Business Models in a Multipath World

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Introduction

While the Internet has drastically changed business and society over the past decades, its architecture has hardly evolved. As a result, a re-design of current Internet architecture is being proposed [1], because of the pressure from new applications, novel business models and innovative networking technologies.

The resource pooling principle [2] advocates making improved use of the Internet's resources by allowing separate resources (such as links or processing capability) act as if they were a single large resource. One particular manifestation of this principle is the development of multipath transport protocols (specifically Multipath TCP [3]), whereby multiple paths between two endpoints can be pooled to appear to the application as a single transport connection, through dynamic scheduling of traffic across the available paths. This has multiple benefits: not only will it provide higher bandwidth but it will also provide higher resilience to link or node failure.

The failure of a path can be regarded as an excessive case of congestion. When multiple paths are used, MPTCP will react to failures by diverting the traffic through paths that are still working and have available capacity. Old and new paths can be used simultaneously and the traffic distribution can adapt to the available rate for each path, without suddenly relocating traffic onto a new path and causing congestion. This provides resilience and robustness, increases resource utilization, and handles more efficiently sudden increases in demand for bandwidth. While these are technical benefits, it is useful to examine the benefits of multipath transport from the perspectives of stakeholders:

- From an *end user's perspective*, one benefit is improved resilience – traffic can quickly move away from a failed link onto an available link, thus reducing unproductive downtime. The other significant benefit will be higher bandwidth due to resource pooling, and thus faster access to Internet resources.
- From a *network operator's perspective*, multipath transport enables the network to be more flexible and so will cope well even when the actual traffic

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matrix differs substantially from that predicted during its design. It can also in theory run at higher utilisation.

From a technical point of view, MPTCP needs only a relatively small change to the TCP/IP stack at the end hosts – which is currently being standardized in the IETF [4].

Although at first sight MPTCP may seem simply to be about technology – with software changes at the end host bringing an improved performance – we believe that it will significantly change the value networks (business models) between stakeholders in the Internet connectivity market. It is the latter that is the subject of this paper.

The main contribution of this paper is, for the first time, to consider what new business models might be enabled by the new flexibility that MPTCP brings. More specifically, this paper is structured as follows:

- Section 1 provides a brief survey of potential use cases for MPTCP and an illustrative selection of the kinds of new opportunities that will be created. As work is ongoing further use cases may be added in the full paper.
- Section 2 provides a more detailed analysis of one specific new use case, using SWOT analysis for the end-user and ISPs.
- Finally, Section 3 presents the first insights of this use case and future work.

The full paper will add analysis of some of the other use cases and will provide more concrete conclusions concerning MTCP adoption.

1. Potential MPTCP Use Cases

Multipath transport can create new or changed business relationships in the value network seen between stakeholders within the market for Internet connectivity. In this section, we give a flavour of the opportunities that may be enabled considering the introduction and adoption of MPTCP. Alternatives for use cases at the end user side, i.e. technical architectures and the corresponding value networks are:

1. End-user with single physical access to one ISP
   - *A. ISP acts as a multipath operator (MPO) and splits the traffic via a proxy*
   - *B. Virtual MPO (VMPO) contracting with end user and ISP splits the traffic*
2. End-user with dual physical access to one ISP
   - *A. A mobile terminal with two access technologies (3G and WLAN/ADSL)*
   - *B. Disjoint connectivity (such as two DSL lines) to the same ISP*
3. End-user with dual physical access to different ISPs
   - *A. Mobile terminal with two access technologies (see the next chapter)*
   - *B. MPO (virtual or ISP) securing the disjoint paths on behalf of the end user*

Note that a similar list of use cases is being analyzed at the content provider side of MPTCP.

In order for a proposed use case to succeed on the market, the business case needs to be positive for all stakeholders in the corresponding value network. We perform *SWOT* (Strength, Weaknesses, Opportunities and Threats) *analysis*, in order to identify

the critical factors and evaluate viability of the use cases. In the following use case we demonstrate our approach by applying SWOT analysis on one of the use cases (3.A).

2. Use Case: MPTCP Capable Host with Multihomed Access to Different ISPs

This use case examines a scenario where the end-user multihomes, i.e. has two physical access connections to two different ISPs. More specifically we assume that the ubiquitous 3G connectivity of mobile terminals is supplemented by high WLAN bandwidth when available. Another more ambitious version of this use case is when the end user multihomes by using two 3G SIM cards in the mobile terminal.

