MP-DCCP

for enabling transfer of UDP/IP traffic over multiple data paths in multi-connectivity networks

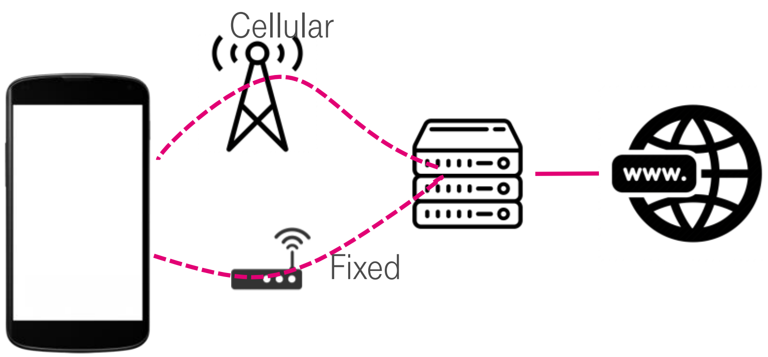
draft-amend-tsvwg-multipath-dccp-02
draft-amend-tsvwg-multipath-framework-mpdccp-01
draft-amend-tsvwg-dccp-udp-header-conversion-01

IETF 105 Meeting, ICCRG, Montreal, July 2019

Markus Amend

LIFE IS FOR SHARING.

MOTIVATION 1/2



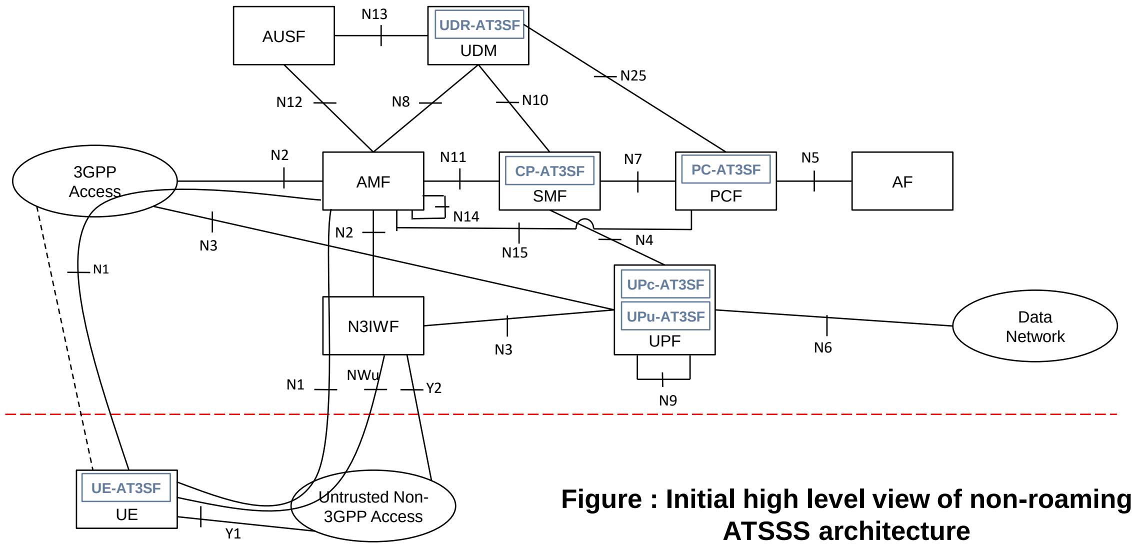
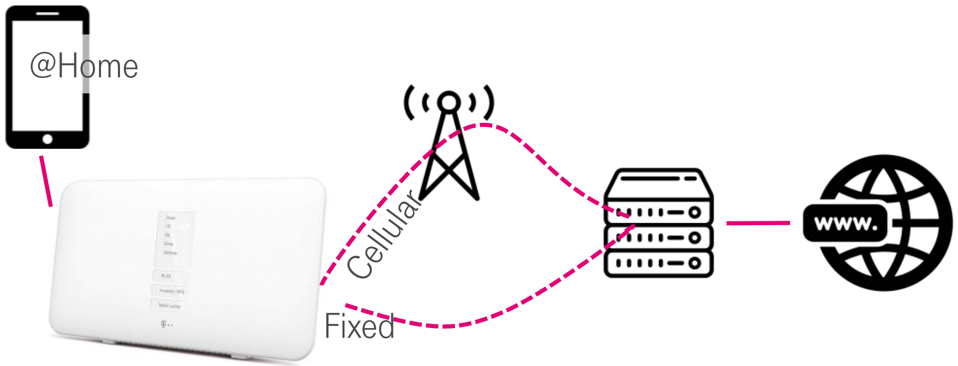


Figure : Initial high level view of non-roaming ATSSS architecture

Mobile device multi-connectivity based on expected 3GPP Rel. 16 ATSSS specification

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+-----+                      ------
|     |                  /            \
|HOST|       +------+   |  Wireless    +-----\+------+
|     +------+      | +-+     3G/4G    |       |      |        *****
+-----+ Wireless    +-+  \            /        |      |      **      **
                     |      |        ------            |      |     *           *
+-----+      | CPE  |                          | HAG +---*  Internet *
|     |      |      |        ------            |      |     *           *
|HOST+------+       +-+  /            \        |      |      **      **
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+-----+      +------+   |     Fixed    +-----/+------+
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Residential multi-connectivity based on Hybrid Access at BBF

