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# MPTCP Experiences in the NorNet Testbed
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Abstract

This document collects some experiences of Multi-Path TCP (MPTCP) evaluations in the NorNet testbed.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on June 5, 2020.

Table of Contents



## 1. Introduction

### 1.1. Abbreviations

- TCP: Transmission Control Protocol
- MPTCP: Multi-Path TCP

### 1.2. Multi-Path TCP

The Multi-Path TCP (MPTCP) extension for the Transmission Control Protocol (TCP) has been defined in [3], [4], [1], [2], [5]. There are also detailed introductions provided for example by [8], [9] as well as lots of further information material on [6]. MPTCP is therefore not introduced in more detail here.

### 1.3. Scope

The scope of this document is to collect some experiences with the usage of MPTCP in the NorNet testbed, a large-scale Internet testbed for multi-homed systems.

## 2. Testbed Evaluation

### 2.1. The NorNet Testbed

The NorNet testbed (https://www.nntb.no) introduced in [11], [15], [10] is a programmable testbed platform with focus on the evaluation of multi-homed systems. It consists of programmable nodes that are distributed all over Norway as well as further locations in other countries. NotNet is built and operated by the Simula Research Laboratory and financed by Forskningsraedet (the Research Council of Norway) through their INFRASTRUKTUR program (project number 208798/F50).

NorNet has two main components: NorNet Core and NorNet Edge. NorNet Core consists of currently 20 programmable sites (https://www.nntb.no/pub/nornet-configuration/NorNetCore-Sites.html), most of them multi-homed to several network providers. Details can be found in [12], [14], [11] and [16]. NorNet Edge consists of several hundreds of smaller nodes connected to all mobile broadband providers in Norway (http://robustenett.no/map), details can be found in [13]. Together, these two components offer a unique platform for experimental networking research. NorNet is made available to the international networking research community.

Further details on NorNet can be found on the NorNet website [17].

### 2.2. Multi-Path TCP in NorNet

The NorNet nodes are Linux-based and therefore run the Linux MPTCP implementation by Universite catholique de Louvain-la-Neuve (see [18]). With support by all NorNet Core nodes (circa 100 nodes at currently 20 sites) and most NorNet Edge nodes (several hundreds), NorNet probably provides the world's largest MPTCP experimentation platform.

### 2.3. NetPerfMeter

NetPerfMeter [19], [7] is a network performance meter for the UDP, TCP, MPTCP, SCTP and DCCP transport protocols over IPv4 and IPv6. It simultaneously transmits bidirectional flows to an endpoint and measures the resulting flow bandwidths and QoS. The results are written as vector and scalar files. NetPerfMeter is provided in NorNet to allow for transport protocol comparisons and transport protocol performance evaluations.

## 3. Research Results and Work in Progress

So far, work has been done on evaluating MPTCP in the real-world Internet. The following list is a short overview of current research:

- [20] examines the different properties of 3G paths (UMTS as well as CDMA2000) in NorNet Edge. These results provide an overview of the QoS characteristics that can be expected by multi-path transport protocols (and particularly by MPTCP) on different paths.

- [21] analyzes the impact of buffer bloat on MPTCP connections over mobile broadband (2G, 3G) and WLAN paths. Furthermore, it proposes and evaluates Multi-Path Transport Bufferbloat Mitigation (MPT-BM), a bufferbloat mitigation algorithm to improve MPTCP performance in buffer-bloated wireless networks.

- [22] examines the performance benefits of multi-path transport with MPTCP under heterogeneous wireless networks. It furthermore introduces and evaluates the Dynamic Relative Path Scoring (DRePaS) algorithm that optimizes the path management in such setups.

- [23] examines the performance benefits of the state-of-the-art Linux MPTCP implementation in a large-scale NorNet setup, covering sites in multiple countries on different continents. It particularly also shortly introduces the NetPerfMeter measurement tool that is used to perform the measurements, and particularly its extension for MPTCP.

- [24] examines how the IPv4/IPv6 identity duality can be utilized with MPTCP in order to improve performance even in case of only a single ISP connection.

- [25] provides an introduction to the NetPerfMeter tool for MPTCP experiments.

- [26] presents MPTCP's architecture and multi-path congestion control algorithm concepts. Then, it examines three test scenarios in the NorNet testbed, particularly highlighting the performance difference between using uncoupled and coupled congestion controls in multi-homed, real-world Internet setups.

- [27] introduces a scanning infrastructure to search for MPTCP-capable hosts in the Internet. In a study, it used the top-1M Alexa servers to test the platform and gain insight about server support for MPTCP.

- [28] proposes a practical shared bottleneck detection (SBD) algorithm for MPTCP, namely MPTCP-SBD. Through extensive emulations, it is shown that MPTCP-SBD outperforms all currently deployed MPTCP coupled congestion controls by accurately detecting bottlenecks resulting in throughput gains in the absence of shared bottlenecks, while remaining fair to TCP in shared bottlenecks scenarios.

- [29] proposes a send-window BLocking ESTimation scheduler, BLEST, which aims to minimise head-of-line-blocking in heterogeneous networks. BLEST increases the potential for capacity aggregation by reducing the number of spurious retransmissions.

- [30] examines path management strategies for MPTCP in real-world, multi-homed Internet setups. Particular goal is to highlight the performance impact of different path management and congestion control settings in such realistic scenarios.

- [31] analyses the actual buffer size requirements for MPTCP in heterogeneous, multi-homed Internet setups. Particular goal is to provide some guidelines on buffer size requirements for achieving a reasonable throughput, while on the other hand not wasting resources.

- [32] examines the relationship of buffer size with throughput and congestion control algorithms, based on the statistical predictive modelling method.

- [33] examines the application of MPTCP for real-time video streaming for future Mobile Edge Computing (MEC) scenarios.

## 4. Security Considerations

Security considerations on MPTCP are described in [3].

## 5. IANA Considerations

This document has no actions for IANA.

## 6. Acknowledgments

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