PERFORMANCE OF MODERN WEB PROTOCOLS OVER GEOSTATIONARY SATELLITE LINKS

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Abstract

The Internet changes with the rise of encrypted protocols, especially QUIC. This is problematic for Internet via geostationary satellites, because Performance Enhancing Proxies, which mitigate the negative effects of high latency links, cannot be used any longer. Considering recent developments, we run performance measurements with artificial websites, protocols (HTTP/1.1, HTTP/2, VPNs and QUIC), and setups (testbed and real geostationary satellite Internet access). The measurement results show strengths but also problems of novel Internet protocols.

1 Introduction

Decades have gone since the first standard documents for TCP (RFC 793 [1]) and HTTP (RFC 2068 [2]). In the meantime many updates have been released, see RFC 7414 [3] for TCP or HTTP/2 (RFC 7540 [4]). QUIC is a novel transport protocol, which has been initially developed and deployed by Google [5]. QUIC is designed to be fast, secure and evolvable. It is the basis for HTTP/3 [6], has the potential to supersede TCP, and is currently being standardized by the IETF [7]. The first set of standard documents (referred to as QUICv1) is expected to be finalized this year. Subsequent QUIC releases (QUICv2) will discuss, among other features, Multipath Communication and Forward Error Correction (FEC). Fig. 1 shows a comparison of the TCP/TLS/HTTP and QUIC protocol stack.

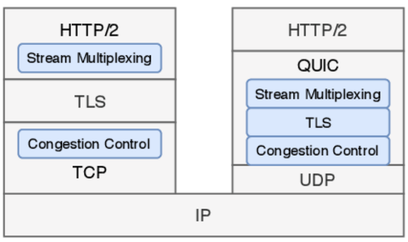

Figure 1: HTTP/TLS/TCP layers compared to QUIC (adapted from [5])

In today's Internet, the high latency caused by the propagation delay of geostationary satellite links is a problem for commonly deployed TCP implementations. Performance Enhancing Proxies (PEPs) [8], as shown in Fig. 2, mitigate this problem by transparently splitting TCP connections (Split TCP). On the satellite link, an optimized protocol can be used by the network operator. PEPs cannot split TCP connections if they are encrypted within VPNs. The performance of VPNs over a geostationary satellite link is therefore poor [9].

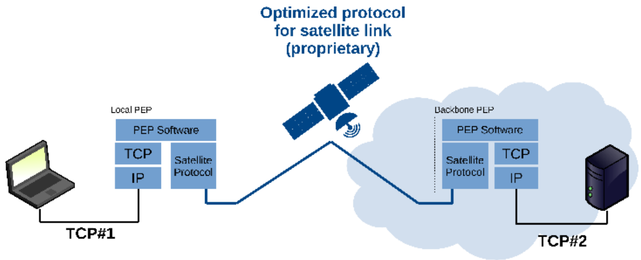

Figure 2: Performance Enhancing Proxies (PEPs) and Split TCP

Middleboxes such as PEPs are considered as root cause for the ossification of the Internet [10], therefore QUIC has encrypted transport layers by design [7]. As it is the case for VPNs, this prevents the use of PEPs and is therefore problematic for satellite Internet access. The non-applicability of PEPs is also problematic for cellular networks (5G) and terrestrial-satellite networks.

2 Related Work

Brief listing:

- [11] Performance measurements with HTTP/1.1 and HTTP/2.
- [12] Performance measurements with QUIC: page load time doubles.
- [9] Performance measurements with HTTP, VPN and QUIC.
- [13] QUIC time-sequence diagrams with different implementations and operators.

3 Measurement Setup

Based on recent publications [9] [13], we continue the performance evaluation of website page load times in typical scenarios. We set up artificial websites:

- One single large object (e.g., file download)
- Multiple small objects (e.g., a news website)

The protocols of interest are:

- HTTP/1.1
- HTTP/1.1 with VPN (PEPs not applicable)
- HTTP/2
- HTTP/2 with VPN (PEPs not applicable)
- QUIC and HTTP/3 (PEPs not applicable)

We do not consider non-secure HTTP, i.e., only HTTPS is used. QUIC is based on TLS 1.3 [14], which we also use for the other protocols in order to provide a fair comparison. We use different implementations of QUIC.
Finally, we use a real operator as well as a testbed to carry out the measurements.

4 Evaluation

Brief listing of expected outcomes:

- HTTP/2 and HTTP/3 is beneficial for websites with small objects (single request, multiplexing).
- HTTP/2 and HTTP/3: If total size is equal, there is little difference whether one single large object or multiple small objects are transferred.
- In case of VPNs, i.e., when PEPs are not applicable, the performance suffers.
- QUIC often performs better than TCP with VPN (faster connection setup), but worse than TCP with PEPs. QUIC is work in progress, therefore the performance depends a lot on the implementation and its parameters.
- There are differences depending on whether a testbed or real satellite Internet access is used.

5 Future Directions

We give an update of the strategies discussed in [13] for improving the performance of QUIC over satellite. Additionally, we would like to mention the idea of explicit QUIC proxies as shown in Fig. 3.

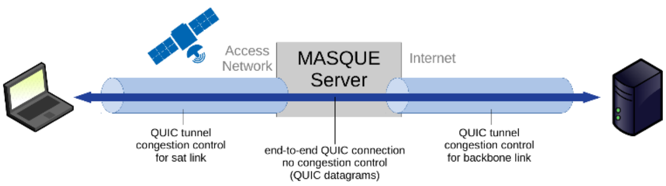

Figure 3: Explicit QUIC proxies as replacement for PEPs

The client does not connect directly to the server. Instead, it first connects to an explicitly specified QUIC proxy (MASQUE server, based on the IETF MASQUE working group). The outer QUIC tunnels are responsible for flow and congestion control suitable for specific path segments (e.g., satellite link). The inner connection has no flow and congestion control, but the packets are still end-to-end authenticated and encrypted. We have recently proposed this idea at an IETF mailing list [15].

7 References

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