Measuring YouTube Content Delivery over IPv6

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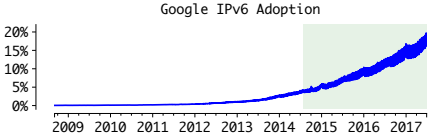
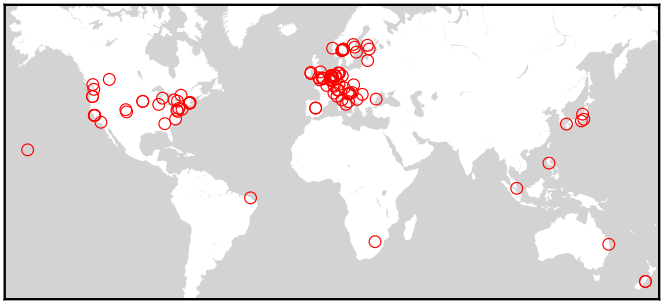
Motivation

- IPv6 contributes ∼25% [1] of traffic within Comcast.
- Swisscom reports ∼60% [1] of IPv6 traffic is YouTube.
- IPv6 traffic largely dominated by YouTube [2].



shaded region represents the duration of the longitudinal study.

Do users experience benefit (or suffer) from YouTube streaming over IPv6?



∼100 dual-stacked SamKnows probes (∼66 different origin ASes)

NETWORK TYPE	#
RESIDENTIAL	78
NREN / RESEARCH	10
BUSINESS / DATACENTER	08
OPERATOR LAB	04
IXP	01

RIR	#
RIPE	60
ARIN	29
APNIC	10
AFRINIC	01
LACNIC	01

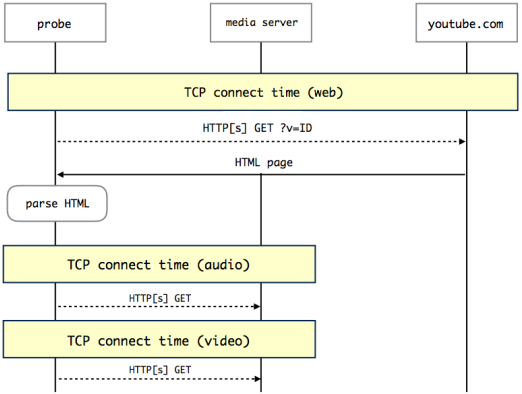
Research Contribution

- HE (RFC 6555) makes clients to prefer streaming YouTube videos over IPv6.
- Observed performance (both in terms of latency and throughput) over IPv6 is worse.
- Stall rates are low, bitrates that can be reliably streamed are comparable.
- When a stall occurs, stall durations over IPv6 are higher.
- Worse performance is due to GGC nodes that are IPv4-only.

This is the first study to measure YouTube content delivery over IPv6

Methodology | Selection of YouTube Videos

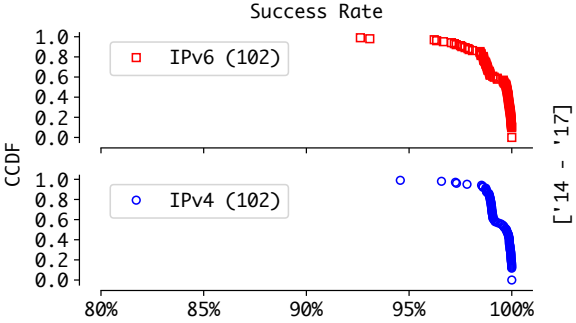
- Using YouTube v3 API [3].
- Video Selection Criteria:
  1. Video duration > 60s.
  2. Available in Full HD.
  3. No regional restrictions.
- List updated every 12h.
- Probes daily pull the list.



- The test supports non-adaptive and step-down playout modes only.
- Results are biased our vantage points (centered largely around EU, US and JP).

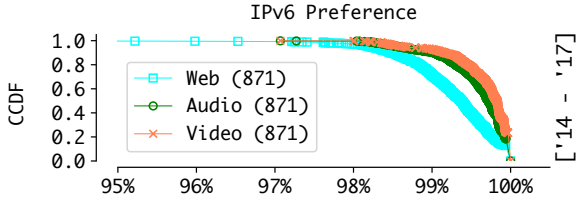
Success Rate

- Number of successful iterations to total iterations.
- The test executes once every hour (over both AF).



