UC SANTA BARBARA

MOMENTLab
Mobility Management and Networking

MPTCP Performance Over Heterogenous Subpaths

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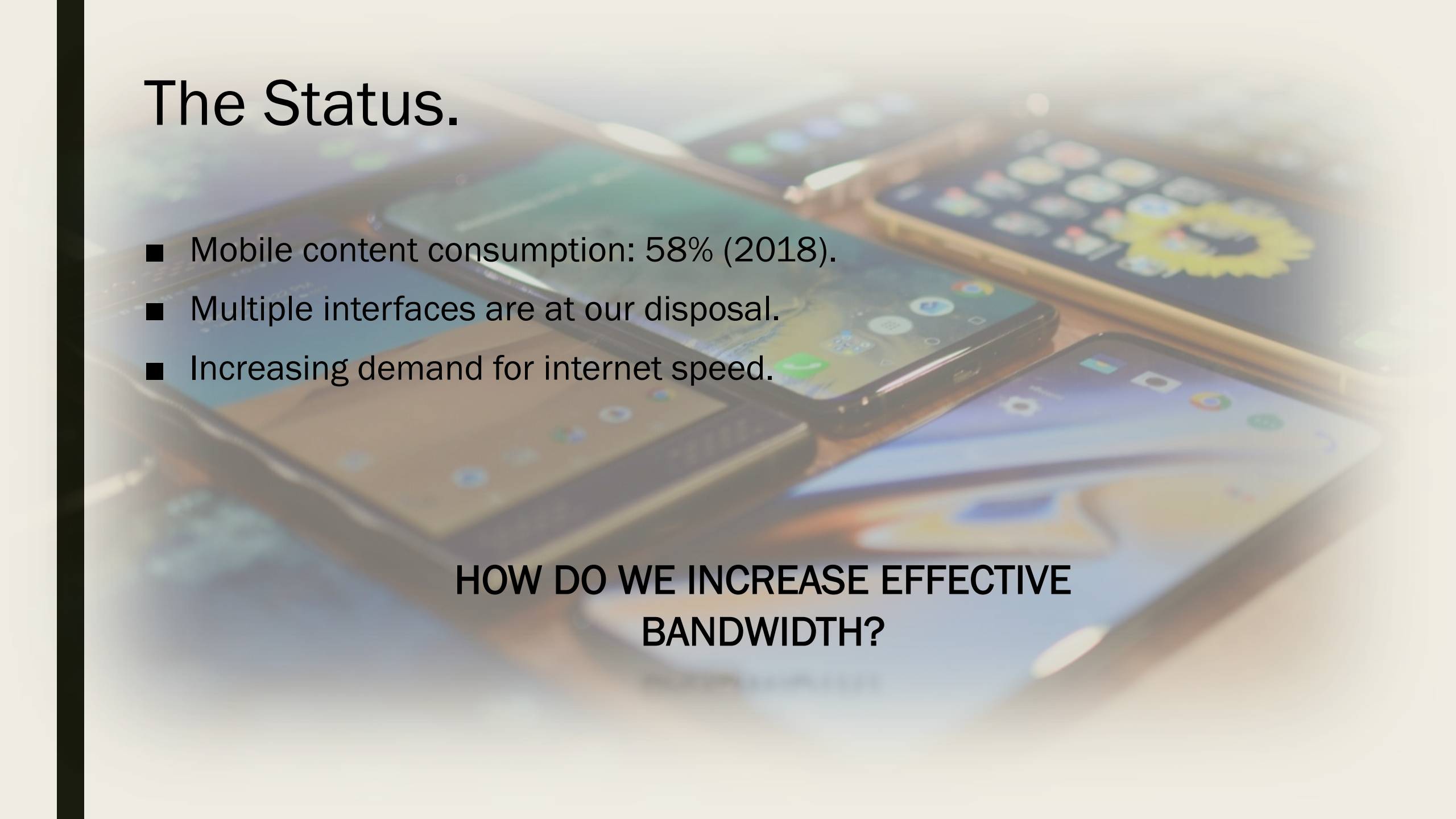
The Status.



- Mobile content consumption: 58% (2018).
- Multiple interfaces are at our disposal.
- Increasing demand for internet speed.

HOW DO WE INCREASE EFFECTIVE BANDWIDTH?

Smartphones have multiple interfaces.

Multi-path TCP aggregates bandwidth.

Concurrent transmission of data over multiple paths.

Where MPTCP excels...

- Better resource utilization.
- Higher throughput.
- Smoother reaction to failures.
- Works better with paths with comparable qualities.

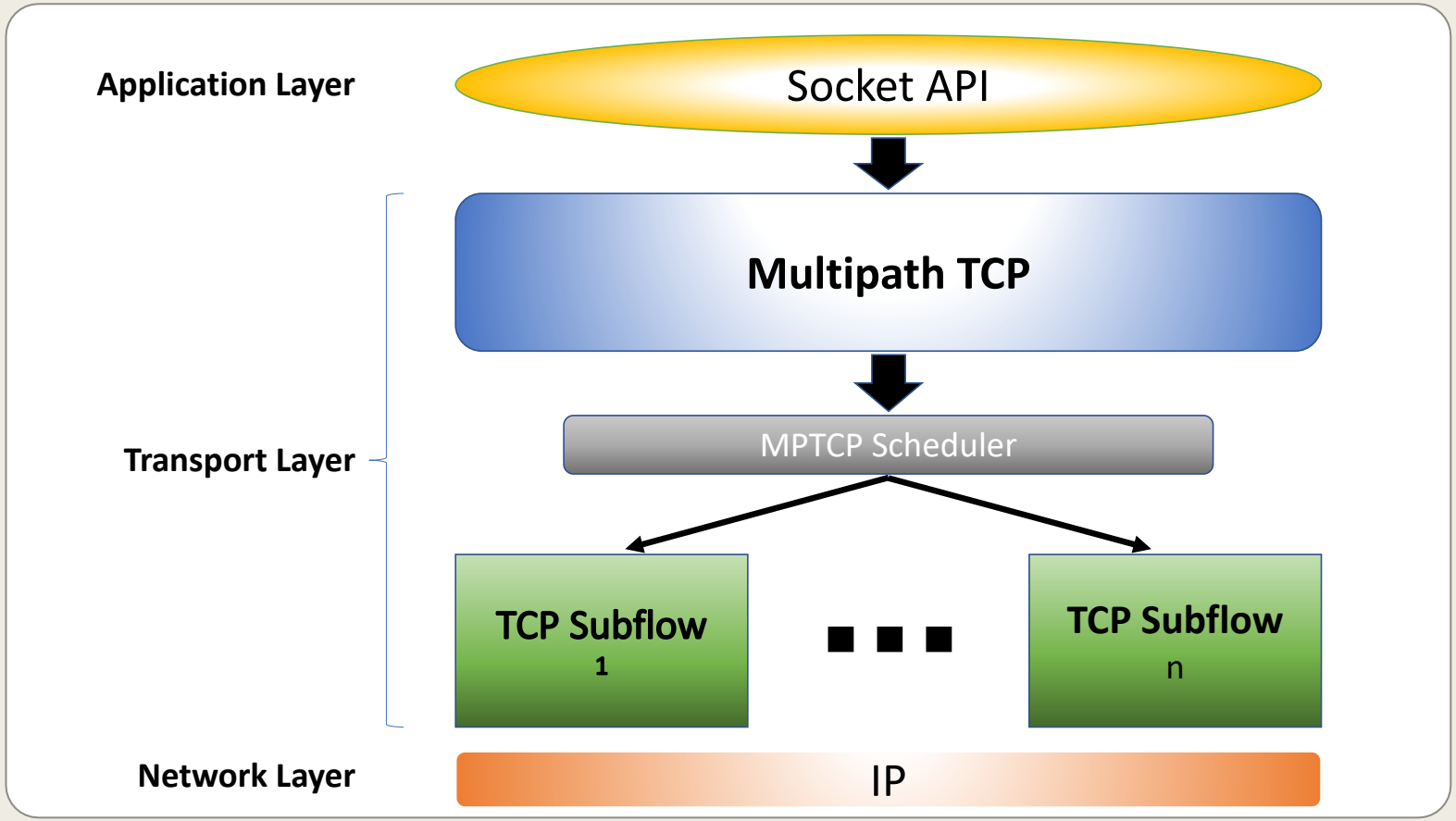
So is MPTCP the most optimal solution then?

