An Anatomy of Mobile Web Performance over Multipath TCP

Bo Han

AT&T Labs – Research

Joint work with Feng Qian (Indiana University), Shuai Hao and Lusheng Ji

Multipath TCP (MPTCP)

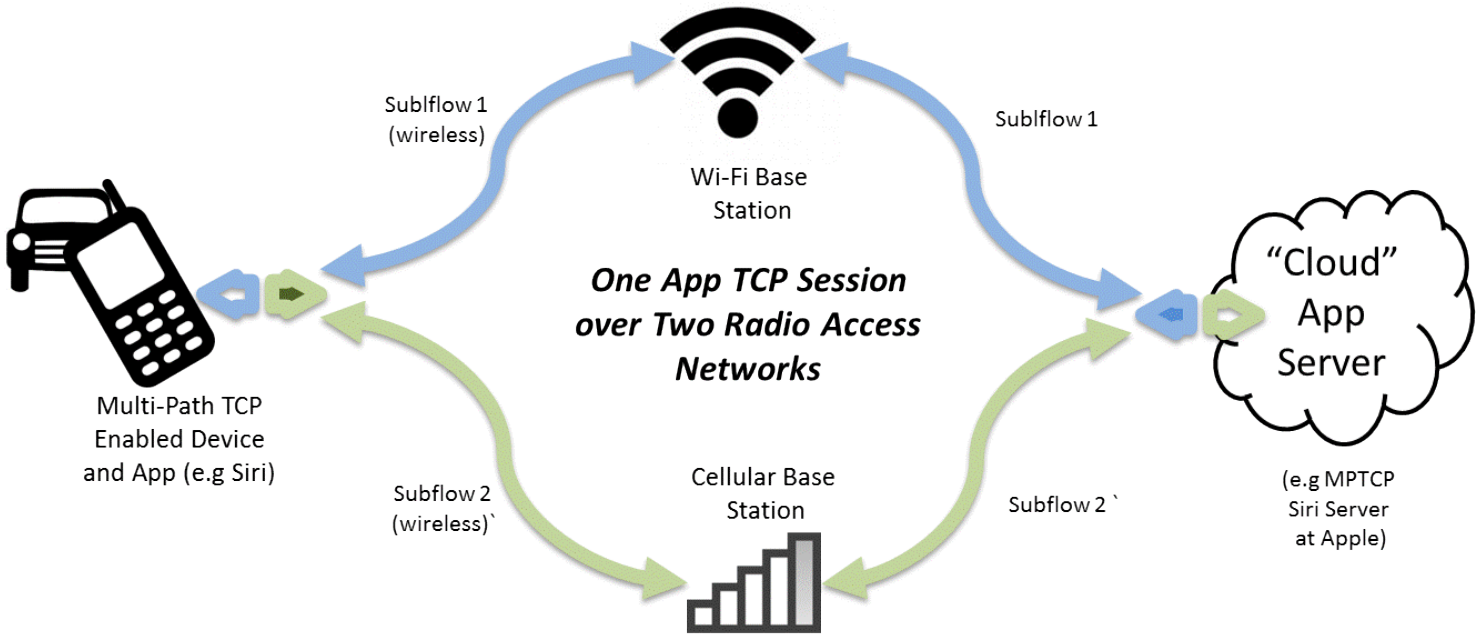


Figure source: http://www.itsa.org/

- A set of extensions to regular TCP, sending data of a single flow over multiple paths simultaneously
- Implementation in Linux, Apple iOS etc.
- Existing work about file transfer using MPTCP over WiFi and cellular

Characteristics of Mobile Web and Implications of MPTCP

Unique features of web browsing

- Page load interleaved with network transfer and local computation
- Many short-lived TCP connections with only a few round-trips
- Diverse and complex interactions with the transport layer

Understand implications of using MPTCP through following questions

- Can MPTCP reduce Page Load Time (PLT), compared to single path TCP (SPTCP)?
- How does the PLT reduction change under different network conditions of each path?
- How do different web protocols (e.g., HTTP and SPDY) interact with MPTCP?

