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Measuring and Comparing Internet Path Stability in IPv4 and IPv6

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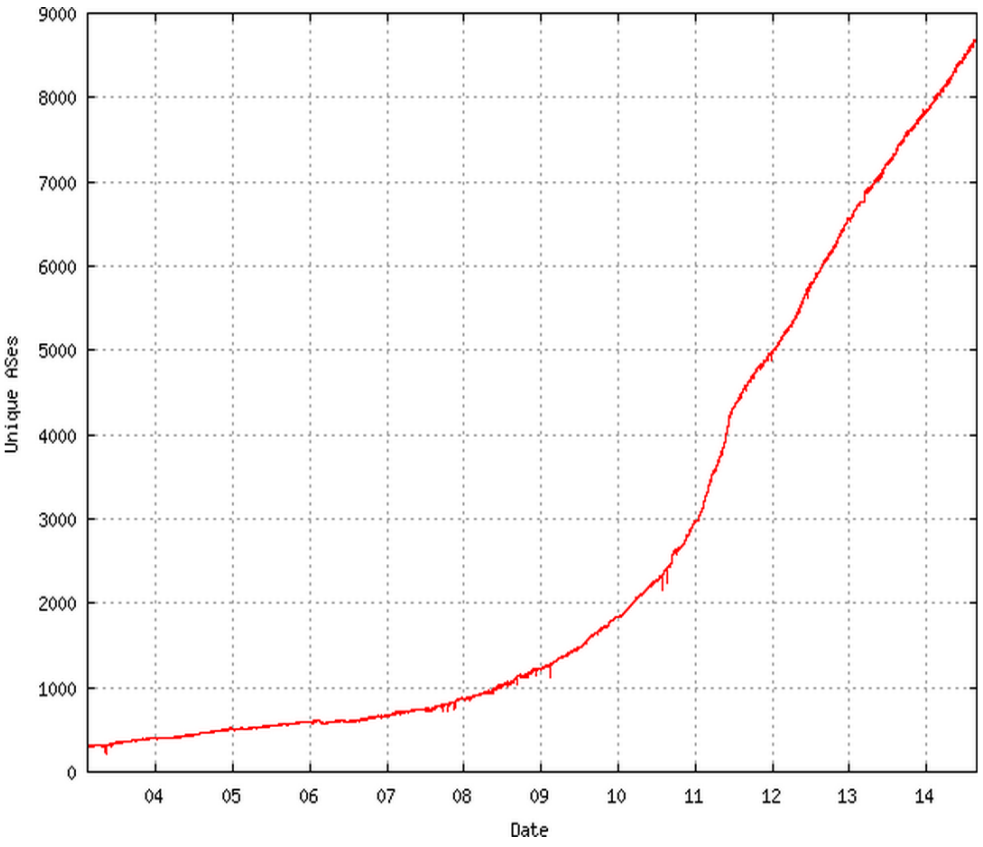
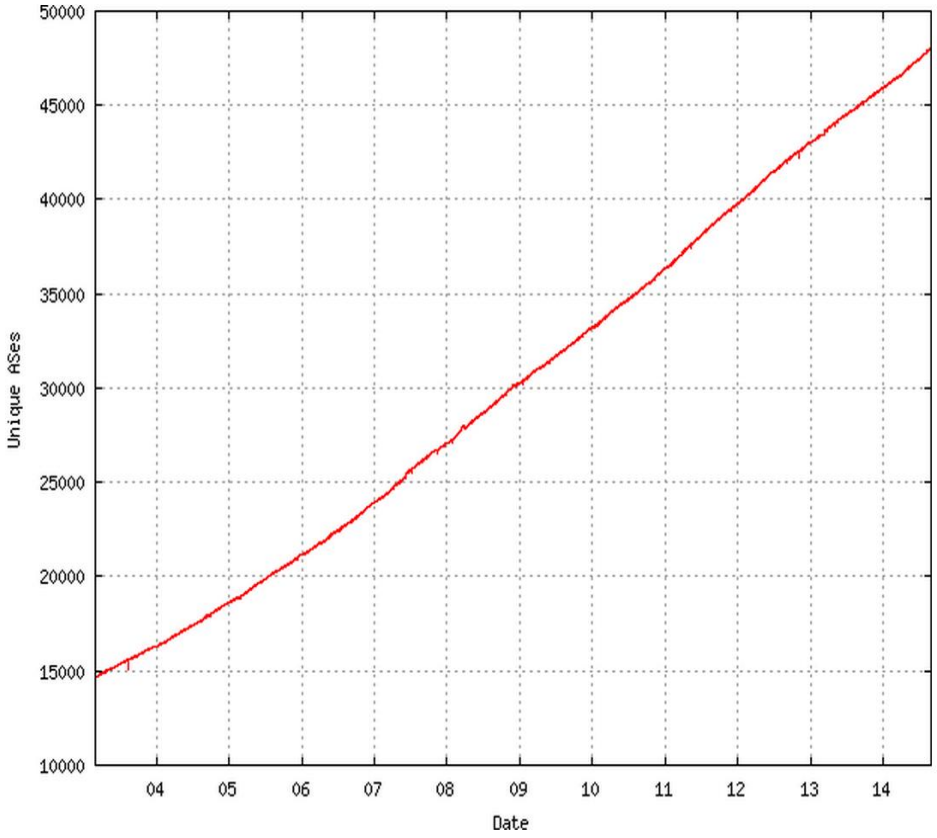
August 26, 2014

