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Alternative Transmission Strategies for Multipath Transport of Multimedia Streams over Wireless Networks

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Overview: Motivation

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Motivation:
Resilience by Redundancy

Multi-Homing

- Connections to multiple Internet Service Providers (ISP)
- Idea: if one ISP has problems, another connection still works

Use ISP connections simultaneously => multi-path transfer!

Motivation: Multi-Path Transfer

- Multi-homing is already quite ubiquitous
  - You are probably carrying a multi-homed device already!
    - Example: smartphone or tablet with UMTS and W-LAN
- Multi-path transfer becomes increasingly popular
  - Concurrent Multi-Path Transfer for SCTP (CMT-SCTP)
    - Multi-Path TCP (MPTCP)
- Multi-path transfer is also useful for multimedia content
    - Especially if single-path transfer is too slow
  - Two separated channels to fulfil bandwidth requirements
    - **=> Question: how to schedule data onto paths?**

Appropriate multi-path transmission strategies needed!

Overview:
Multipath Transmission Strategies

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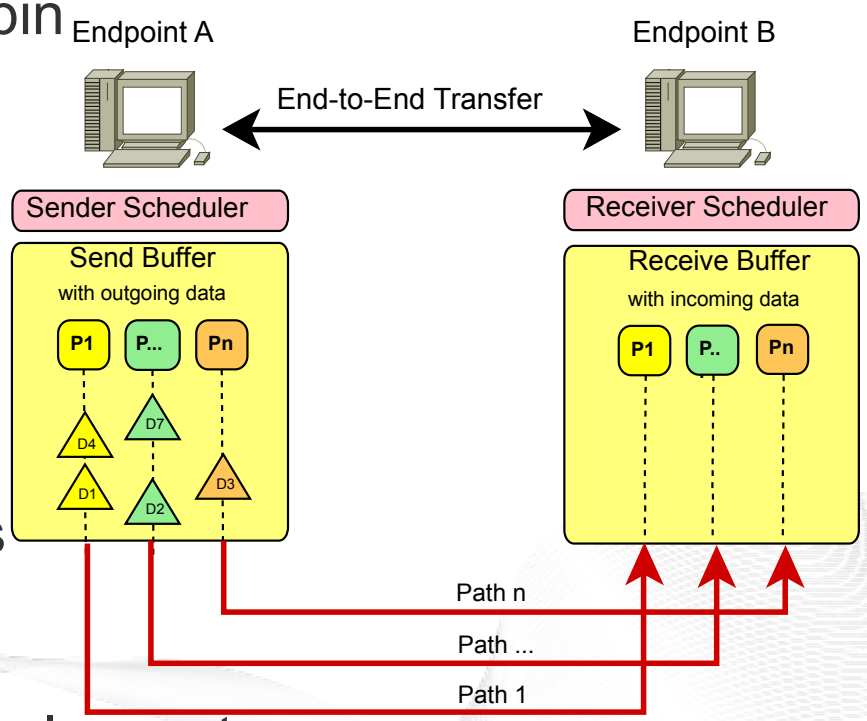
Scheduling Challenges

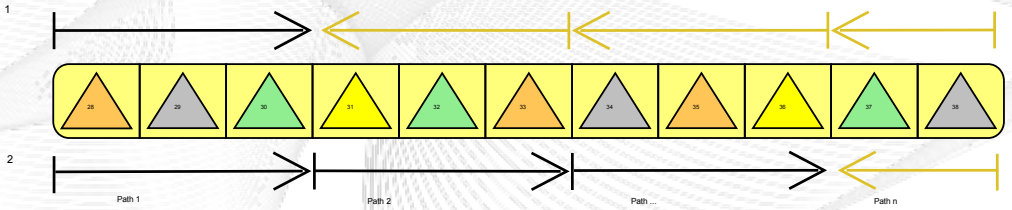
- **Sender schedules messages over paths**
  - Usually: round-robin
- Receiver reorganises message order
- Paths with similar characteristics
  - => no problems
- Paths with dissimilar characteristics
  - Different bandwidth, delay, loss rate
  - Receiver may have to wait for delayed data on other paths
  - => delay, data loss (too late real-time data is useless!), ...