Not Quite.

Let us look at MPTCP default scheduler.

MPTCP ‘RTT-Aware’ Scheduler

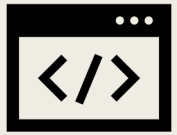
- Path selection: **minimum RTT subpath.**
- Preferable until **cwnd** is full.

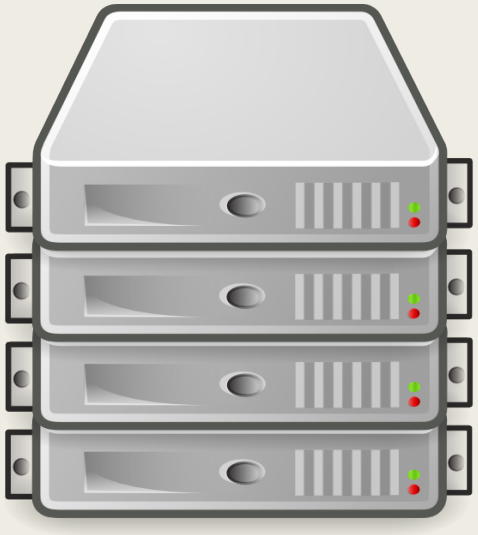


MPTCP Scheduler

Subflow 1 (LTE)

Subflow 2 (Wi-Fi)

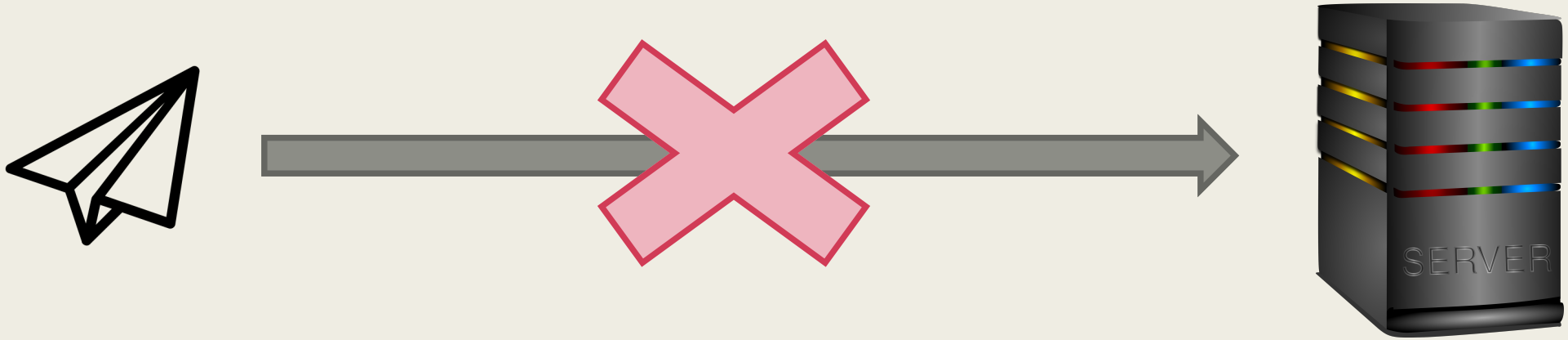




MPTCP-enabled server

The Problem

- **Heavy reliance** on RTT
- **Ignores** other path characteristics.
  - *For instance, loss rates.*