Why it can be important?

Only **4.3%** of request to **Google** servers come over **IPV6**.
IPv6 deployment has picked up speed recently.





No information in hands yet?

Several measurement studies tracking IPv6 deployment.

Control plane metrics focused:

- ✓ Topology
- ✓ Traffic volume
- ✓ Number of IPv6 address space allocated/growth in AS-level.

Performance-related metrics:

- ✓ Delay difference between IPv4 and IPv6.

Less known about stability.

Why it can be important?

New technology ⟶ **Better performance**

Do IPv6 customers experience better or the same stability in compare with IPv4?

What we did?

A controlled measurement study of routing stability of IPv6 paths and compare it with stability of corresponding IPv4 paths.

The goal is to understand whether there are differences in update dynamics of IPv6 vs. IPv4 path in terms of **frequency** and **pattern of path changes**.

We used **NorNet Core** infrastructure which provides us multiple paths between the same set of end nodes.

NorNet-Trace Service

- ✓ Runs as a service in all tunnelboxes and measures Internet paths continuously.
- ✓ A regular traceroute-like measurement via all local ISPs to all remote site's ISPs connection via IPv4 and IPv6.
- ✓ This service runs every 10 minutes.

- ✓ All Result are imported into the ***NorNet Core topology database,*** which the results for contains:
  - Measurement timestamps,
  - Source and destination sites and ISPs,
  - Path Length,
  - Round-Trip-Time (RTT) and Hops IP,

- ✓ No response is recorded as undefined (”*”)
- ✓ The sequence of path changes for each relation is calculated.

What we found?!

We present results for:

- ✓ Path length distribution
- ✓ Use of load balancing and path stability
- ✓ Pattern of routing changes: Do they arrive in bursts or happen independently?

