Using P4 Hardware Switches to Implement and Improve the Performance of the Tor network

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Abstract

A Tor is a network of relays run by volunteers all around the world. Using Tor, an Internet connection will pass three such relays that are randomly chosen. When the packets of a connection pass a relay, their source/destination IP addresses will be changed and their payload will be encrypted/decrypted at a new layer. Thus, a Tor network can enhance security and privacy for Internet users. However, because ToR relays are currently implemented as software routers called the "onion routers," their performances in terms of latency and throughput are very low. In this work, we design and implement a Tor relay in the programmable data plane of a P4 hardware switch. Experimental results show that our P4-based Tor network can run 200 times faster than the Internet Tor network.

Design and Implementation

Two AES modes are implemented in the pipelines of a P4 hardware switch. The first mode is the ECB mode and the second mode is the CTR mode.

T-table is an optimization for running the AES algorithm on a 32-bit processor. It uses four lookup tables and several XOR operations to replace the matrix multiplication in the AES. Also, we use registers to handle a packet of arbitrary sizes and multiple packet problems. Then, we use our-defined RegisterAction to design the register read/write action without the race condition. Figure 1 shows the overview of the packet processing flow in the P4 switch.

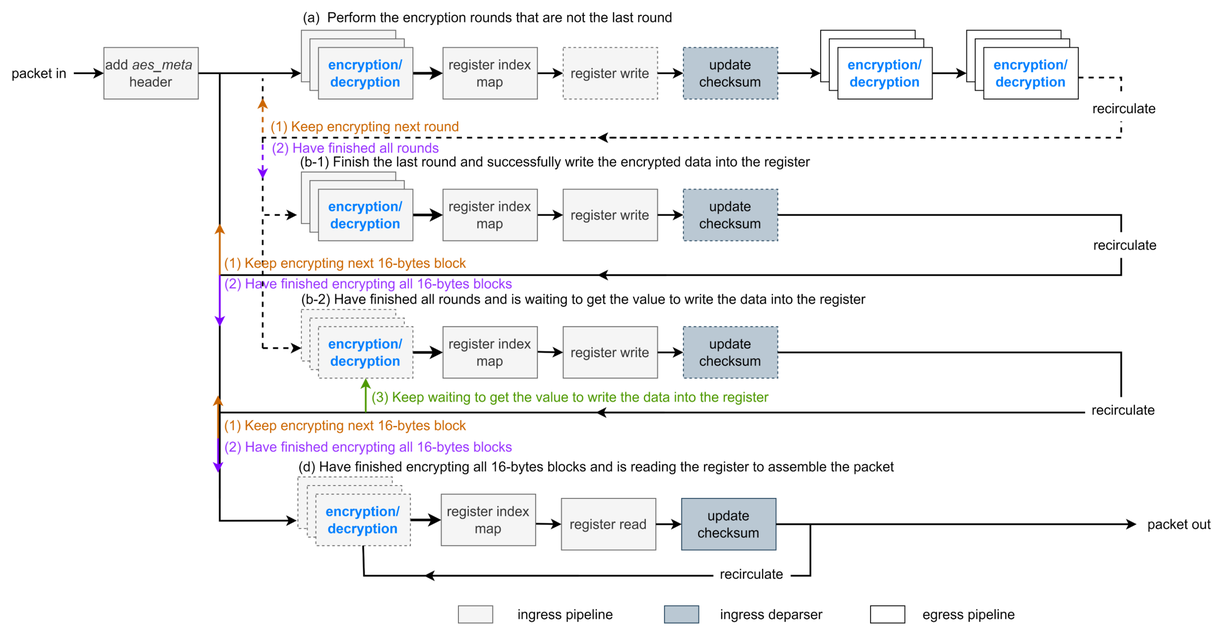

Figure 1: The packet processing flow of the AES ECB mode when using the egress pipeline for performance optimization

Performance Evaluation

We compare the performance of downloading files of different sizes using an onion-router-based path with that of a P4-based. Figure 2 shows the latency of downloading 1 KB, 10 KB, and 100 KB text files.