MOTIVATION 2/2

140.000 residential customer of a European ISP over one week in August 2018

Layer 3	Layer 4	>Layer 5	Share [%]	
IPv4 and IPv6	TCP		82.77	
	UDP	QUIC	11.76	16.33
		RTP	2.64	
		Other	1.93	
	Other		0.53	
Other			0.37	

Demand

Multi-connectivity should cover the whole IP traffic mix in which TCP loses its dominating role because of QUIC

Findings

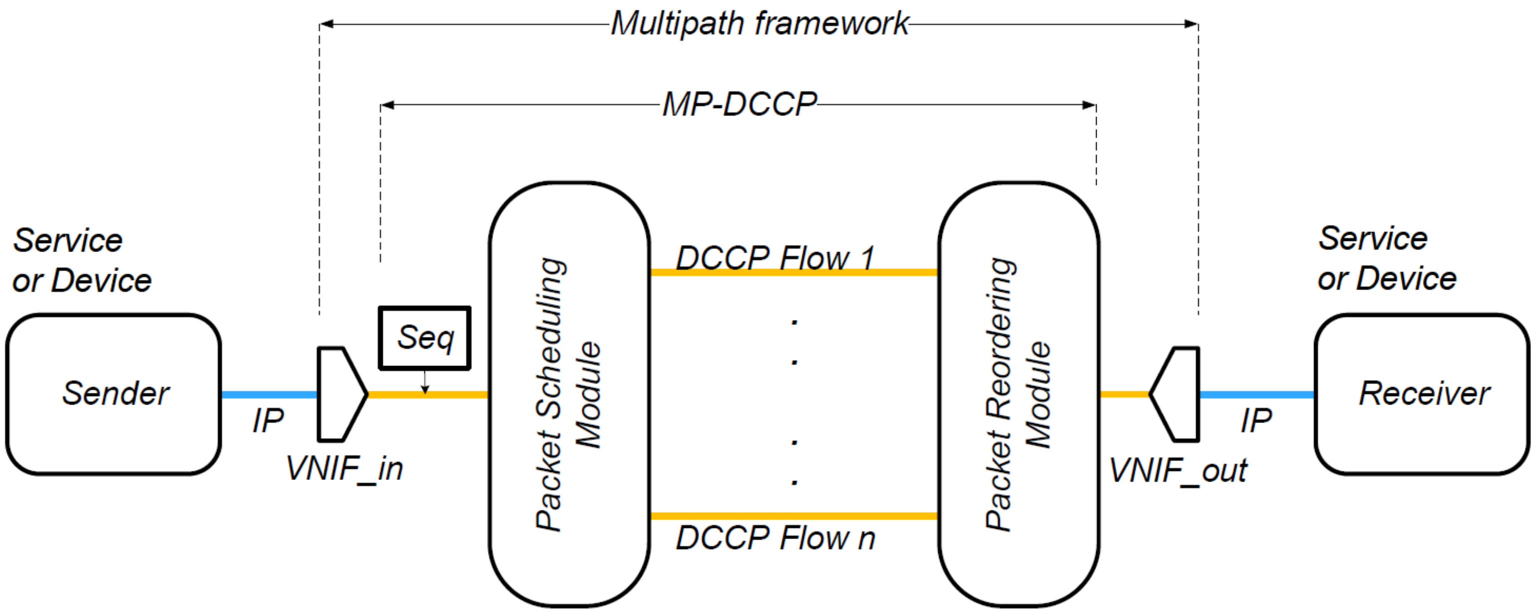
MP-TCP is a good candidate to enable the TCP share for multi-connectivity. A finding from MP-TCP is, that its congestion control empowers beneficial traffic splitting.

Multipath support for UDP or even IP does not exist.

UDP or IP encapsulation into MP-TCP is not an option as it would impose reliable in-order delivery.

A potential multipath solution for UDP/IP must not impose TCP like reliability, additional high latency, packet scrambling or head-of-line blocking.Otherwise it breaks the UDP and IP principles on transportation and service expectations!