- 99% of probes achieve success rate of more than 94% over IPv4.
- 97% of probes achieve success rate of more than 94% over IPv6.
- Slightly lower success rates over IPv6 due to network issues closer to probes.

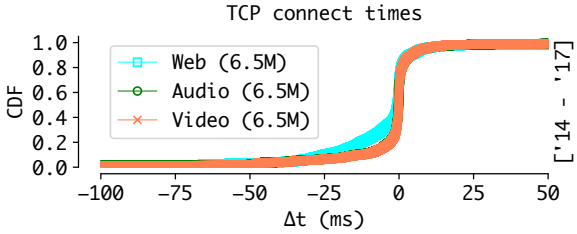
IPv6 Preference



- RFC 6724 [4] makes apps prefer connections made over IPv6.
- RFC 6555 [5] allows apps to fallback to IPv4 when IPv6 connectivity is bad.
- TCP connections over IPv6 are preferred at least 97% of the time.

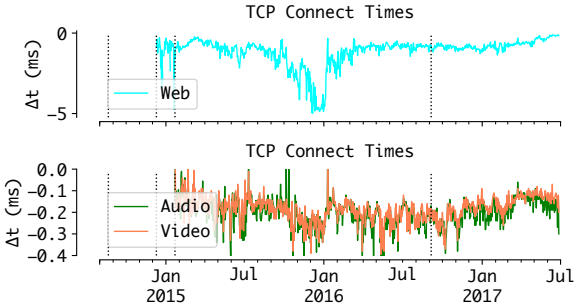
Clients prefer streaming YouTube videos over IPv6

TCP connect times



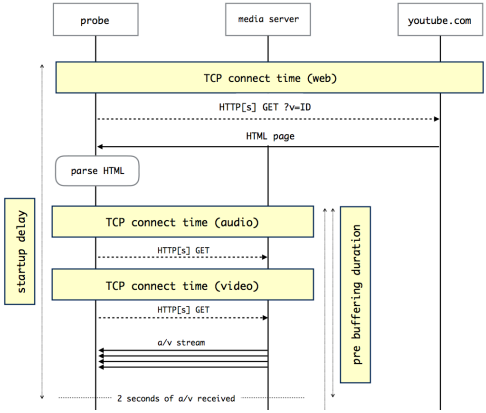
- 63% of a/v streams (and 72% of the web connections) are slower over IPv6.
- 14% of a/v streams are at least 10 ms slower over IPv6.

TCP connect times

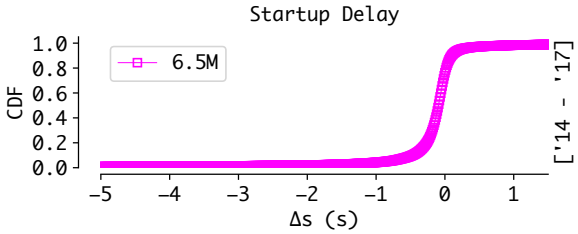


- TCP connect times consistently higher over IPv6 and have not improved over time.
- TCP connect times towards the webpage worse over IPv6 than towards media servers.

Sequence Diagram (contd.)

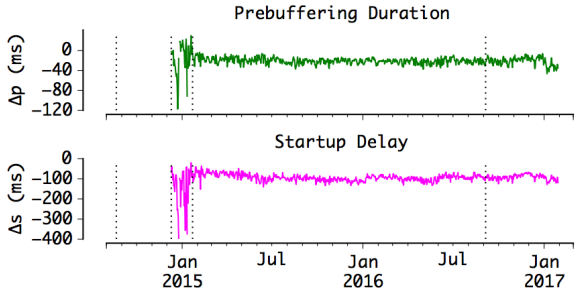


Startup Delay



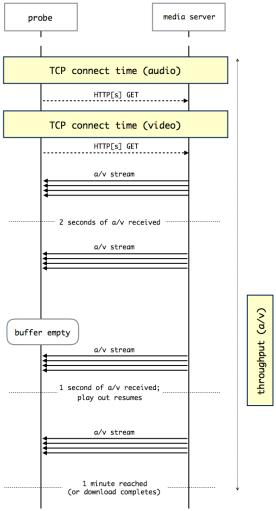
- 80% of the samples are slower over IPv6.
- Half of the samples are at least 100 ms slower over IPv6.