Contributions

1. A cross-layer tool that incorporates multipath information into web performance analysis
2. Systematic comparison of HTTP/SPDY performance over SPTCP and MPTCP under diverse settings
3. Root cause identification of why SPDY is superior to HTTP in a multipath environment
4. Concrete recommendations for efficient use of MPTCP with mobile web

The `tcpdump-mpw` Tool

Extends `tcpdump` to extract HTTP/SPDY request/response data from raw packet traces

Performs the following processing from lower to higher layers

- MPTCP subflow assembling
- MPTCP logical connection assembling
- TLS/SSL decryption
- HTTP/SPDY parsing
- Web object information extraction

Generates a table providing details about each HTTP/SPDY transaction

Experiment Testbed

Chrome browser (version 41) on a laptop

- Equipped with a built-in WiFi interface and an external LTE modem

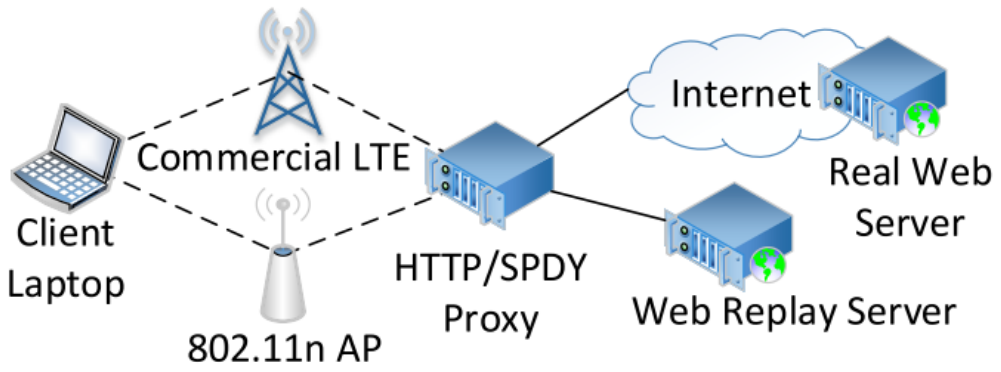
An HTTP proxy or a SPDY proxy

- Most websites do not yet support SPDY *

Use Dummynet to add delay, loss, or throughput cap to the two wireless paths

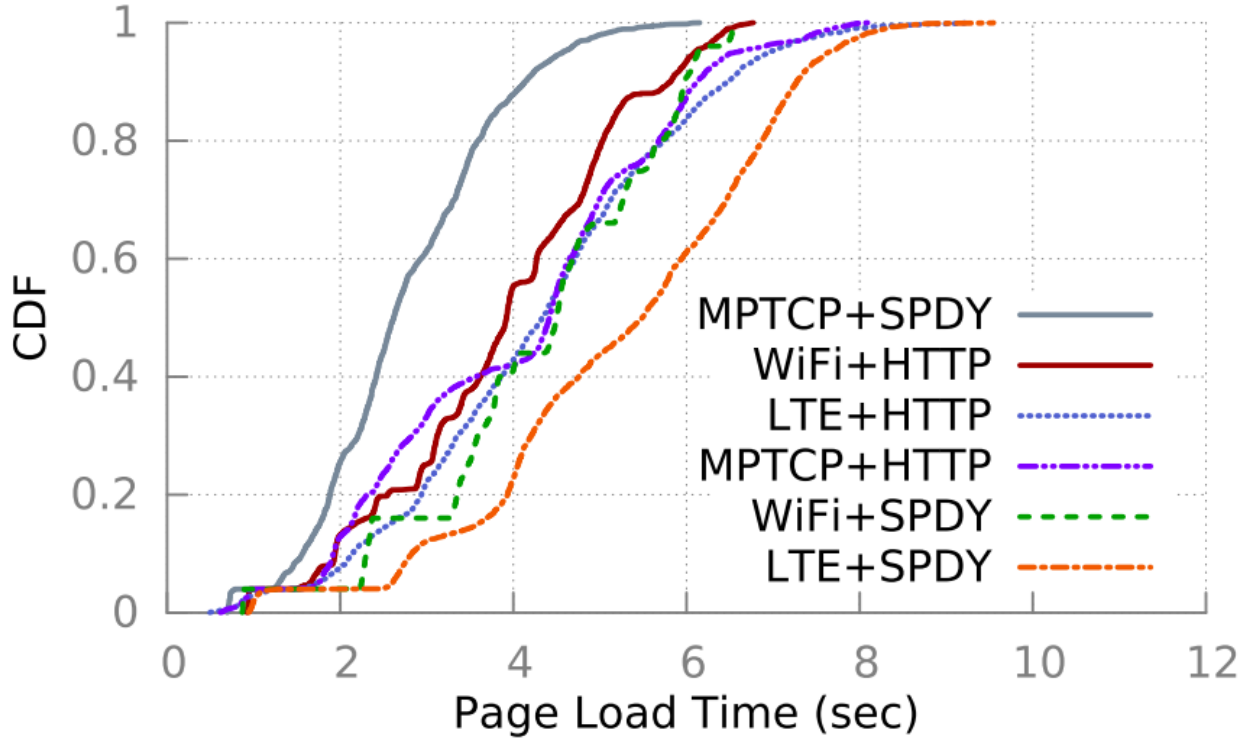
Proxy fetches pages from either a replay server or real websites