SOLUTION: MP-DCCP FOR UDP MULTIPATH TRANSMISSION



https://tools.ietf.org/html/draft-amend-tsvwg-multipath-dccp-02

https://tools.ietf.org/html/draft-amend-tsvwg-multipath-framework-mpdccp-01

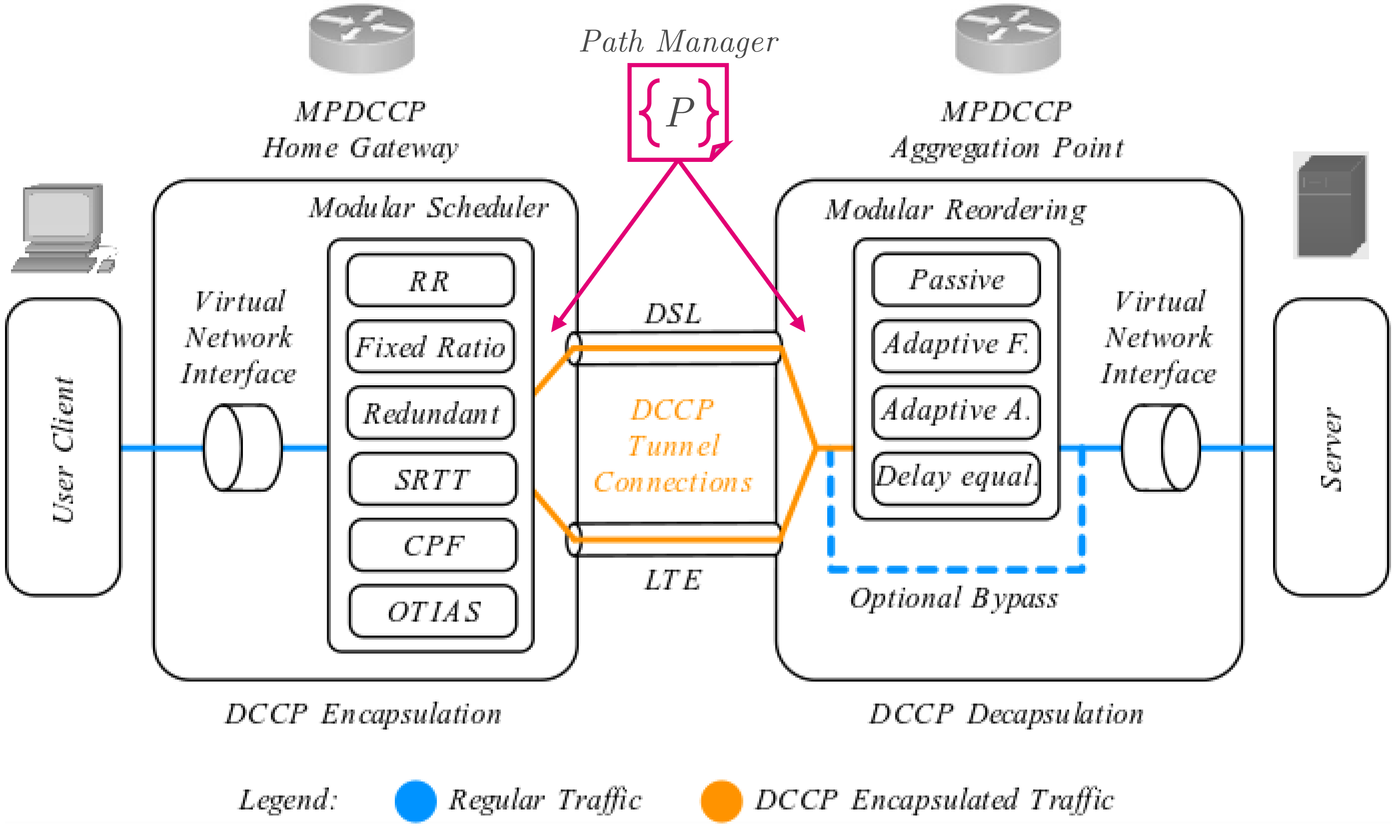
https://tools.ietf.org/html/draft-amend-tsvwg-dccp-udp-header-conversion-01

ANALYSIS AND RESULTS – TESTBED AND NS3 SIMULATIONS

Prototype is available inside Linux Kernel and ns-3 for residential and mobile use case each

- support seamless handover and path aggregation
- modular scheduler for distributing traffic
- modular re-assembly to compensate latency differences
- modular path manager to establish DCCP flows dynamically
- DCCP-UDP conversion to connect through non-DCCP aware middleboxes

→ Analysis Objective – test the ability of the framework to improve QoS/QoE on volatile paths

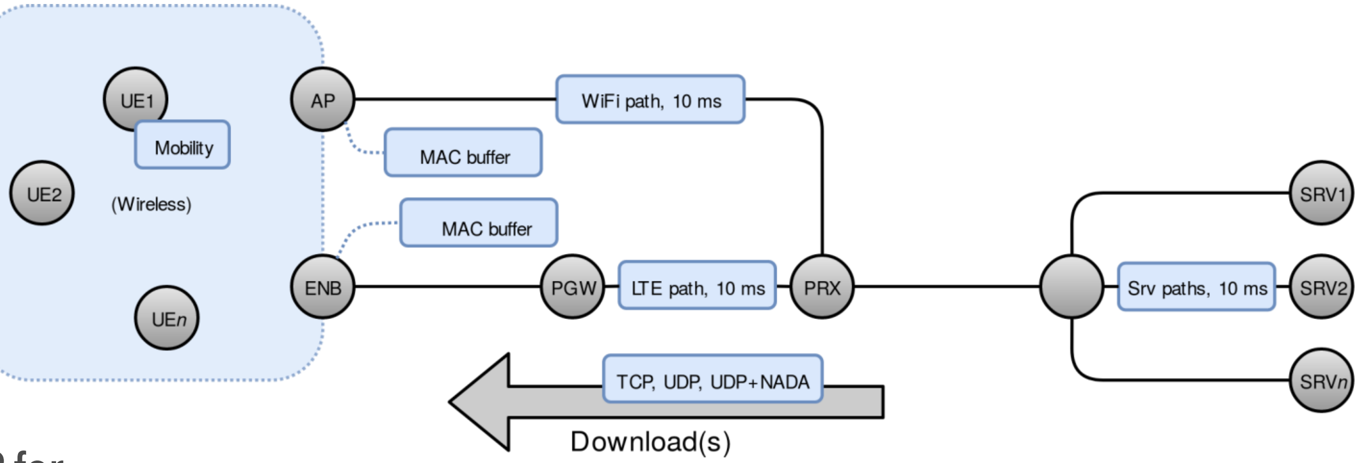


NS3 SETUP AND RESULTS

Arbitrary number of users & servers

Excess capacity on wired links (multi-Gbps)

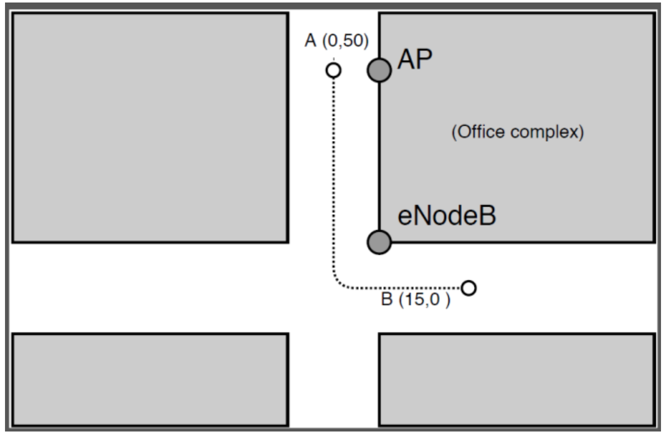
Link latency per the figure, 0 ms if not stated



Question: How fast handover is when using MPDCCP for switching and aggregation use cases?

