# Measuring YouTube from Dual-Stacked Hosts

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Leone FP7 EU Project: leone-project.eu

- Large IPv6 broadband rollouts[1] since World IPv6 Launch Day in 2012.
- Increased global adoption of IPv6 to 6% (as seen by Google as of March 2015).

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- Studies show how YouTube contributes heavily to volumes of IPv6 traffic [1]:

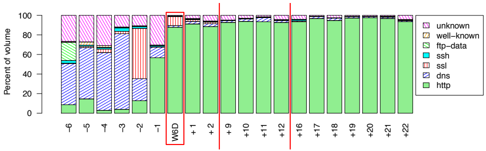


**Fig. 7.** Application mix per day for *all* IPv6 traffic (campus).

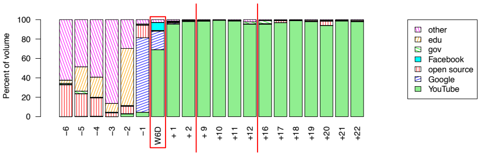


**Fig. 8.** Daily HTTP mix (campus).

[1] Comcast, Deutsche Telekom AG, AT&T, Verizon Wireless, T-Mobile USA

*Do users experience benefit (or an added penalty) when streaming YouTube videos over IPv6?*

1. TCP connect times to YouTube makes Happy Eyeballs [2] prefer IPv6.
2. Lower throughput is achieved when streaming YouTube over IPv6.
3. YouTube content caches over IPv6 are largely absent.

*To the best of our knowledge, this is the first study to compare YouTube performance over IPv4 and IPv6 from dual-stacked networks.*

# *Methodology*

1. Takes a YouTube URL as input and scrapes the downloaded HTML page.
2. Extracts container formats[2], available resolutions and media server locations.
3. Locally resolves DNS names of media server locations.
4. Establishes concurrent TCP connections for audio and video streams.
   - Measures TCP connect times by recording `connect(...)` call completion time.
   - DNS resolution time is not accounted.
5. Fetches audio and video streams over concurrent HTTP sessions.
   - Ensures temporal synchronization between audio and video streams.
   - Measures throughput achieved over the single TCP connection for each stream.
6. Extracts frame timestamps from container to mimic a playout.
   - A 2 second prebuffering is applied before starting playout timer.
   - Measures stall duration whenever a frame fails to arrive before its playout time.
   - A stall triggers 1 second of rebuffering before resuming playout timer.

[2] The YouTube test supports three container formats: MP4, WebM and FLV

# Methodology | Speed Test

- Measures achievable throughput over the line.
- Uses 3 simultaneous TCP connections to fetch 1 GB, non-zero, binary file.
- HTTP GET request is made to the nearest (based on latency) M-Lab server.
- Detailed in the SamKnows test suite [3] description.

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- We modified the test to also enable measurements over IPv6.
- We use these line rates to baseline our YouTube throughput measurements.

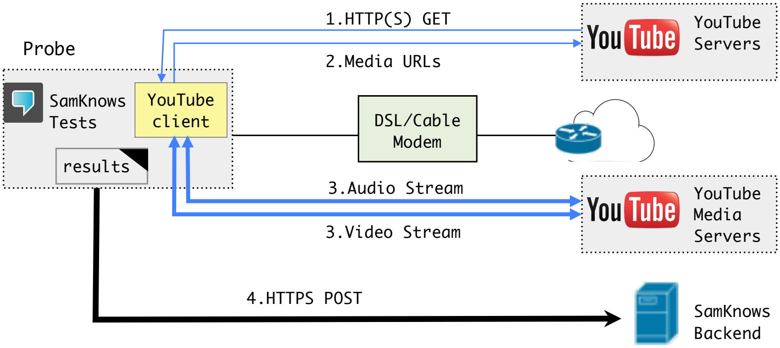
- We use the YouTube v3 API[3] to prepare a list of globally popular videos where:
  1. Video duration > 60s.
  2. Video is available in Full HD format.
  3. Video has no regional restrictions.