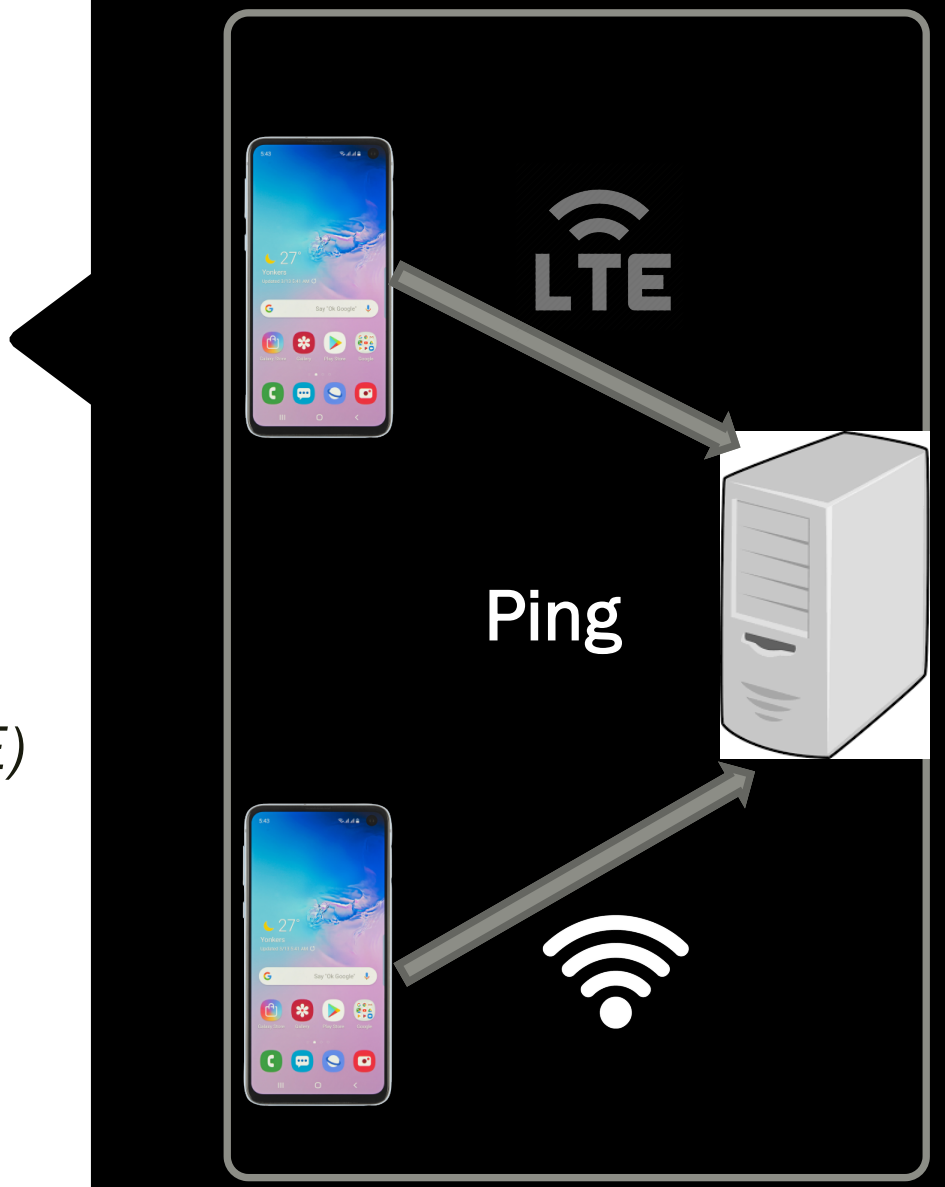
Questions

How does interface selection impact MPTCP's availability and server reachability?

When is single path TCP a better choice than multi path TCP?

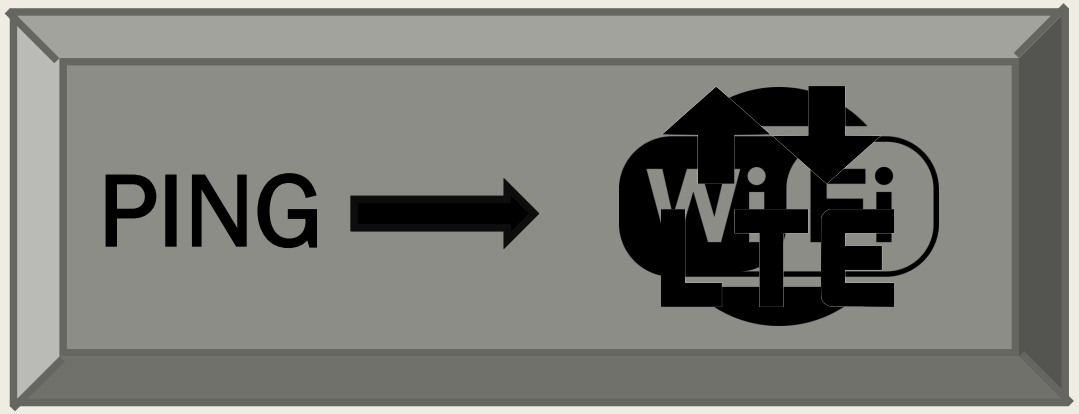
Latency and Reachability Survey

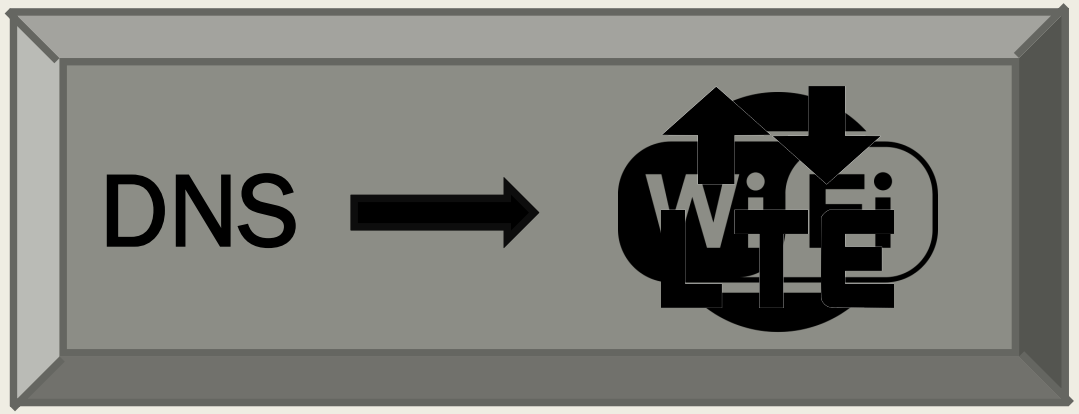
- Dataset used: Tranco top 10K websites
- Two stages of the test:
  - *DNS resolution (Wi-Fi and LTE)*
  - *Ping the resolved IP address (Wi-Fi and LTE)*



