Major results

- Compared with SLAM, the measurement results of FlowTrace is not influenced by load balancing mechanisms. Besides, FlowTrace can accurately measure queuing delays.

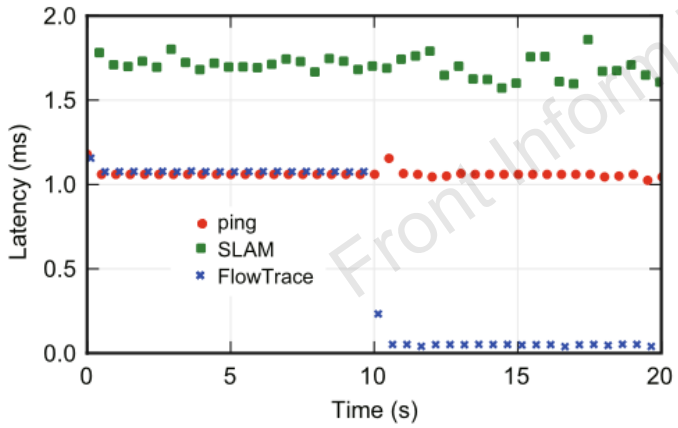

Fig. 15 Measurement results in two paths when the flow is balanced at 10 s

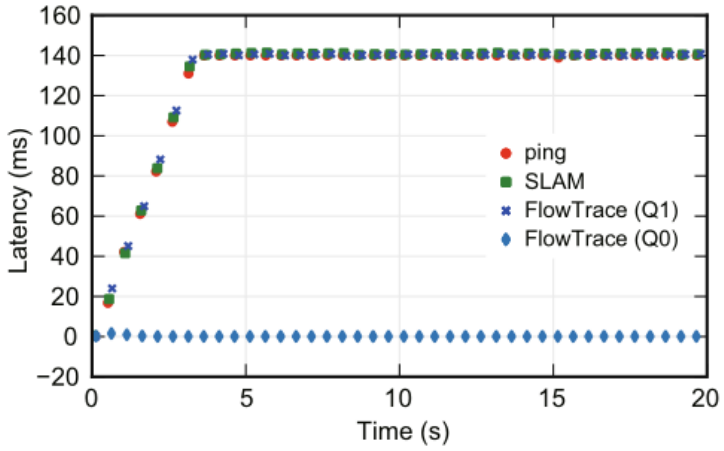

Fig. 16 Measurement results in two queues

Conclusions

- We have introduced FlowTrace as a real-time network path tracing and latency measurement tool for SDN.
- We implemented FlowTrace in the Floodlight controller. The evaluation results show FlowTrace can find flow paths with low overheads, and can measure latency with high accuracy.
- Our design is based on OpenFlow protocol, which means that FlowTrace can be easily deployed in enterprise networks without hardware modifications.