RIPE **57**
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Google™

Global IPv6 statistics

Measuring the current state of IPv6 for ordinary users

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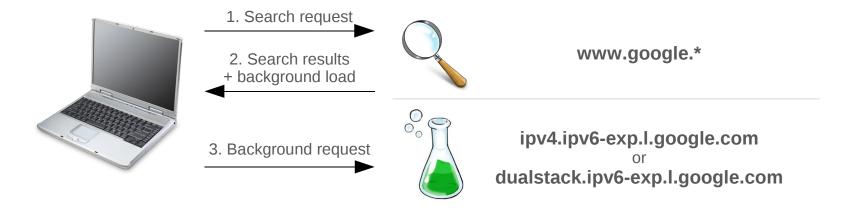Software Engineer

Motivation

- There is too little data about IPv6 among clients

    - Existing measurements mostly on a small scale and/or only indirectly related to client IPv6 availability (e.g., IPv6 traffic percentage, IPv6-enabled ASNs)

    - Best existing number is probably **0.086%** (Kevin Day, March 2008)

- General worry that turning on IPv6 can cause all sorts of brokenness

    - Tunnels that someone forgot

    - Suboptimal routing

    - Home routers doing evil things to AAAA queries

- We need to figure out **how common** IPv6 is among our users,
  how prevalent **brokenness** is, and how we can best serve our IPv6 users

    - Our question: What is the impact of adding an AAAA record to a web site?

Methodology

- Enroll a small fraction of ordinary Google users into an "IPv6 experiment", where their browser is asked to perform a background request

  - Involves users from all datacenters equally, but background request goes to one of two datacenters (one in the US, one in Europe)

  - Cryptographically signed to avoid easy injection of false data

1. Search request

www.google.*

2. Search results
+ background load

3. Background request

ipv4.ipv6-exp.l.google.com
or
dualstack.ipv6-exp.l.google.com

- Recorded information:

  - IPv4 and IPv6 addresses, as applicable

  - Image request latency

  - Browser/OS details (User-Agent string)

Key figures

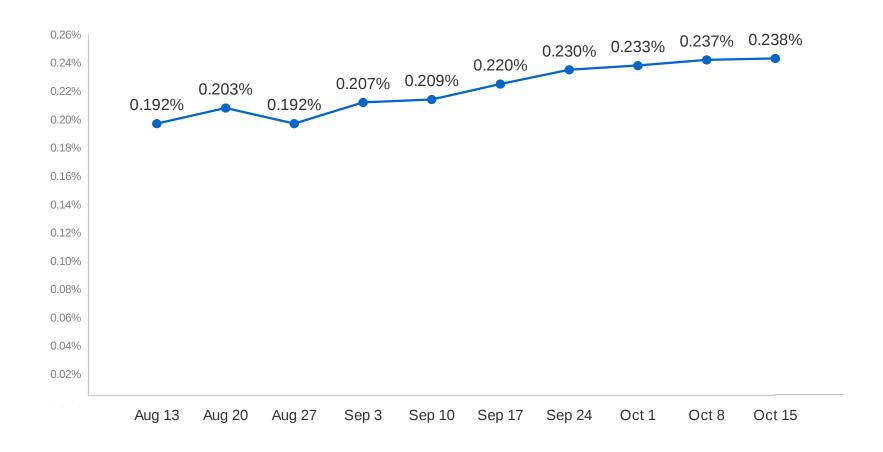Overview of connectivity and latency data

Connectivity

- **0.238%** of users have useful IPv6 connectivity (and prefer IPv6)

- **0.09%** of users have *broken* IPv6 connectivity

    - That is, adding an AAAA record will make these users unable to view your site

    - Due to statistical issues, this is a much less accurate figure
      (could easily be 0.06% or 0.12%), so take it with a grain of salt

- Probably at least **a million** distinct IPv6 hosts out there

    - Again, a number with statistical caveats
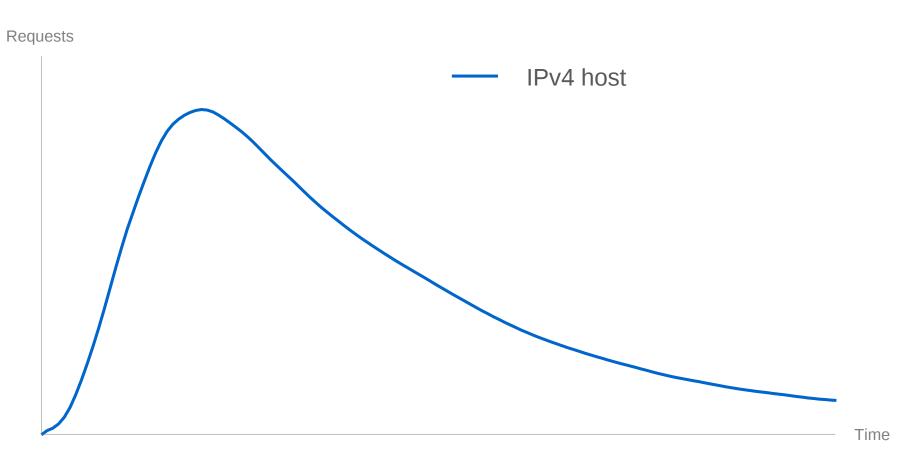
Connectivity development over time