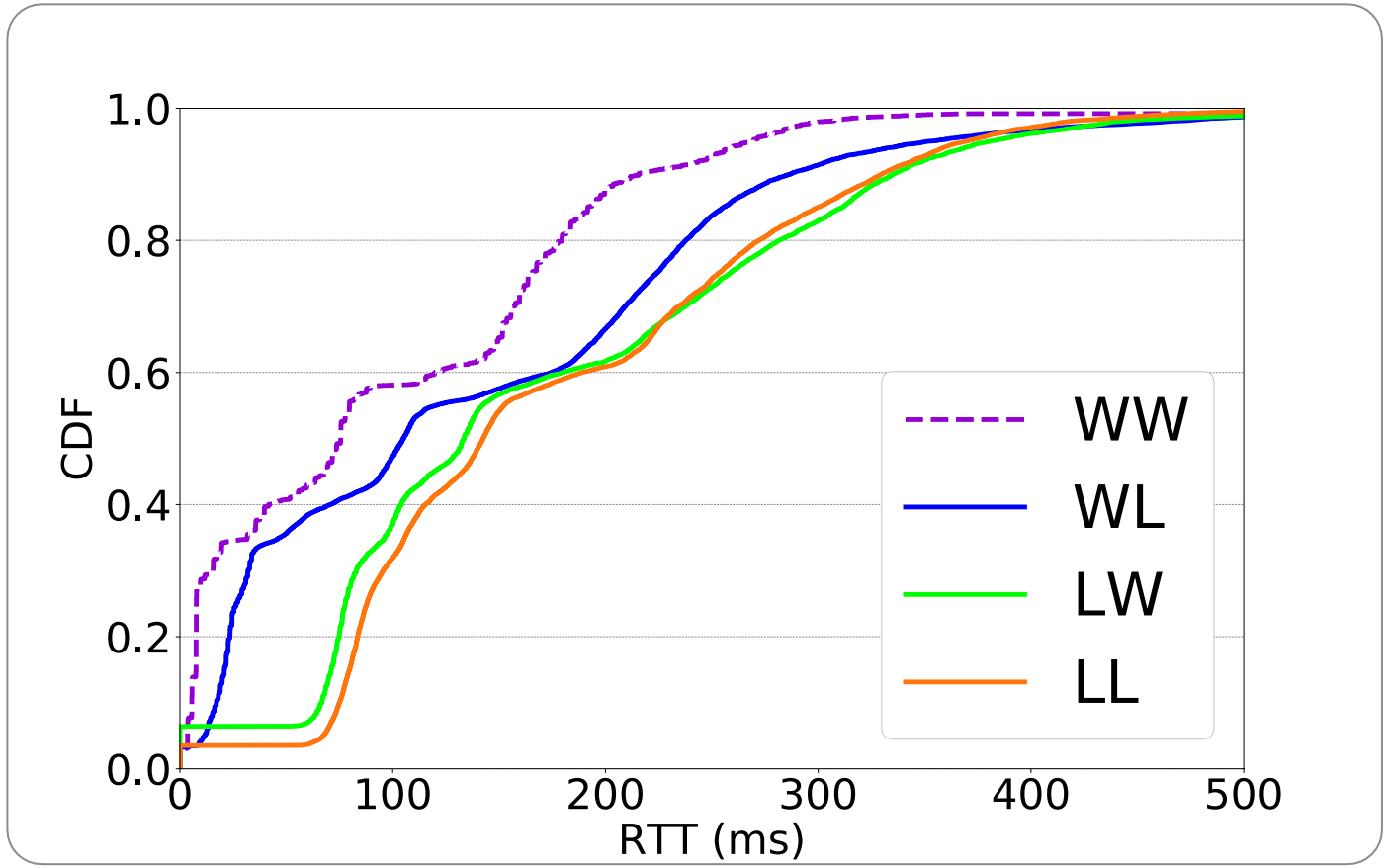
Survey Results

- We collect four datapoints:
  - ***WW:*** *Ping through Wi-Fi interface using address resolved on Wi-Fi DNS*
  - ***WL:*** *Ping through Wi-Fi interface using address resolved on LTE DNS*
  - ***LW:*** *Ping through LTE interface using address resolved on Wi-Fi DNS*
  - ***LL:*** *Ping through LTE interface using address resolved on LTE DNS*





Survey Results: Latency



WW: Ping through Wi-Fi interface using address resolved on Wi-Fi DNS
WL: Ping through Wi-Fi interface using address resolved on LTE DNS
LW: Ping through LTE interface using address resolved on Wi-Fi DNS
LL: Ping through LTE interface using address resolved on LTE DNS

- Ping interface is Wi-Fi:
  - Wi-Fi outperforms LTE ~ ***40ms***
- WW is better than LW/LL ~ ***75ms***
- Ping interface is LTE:
  - Wi-Fi outperforms LTE *(**60%** websites)*

Key observation: LTE resolved IPs incur larger delays!

Server Reachability

- Unreachable servers **!=** MPTCP deployment
- **> 4.5%** unreachable servers.
- Servers behind NATs.
- Interference by middleboxes.

Percentage of unresponsive servers

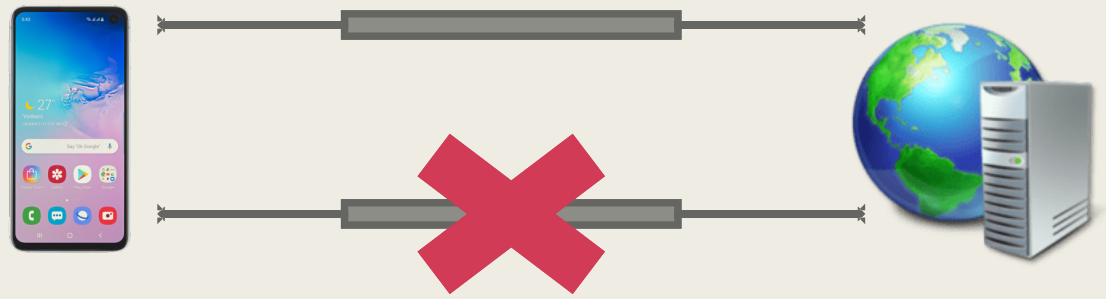
Ping Interface	Resolution Interface	Percentage
Wi-Fi	LTE	**4.57%**
LTE	Wi-Fi	3.59%
LTE	LTE	3.50%
Wi-Fi	Wi-Fi	3.26%

Unreachable servers

=

Unavailability of end-to-end path.

MPTCP will be impossible to use.

