Assessment of Multipath QUIC Protocol Performance : A Survey

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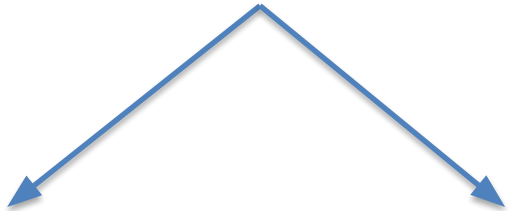
OBJECTIVE

The objective is to assess various research papers concerning the performance of MPQUIC in various environments, particularly 5G. Additionally, an examination of MPTCP and QUIC, the predecessors of MPQUIC, will be conducted to gain insights into the development of this protocol. The analysis will entail scrutinizing the authors' studies and ultimately presenting a concise summary of the findings.

MOTIVATION

Why Multipath QUIC



- Enhanced reliability and performance in case of line-of-sight being blocked
- Resilient to network connectivity failures

Pool various network resources for multi-homed devices with various network interfaces

LITERATURE SURVEY/RELATED WORK

The Papers that were used for the survey are provided in here and a brief on each paper has been provided in the report:

1) MultiPath TCP: From Theory to Practice

2) Multipath TCP: Analysis, Design and Implementation

3) The QUIC Transport Protocol: Design and Internet-Scale Deployment

4) Multipath QUIC: Design and Evaluation

5) Selective Redundant MP-QUIC for 5G Mission Critical Wireless Applications

6) XLINK: QoE-Driven Multi-Path QUIC Transport in Large-scale Video Services

LITERATURE SURVEY/RELATED WORK

The Papers that were used for the survey are provided in here:

7) MultiPath TCP: From Theory to Practice

8) Performance Evaluation of MPTCP on Simultaneous Use of 5G and 4G Networks

9) MPTCP or MPQUIC - Which One is Better for General-Purpose Networking

PROPOSED METHODOLOGY/ WORK PLAN

Literature Survey

Understanding the design, implementation and the role of Multipath QUIC, QUIC and MPTCP

Creation of the topology in a real-time 5G testbed using Oracle VM Virtualbox

virtualization of x86 architecture using Virtualbox, configuring network adapters, enabling firewall, conducting experiments, and analyzing the results.