- List is refreshed every 12h on the SamKnows backend.
- Each probe pulls this list on a daily basis.

[3] *https://developers.google.com/youtube/v3/docs/videos/list*

# Methodology | Selection of Video Bitrate

- YouTube provides a list of available resolutions (and their required bitrates).
- The YouTube test currently does not support DASH [4].
- We use speed test results to limit maximum bitrate.
- We also support 2 operation modes:
  1. Non-adaptive mode.
     - Test downloads the same video resolution despite stalls.
     - Although, does not mimic the behavior of YouTube players.
     - However, still useful to compare IPv4 vs IPv6 performance in identical conditions.
  2. Step-down mode.
     - Test steps down to a lower video resolution on a stall.
     - Portrays a more user-oriented behaviour.




- YouTube test runs every hour (once for IPv4 and subsequently for IPv6).
- Speed test runs every 6 hours (once for IPv4 and subsequently for IPv6).

# Methodology | Measurement Trials

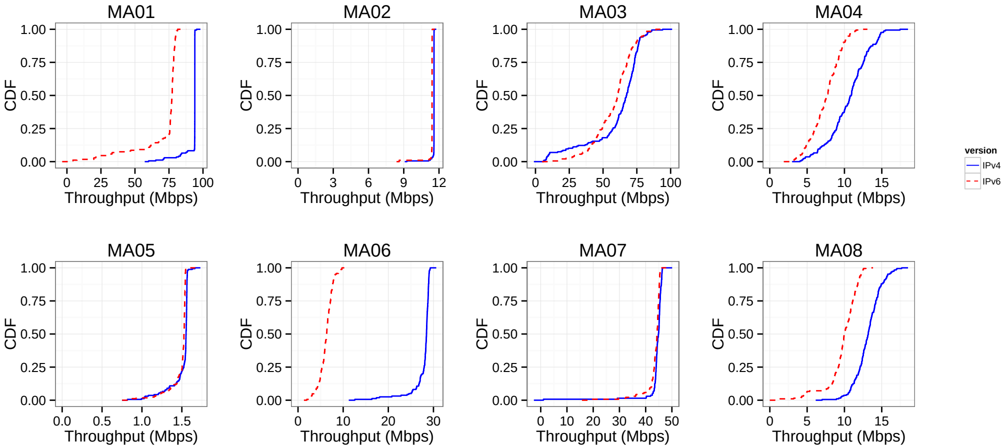


| # | LOCATION | PROVIDER | TYPE |
|---|---|---|---|
| #01 | BREMEN | KABELDEUTSCHLAND | RESIDENTIAL |
| #02 | BREMEN | DEUTSCHE TELEKOM | RESIDENTIAL |
| #03 | STOCKHOLM | SITAB | RESIDENTIAL |
| #04 | FUKUOKA | ASAHI NET | RESIDENTIAL |
| #05 | MADRID | JAZZ TELECOM | RESIDENTIAL |
| #06 | ALLEUR | EDPNET | RESIDENTIAL |
| #07 | BREMEN | DEUTSCHE TELEKOM | RESIDENTIAL |
| #08 | SHIZUOKA | BIGLOBE NEC | RESIDENTIAL |
| #09 | CERN | CERN | RESEARCH |
| #10 | BREMEN | DFN | NREN |
| #11 | TIMISOARA | ROEDUNET | NREN |
| #12 | LOUVAIN | BELNET | NREN |
| #13 | BREMEN | DFN | NREN |
| #14 | HELSINKI | FUNET | NREN |
| #15 | LONDON | BSKYB-BROADBAND | LAB |
| #16 | TORINO | TELECOM ITALIA | LAB |
| #17 | MADRID | BT ESPANA | LAB |
| #18 | IPSWICH | BT UK | LAB |
| #19 | NIIGATA | NDAC | IXP |
| #20 | BRAUNSCHWEIG | GAERTNER DATENSYSTEME | BUSINESS |
| #21 | OLTEN | INIT SEVEN | BUSINESS |