* http://w3techs.com/technologies/details/ce-spdy/all/all



Path	Downlink (Kbps)	Uplink (Kbps)	RTT (ms)
WiFi	7040	2020	50
LTE	9185	2286	70

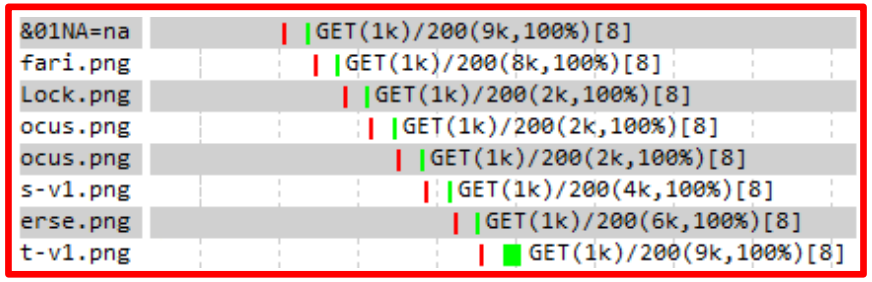
Baseline Experiments



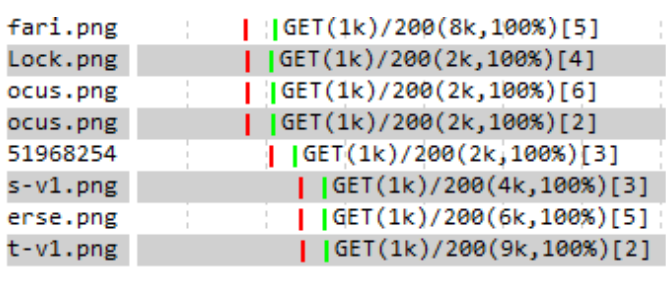
SPDY over MPTCP performs significantly better than SPDY over single path TCP

HTTP over MPTCP does not always outperform HTTP over single path TCP

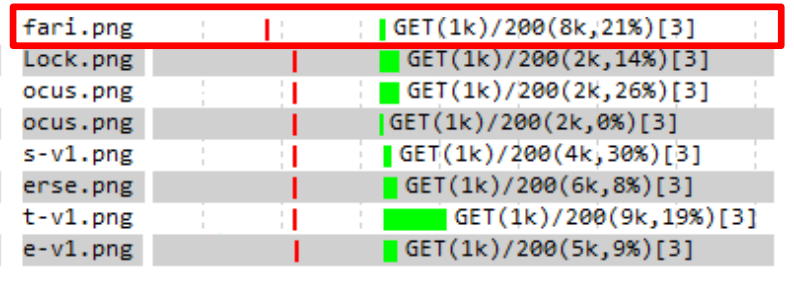
Interaction between MPTCP and the Web Browser



(a) HTTP over MPTCP



(b) HTTP over SPTCP (WiFi)



(c) SPDY over MPTCP

Generated by the **`tcpdump-mpw`** tool

GET(1k)/200(8k,21%)[3]: GET request with size 1KB, 200OK response with size 8KB, 21% of the data is transferred over WiFi, and the transaction occurs on (MP)TCP connection 3

Red and green bars correspond to HTTP request and response, respectively

Sequential object transfer on a single connection for HTTP over MPTCP

Other Experiments

Impact of WiFi loss

- MPTCP helps significantly mitigate the impact of packet loss on SPDY, due to path diversity

Impact of latency

- Performance degradation depends on the MPTCP scheduling algorithm

Effect of congestion control algorithm

- Overall impact of congestion control on the PLT is small, in particular for HTTP

Experiments for real web servers

- The disparities among the six schemes become smaller than the baseline experiments

Find the details in the paper!

Discussion

Client device: a laptop

- Changing to a smartphone or tablet may shrink the observed disparities

Energy consumption

- May potentially reduce energy consumption due to shorter radio-on time

Mobility

- Leverage MPTCP's backup mode to ensure the smooth transition

Other limitations

- Network conditions, Chrome browser, and web servers

Conclusion

- The first measurement study of mobile web performance over MPTCP
- Systematically compared HTTP/SPDY performance over SPTCP and MPTCP under diverse settings
- Discovered unexpected interactions between MPTCP and HTTP/SPDY
- Plan to explore how HTTP/2's new features, such as server push, can benefit from MPTCP

MPTCP is mostly beneficial for mobile web, but need to use it carefully!

An Anatomy of Mobile Web Performance over Multipath TCP

Bo Han

AT&T Labs – Research

Joint work with Feng Qian (Indiana University), Shuai Hao and Lusheng Ji