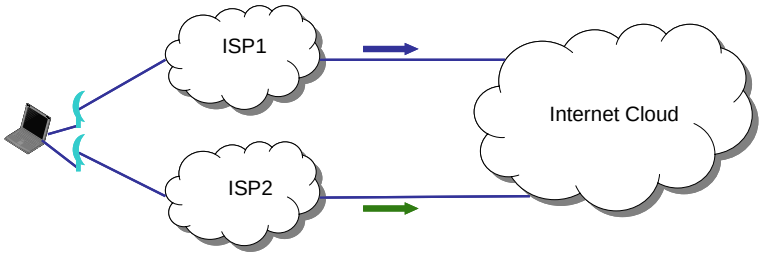

Figure 1. Technical architecture (and value network) of the chosen use case.

From the end-user perspective, MPTCP mainly allows more efficient usage of the device capabilities in this use case. 3G enables ubiquitous connectivity while WLAN access, e.g. in home or office, offers higher bandwidth. Due to two separate access connections the cost of multihoming may be higher. If the disparity between 3G and WLAN access bandwidths is large, the advantages of MPTCP may be small compared to the increase in complexity, which can hinder deployment.

Table 1. SWOT analysis for end-user

Strengths • Power to race ISPs	**Weaknesses** • Overhead of two contracts and bills • Disparity in access bandwidths (3G vs. WLAN)
Opportunities • More seamless and robust connectivity • Higher bandwidth spotwise	**Threats** • Higher costs (flat and/or metered rates) • Shorter stand-by time if using multiple radio interfaces at the same time (mobile user)

As multihoming is controlled by the end-user, the chances for ISPs to affect the use case are small. However, the total number of subscriptions can be higher since both ISPs can maintain existing customer relationships, and customer demand for MPTCP can bring new customers. However, customers may only be willing to pay less for the individual access. Multihoming may also increase competition between ISPs since network performance (either good or bad) becomes more visible to customers.

Table 2. SWOT analysis for ISPs (from perspective of ISP1)

Strengths • Ownership of at least one customer access line • Existing customer relationship will be maintained	**Weaknesses** • Inability to provide multipath without involvement of a second ISP, unless additional technical solutions are in place

Opportunities	Threats
• Revenue by access provision and carrying at least one share of traffic • Additional revenue through multihoming of prior sole ISP2 customers • Good quality (high throughput) visible to customer and may become chargeable	• Bad network performance may become visible (comparability with ISP2) and may lead to churn • Customers want to pay less for the individual access when they need two for full multihoming

MPTCP will enable customers to have parallel access contracts with mobile and WLAN operators. This will lead to increased number of customers of both 3G and WLAN operators, and therefore demand and price competition could potentially lead to bundle offerings through partnering of 3G and WLAN operators.

3. Conclusions and Future work

Although MPTCP is a mere technical change to the TCP protocol, it will have considerable impact on the value network of Internet access provisioning. The direction of the impact will depend on the way users chose to set up their access links as described in the use cases of Section 1. On one hand, increased competition between ISPs may take place because ISPs become more comparable in real time, due to higher visibility of throughput and network performance. This may lead to increased pricing competition and potentially a change from flat rate access to performance dependent pricing models. On the other hand, ISPs may partner with each other or offer bundles of different physical access links to provide multi homing for MPTCP. Finally completely new models, like the 'virtual' Multi-Path Operators (VMPO) who act as retailer for multiple accesses to others ISPs, will arise.

We plan to extend our work by analyzing the most important factors that could influence the adoption of MPTCP. In particular, we will analyse some of the most interesting use cases, referred in Section 1, in order to provide a more detailed analysis of the value networks that will evolve. We will use evaluation techniques, such as SWOT analysis and Porter's 5 forces. In addition, we will study the benefits of coordinated congestion control [5] that MPTCP provides and we will concentrate on user's incentives for switching from classic TCP to MPTCP.

References

[1] C. Kalogiros, A. Kostopoulos and A. Ford, On Designing for Tussle: Future Internet in Retrospect, *EUNICE 2009*, Springer LNCS 5733, (September 2009), 98–107, Barcelona, Spain.

[2] D. Wischik, M. Handley and M. Bagnulo Braun, The Resource Pooling Principle, *ACM SIGCOMM CCR*, volume 58, issue 5, (October 2008), 47–52.

[3] A. Ford and C. Raiciu, TCP Extensions for Multipath Operation with Multiple Addresses, *IETF Internet-Draft (work in progress)*, draft-ford-mptcp-multiaddressed, (July 2009).

[4] Multipath TCP (MPTCP) BOF, http://trac.tools.ietf.org/area/tsv/trac/wiki/MpTcpBofDescription, (June 2009).

[5] P. Key, L. Massoulié and D. Towsley, Path selection and multipath congestion control, *IEEE INFOCOM 2007 Anchorage, AL, Piscataway, NJ: IEEE Press*, (April 2007), 143–151.