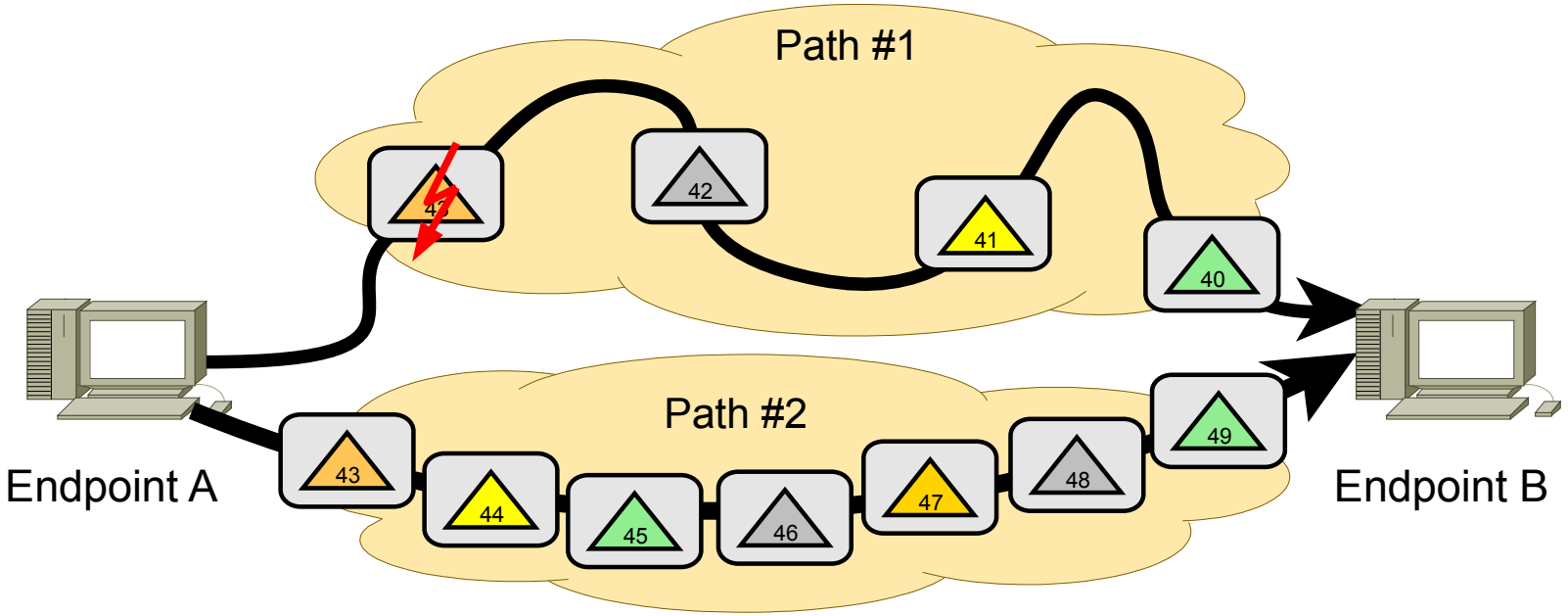
Confluent Sequence Numbers (ConSN)