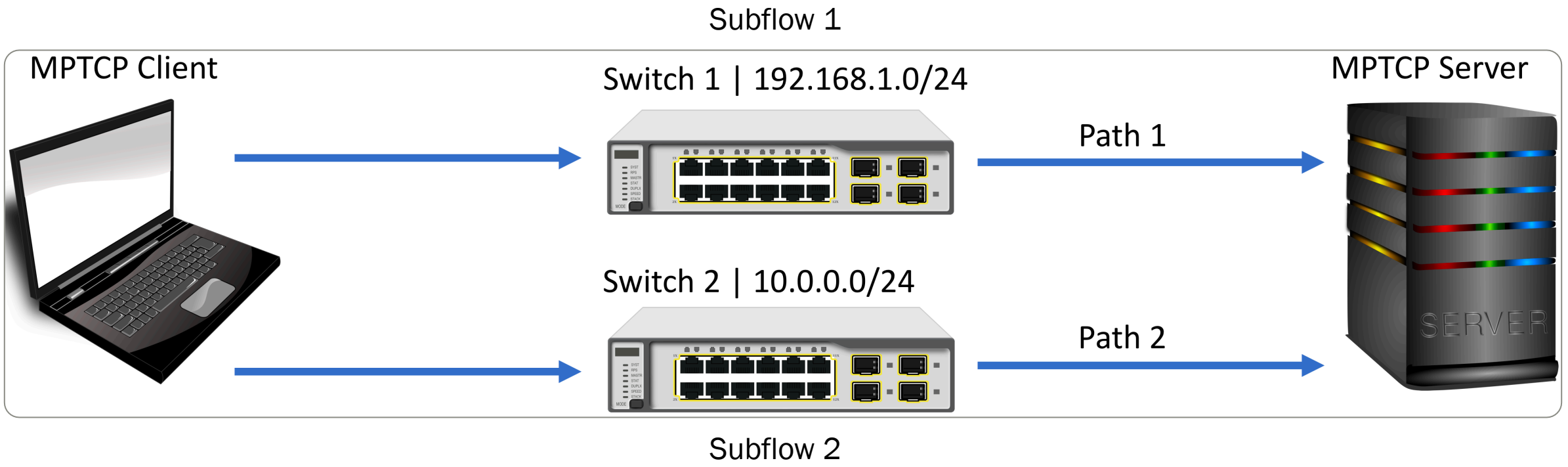


Takeaway

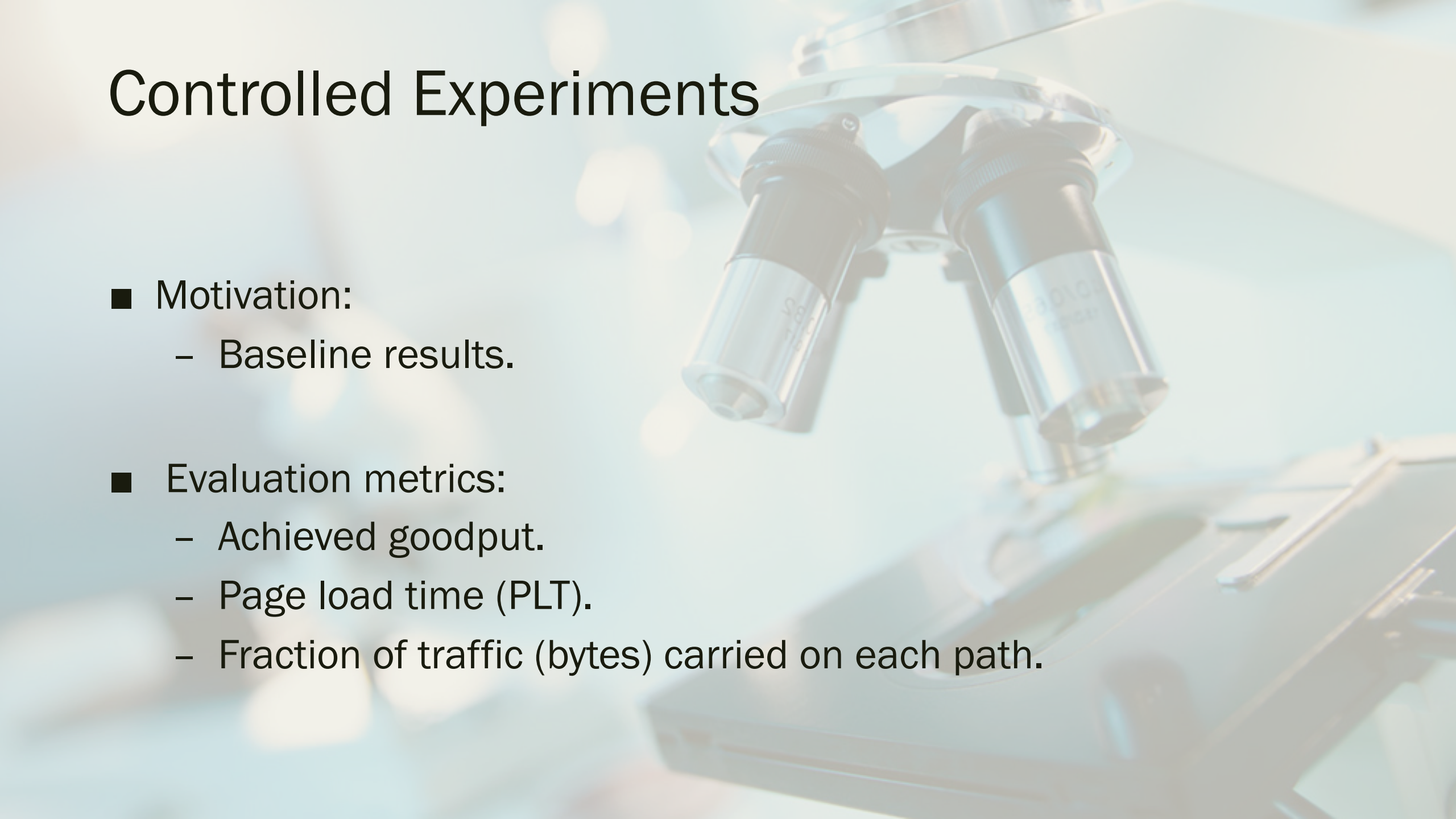
- *Considerable disparity* between LTE and Wi-Fi.
- Path selection process ?
- MPTCP performance ?

Experiments studying the effect of varying *latency* and *loss rates*.

Controlled Experiments: The Testbed



Controlled Experiments



- Motivation:
  - Baseline results.

- Evaluation metrics:
  - Achieved goodput.
  - Page load time (PLT).
  - Fraction of traffic (bytes) carried on each path.