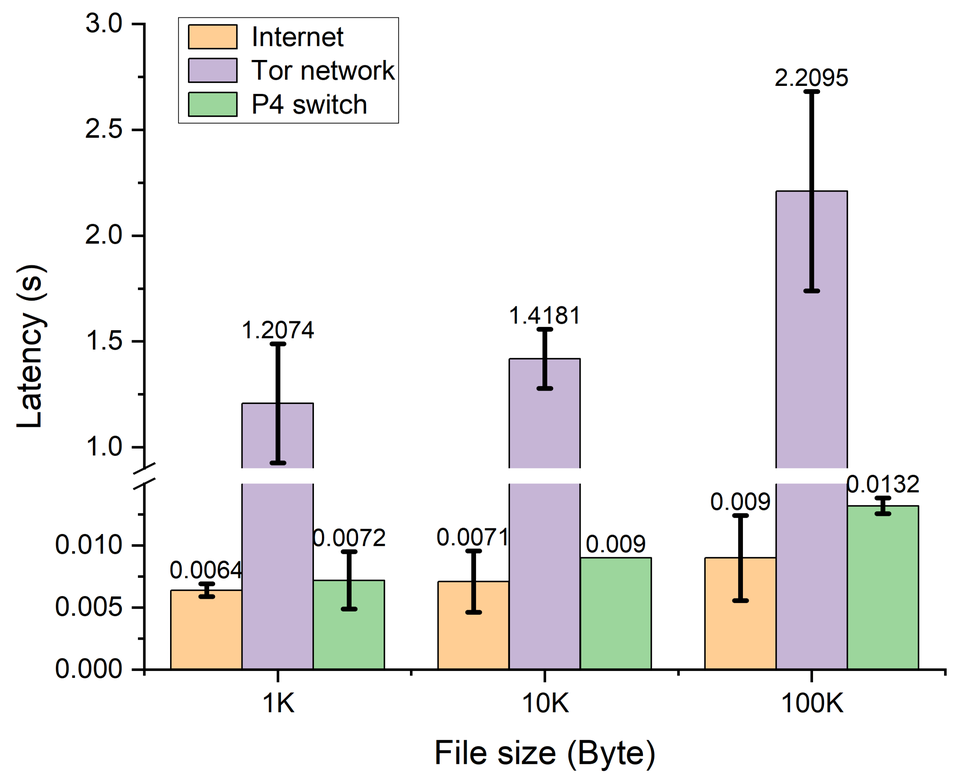

Figure 2: The latency of downloading 1 KB, 10 KB, and 100 KB text files

Figure 3 shows the throughput of downloading 1 MB, 10 MB, and 100 MB, 1 GB, 10 GB text files.

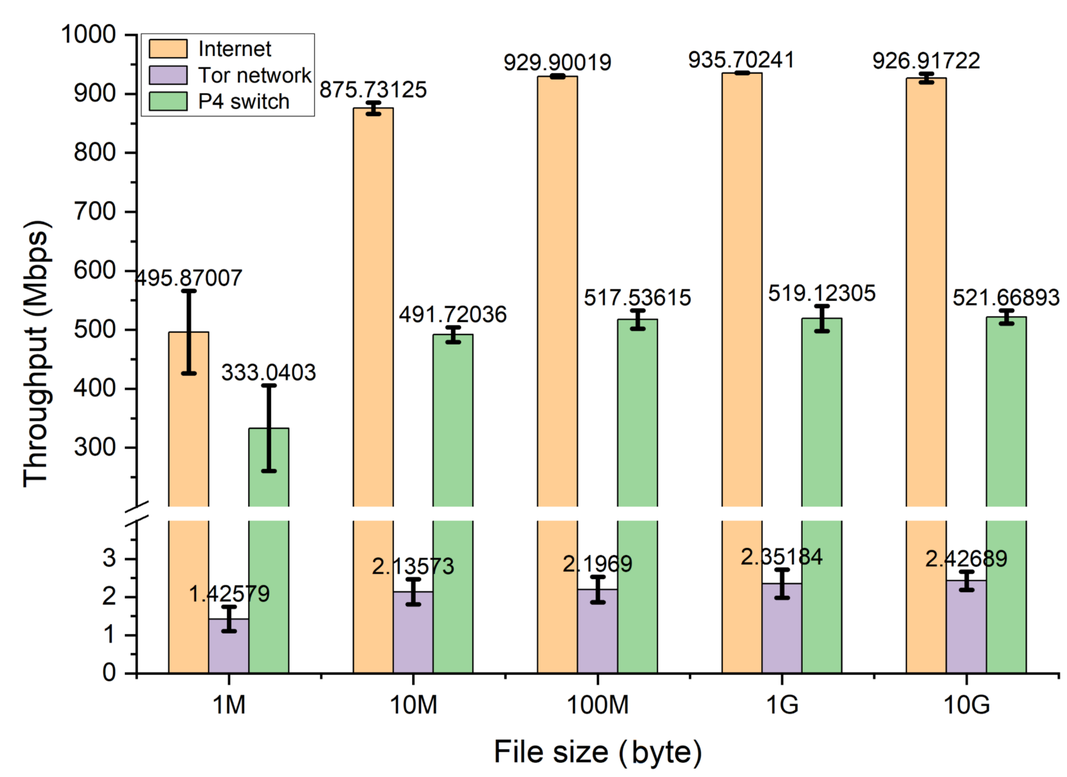

Figure 3: The throughput of downloading 1 MB, 10 MB, and 100 MB, 1 GB, 10 GB text files

The experimental results show that our approach provides higher throughput and lower latency than the Tor network. Using a P4 switch can effectively reduce the packet processing delay caused by an onion router.