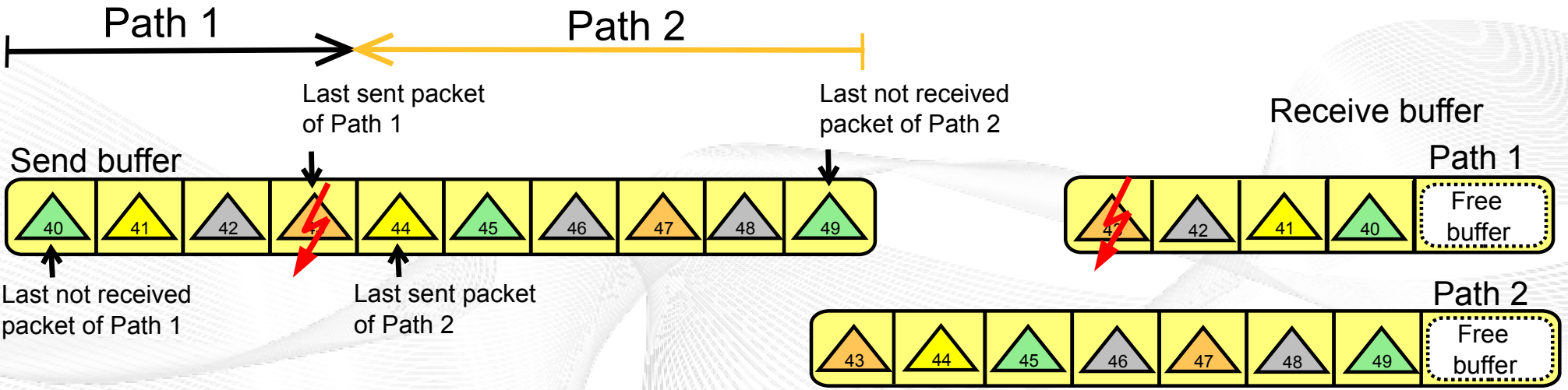
- Idea
  - Segment sequences of the paths will be confluent
  - If there is a problem on one path, the segment sequences on the others run towards the missing segments
  - Retransmission tries to avoid blocking of other paths
    - Preventive retransmissions are also possible

- Two scenarios
  1. Path #1 ascending, other paths descending order
  2. Path #*n* descending, other paths ascending order



A ConSN Example





Path Delay Compensation (PDC)

- Idea
  - **Compensate delay differences** among paths **by buffering** of data
  - Usage of smoothed RTT (sRTT) to decide the outgoing path of a packet
  - Receiver should get the packets at the right time
- Not possible for all RTT differences (limited buffer space)

Split Error Correction (SEC)

- Idea
  - **Forward Error Correction** (FEC) on Transport Layer
    - Transmission of original media stream over high-bandwidth path
    - Redundancy information over low-bandwidth path to make repair of damaged data blocks possible
- Independent of the underlying protocol layers (but needs delivery of damaged packets)
- Sender can **split data** (original + FEC) **to different paths**

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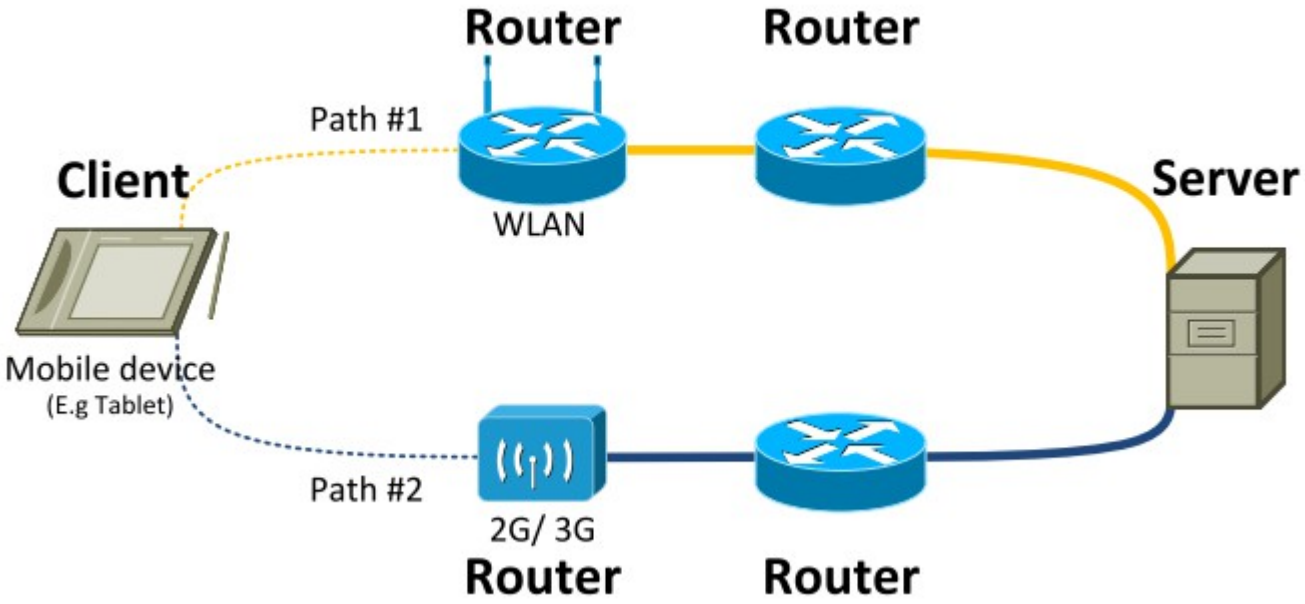
Evaluation Setup for a Simple Proof of Concept