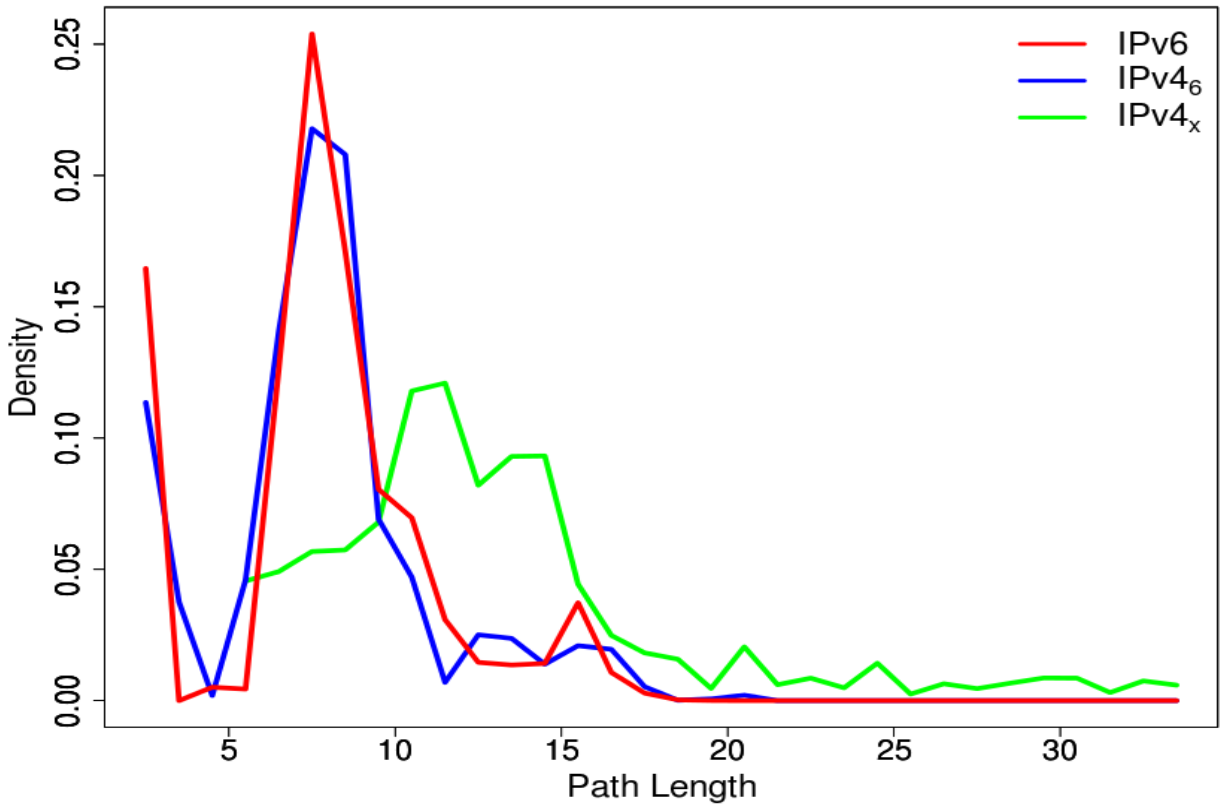
All NorNet Core sites or providers do not have IPv6 connectivity,

Therefore we distinguish IPv4:

- ✓ Those where we have corresponding IPv6 connections → $IPv4_6$
- ✓ Those where there is no corresponding IPv6 connection → $IPv4_X$

Our main focus is on comparing IPv6 and $IPv4_6$ paths.