Startup Delay

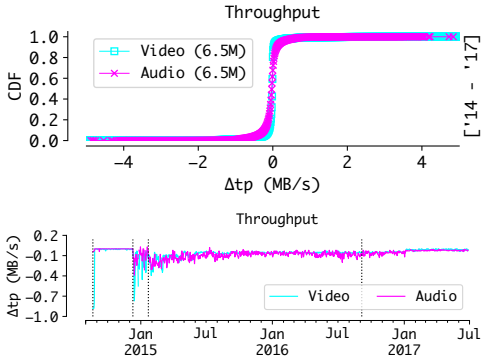


- Prebuffering durations are ∼25 ms higher over IPv6.
- Startup delays are ∼100 ms higher over IPv6.
- Initial interaction with the web server makes startup delay worse over IPv6.

Sequence Diagram (contd.)

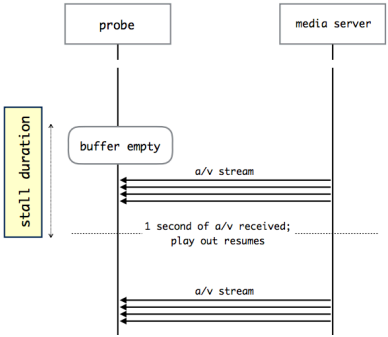


Throughput

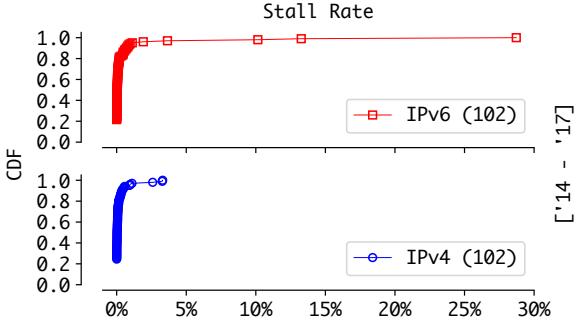


- 80% of video and 60% audio samples achieve lower throughput over IPv6.
- The throughput is consistently lower over IPv6, but it has improved over time.

Sequence Diagram (contd.)

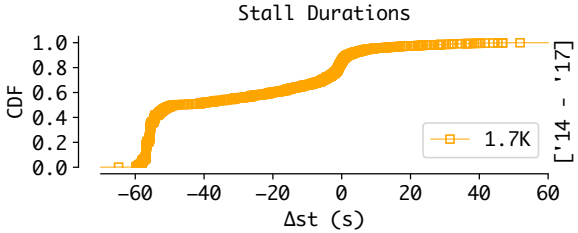


Stall Rates



- 90% of the probes witness less than 1% stall rate over both address families.
- Bitrates reliably streamed is also comparable over both address families.

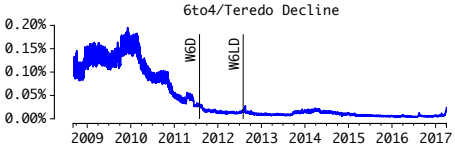
Stall Durations



- 80% of samples experience stall durations that are at least 1s longer.

Recommendations

- Update RFC 6555 with a lower HE timer value.
  - We have shown [6] that reducing HE timer value to 150 ms (from 300 ms) helps.



- ISPs should put latency as a first-class citizen.
- ISPs should ensure GGC nodes are dual-stacked.
  - Request an IPv6 prefix allocation from Google.

Takeway

- Clients prefer streaming YouTube videos over IPv6.
- Observed performance (both in terms of latency and throughput) over IPv6 is worse.
- Stall rates are low, but when a stall occurs, stall durations over IPv6 are higher.
- Worse performance due to GGC nodes that are IPv4-only.

- Reproducibility Considerations:
  - The test is open-sourced: https://github.com/sabyahsan/youtube-test
  - The dataset is released: https://github.com/vbajpai/2017-ccr-youtube-analysis

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References

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[2] N. Sarrar, G. Maier, B. Ager, R. Sommer, and S. Uhlig, "Investigating IPv6 Traffic - What Happened at the World IPv6 Day?" ser. Passive and Active Measurement Conference, 2012, pp. 11–20. [Online]. Available: https://doi.org/10.1007/978-3-642-28537-0_2

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[6] V. Bajpai and J. Schönwälder, "Measuring the Effects of Happy Eyeballs," ser. Applied Networking Research Workshop, 2016. [Online]. Available: http://dl.acm.org/citation.cfm?id=2959429