Multipath TCP

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Abstract – Multipath TCP is a recent TCP extension that supports reliable transmission of data over different communication channels simultaneously. Despite its recent standardization (January 2013), it has already been used to launch new services.

The Transmission Control Protocol (TCP) is one of the most important protocols on the Internet. It provides a reliable service on top of the unreliable network layer protocols (IPv4 and IPv6). TCP has evolved continuously since the first experiments in research networks in the 1980s. Still, one of the early design decisions of TCP continues to frustrate many users. TCP and IP are separate protocols, but the separation between the network and transport protocols is not complete. Each TCP connection is bound to the IP addresses used on the communicating hosts at connection-establishment time. As a consequence of this and despite the growing importance of mobile nodes such as smartphones and tablets, TCP connections cannot move from one IP address to another. When a laptop switches from Ethernet to Wi-Fi it obtains another IP address that cannot simply be used to continue existing connections.

Since 2008, ICTEAM researchers have participated to the design and standardization of Multipath TCP. Multipath TCP is a modern TCP extension that enables hosts to exchange data for a single connection over different interfaces or path. With Multipath TCP, a laptop that switches from Ethernet to Wi-Fi obtains another address and can still use it for the same connection. More precisely, Multipath TCP was designed with the following goals:

- It should be capable of using multiple network paths for a single connection.
- It must be able to use the available network paths at least as well as regular TCP, but without starving TCP.
- It must be as usable as regular TCP for existing applications.
- Enabling MPTCP must not prevent connectivity on a path where regular TCP works.

In addition to contributing to the design of the protocol, ICTEAM researchers have developed the reference implementation of Multipath TCP in the Linux kernel. The quality of this implementation has demonstrated that Multipath TCP is a viable protocol that can be deployed in today's Internet. Our open-source implementation [2] has already been reused by several companies to deploy commercial services.

The Multipath TCP standard [1] was published by the Internet Engineering Task Force (IETF) in January 2013. In September 2013, Apple surprised the Internet community by deploying Multipath TCP on all its iPhones and iPads to support the Siri voice recognition application. Multipath TCP allows a seamless handover between WiFi and cellular networks for this application. There are now more than several hundred millions of Apple devices that use Multipath TCP, making it the fastest TCP extension to have ever been deployed.

This is not the only utilization of Multipath TCP on smartphones [4]. As already demonstrated by ICTEAM researchers in 2012, the open-source implementation of Multipath TCP can also efficiently be used on Android smartphones. This motivated Samsung and LG to port our open-source implementation on their smartphones. In Korea, Multipath TCP is used to provide higher bandwidth on smartphones by combining fast LTE and fast WiFi. Thanks to the work of ICTEAM researchers, Korean smartphones reach bandwidths of up to 1 Gbps.

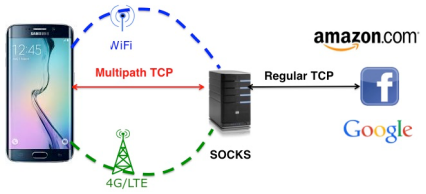

Figure 1: Multipath TCP deployed on smartphones in Korea.

Another new use case for Multipath TCP combines fixed and mobile networks. In Europe, but also in Asia and America, governments push network operators to provide high bandwidth to all residential users. In large cities, high bandwidth can be offered by deploying optical fibers. However, in less densely populated areas, this is not sustainable from an economic viewpoint and operators wish to combine their fixed and mobile assets. This is the type of product that Tessares, a spinoff created by ICTEAM researchers, builds. Tessares installs Multipath TCP on DSL routers and uses it to efficiently combine DSL and LTE networks. Other companies such as intel, Ericsson, Swisscom, OVH or Nokia are also active in this market. Several of them also reuse the open-source implementation of Multipath TCP [2,3].

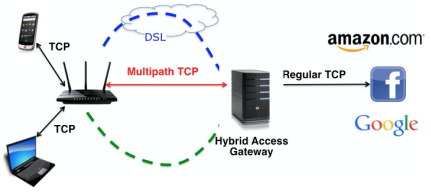

Figure 2: Multipath TCP used in Hybrid Access Networks.

Other use cases for Multipath TCP are still being developed both by researchers in the labs and by several companies. This success story demonstrates both the quality of the research conducted by ICTEAM researchers and the multiplicative effects that an open-source implementation brings.

References

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[4] De Coninck, Q., Baerts, M., Hesmans, B., Bonaventure, O., "Observing Real Smartphone Applications over Multipath TCP", IEEE Communications Magazine, to appear.