

Network Working Group
Internet-Draft
Intended status: Informational
Expires: May 2, 2018

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October 29, 2017

Considerations for MPTCP operation in 5G
draft-purkayastha-mptcp-considerations-for-nextgen-00

Abstract

MPTCP is deployed in devices which have multiple interfaces to different networks. It takes advantage of these multiple interfaces to improve user experience by bandwidth aggregation, redundancy, and increased reliability by having a fallback option. This document describes scenarios where next generation (5G) mobility management frameworks may impact MPTCP operations thus potentially jeopardizing achievement of some of these gains.

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1. Introduction

Utilization of MPTCP in devices with multiple interfaces is very attractive. MPTCP is being deployed and widely adopted in today's smart devices, which typically have multiple network interfaces such as Cellular and Wifi. It provides reliability, bandwidth aggregation capability, and handover efficiency. MPTCP assumes that an interface is associated to only one IP address. This document describes next generation mobility management frameworks that may assign more than one IP address (to a given user device) over a single interface. In this scenario, MPTCP may not produce desired results.

This document describes the anticipated difficulties for MPTCP when working on devices which are being managed by modern mobility management protocols. The goal of this document is to make the WG aware of the upcoming situation and gauge interest in working to preserve MPTCP efficiency.

2. MPTCP background

Multipath TCP is an extension to TCP allowing hosts to use multiple paths to send and receive the data belonging to one connection. The simultaneous use of these multiple paths (sub-flows) for a TCP/IP session improves resource usage within the network and, thus, improves user experience through higher throughput and improved resilience e.g. to network failure.

A Multipath TCP connection is composed of several TCP connections that are called sub-flows. MPTCP manages the creation, removal, and utilization of these sub-flows to send data.

Once an MPTCP connection has begun, further sub-flows can be added to the connection. Hosts have knowledge of their own addresses, and can become aware of the other host's addresses through signaling exchanges. If extra paths are available, additional TCP sessions ("sub-flows") are created on these paths, and are combined with the existing MPTCP session, which continues to appear as a single connection to the applications at both ends. Standard TCP versus MPTCP protocol stacks are illustrated in Figure 1, from [RFC6824].

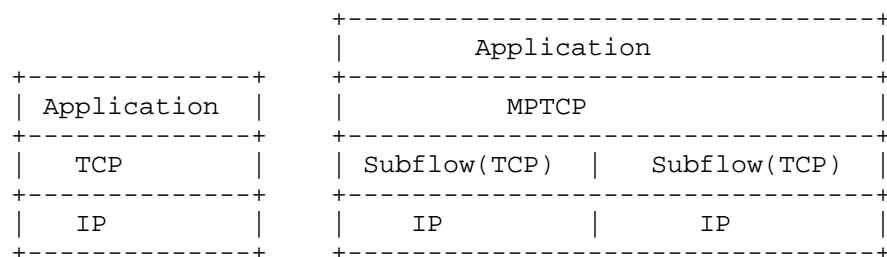


Figure 1: Standard TCP vs MPTCP Protocol Stacks

3. Mobility management protocols

Mobility management is needed because the IP address of a mobile node may change as the node moves. A fair number of network-layer (IP) mobility protocols have been standardized. They all employ a mobility anchor to allow a mobile node to remain reachable after it has moved to a different network. 3GPP 5G has adopted distributed approach and pushed the mobility anchor towards the edge of the network.

3.1. Centralized mobility management (e.g. DSMIP, PMIP)

Existing network-layer mobility management protocols have primarily employed a mobility anchor to ensure connectivity of a mobile node by forwarding packets destined to, or sent from, the mobile node after the node has moved to a different network. The mobility anchor has been centrally deployed in the sense that the traffic of millions of mobile nodes in an operator network is typically managed by the same anchor. Redirecting packets this way can result in long routes.

3.2. Mobility Handling in 5G

3GPP standards organization is currently defining 5G network architecture and systems. This is referred to as multi-homed PDU Session.

In 5G networks, mobility framework under development suggest that IP mobility, network access solutions, and forwarding solutions should enable traffic to avoid traversing a single mobility anchor far from the optimal route. Mobility anchors are distributed in such a way that the mobility anchors are positioned closer to the user; ideally, mobility agents could be collocated with the first-hop router.

