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Increasing latency on paths through the Internet has a negative impact on latency-sensitive applications such as audio and video conferencing, as well as on the perception of responsiveness of many other applications. Measurement is key to addressing this issue, in two ways. First, the symptoms of excessive latency can be hard to isolate, and the causes obscure: the deployment of passive and active measurements of latency is crucial to any effort to address the latency problem. Second, while content and service providers have long attempted to address latency issues through the development of content delivery networks (CDNs), an emphasis on bandwidth as the primary measure and unit of comparison of Internet access performance has removed incentive for ISPs providing Internet connectivity (access providers) to pay much attention to latency.

On this second point, any effort to reduce latency must include a re-emphasis on latency as a measure of access performance. This, in turn, requires advances in measurement. While they may be inaccurate, bandwidth measurements of access links are easy to understand, and correlate well with perceived access performance. Measuring latency is made more difficult by the need to choose a reference point to which latency can be measured, by nonlinear effects due to queueing, and to complexity introduced by CDNs. The development of such a metric for access provider comparison is as much an education and awareness-raising effort as it is a technical problem to solve; regardless, it is a necessary first step to providing a powerful incentive to reduce latency on the access segment.

The latency problem is not by any means a new one. It impacts not just classical latency-sensitive applications such as two-way audio and video: if users of a website perceive too much delay in accessing that site, they are likely to move on. Therefore,

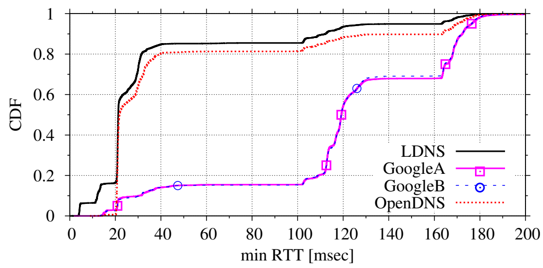

Figure 1: Typical anomaly: DNS resolver dependent latency in CDN access.

content and over-the-top service providers have devoted significant effort to reducing both in-network latency as well as service response time in access to their offerings. The development of distributed content delivery networks (CDNs) has latency reduction as one of its primary goals, while increasing complexity that makes it more difficult to diagnose latency issues. Here, the role of measurement is to understand the impact of these economically-driven behaviors on the network, and to gain insight as to where the greatest gains can be made.

To illustrate this complexity, we present an example from a work presently under submission. We applied Tstat [1] to passively observe latency to several CDNs from an access network. By separating clients based on the DNS resolver they used – that of the access provider versus Google or OpenDNS – we verified that CDNs use the address of the recursive resolver involved in a lookup for a particular hostname to find the lowest-latency location from which to serve a resource. When the recursive resolver is located at the access provider, the estimate of the best location is often much better as when using a generic, nonlocal DNS resolver. Figure 1 illustrates a possible negative effect of this arrangement. Here we examine the CDF of the minimum RTT of flows to Facebook, categorized by the DNS resolver used by the clients, for the entire day 22 March 2013. Non-optimal DNS hostname to IP mapping strategies used by the CDN on this day caused Google DNS clients to request resources from data centers located on the other side of the Atlantic. The effect is that clients using local DNS resolution saw median RTTs of 20ms, while clients using Google DNS see RTTs six times longer.

Based on similar observations, work recently submitted to the IETF proposed to address this problem by exposing client identity information to directly to authoritative nameservers[1]. The guidance produced by this result, "to reduce latency, change your DNS provider", is somewhat counterintuitive based on an end-to-end model of the Internet. This illustrates the importance of measurement in making operational latency reduction decisions.

Measuring latency alongside bandwidth by traditional, active means without coordination has the potential to unacceptably increase network load, especially on mobile networks which have limited last-mile capacity; measurement advances here include large-scale measurement coordination and new active, passive, and hybrid measurement techniques for latency estimation.

In the former category, the IETF LMAP effort currently underway is well-placed to coordinate active latency estimation using TWAMP or other active measurement protocols. Beyond LMAP, the European Commission FP7-funded mPlane consortium[2] is presently defining an architecture for measurement interoperation, coordination, and automation which will have wider applicability to latency measurement and diagnosis. Core to the mPlane architecture is the notion of *type equivalence* in measurements: that there are a wide variety of existing measurement tools available, which produce measurements which can be compared with each other to varying degrees. By denoting the output of each tool with detailed information about the types of data it produces and consumes, mPlane allows measurements to be coordinated in a multi-vendor, multi-algorithm, multi-protocol environment.

In the latter category, there is work to be done on building and deploying scalable passive meters for latency. Here, the QoF flow meter[3], based on the production-grade YAF [2], is also under development within the mPlane project. QoF provides insight into the activity of TCP flows at scale by exporting per-flow TCP dynamics information. It is designed to support both research and network operations, exporting IPFIX for integration with other flow-based monitoring tools. Among other things, it measures TCP round trip time on a per-flow basis, using the TCP timestamp feature as in [3] to adjust for the distance between the observation point and the sender, and heuristics to minimize error due to application delay. For applications over TCP, this data provides a basis for measurement of operational networks; both to understand network latency problems, as well as to evaluate the effectiveness of latency-reduction approaches. Such large-scale passive latency estimation can reduce reliance on simulations which may not account for unmodeled interactions within the network.

In short, latency reduction efforts can be guided, driven, and verified by solid measurements. Indeed, economic approaches to incentivize the deployment of latency reduction technologies in access networks would greatly benefit from the definition and publicization of a standard, easily measurable access network latency metric, though the authors acknowledge the difficulty of this effort.

[1] http://tools.ietf.org/html/draft-vandergaast-edns-client-subnet-01

[2] http://www.ict-mplane.eu

[3] pre-release available at http://github.com/britram/qof

References

[1] A. Finamore, M. Mellia, M. Meo, M.M.Munaf'o, D.Rossi Experiences of Internet traffic monitoring with Tstat. In *Network*, vol. 25, no. 3, May–June 2011, IEEE.

[2] C. Inacio and B. Trammell YAF: Yet another flowmeter. In *Proceedings of the 24th Large Installation System Administration Conference (LISA 2010)* (San Jose, California, USA, Nov 2010), USENIX Association.

[3] B. Veal, K. Li, and D. Lowenthal New methods for passive estimation of tcp round-trip times. In *Proceedings of the 6th international conference on Passive and Active Network Measurement* (Boston, 2005), PAM'05, Springer-Verlag (LNCS 3431).