Scenario:

- Moving from A → B → A: WiFi outage near B
- Fail-over onto LTE path when approaching B
- Return to WiFi when approaching A

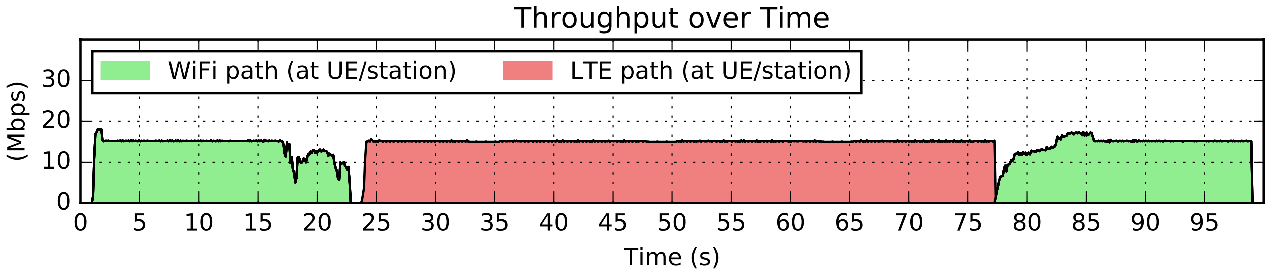


SWITCHING AND AGGREGATION– NS3, UDP TRAFFIC

Switching Mechanism

- Single path scheduler is used (meaning no splitting)
- WiFi path is prioritized over the LTE path
- Condition for PKT-push: CWND > in-flight
- All packets are pushed onto first available path (only)

→ When WiFi is available, push all onto WiFi path



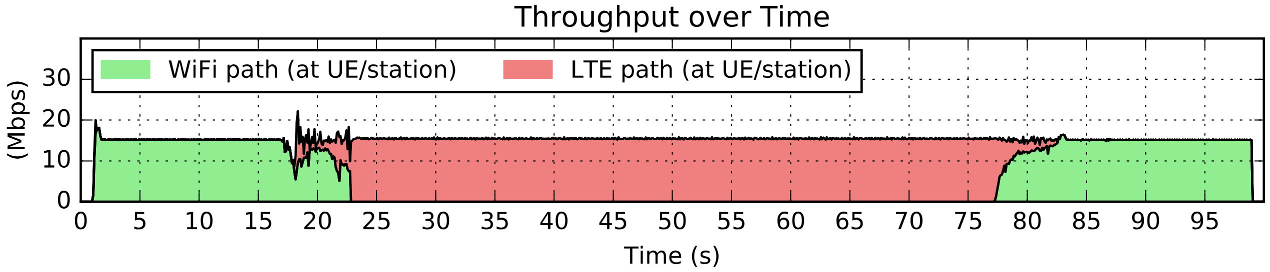
After detecting the physical loss, stream is handed over to cellular without connectivity brea

When WiFi returns, stream is handed over to Wi-Fi again

Aggregation Mechanism

- Cheapest path first scheduler is used (will aggregate)
- WiFi path is prioritized over the LTE path
- Condition for PKT-push: CWND > in-flight
- Fill WiFi window first, then fill LTE window (if needed)

→ When WiFi is sufficient, only WiFi is used



Additionaly to the scenario on top, using path aggregation combined with path prioritzation

on WiFi enables a smooth handover, keeping QoS stable

SWITCHING AND AGGREGATION– NS3, UDP + NADA TRAFFIC

Evaluate support for congestion controlled UDP services

NADA –Congestion control for real-time media

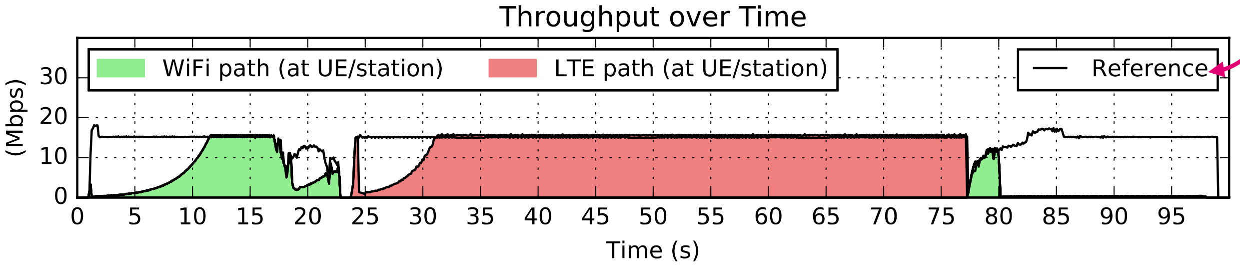
NADA behavior:

- Will increase rate when the latency is stable/low
- Will decrease the sending rate when latency increases
- Puts a cap on the sending rate (1.5 Mbps default, increased 10x for simulation)
- Targets low latency; tries to avoid buffer bloat

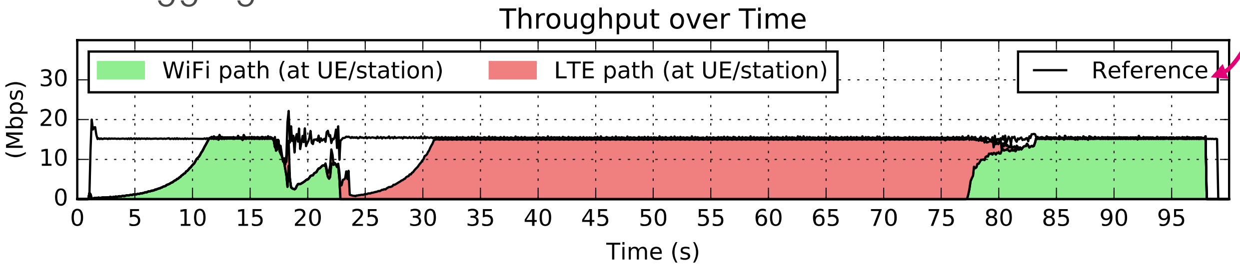
→ Aggregation advantage if the flow is large and the server congestion control is latency sensitive

