

TCP Congestion Signatures

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ABSTRACT

We develop and validate Internet path measurement techniques to distinguish congestion experienced when a flow self-induces congestion in the path from when a flow is affected by an already congested path. One application of this technique is for speed tests, when the user is affected by congestion either in the last mile or in an interconnect link. This difference is important because in the latter case, the user is constrained by their service plan (i.e., what they are paying for), and in the former case, they are constrained by forces outside of their control. We exploit TCP congestion control dynamics to distinguish these cases for Internet paths that are predominantly TCP traffic. In TCP terms, we re-articulate the question: was a TCP flow bottlenecked by an already congested (possibly interconnect) link, or did it induce congestion in an otherwise idle (possibly a last-mile) link? TCP congestion control affects the round-trip time (RTT) of packets within the flow (i.e., the flow RTT): an endpoint sends packets at higher throughput, increasing the occupancy of the bottleneck buffer, thereby increasing the RTT of packets in the flow. We show that two simple, statistical metrics derived from the flow RTT during the slow start period — its coefficient of variation, and the normalized difference between the maximum and minimum RTT — can robustly identify which type of congestion the flow encounters. We use extensive controlled experiments to demonstrate that our technique works with up to 90% accuracy. We also evaluate our techniques using two unique real-world datasets of TCP throughput measurements using Measurement Lab data and the Ark platform. We find up to 99% accuracy in detecting self-induced congestion, and up to 85% accuracy in detecting external congestion.

Our results can benefit regulators of interconnection markets, content providers trying to improve customer service, and users trying to understand whether poor performance is something they can fix by upgrading their service tier.

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