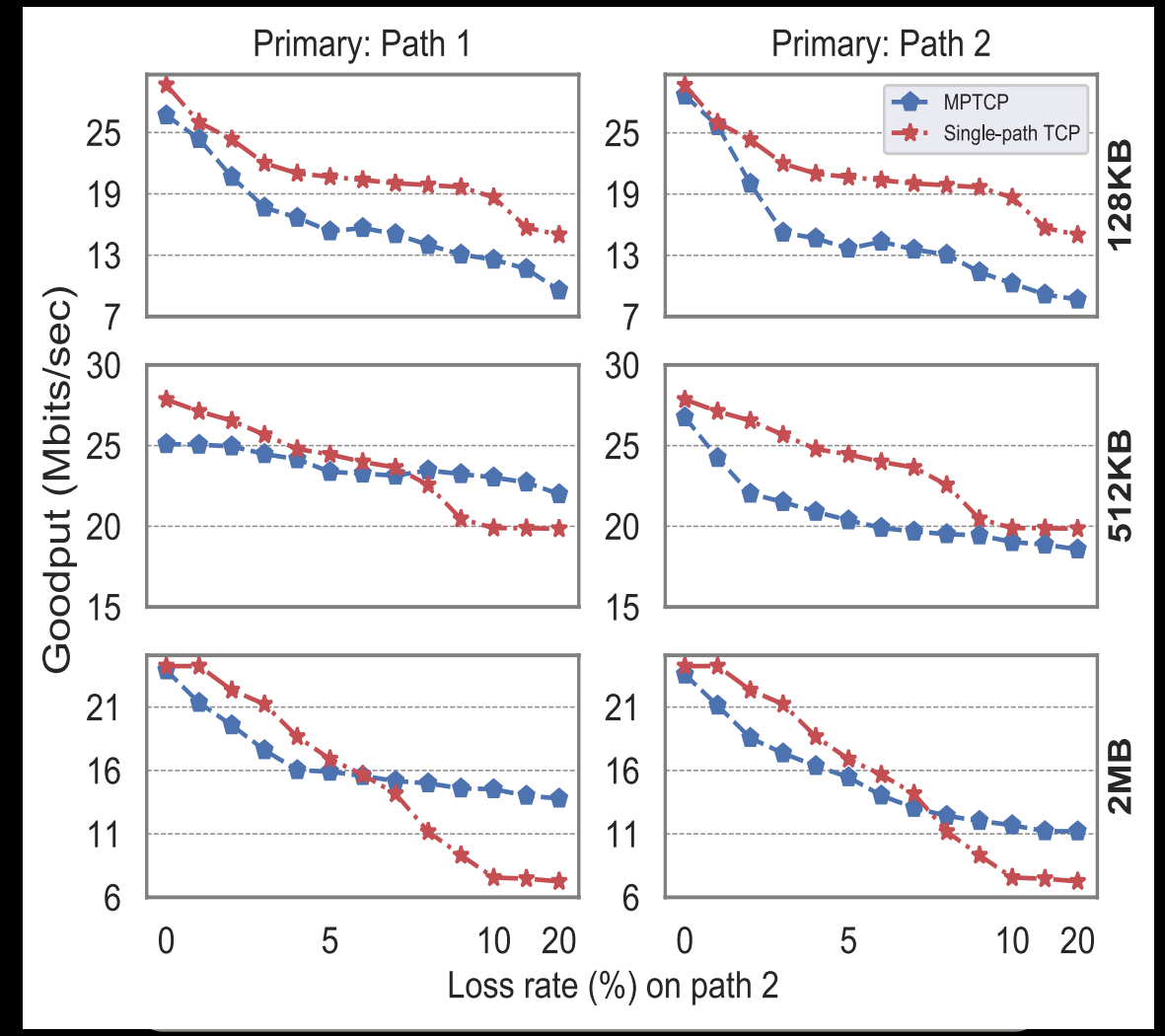
Controlled Experiments

- Methodology:
  - Achieved goodput: Client runs iPerf test 100x for every file size.
  - Page load time: Performance of the top 1000 websites.

- Experimental configurations:
  - File size used: 128K, 256K, 512K, 1MB and 2MB.
  - Primary path selection at the beginning of the test (Path 1 or 2)
  - Inter-path latency difference: 0ms to 500ms (50ms increments).
  - Inter-path loss rate difference: 0% to 10% (1% increments), 15%, and 20%.

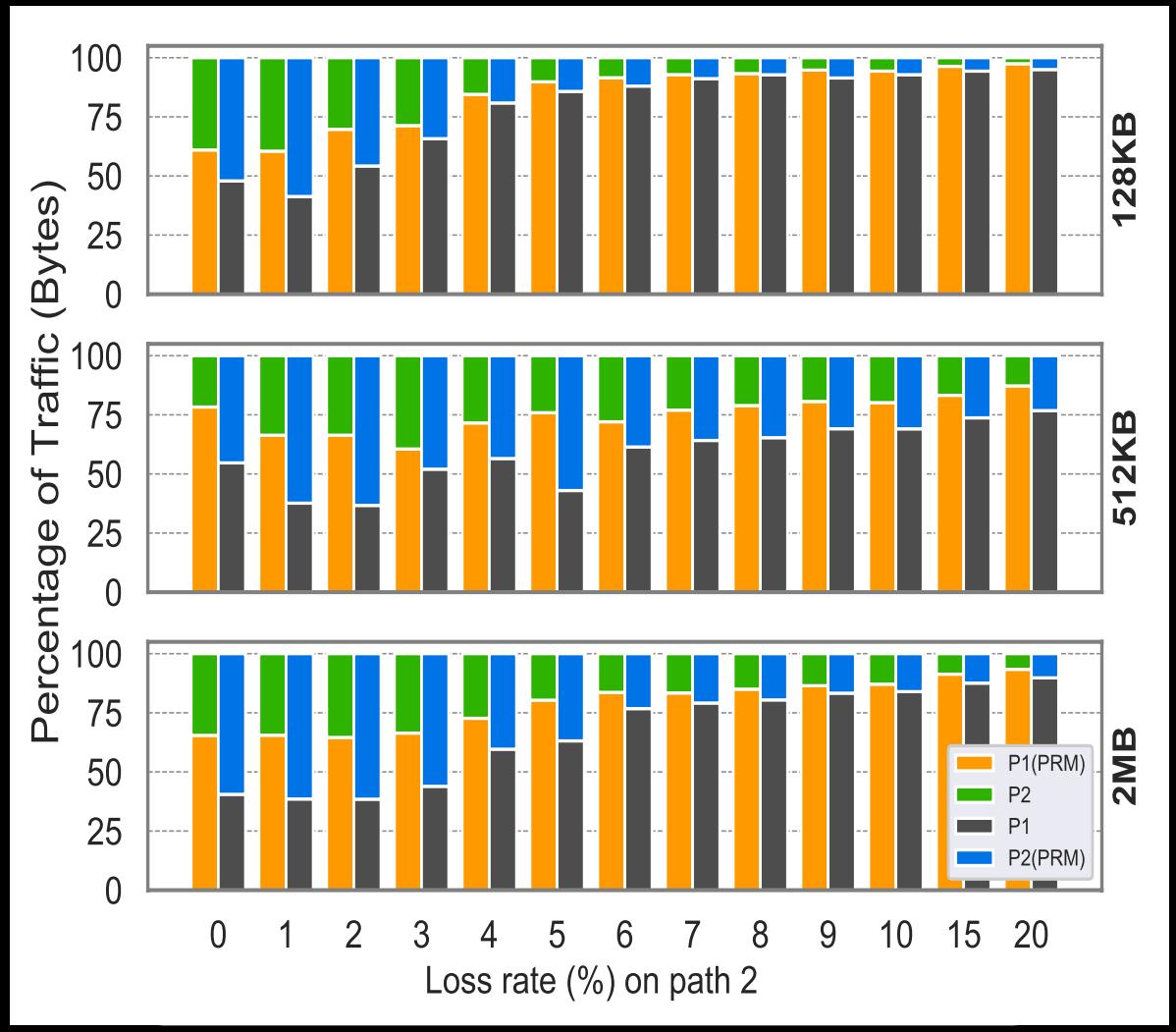
Achieved Goodput

- Varying latency…
  - *MPTCP > single path TCP*
- Varying loss rates…
  - ***Single path TCP > MPTCP (short flows)***
  - *Single path TCP ~ MPTCP (longer flows)*