Reference line indicates previous results of UDP without NADA

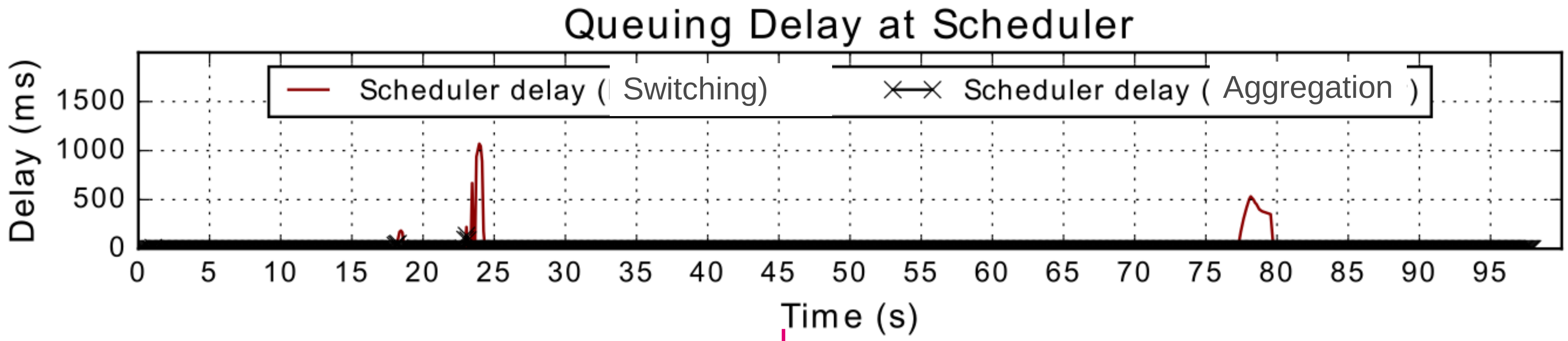
Switching



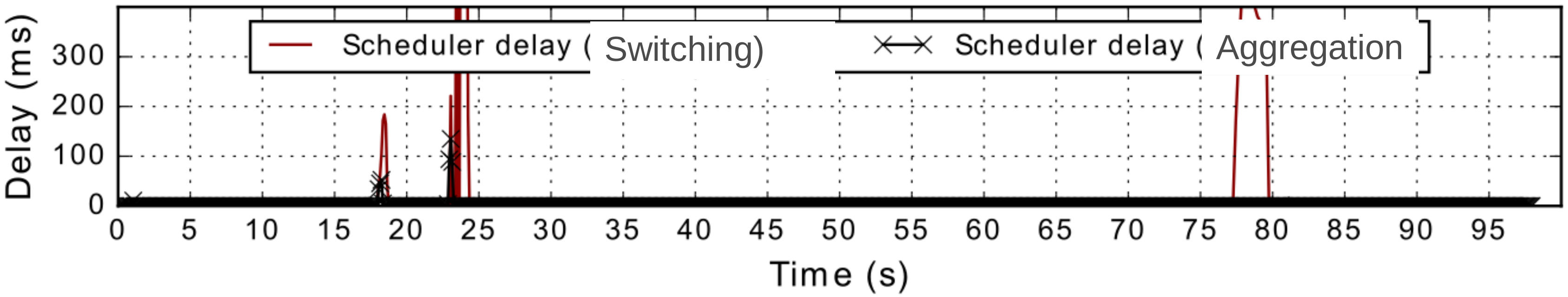
Aggregation



SCHEDULING DELAY– NS3, UDP + NADA TRAFFIC



Zoomed view



Queuing delay at scheduler over time

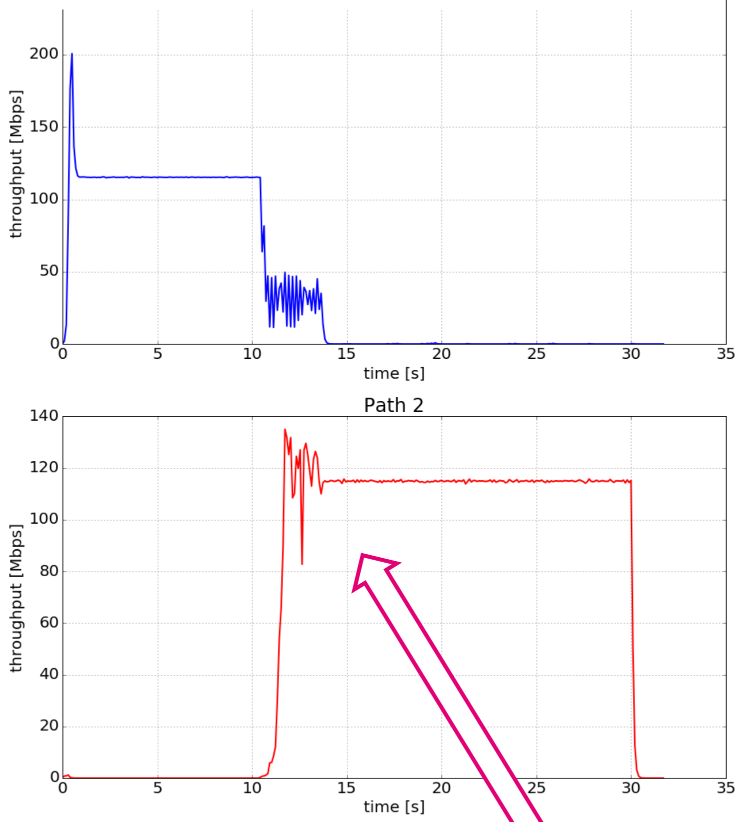
Switching ⟶ peek delay > 1000 ms during handover

Aggregation ⟶ peek delay < 200 ms during handover

TESTBED RESULTS – UDP IN A HANDOVER, AGGREGATION MODE

Latency triggered smooth handover

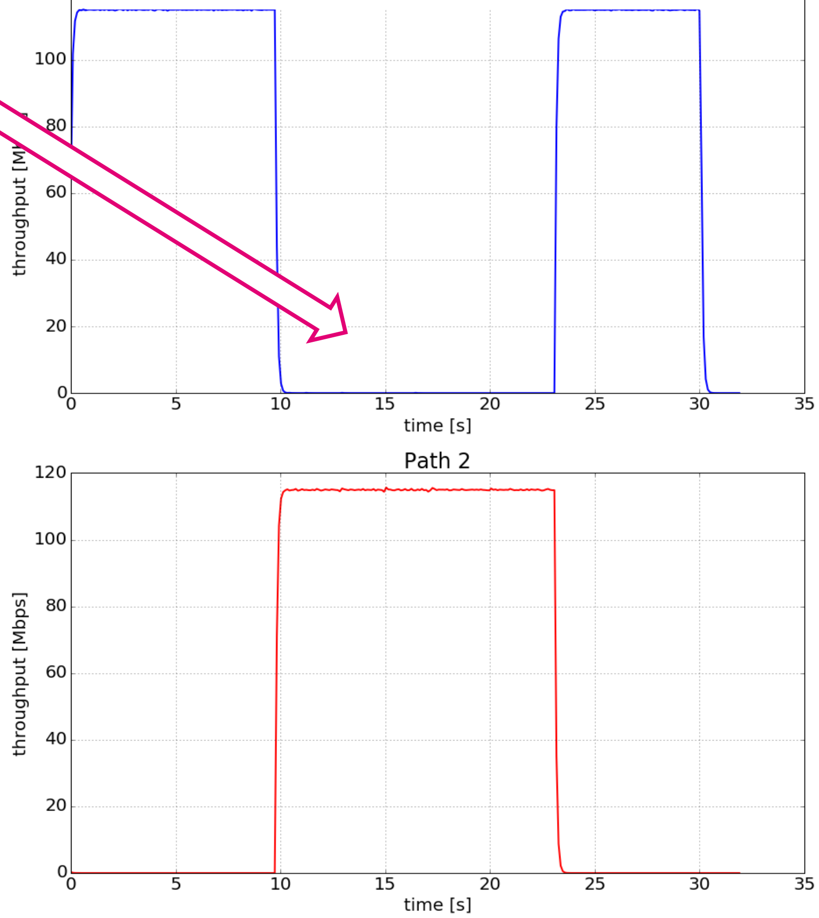
(Shortest RTT scheduler)



Path usage: a break in cheapest path (immediately visible at sender) at 10s, path back up at 23s

Connectivity loss triggered handover

(Cheapest pipe first scheduler)



Path latencies 10ms/40ms

Latency change on path 1 to 90ms

MANAGING PACKET DELAY VARIATION IN TRAFFIC AGGREGATION

Packet delay variation when traffic is aggregated on two paths with different latencies

