

Transport Area Working Group
Internet-Draft
Intended status: Informational
Expires: September 12, 2019

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March 11, 2019

**IP compatible multipath framework for heterogeneous access networks
draft-amend-tsvwg-multipath-framework-mpdccp-00**

Abstract

More and more of today's devices are multi-homing capable, in particular 3GPP user equipment like smartphones. In the current standardization of the next upcoming mobile network generation 5G Rel. 16, this is especially targeted in the study group Access Traffic Steering Switching Splitting [3GPP, TR 23.793]. ATSSS describes the flexible selection or combination of 3GPP untrusted access like Wi-Fi and cellular access, overcoming the single-access limitation of today's devices and services. Another multi-connectivity scenario is the Hybrid Access [[draft-lhwxyz-hybrid-access-network-architecture](#), [draft-muley-network-based-bonding-hybrid-access](#)], providing multiple access for CPEs, which extends the traditional way of single access connectivity at home to dual-connectivity over 3GPP and fixed access. A missing piece in the ATSSS and Hybrid Access is the access and path measurement for efficient and beneficial traffic steering decisions. This becomes particularly important in heterogeneous access networks with a multitude of volatile access paths. MP-TCP can be employed in such scenarios and concerning the ATSSS, it is the agreed protocol for the traffic splitting mode. A decision for MP-TCP though leaves the increasing share of UDP in today's traffic mix (<https://arxiv.org/abs/1801.05168>) unconsidered. In this document, a network architecture leveraging the MP-DCCP network protocol is proposed, which enables above scenarios and address the formulated issues either independent or complementary to MP-TCP.

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Table of Contents

- [1.](#) Introduction [2](#)
- [2.](#) IP compatible multipath framework based on MP-DCCP [3](#)
- [3.](#) Application and placement [5](#)
- [4.](#) Conclusion [6](#)
- [5.](#) Security Considerations [6](#)
- [6.](#) Acknowledgments [6](#)
- [7.](#) Informative References [6](#)
- Authors' Addresses [7](#)

[1.](#) Introduction

Multi-connectivity access networks are evolving. Ongoing standardization at 3GPP for 5G mobile networks [3GPP, TR 23.793] or the so called Hybrid Access networks [[draft-lhwz-hybrid-access-network-architecture](#), [draft-muley-network-based-bonding-hybrid-access](#)] already provides or will provide in the near future the ability for multi-connectivity to a broad mass. A superior resilience against network outages, higher capacities and network cost optimizations are only some of the reasons why it make sense to introduce multi-connectivity. Since the multi-connectivity architectures are almost mature, it requires network protocols

providing the technology to exploit multi-connectivity. In the simplest case, multi-connectivity means load-balancing, distributing individual flows over multiple paths to distribute the load. However, this has no effect on resilience or capacity gain on those load balanced individual flows. More complex are those scenarios where an individual flow can be seamlessly shifted between multiple paths or can even aggregate those paths for leveraging the sum capacities. Like [3GPP, TR 23.793] this document refers to the three distribution schemes Steering (load balancing), Switching (seamless handover) and Splitting (capacity aggregation).

MP-TCP [RFC6824] is a protocol, which can be applied in the above mentioned use cases and covers load-balancing, seamless communication handover and also capacity aggregation. Further, it deals with heterogeneous and volatile access networks, since it profits from the TCP inherent congestion control. By design, MP-TCP is limited to TCP services and excludes any other network protocol, in particular UDP. For future multi-connectivity systems, it is not sufficient anymore to rely on supporting only TCP. The increasing share of UPD traffic, mainly impacted by the QUIC introduction, may significantly reduce the share from TCP. It might be expected that with HTTP/3 carried over QUIC [draft-ietf-quic-http], the previous strong dominance of TCP will be challenged by UDP.

2. IP compatible multipath framework based on MP-DCCP

A new approach, which overcomes MP-TCP's restriction to TCP services and providing IP compatibility, is depicted in Fig. 1. The architecture employs MP-DCCP [draft mp-dccp] in combination with an encapsulation scheme. For simplification, Fig. 1 assumes a traffic direction from the left (sender) to the right (receiver) and requires application in each direction for bi-directional transmission. The architecture in Fig. 1 can replace or complement MP-TCP to reach IP compatibility.

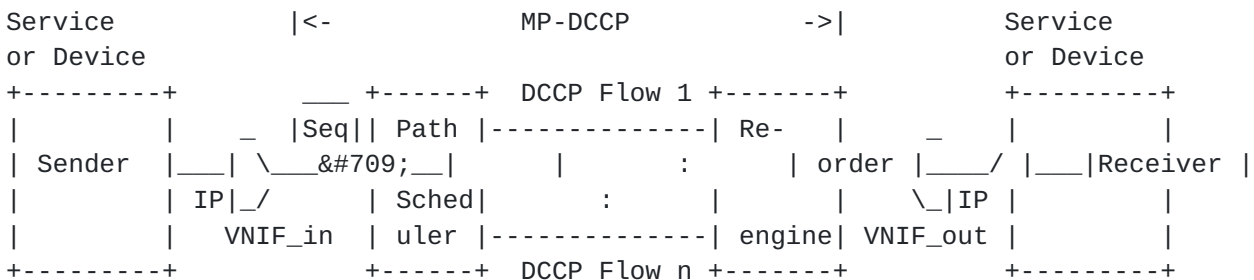


Figure 1: IP compatible multipath framework based on MP-DCCP

PDU generated from the sender and travelling through the architecture in Fig. 1 passes the components in the following order:

1. Sender: Generates any PDU based on the IP protocol.
2. VNIF_in: IP based Virtual Network Interface as entry point to the MP-DCCP framework. A simple routing logic in front (between (1) and (2)) can act as gatekeeper and decides upon redirecting traffic through the VNIF or bypassing it. The VNIF adds an extra IP layer to reach the multi-connectivity termination point.
3. Seq: Sequencing of in (2) passed PDUs depending on the incoming order. Adds an incrementing number, which is later added to the DCCP encapsulation in (4).
4. Path Scheduler: Decision logic for scheduling sequenced PDUs over the individual connected DCCP flows for multipath transmission. The path scheduler can use the information from the DCCP flows (see (5)) inherent congestion control information like CWND, packet loss, RTT, Jitter. After selection of a DCCP flow, the PDU is encapsulated into the individual flow. Further information, at least the sequencing, is added on top as DCCP option.
5. DCCP Flow(s): Responsible to transmit the encapsulated PDUs to the MP-DCCP exit point.
6. Reorder engine: Depending on the sequencing information of (3), a re-assembly of the PDU stream can be applied. The strictness of re-ordering shall be configurable up to no re-ordering.
7. VNIF_out: Releases PDUs that have passed the re-ordering engine and strips the DCCP specific overhead. Again routing is responsible to deliver the PDUs to the receiver based on the destination information in the PDU.
8. Receiver: Receive the PDU as generated in (1).

The simple enclosing of the MP-DCCP with Virtual Network Interface (VNIF) provides the IP compatibility. However, a service or protocol classifier between sender and VNIF can reduce the scope to particular traffic, e.g. UDP, by simple routing decisions. The MP-DCCP takes over responsibility for the multi-path transfer of the traffic, which is directed through the VNIF_in. For possible re-assembly operations the IP packets are stamped with a continuously incremented stamped sequence number. This is not a mandatory operation, but assumed required in most seamless handover and capacity aggregation use cases. The path scheduler decides for each IP packet which DCCP flow

is appropriate, based on a configurable decision logic and supported by the congestion control information of the DCCP flows available for transmission. A DCCP flow selection for a PDU leads to its encapsulation into the respective DCCP flow and adding extra information required for the multipath transmission, e.g. the sequence number. Encapsulation also means, that to the original PDU a DCCP and IP header is added to reach the multi-connectivity end-point. When the encapsulated PDUs arrive at the multi-path termination point, they are re-ordered depending on the carried sequence number and a configurable logic. The re-ordering engine may also include a logic in which packets are just forwarded (no re-ordering). Re-ordering needs to be considered carefully since any active intervention changes the latency responsiveness. The multi-path termination is finally completed when the DCCP overhead is stripped and the PDU leaves VNIF_out. Further routing depends again on the IP layer of the original PDU.

3. Application and placement

The framework of Fig. 1 gives most flexibility in applying multipath support in different architectures and allows MP-DCCP to be applied at any place between sender and receiver. Fig2. to Fig. 5 gives an impression about the universality which covers any imaginable architecture.

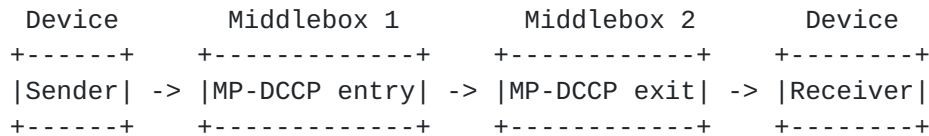


Figure 2: Sender and receiver independent MP-DCCP

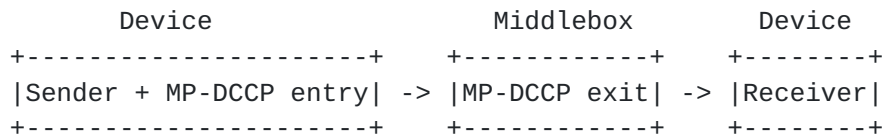


Figure 3: Sender integrated but receiver independent MP-DCCP

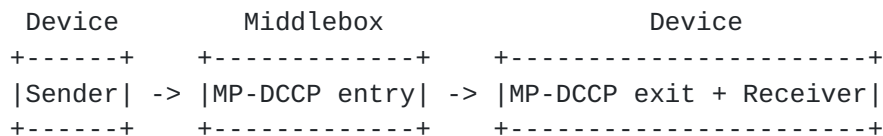


Figure 4: Sender independent and receiver integrated MP-DCCP

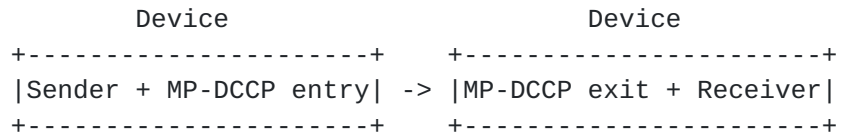


Figure 5: Sender and receiver integrated MP-DCCP

4. Conclusion

The specified IP compatible multipath framework based on MP-DCCP in this document comprises several benefits:

- o Pure routing
- o Inherent path estimation and measurement
- o Imposes no reliability or in-order delivery
- o Modular re-ordering
- o Modular scheduling
- o IP compatible
- o Based on the standardized DCCP.

Middle-box traversing, when the framework is applied in uncontrolled environments, is addressed in [[RFC6733](#)] and [draft u-dccp].

5. Security Considerations

[Tbd]

6. Acknowledgments

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