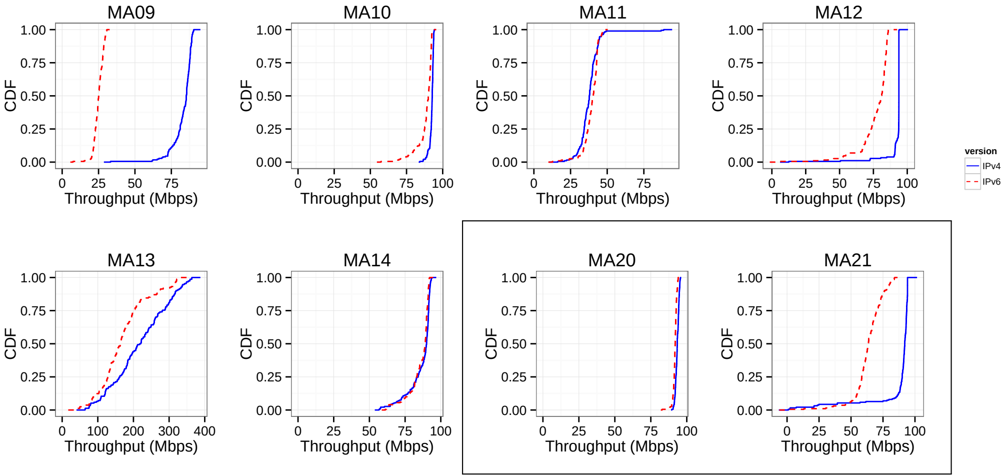
# *Data Analysis*[4]

[4] The results are derived from measurements conducted for 20 days in September 2014.

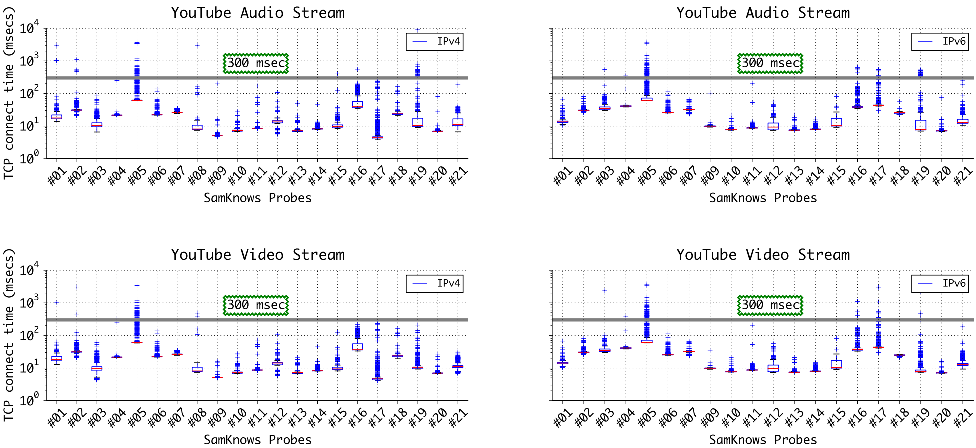
# Data Analysis | Speed Tests (Residential)



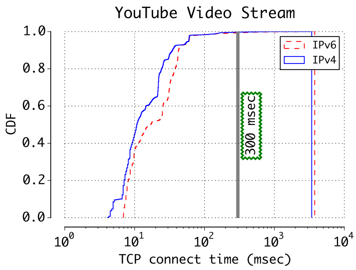
# Data Analysis | Speed Tests (Research, Business)