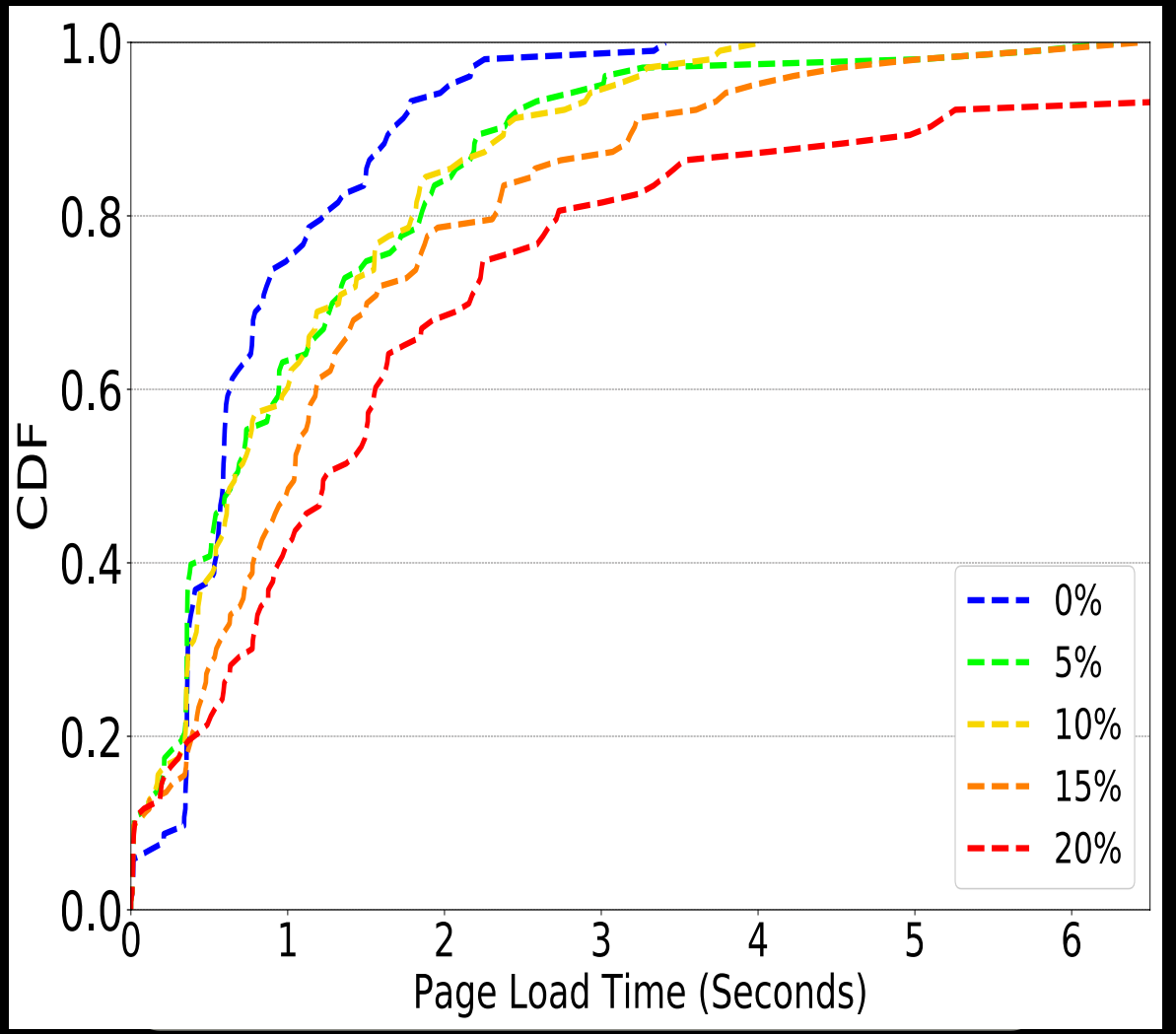
Fraction of Traffic

- Varying latency:
  - *Traffic directed onto the minRTT path.*
- Varying loss rate across path:
  - *Default scheduler **does not** consider loss rate.*
  - *Considerable traffic through loss path.*



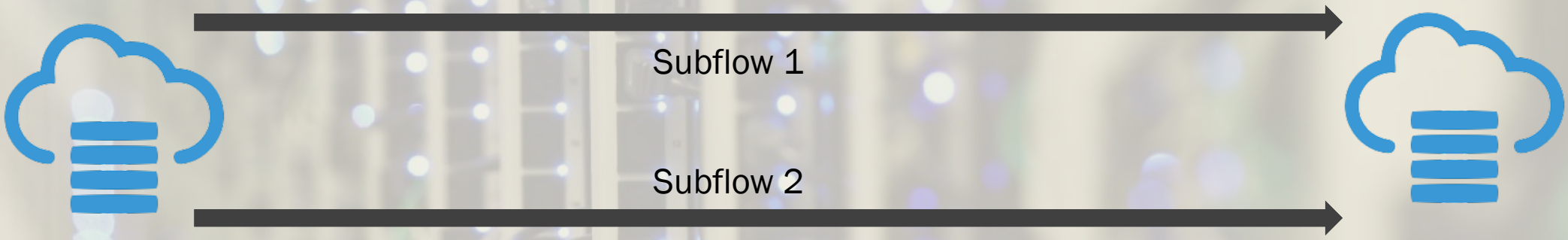
Page Load Time

- Varying latency:
  - *Consistent trend.*
- Varying loss rate:
  - *Load times ⬆ as loss rates ⬆*
  - *MPTCP scheduler ignores RTT for re-transmitted and lost packets.*