Chart showing connectivity percentages by week:

Date	Value
Aug 13	0.192%
Aug 20	0.203%
Aug 27	0.192%
Sep 3	0.207%
Sep 10	0.209%
Sep 17	0.220%
Sep 24	0.230%
Oct 1	0.233%
Oct 8	0.237%
Oct 15	0.238%

Week averages, 2008

Latency

Latency distribution function, clients visiting ipv4.ipv6-exp.l.google.com

Requests

— IPv4 host

Time
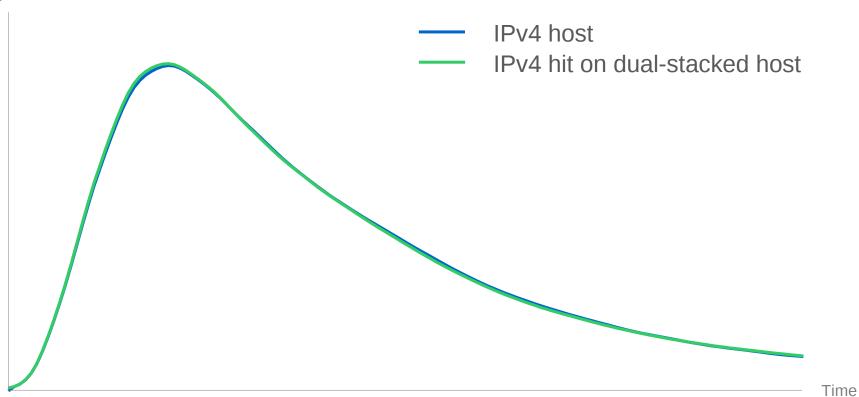
Note: This graph is *not* indicative of ordinary Google service latency

Latency

Requests

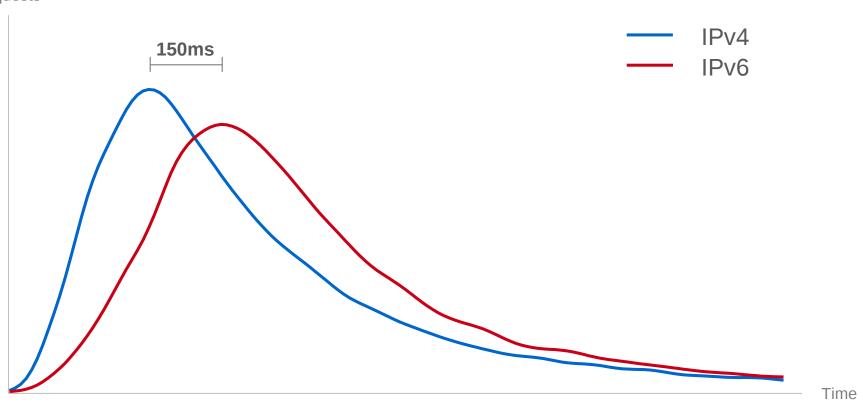IPv4 host
IPv4 hit on dual-stacked host

Time

- We cannot directly graph IPv4 vs. IPv6 latency

  - IPv6-enabled hosts are likely to have faster network connectivity overall (universities, power users, etc.)

  - Need a way to remove inherent bias

- Solution: Find pairs of hits from the same /24 IPv4 network, discard all other data

  - Gives comparable (paired) data sets

- This means we are measuring relative latency for a *different set* of users, but the data is still indicative of what you can expect today
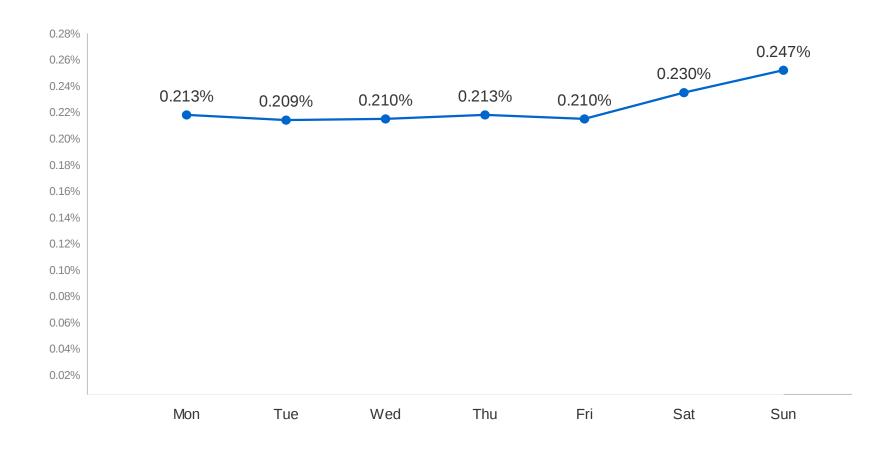
Relative IPv4/IPv6 latency (paired data)