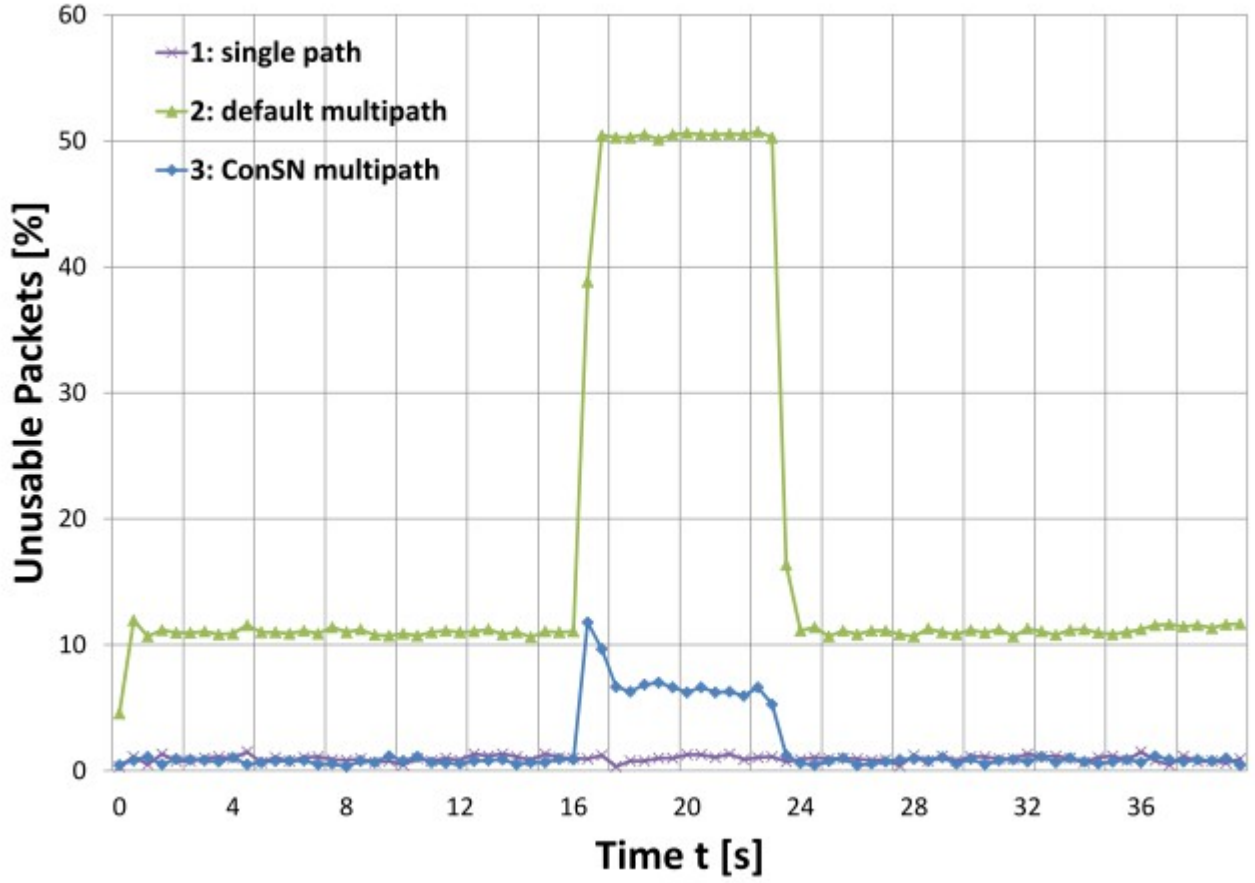


Network	Payload Download	Payload Upload	Delay	Loss
3G HSDPA	4.0 Mbit/s	1.5 Mbit/s	160 ms ± 150	0 %
WLAN	25.0 Mbit/s	6.0 Mbit/s	31 ms ± 4	<1 %

