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Exploring Multipath TCP Schedulers in Heterogeneous Networks

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ABSTRACT

Multipath transmission control protocol (MPTCP) is a transport layer protocol that transmits TCP segments on more than one path in multihomed devices. It was designed with the aim of bandwidth aggregation and redundant connections. Currently, multihomed devices have wireless interfaces of heterogeneous nature. MPTCP is not able to give its optimal performance in heterogeneous networks. This paper presents an experimental performance study of four different schedulers, namely roundrobin, default, blest, and redundant. The testbed comprises ethernet, LTE, and wifi networks to connect multihomed devices. The authores have compared the scheduler performance in terms of throughput, download time, and path utilization rate in homogenous and heterogenous scenarios. Results showed that round robin provides optimal throughput in homogenous networks and also performs bandwidth aggregation by utilizing both the paths but fails to perform in heterogenous networks. Blest provides best throughput among the four schedulers but prefers fast path only.

KEYWORDS

MPTCP, Path Utilization, Scheduler, TCP

INTRODUCTION

Multipath TCP is (MPTCP) an extension of TCP, evolved for today 's multihomed devices. MPTCP is an ongoing effort of the IETF's Multipath TCP working group Ford et al. (2012). The TCP is a widely used single path protocol, if that fails for any reason then the connection has to be reestablished. MPTCP on the other hand establishes a single connection with all the available interfaces, to deal with the network failures. MPTCP also benefits resource utilization, and bandwidth aggregation Paasch and Barre (2014). As of today, the Linux Kernel MPTCP implementation Apple (2017) is one of the most widely used MPTCP implementations besides Apple's implementation for the cloud-based assistant system Siri Postel (1981).

TCP is mainly designed for wireline networks. MPTCP is built over TCP and is designed for smart home devices, which mostly use wireless networks. A smartphone is having two wireless interfaces, WIFI, and Cellular networks. Thus, MPTCP has to deal with the wireless channel impairments. This is because packet loss, network delay, roundtrip time variation is very probable in wireless networks. Indeed, the MPTCP have to deal with more than one wireless networks with different network charac-

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teristic. Thus, to aggregate, the throughput of the multiple paths in MPTCP of different characteristics is a challenging issue.

The performance of MPTCP depends upon packet Scheduler. A scheduler assigns the packets to the available paths. A wrong scheduling decision leads to decrease in performance of MPTCP in both the heterogenous networks and homogenous networks such as decrease in throughput, higher download time, poor path utilization. Heterogeneity of paths leads to increase in out of order packets which in turn causes Head of Line (HOL) blocking issue, due to receiver window limitation. An optimized packet scheduler, will use all the available paths, will reduce out of order packets in order to increase throughput and decrease download time.

Hence, our study aims to experimentally verify the behavior of MPTCP schedulers in different wire- less networks. We have examined MPTCP scheduler performance concerning Through- put, Download time, and Path utilization rate. The testbed comprises of two scenarios homogenous (WIFI WIFI) and heterogeneous (WIFI- LTE and WIFI -Ethernet). We have analyzed that Round robin per- forms best in homogenous networks by utilizing all the available paths, but is unable to perform in heterogenous net- works. Blest, is able to perform with heterogenous networks by preferring fast paths only which reduces out of order packets.

This paper makes the following contributions. First the experiment study for the comparison be- tween the throughput of MPTCP schedulers. Secondly, we have observed the MPTCP schedulers' download time for different file sizes. Lastly, we have analyzed the effect of scheduling policies on path utilization rate.

The rest of the paper is organized as follows, we provide a brief introduction, and the most relevant research work in the literature is provided in Section 2. Section 3 provides details about Experimental setup and study Finally we conclude our analysis in section 4.

BACKGROUND & MOTIVATION

In single path TCP if packets are not lost or not retransmitted, then they will arrive in order Paasch (2014). In MPTCP as packets are going to traverse through multiple paths, with different characteristics causing out of order at the receiver end Hurtig (2018). This results in Head of Line Blocking impacting the throughput.

Analysis of Existing MPTCP Scheduling Algorithms

The MPTCP architecture is introduced in RFC Ford et al. (2012). Over the past years, there has been a lot of research on MPTCP implementation, design, and performance issues. The scheduler deals with the se- lection of paths, to increase the throughput compared to single path TCP. Fig 1, depicts the scheduling process, the scheduler is invoked, either when a new packet has arrived from the application layer or acknowledgment is received. The scheduler will acquire the path characteristics, round trip time (RTT), signal strength, and through- put, loss rate. The transmission performance of the paths is evaluated with these parameters. The best path is selected to establish the connection.

A wealth of research has been done to resolve the unsolved issues of packet scheduling in MPTCP. Some works implement Round Robin Hwang and Yoo (2015). This scheduler selects the paths one after another in turn. It could not perform in heterogeneous networks. To face the heterogeneity, MinRTT was evolved which selects the path with the lowest RTT. MinRTT Raiciu (2012), is the default scheduler of MPTCP to date. The amount of data on this selected path is decided by its congestion window. This scheduler worked well except on memory constrained devices that use a small receive window This problem was identified by Costin Raiciu Yang et al. (2014) to avoid the head-of-line blocking issue caused by a limited receiver window. Likewise, DAPS Lim (2017) replaced RTT by the forward delay that is sending time plus inflight time to estimate the time taken by the packet to reach the destination. Although the work added more precision, this delay aware scheduler is advantageous

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