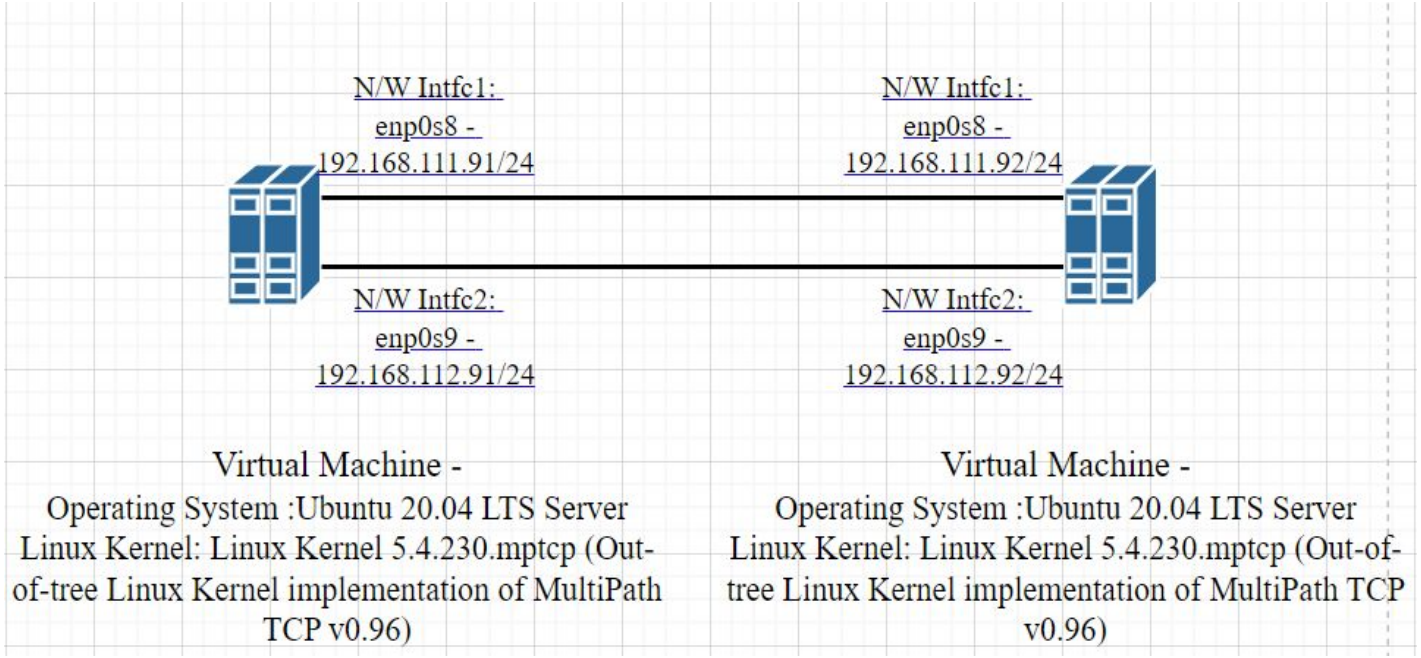
Implementation

Establish a QUIC server and client utilizing the quic-go library. Customize MPQUIC to establish paths for each network interface. Assess performance through traffic generation using tools such as qperf. Evaluate resilience by simulating various network conditions, including bandwidth variations, loss of line of sight, and scenarios where a path is disrupted or blocked.

Performance Evaluation

Assess various performance metrics by adjusting bandwidth, latency, and network link loss to mimic a 5G mmWave environment. Measure efficiency by incorporating network scenarios such as line of sight (LOS) and testing situations where a path becomes unavailable or blocked.

Creation of 5G Network Topology using VM's



IMPLEMENTATION OF MPQUIC IN 5G SYSTEM

Implementation of Multipath QUIC in Go

- The client and server applications are setup using the ‘Go’ language.(Version 1.17)
- The MPQUIC implementation is based on the existing quic-go library available on github.
- The scheduler is implemented as a separate goroutine(thread) that runs concurrently with the main event loop of the quic-go server with the support for:
    1. Path Management
    2. Congestion Control
    3. Retransmission

IMPLEMENTATION OF MPQUIC IN 5G SYSTEM

Experimental Study and Evaluation

- To study the network performance, we used qperf. (similar to iperf).“qperf” was used to measure the throughput of the QUIC network traffic.
- For each experiment the following information is collected:
    1. Throughput in bps
    2. Congestion Window size
- Multiple experiments are conducted varying the bandwidth, the packet loss rate, and the delay. Also, varying congestion algorithm and scheduler.
- Each experimented is repeated 5 times, and the mean throughput is measured.

IMPLEMENTATION OF MPQUIC IN 5G SYSTEM

Testing Multipath QUIC Resiliency:

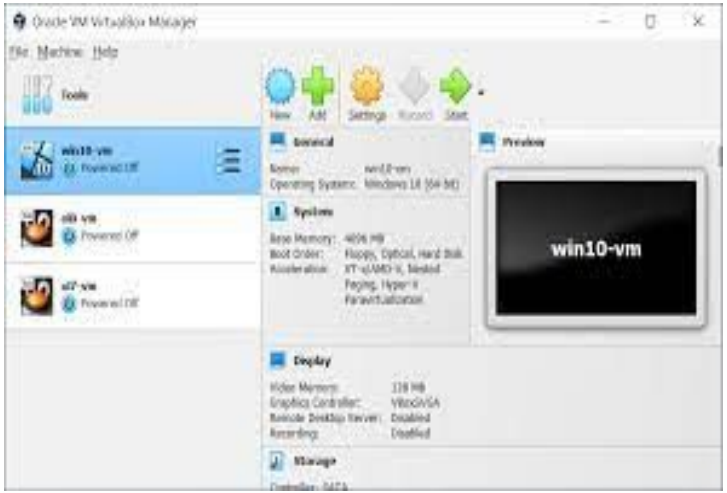
- To evaluate the resiliency of Multipath QUIC, we test two scenarios:

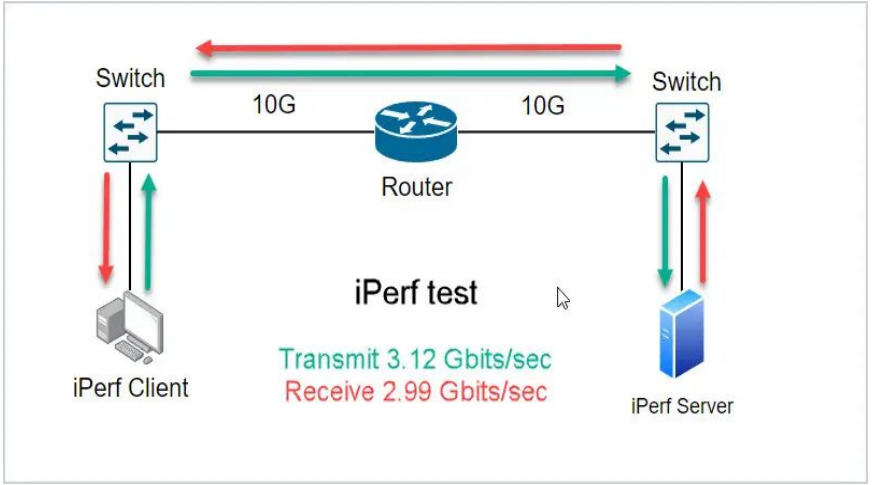
  1. When one path does down due to changing network condition.

  2. When one path is blocked due to the loss of the line of sight during the transmission.
- To address the scenario when one path is blocked, on-the-fly pack retransmission is used (with help of goroutines and interrupt time intervals).
- To measure the effectiveness of our on-the-fly packet re-transmission approach, we will measure interrupt latency - the time between an interrupt being generated and the second thread acquiring the lock.

TOOLS TO TEST MP-QUIC PERFORMANCE

1. Traffic Control (TC) Tools.
2. QPerf
3. Oracle VM Virtualbox /Visual Studio Code
4. Go Programming Language
5. Ubuntu 20.04 OS





PERFORMANCE PARAMETERS OF MPQUIC IN 5G NETWORKS

1.Bandwidth:

- Multiple pathways with varying bandwidth affect MPQUIC performance.
- Using 2 links with 500 Mbps achieves 5G connectivity via mmWave specification.

2.Delay:

- Latency of [(40,0), (40,40), (40,80)] microseconds with a 5% normal distribution represents network characteristics.
- Distance, routing, and processing time impact the delay.

3.Schedulers:

- Blest, default lowest RTT, and ECF schedulers are assessed to determine their impact on MPQUIC performance.

PERFORMANCE PARAMETERS OF MPQUIC IN 5G NETWORKS (Continued)

4. Congestion control algorithms:

- Balia, Cubic, and Olia are evaluated to assess MPQUIC performance under different network congestion conditions.
- **Socket Statistics** allows for the monitoring of each subflow's transmission and reception rates, as well as other metrics such as the number of bytes transmitted, the number of retransmissions, and the round-trip time.

5. Line-of-Sight:

- line of sight between the sender and receiver enhances the performance of MPQUIC by minimizing packet loss, latency, throughput and congestion.
- To mitigate this issue, techniques such as beamforming and MIMO are used.
- Nonetheless, barriers like buildings, landscapes, and other wireless devices can obstruct this line of sight and impede the efficacy of MPQUIC.

ADVANTAGES & DISADVANTAGES OF MULTIPATH IN 5G NETWORKS

Pros:

1. Increased data transfer speeds.
2. Improved network reliability.
3. Enhanced coverage.

Cons:

1. Signal interference.
2. Complex signal processing
3. Limited capacity

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THANK YOU