- Link emulation with *NetEm*
- Performance evaluation with *NetPerfMeter*

ConSN with Sufficient WLAN Bandwidth

Delay jump on 3G path:
t=16s to t=24s

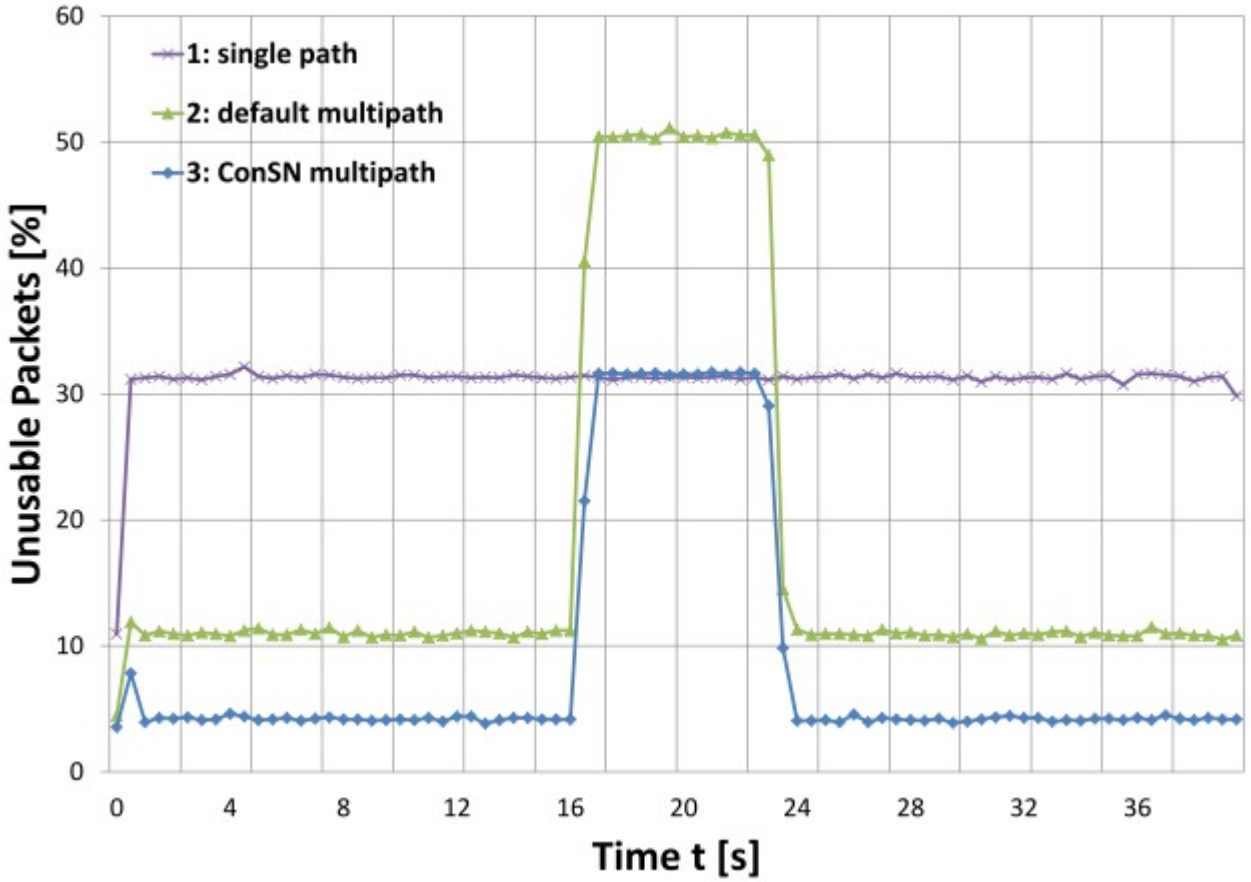


Coupling WLAN and 3G Links

(WLAN alone would be

ConSN with Insufficient Bandwidth for Single-Path Transfer

Delay jump on 3G path:
t=16s to t=24s

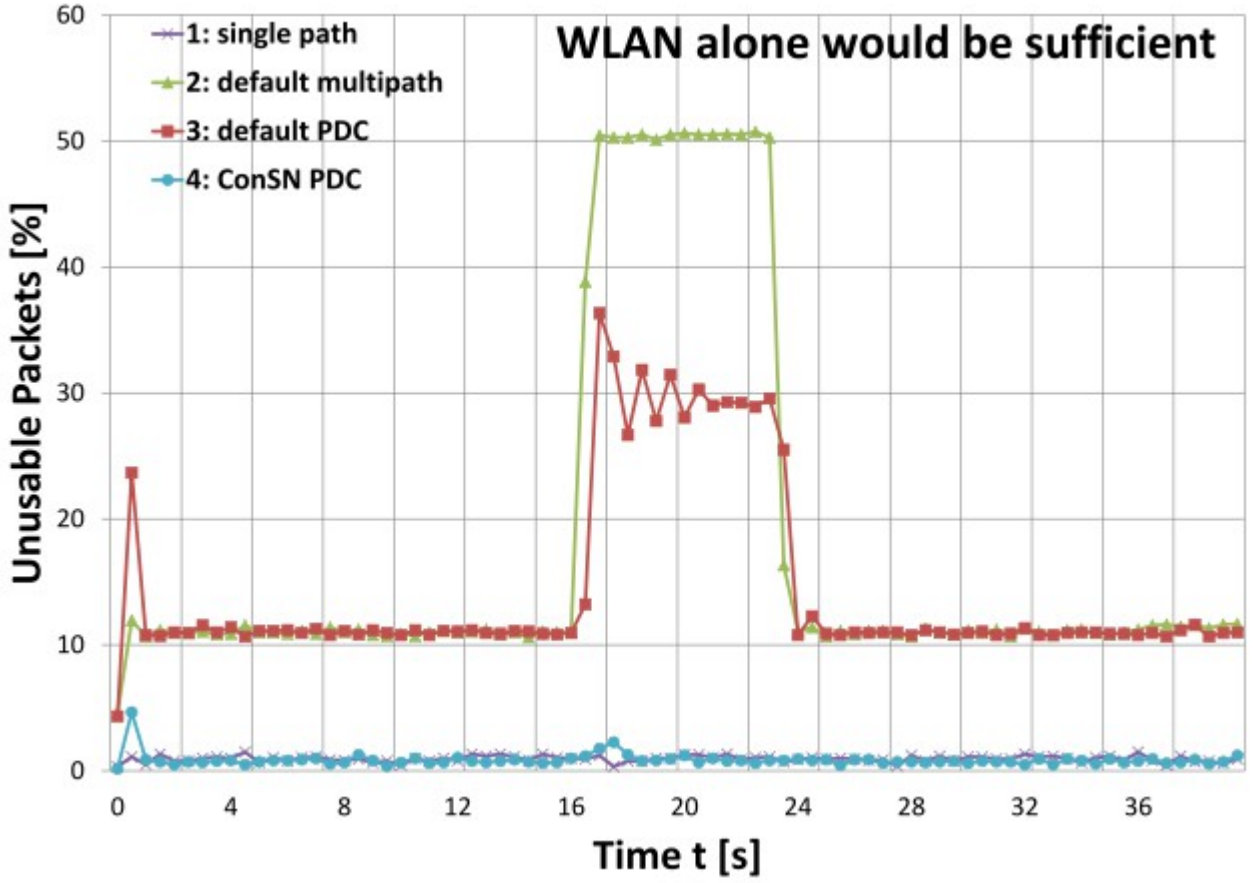