The current definition specifies that a PDU (packet data unit) Session may be associated with multiple IPv6 prefixes. The PDU Session provides access to the Data Network via more than one PDU (IPv6) anchor. The different user plane paths leading to the IP anchors branch out at a "common" UPF (user plane function) referred to as a UPF supporting "Branching Point" functionality. The Branching Point (BP) provides forwarding of uplink traffic towards the different IP anchors and merge of downlink traffic to the mobile device i.e. merging the traffic from the different IPv6 anchors on the link towards the device. The BP and UPFs (IP anchors) are illustrated on Figure 2, as described in [_3GPP.23.501].

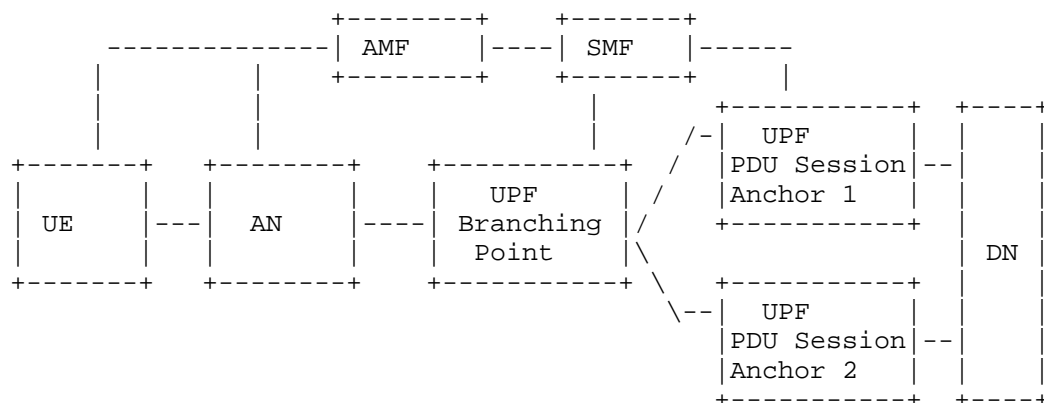


Figure 2: Multi-Homed PDU Session: Service Continuity Case

4. Considerations for MPTCP

Using MPTCP (as currently defined) in 5G network, which may assign multiple IP addresses (to a given device) on the same interface, may need special consideration.

As we know, MPTCP currently interprets multiple IP addresses as indicating separate distinct network interfaces. This incorrect interpretation may lead to not realizing fully the benefit of MPTCP applications such as bandwidth aggregation, redundancy, and reliability in 5G systems.

5. MPTCP operation use case

5.1. BW management increase BW as needed and load balancing features

One of the main goal of using MPTCP is to increase the BW associated to a TCP session when needed. The additional BW is obtained by creating sub-flows over interfaces other than the one already in use (e.g. using different IP addresses) and associating these sub-flows to the existing TCP session, which altogether form the MPTCP session. The total BW available for an MPTCP session is the accumulation of all the sub-flows associated to the same MPTCP session.

In situations, when MPTCP sub-flows are created using IP addresses associated to the same interface, MPTCP operation is impacted. Adding up sub-flow using the same interface doesn't increase the available BW (considering that the bottleneck may be between the device and the PoA). In this case, MPTCP may continue to add more sub-flows but there may not be proportional gain in bandwidth. In this context, MPTCP functionality is inefficient; the expected MPTCP behavior not being met.

Similar situation arises for load balancing. MPTCP may try to add sub flows associated to the same interface and attempt to distribute the load. From operational perspective, we may not see proportional gain in load balancing.

5.2. Backup path management - created in advance to be available when needed

MPTCP may associate sub-flows to an MPTCP session with one or many of these sub-flows being identified as "backup" sub-flows. Backup sub-flows are used only when no regular sub-flows are available (e.g. if a link failure occurs).

As described in the previous section, the backup mechanism is ineffective if the backup path is using the same interface as the

regular path. If the interface goes down, then the backup path becomes unavailable, at the same time as the regular path. In this case, no backup path is ready to handle data traffic. New sub-flows will need to be created to backup the regular sub-flow, which is unavailable. Packets loss and retransmissions will become inevitable resulting in bad user experience.

6. IANA Considerations

This document requests no IANA actions.

7. Security Considerations

TBD

8. Informative References

[_3GPP.23.501]

3GPP, "System Architecture for the 5G System", 3GPP TS 23.501 1.4.0, 9 2017, <<http://www.3gpp.org/ftp/Specs/html-info/23501.htm>>.

[RFC6824] Ford, A., Raiciu, C., Handley, M., and O. Bonaventure, "TCP Extensions for Multipath Operation with Multiple Addresses", RFC 6824, DOI 10.17487/RFC6824, January 2013, <<https://www.rfc-editor.org/info/rfc6824>>.

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