Path length distribution

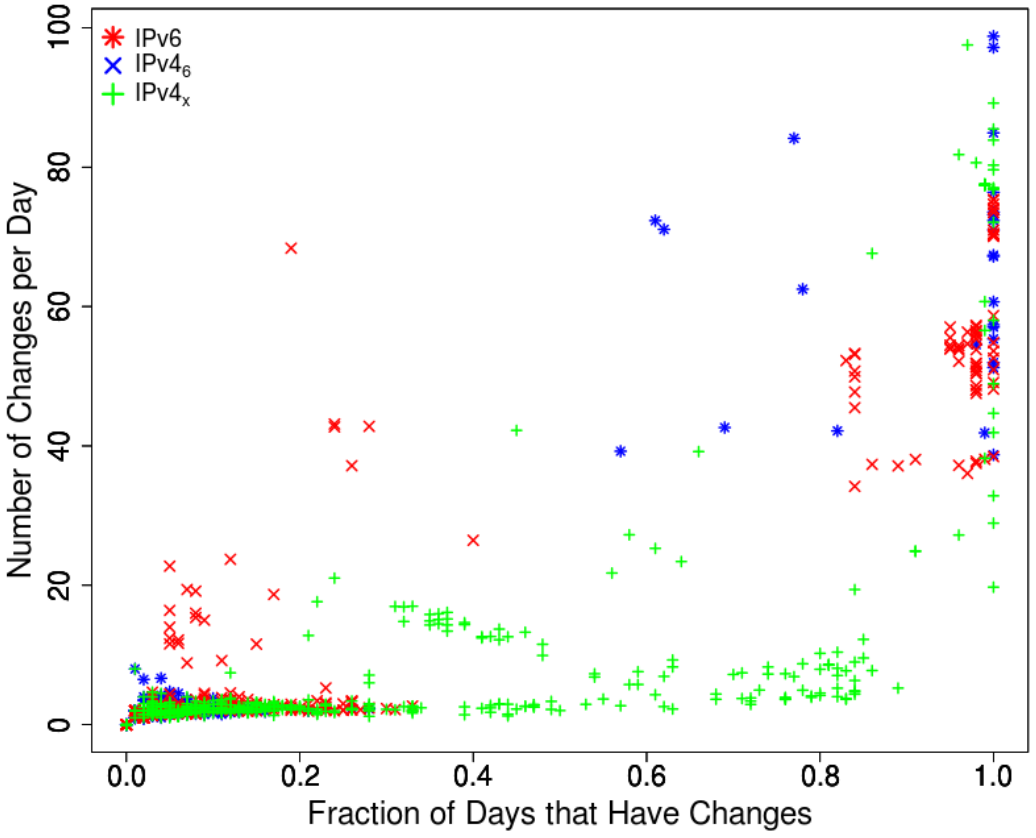


- Each path is weighted according to how often it is seen in our measurements.

- ✓ No clear difference between IPv6 paths and IPv4$_6$
- ✓ 65% of paths between 7 and 12.
- ✓ IPv4$_x$ paths are longer which are qualitatively different (technology and geographic distribution).

Load balancing

Clear dichotomy in IPv6 and IPv4$_6$ paths.



On closer inspection:

27% of IPv6
9% of IPv4$_6$

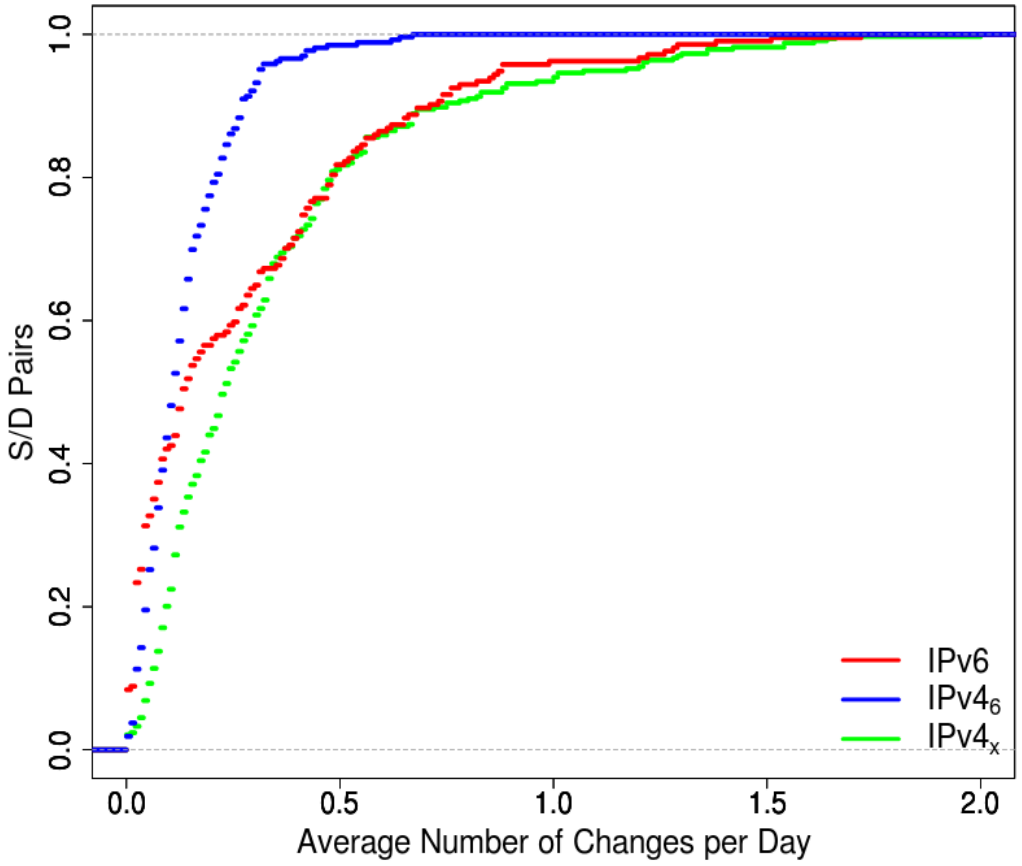
More than **10** changes in average
(Load balancing)

Surprising: More load balancer in IPv6 than corresponding IPv4.