Coupling WLAN and 3G Links

(WLAN capacity too

Adding Path Delay Compensation

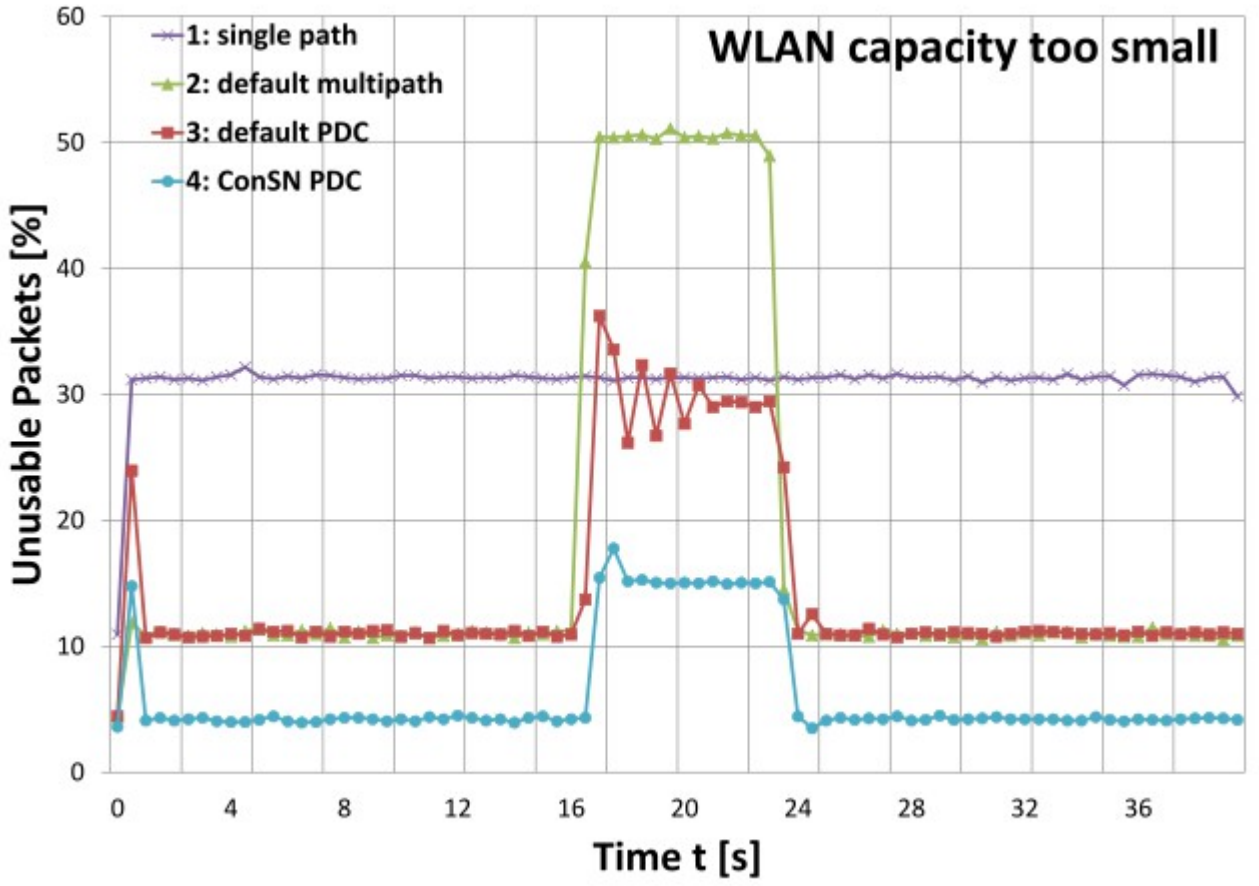
Delay jump on 3G path:
t=16s to t=24s



Coupling with Path Delay Compensation
(WLAN alone would be

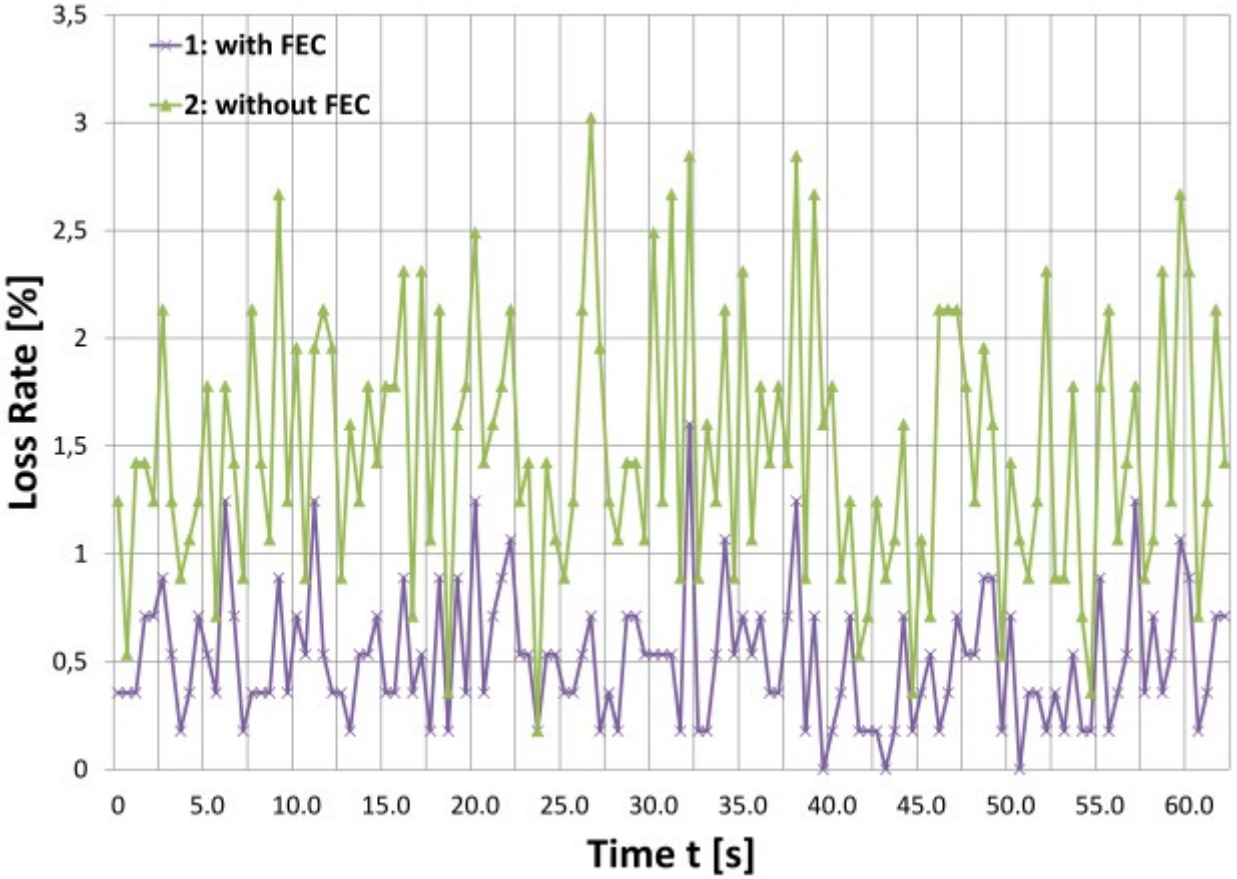
Adding Path Delay Compensation

Delay jump on 3G path:
t=16s to t=24s



Coupling with Path Delay Compensation
(WLAN capacity is too small)

Using Split Error Correction



Using the Small-Bandwidth Path for Split Error Correction

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Conclusion and Outlook

- Multi-path transfer is becoming increasingly popular
  - Interesting use case: multimedia transport
    - Appropriate scheduling is a challenge!
- Some simple but useful strategies proposed
  - Confluent Sequence Numbers and Path Delay Compensation
    - Split Error Correction
- Promising proof of concept in a very simple test setup, but much more **realistic evaluation** with **real codecs** needed!

Real Internet experiments in the NorNet testbed!

Any Questions?

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