Data breakdowns

Drilling in to get a more detailed look

Connectivity by weekday (UTC)
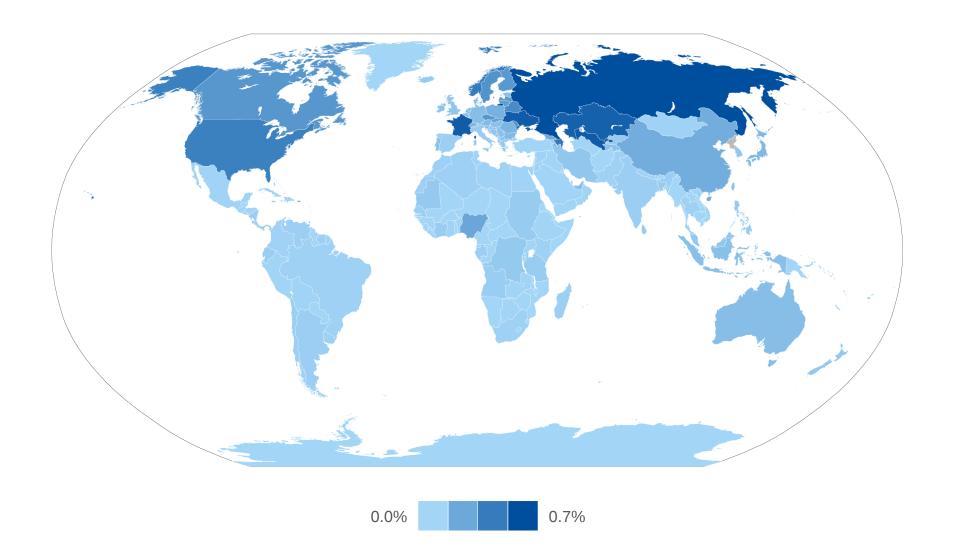
Connectivity by country

- Based on the IPv4 address, geolocate the user, then group by country
  - Some countries with relatively little Internet traffic removed

Country	IPv6 penetration
Russia	**0.76%**
France	0.65%
Ukraine	0.64%
Norway	0.49%
United States	0.45%
…	
China	0.24%
Japan	0.15%

Connectivity by country

0.0% 0.7%

Method of IPv6 connectivity

- Based on the IPv6 address, we can infer how the user gets IPv6 access

  - Unfortunately, no good way of distinguishing native from tunnels based on the address alone

  - Vista with Teredo doesn't try IPv6 by default, so probably undercounted

Method	Global usage
6to4	67.9%
Native/other	29.1%
ISATAP	1.6%
Teredo	1.4%

- Some countries stand out

  - United States, Canada: 95% 6to4

  - **France: 95% native** (almost all free.fr)

  - China: 71% native, 25% ISATAP

Breakdowns by OS

IPv6 penetration and connectivity type by operating system
Ranked by overall IPv6 penetration

Operating system	IPv6 penetration	Native/other proportion	6to4 proportion	Teredo/ISATAP proportion
Mac OS	**2.44%**	**9%**	**91%**	**0%**
Linux	0.93%	86%	13%	1%
Windows Vista	0.32%	55%	43%	2%
Windows Server 2003	0.07%	–	–	–
Windows XP	0.03%	50%	30%	20%
Windows 2000	<0.01%	–	–	–

52% of all IPv6 hits are from Macs with 6to4

97% of all Teredo users are on Windows (even undercounting Vista)

Summary

Brief analysis and conclusions

Overall trends

- IPv6 prevalence is still low, but growing by the week
  - Large (and sometimes surprising) variations among individual countries
  - Still heavily influenced by single deployments (e.g., free.fr)

- It's not that broken
  - ~0.09% clients lost, ~150ms extra latency – don't believe the FUD

- The default policy matters – a lot
  - Vista: 10x IPv6 prevalence over XP (OS defaults to enabling IPv6)
  - Mac OS: 8x IPv6 prevalence over Vista
    (Airport Extreme with 6to4 as default)

- 6to4 is by far the most common transition mechanism
  (at least when you don't count Vista's not-preferred-by-default Teredo)
  - Probably in part due to the AirPort Extreme
  - Consider running your own 6to4 relay for return packets

Future work

- Keep it running
  - Gather more data as time goes by

- Figure out *why* we lose users on the way
  - So we can fix it

- Run different experiments to get more accurate loss numbers
  - Paired data (i.e., two separate background requests) has been done before and is a possibility, but does not solve all problems
  - More client-side logic would help

Questions?

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