Internet innovation with Multipath TCP

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Internet basics

Application
- TCP
- IP
- Datalink
- Physical

Switch 1

Router 1

Application
- TCP
- IP
- Datalink
- Physical
Phase 1: Specify

1994: IP Next Generation (IPng)
IETF RFC1752

1998: IP v6
IETF RFC2460
Phase 2: Implement

1994: IP Next Generation (IPng)
IETF RFC1752

1998: IP v6
IETF RFC2460

2000: IPv6
FreeBSD 4.0
Linux 2.6

2001: IPv6
Windows XP

2003: IPv6
OSX 10.3 Panther

Phase 3: Deploy


1994: IP Next Generation (IPng), IETF RFC1752

1998: IPv6, IETF RFC2460

2000: FreeBSD 4.0, Linux 2.6

2001: IPv6, Windows XP

2003: IPv6, OSX 10.3 Panther

2008: DNS root over IPv6
The origins of TCP

The TCP bytestream model
Endhosts have evolved

Mobile devices have multiple wireless interfaces
User expectations
What technology provides today

3G cell tower

IP 1.2.3.4
What technology provides today

When IP addresses change TCP connections have to be re-established!
Multipath TCP : Specify

2008 : Trilogy Project starts

March 2009
IETF WG created

March 2011
RFC6182 published

Jan. 2013
RFC6824 published
The *new* bytestream model
Multipath TCP : Design objectives

• Multipath TCP is an *evolution* of TCP

• Design objectives
  – Support unmodified applications
  – Work over today’s networks (IPv4 and IPv6)
  – Works in all networks where regular TCP works
Architectural principles

Multipath TCP Data transfer

• Two levels of sequence numbers
Multipath TCP: Implement

- Dec. 2009: First prototype MPTCP on Linux
- Dec. 2010: MPTCP on N900 smartphone
- Sept. 2013: MPTCP iOS
- Mar. 2013: MPTCP FreeBSD
- July 2015: MPTCP Solaris
Multipath TCP: Deploy

- Low-latency for Siri

Voice samples

WiFi

3G/LTE

Sept. 2013
Siri uses MPTCP

“Hey Siri, what song is this?”

Through the Shazam app, Siri can tell you what song is playing around you.

2005  2010  2015  2020
Multipath TCP: Deploy

KT uses MPTCP

July 2015
KT uses MPTCP

2005 2010 2015 2020
Multipath TCP : Deploy

TCP

DSL

Multipath TCP

4G/LTE

Hybrid Access Gateway

Regular TCP

2005  2010  2015  2020

2016

Hybrid Access Networks
• Multipath TCP has brought innovation in the ossified Internet transport layer
  – Our open-source implementation played key role
    • Confirmed to IETF that the design was correct
    • Enabled commercial deployment
      – Smartphones with Apple, LG, Samsung, ...
      – Link bonding with Tessares, OVH, Line Factory, Watchy, ...

• Ongoing research with network protocols
  – IPv6 Segment Routing
  – Fibbing