Internet Measurements with Prespecified Timestamps

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Abstract

Countless organizations and individuals depend on the Internet daily for their critical communications. Internet measurement aims to provide tools to allow these users to better understand the network, achieve better performance, and identify problems they may encounter. However, despite the diverse set of tools available, several basic properties of topology, routing, and performance remain challenging to measure. To improve this state, we propose adding an additional method to the measurement toolkit: the IP prespecified timestamp option. We will discuss the prevalence of support for IP timestamps, and then describe how timestamps can be applied to two fundamental measurement issues: resolving IP aliases, and measuring one-way link delay.

1 The Prespecified Timestamp Option

Prespecified timestamps are an optional extension to the IP header which allow the sender to request timestamp values from any router which forwards the packet. The sender may specify up to four IP addresses in advance; each router forwarding the packet checks whether the first unstamped IP address specified is its own, and if so, appends a timestamp before forwarding.

While some have argued that IP options are not useful due to lack of widespread support and inconsistent implementation [1], we believe that timestamps can play a significant role in supplementing the measurement toolkit. In our work on reverse traceroute [2], we showed how the option can be used to discover hops on the reverse path (from destination to source) and measured the gains in coverage achieved for this application by including timestamps to complement a set of other techniques.

We demonstrate that upwards of 25% of routers provide responses to timestamp requests. Furthermore, to enable future applications of the option, we classify a limited set of consistent, identifiable implementations of timestamp support by routers.

2 Resolving IP Aliases

IP alias resolution refers to the identification of two or more IP addresses (*aliases*) belonging to the same router. Individual routers may have multiple IP addresses associated with them, which can lead to confusion when multiple measurements of the same router are combined. For example, studies mapping network topologies [3] may necessitate comparisons between successive traceroutes. These different traceroutes may involve different IP addresses provided by the same router, depending on which interface the traceroute packet arrived on.

Our technique relies on the fact that the sender can specify up to four IP addresses in a single timestamp probe. By combining requests for candidate alias pairs in a single probe, we infer alias pairs from the timestamp clock values as well as from the topological configuration of the candidate IPs implied by the order of the timestamps. In our studies, timestamp generated alias-pairs which overlapped with a ground truth dataset were 85% accurate.

3 Measuring Delay of a Single Link

Applications such as IP geolocation [4] depend on accurate latency measurements of individual links. Typical values available are simply estimations generated by subtracting round-trip time (RTT) values from successive probes to routers on either end of the link, leading to inaccuracy due to asymmetric routing.

We seek to overcome this limitation where timestamps are supported, by sending a timestamp probe across the link and requesting timestamp values from the routers on either end, and then evaluating the delta between the two timestamps. By making measurements in both forward and reverse directions, we cancel out clock skew with arithmetic manipulation. In a preliminary study over the Internet2 backbone, we found that, for 11 of 13 links, our measurements were within a millisecond of values generated by measurements at the routers themselves.

In conclusion, we believe that IP prespecified timestamps hold significant promise when added to the measurement toolkit. Our studies of the prevalence of support for timestamps and our basic applications demonstrate that timestamps can help to study properties of Internet that have yet remained challenging.

References

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