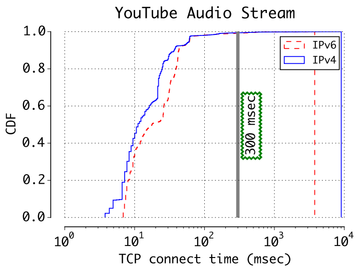


# Data Analysis | TCP Connect Times



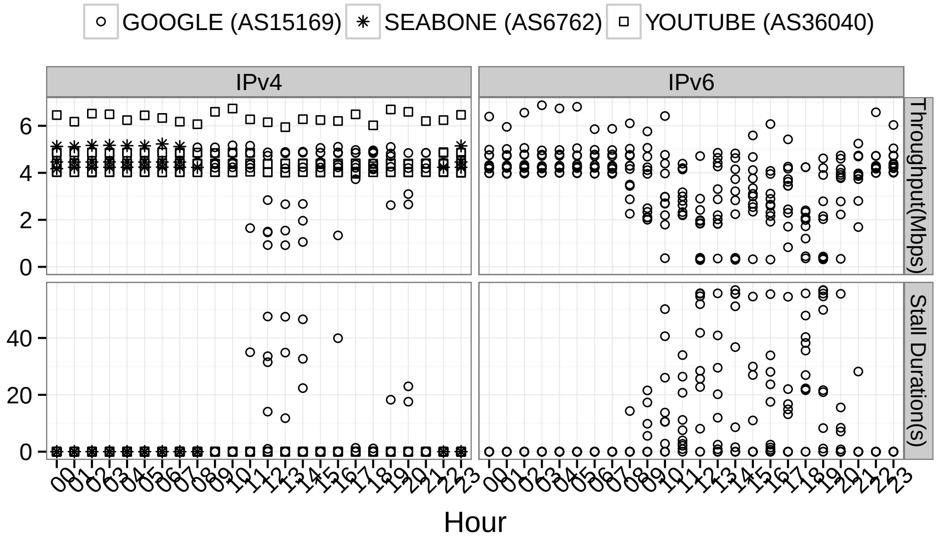
# Data Analysis | Happy Eyeballs




| | IPV6 PREFERENCE | |
|---|---|---|
| | VIDEO | AUDIO |
| #01 | 100.0% | 100.0% |
| #02 | 100.0% | 100.0% |
| #03 | 99.75% | 99.75% |
| #04 | 100.0% | 100.0% |
| #05 | 92.79% | 92.79% |
| #06 | 100.0% | 100.0% |
| #07 | 100.0% | 100.0% |
| #08 | 00.00% | 00.00% |
| #09 | 100.0% | 100.0% |
| #10 | 100.0% | 100.0% |
| #11 | 100.0% | 100.0% |
| #12 | 100.0% | 100.0% |
| #13 | 100.0% | 100.0% |
| #14 | 100.0% | 100.0% |
| #15 | 100.0% | 100.0% |
| #16 | 99.39% | 98.94% |
| #17 | 98.01% | 98.26% |
| #18 | 100.0% | 100.0% |
| #19 | 99.52% | 96.85% |
| #20 | 100.0% | 100.0% |
| #21 | 100.0% | 100.0% |

# Data Analysis | Achievable Throughput and Stall Events



# Data Analysis | Google Global Caches

| CATEGORY | IPV4 | n(PROBES) | IPV6 | n(PROBES) |
| --- | --- | --- | --- | --- |
| CONTENT CACHES | COMHEM (AS39651) | 01 | - | - |
| | ASAHI (AS4685) | 01 | - | - |
| | JAZZNET (AS12715) | 01 | - | - |
| | EDPNET (AS9031) | 01 | - | - |
| | DTAG (AS3320) | 02 | DTAG (AS3320) | 02 |
| | BIGLOBE (AS2518) | 01 | - | - |
| | ROEDUNET (AS2614) | 01 | ROEDUNET (AS2614) | 01 |
| | NORDUNET (AS2603) | 01 | NORDUNET (AS2603) | 01 |
| | BSKYB (AS5607) | 01 | BSKYB (AS5607) | 01 |
| | SEABONE (AS6762) | 01 | - | - |
| | QSC (AS20676) | 01 | QSC (AS20676) | 01 |
| | NG (AS48161) | 01 | - | - |
| CDN | GOOGLE (AS15169) | 20 | GOOGLE (AS15169) | 19 |
| | YOUTUBE (AS43515) | 03 | - | - |
| | YOUTUBE (AS36040) | 02 | - | - |
| | LEVEL3 (AS3356) | 01 | - | - |
| IXP | - | - | INTERLAN (AS39107) | 01 |

# Conclusion

1. TCP connect times to YouTube makes Happy Eyeballs prefer IPv6.
2. Lower throughput is achieved when streaming YouTube over IPv6.
3. YouTube content caches over IPv6 are largely absent.