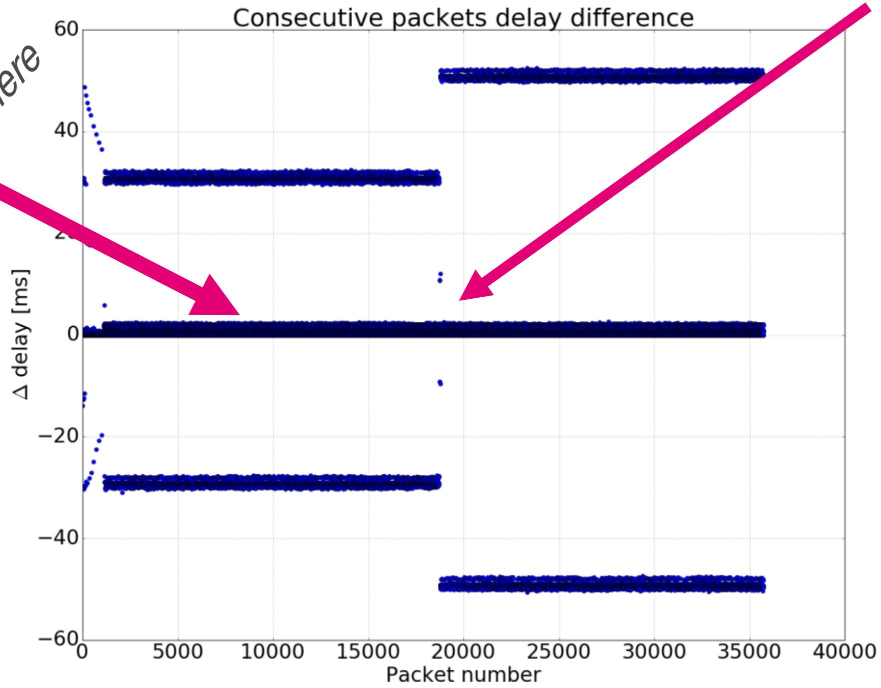
- Traffic aggregated and scheduled 80/20 for ‘quicker’ path (Weighted Round-Robin scheduler)

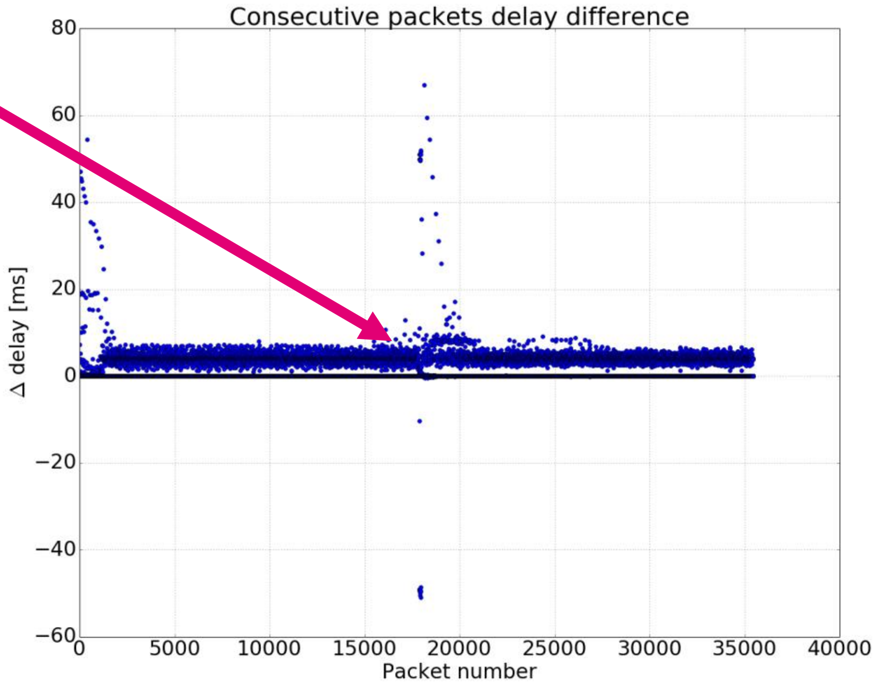
Same scenario, with adaptive packet reordering applied at receiver side