Possible explanation: IPv6 topology is simpler or more sparse than the IPv4 topology.

Path stability

Number of path changes per day for non-load-balanced pairs.



IPv6 paths are less stable than IPv4$_6$.

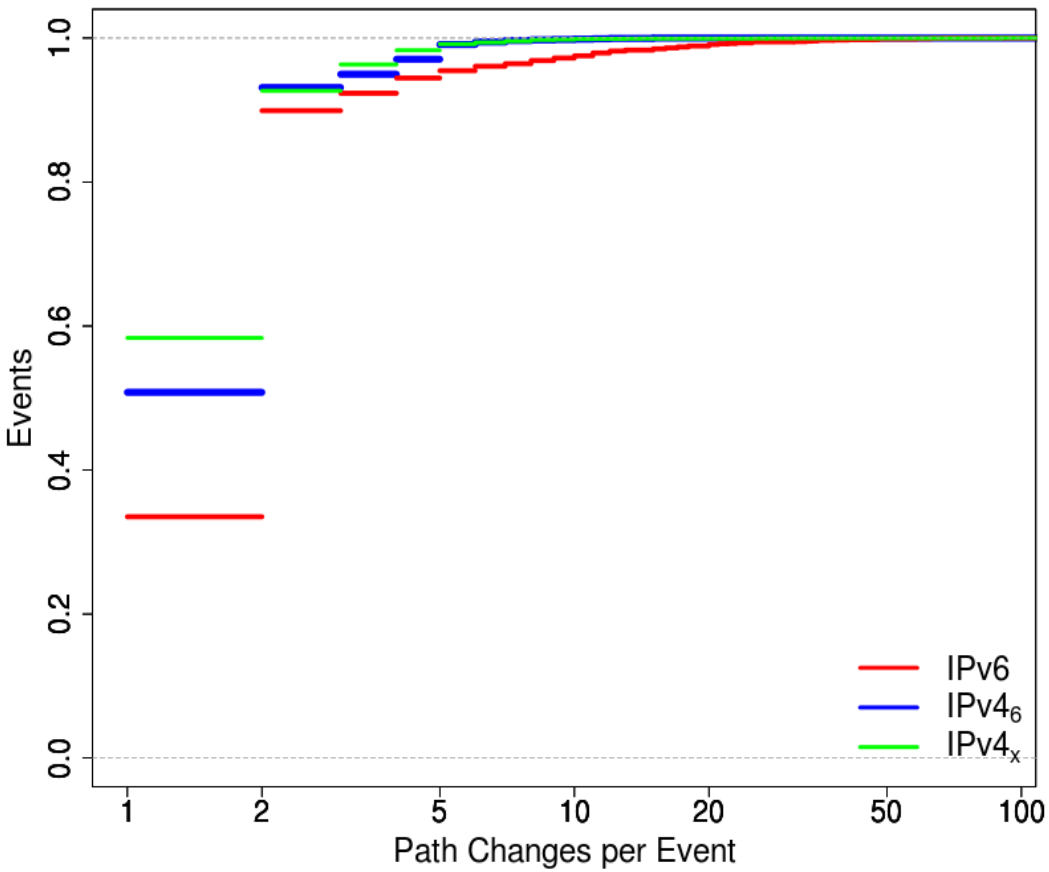
18% of IPv6
1.5% of IPv4$_6$

Have more than **0.5** changes per day

IPv4x are less stable → These paths are often longer (inter-continental connection to china).

How path changes distributed in time? (temporal aspect).

Grouping the path changes belong to each S/D pairs in to events based on how they appear close in time (1 hour time threshold).



Event size 1: **52%** of IPv4$_6$ and **34%** of IPv6

54% of events for **IPv6** consist of 2 path changes.

(very often rerouting and restoration)

Conclusion

- ✓ The path length do not significantly differ between IPv4 and IPv6.
- ✓ However, IPv6 paths change more frequently than IPv4 paths.
- ✓ Load balancing is more common for IPv6 than IPv4, most likely due to a simpler or more sparse topology that gives more equal-cost paths for ECMP load balancing.

Future work

Path similarities and temporal correlations in updates for IPv4 and IPv6 paths, to better understand if the two paths go over the same infrastructure.

Thank you

Questions?