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The entire dataset is publicly released:
*http://www.netlab.tkk.fi/tutkimus/rtc/PAM2015*

# *Appendix*

# Appendix | Summary

| MA | SUCCESS RATE | | STALL RATE | | SPEEDTEST (Mbps) | | GGC |
|---|---|---|---|---|---|---|---|
| | IPV4 | IPV6 | IPV4 | IPV6 | IPV4 | IPV6 | |
| #01 | 100% | 55% | 0% | 0% | 92.56 | 72.35 | - |
| #02 | 100% | 100% | 7% | 1% | 11.55 | 11.37 | - |
| #03 | 100% | 60% | 0% | 0% | 61.82 | 57.99 | IPV4 |
| #04 | 100% | 92% | 0% | 4% | 10.68 | 7.55 | IPV4 |
| #05 | 100% | 100% | 29% | 39% | 1.49 | 1.47 | IPv4 |
| #06 | 100% | 100% | 0% | 1% | 27.83 | 6.16 | IPv4 |
| #07 | 100% | 100% | 0% | 2% | 44.24 | 43.45 | IPv4 |
| #08 | 100% | 0% | 0% | 0% | 13.14 | 9.80 | IPv4 |
| #09 | 100% | 100% | 0% | 0% | 83.20 | 25.06 | - |
| #10 | 100% | 55% | 0% | 0% | 92.29 | 88.54 | - |
| #11 | 100% | 100% | 0% | 0% | 37.87 | 39.10 | BOTH |
| #12 | 100% | 91% | 0% | 0% | 92.15 | 77.40 | - |
| #13 | 100% | 61% | 0% | 0% | 217.99 | 170.46 | - |
| #14 | 100% | 99% | 0% | 0% | 87.09 | 86.34 | BOTH |
| #15 | 96% | 100% | 0% | 0% | 10.99 | 10.82 | BOTH |
| #16 | 100% | 100% | 5% | 30% | 4.35 | 4.31 | IPV4 |
| #17 | 100% | 100% | 1% | 57% | 9.17 | 3.49 | - |
| #18 | 100% | 100% | 0% | 100% | 20.80 | 0.29 | - |
| #19 | 100% | 99% | 7% | 5% | 11.83 | 24.14 | - |
| #20 | 100% | 100% | 0% | 0% | 93.37 | 91.83 | BOTH |
| #21 | 100% | 100% | 0% | 0% | 88.08 | 64.04 | - |

- YouTube Characterization:
  - Gill *et al.* [5] (2007) study YouTube workload patterns in a campus.
  - Cha *et al.* [6] (2007) study YouTube content popularity.
- Passive Measurements:
  - Adhikari *et al.* [7] (2010) use flow data to study YouTube from a tier-1 ISP.
  - Finamore *et al.* [8] (2011) compare YouTube for mobile & PC devices.
  - Dimopoulos *et al.* [9] (2013) study YouTube video sessions.
- Active Measurements:
  - Juluri *et al.* [10] (2011) show Pytomo, a python tool that models a YouTube client.
  - Adhikari *et al.* [11] (2012) use PlanetLab to crawl YouTube video ID space.
  - Juluri *et al.* [12] (2013) use Pytomo to measure YouTube from 3 ISPs.
  - Nam *et al.* [13] (2014) show YouSlow, browser plugin to detect live buffer stalls.

# Appendix | References I


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[12] P. Juluri, L. Plissonneau, Y. Zeng, and D. Medhi, "Viewing youtube from a metropolitan area: What do users accessing from residential isps experience?" in *IFIP/IEEE International Symposium on Integrated Network Management (IM),*, May 2013.

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