- adaptive packet reordering provides in-order delivery of packets

Majority of the packets are here

Latency on ‘slower’ path increased by 30ms





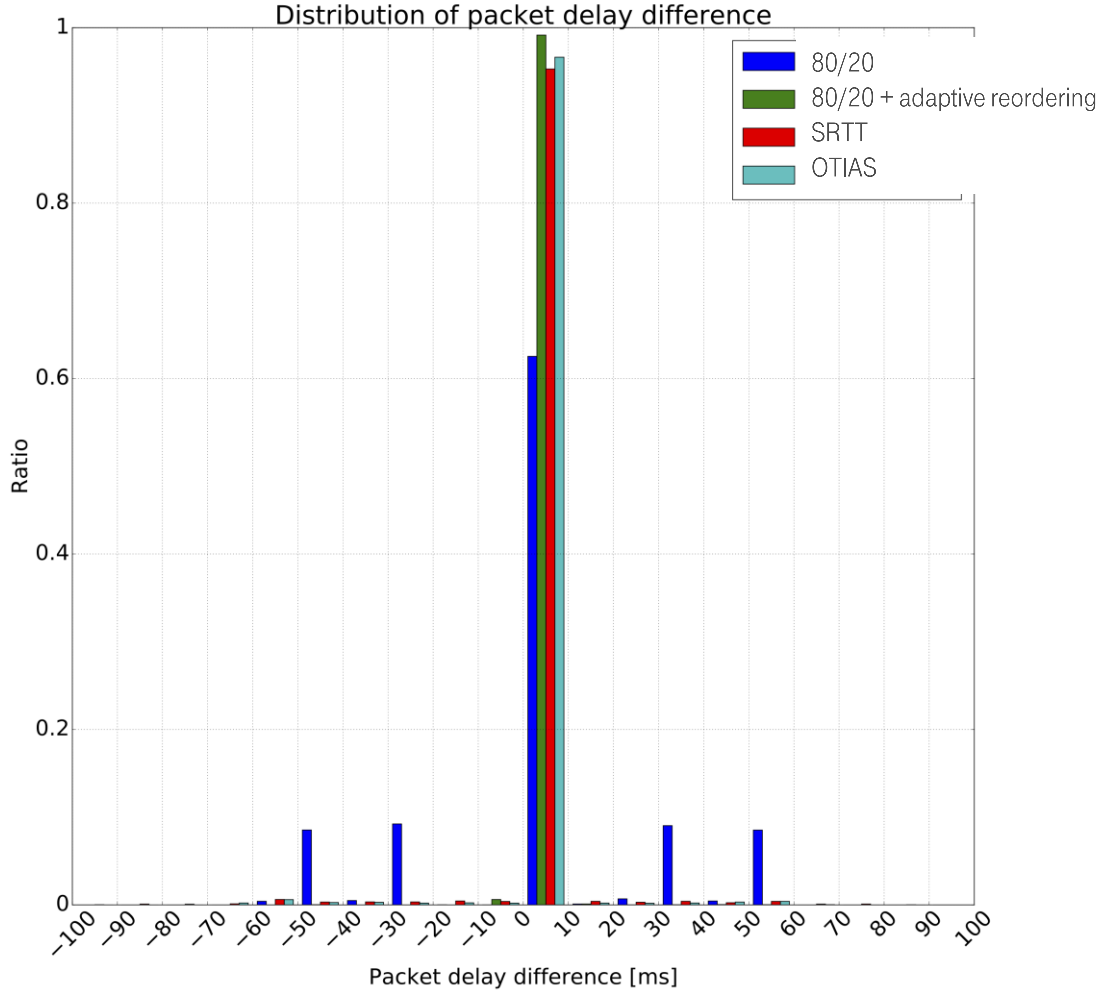
MANAGING PACKET DELAY VARIATION USING SCHEDULING OR REORDERING

Same scenario as on previous slide:

- Similar effect (supression of packet delay variation) can be achieved using intelligent scheduling
- Scheduling algorithms use DCCP-originated path delay information to schedule the traffic on the path providing smaller latency (‘srtt’) and additionally considering send buffer (‘otias’)

→ Delay variation is mostly removed as consequence of that

→ However best results can be achieved with re-ordering on receiver side



CONCLUSION

The prototype implementation and simulation show very good first results according to the demands of Steering, Switching and Splitting of 3GPP ATSSS and BBF Hybrid Access.

UDP/IP traffic can be transmitted in switching or aggregation scenario

Further investigation of congestion controlled UDP flows required

To become an option for being included into 3GPP Rel. 17 a MP-DCCP based architecture needs to be WG adopted until end of next year (IETF109).

Discussions with operators and vendors have been initiated but additional support is always welcome.

Please use iccrg@irtf.org/tsvwg@ietf.org or markus.amend@telekom.de to get in touch with us.

Further documents

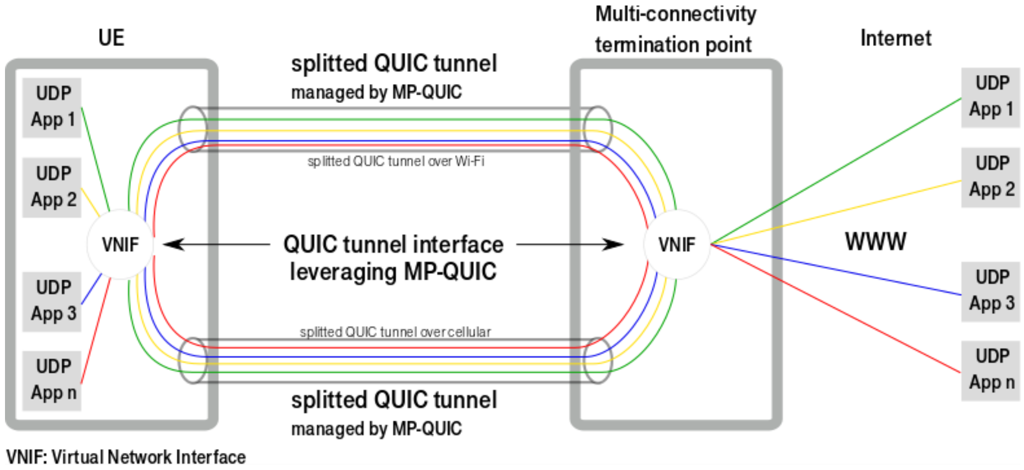
Paper with detailed results: https://arxiv.org/pdf/1907.04567.pdf

IETF 104 presentation: https://datatracker.ietf.org/meeting/104/materials/slides-104-tsvwg-sessb-43-markus-amend-multipath-dccp-00

BACKUP

WHY NOT USING MP-QUIC?

MP-QUIC is a reliable and end-to-end encrypted protocol. Its application for enabling multipath transfer for UDP/QUIC traffic only works as QUIC tunnel, managed by MP-QUIC.



- **Useless encryption is applied and requires resources**
  - UDP as guest: Turns UDP into reliable transmission ☹
    - QUIC as guest: Encryption over Encryption, otherwise like TCP below ☹☹
  - TCP as guest: TCP's CC + reliable in-order delivery over outer QUIC's CC + reliable in-order delivery ☹☹☹

REQUIRED (MP-)QUIC ADAPTATIONS

In case MP-QUIC shall become an alternative for ATSSS and Hybrid Access like network architectures, it would require a paradigm change:

→ Configurable encryption for

- reducing the useless overhead in case of QUIC over MP-QUIC over trusted network paths
- designing a MP-QUIC ↔ QUIC converter

→ Deal with unreliable traffic to some extent and remove at least the reliable and in-order delivery feature

- Unreliable traffic support requires a complete re-work of current MP-QUIC framework, which bases on QUICs reliable and in-order delivery.