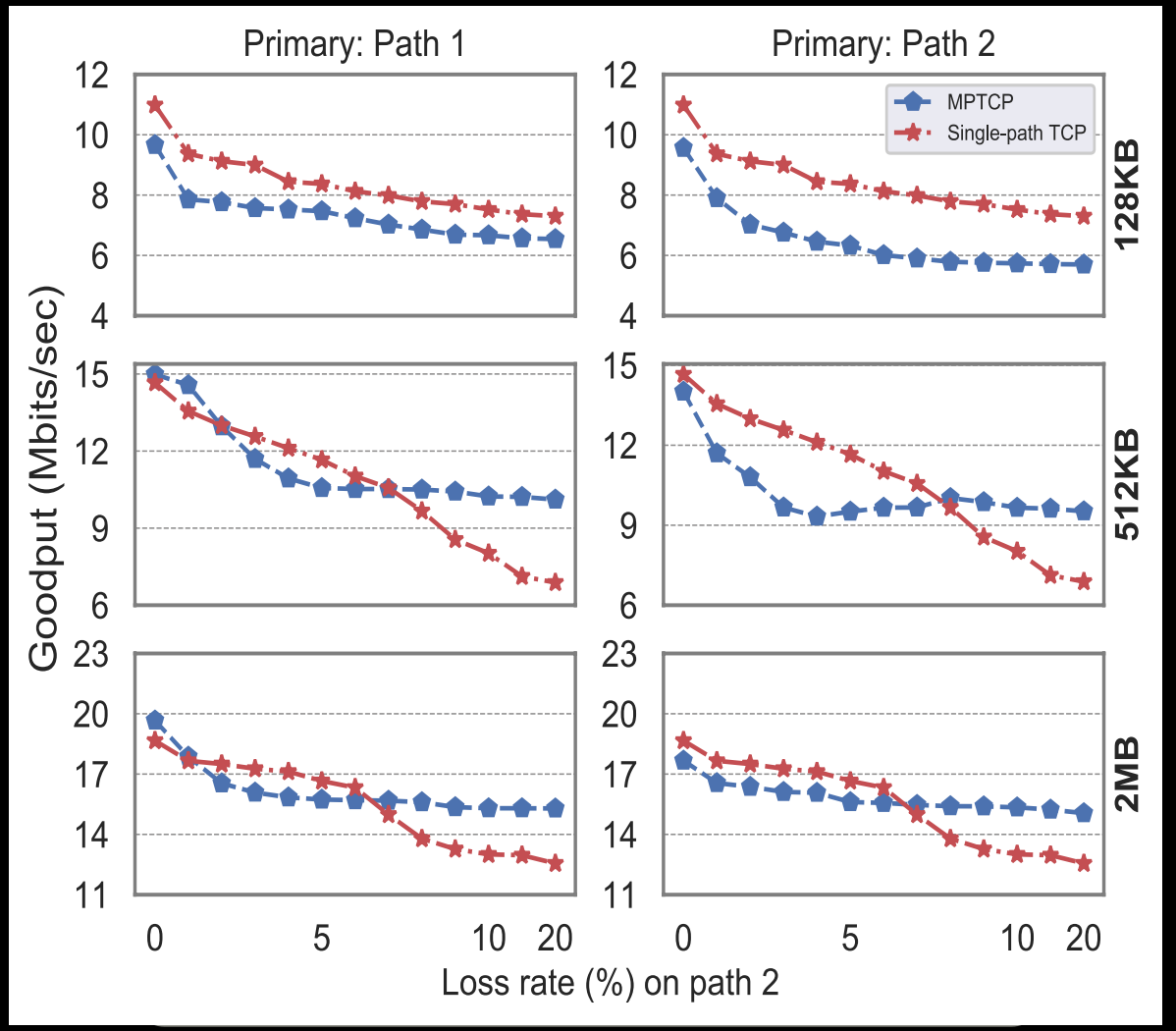
Real World Experiments

- Two MPTCP-enabled cloud instances.
  - *Client -> California, US.*
  - *Server -> Virginia, US.*
- Two wired interfaces.
- Same experimental configurations and evaluation metrics.



Achieved Goodput

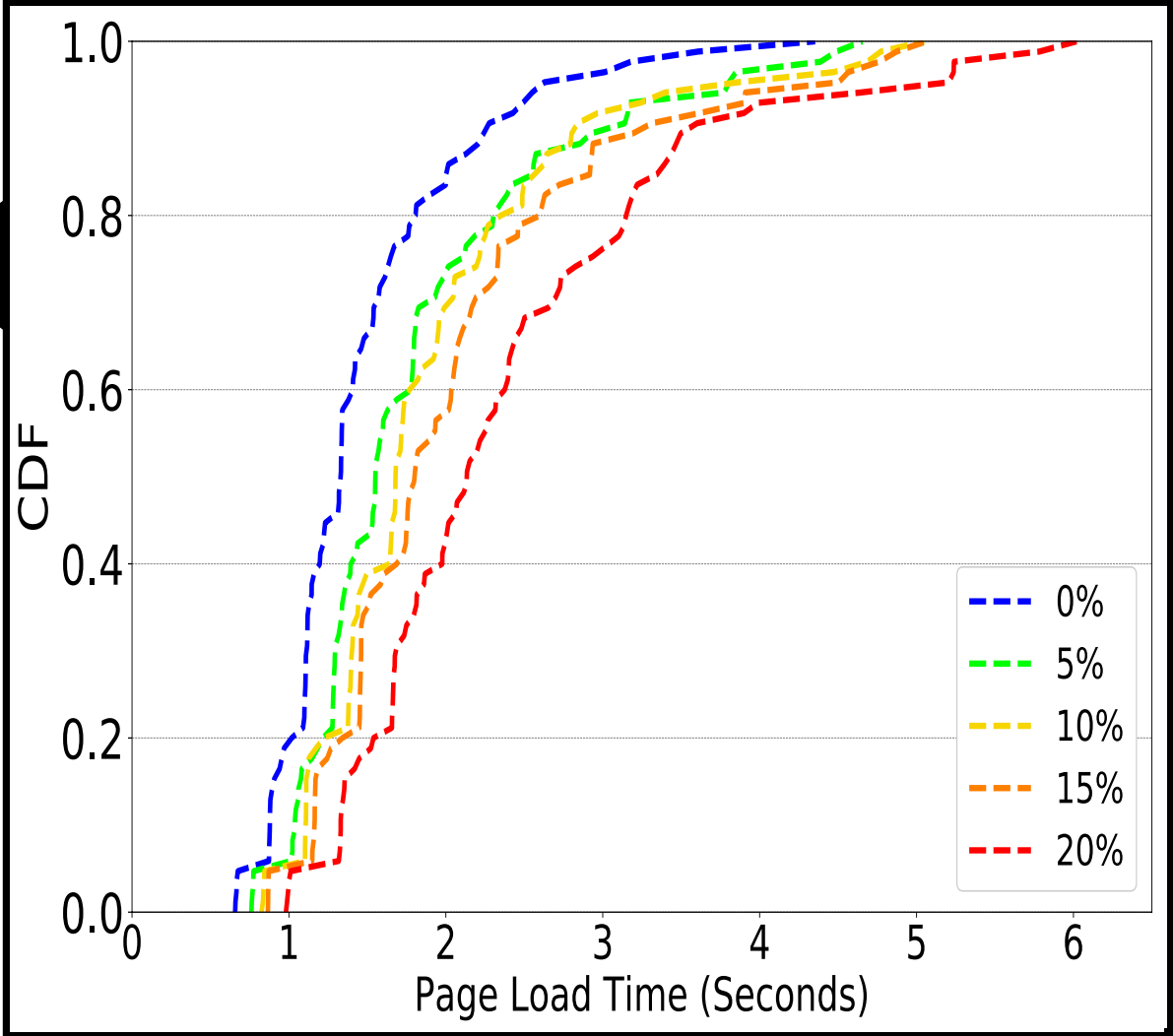
- Real world experiments ~ controlled experiments.
- Varying latency…
  - *MPTCP > single path TCP*
- Varying loss rates…
  - ***Single path TCP > MPTCP***



Page Load Time

- Little effect with increasing RTT
- The default scheduler **ignores** other path characteristics.
- Lossy path = page load time ⬆

Importance of primary path selection!



Takeaway and Conclusion

A full scale MPTCP deployment is quite feasible with some important considerations.

OUR RESULTS POINT TO THREE KEY FINDINGS

Round-trip Times

Wi-Fi is preferable.

Reachability

LTE DNS resolution ✖

Decrease dependency on LTE for DNS resolution.

***Heterogeneous* Paths**

Loss rate ⬆ MPTCP performance ⬇

At a minimum, consider loss rate for path selection.

Thank you!

Questions?

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