Comparison of Performance over IPv6 vs. IPv4

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Background

• Address space in IPv4 not enough for growth
  • IANA has allocated all v4 addresses
  • Asian regional registry has begun "hyper-austerity"
  • Nortel sold 667,000 v4 addresses to Microsoft for $7.5 million, about $11/address.
Background

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- IPv4 and IPv6 will coexist for a long time
- Opportunity to select based on performance
## Background: Header Format

### IPv4 Header
- **Version**: 4
- **IHL**: 5
- **Type of Service**: 8
- **Total Length**: 16
- **Identification**: 16
- **Flags**: 3
- **Fragment Offset**: 11
- **Time to Live**: 8
- **Protocol**: 8
- **Header Checksum**: 16
- **Source Address**: 32
- **Destination Address**: 32
- **Options**: 0-32
- **Padding**: 0

### IPv6 Header
- **Version**: 6
- **Traffic Class**: 8
- **Flow Label**: 20
- **Payload Length**: 32
- **Next Header**: 8
- **Hop Limit**: 8
- **Source Address**: 128
- **Destination Address**: 128

### Differences
- **Fields name kept from IPv4 to IPv6**: Version, IHL, Identification, Flags, Fragment Offset, Time to Live, Protocol, Header Checksum, Source Address, Destination Address
- **Fields not kept in IPv6**: Type of Service
- **Field name and position changed in IPv6**: Options, Padding
- **New field in IPv6**: Traffic Class, Flow Label, Payload Length, Next Header, Hop Limit

Related Work

- Evaluating IPv6 on a large-scale network, Shiau, Li, Chao & Hsu, 2006
- Hopcount and E2E Delay: IPv6 versus IPv4, Zhou & Mieghem, 2005
- Understanding Current IPv6 Performance: A measurement study, Wang Ye & Li, 2005
- Identifying IPv6 Network Problems in the Dual-Stack World, Cho, Luckie & Huffaker, 2004
Performance: v4 versus v6

Dataset:

- Pings from three locations in the U.S.:
  - San Jose CA, Dallas TX, and Reston, VA.

- to ~7,000 globally distributed dual-stack nameservers

- for period of April – Dec. 2010

- 44 million measurements
Diagram of Probes to Nameserver

Akamai Server

96.17.144.33

2001:559:0:300::6011:9021

IPv4 network

IPv6 network

Nameserver

24.111.160.178

2001:4978:117:1::10
Summary Statistics on Latency

<table>
<thead>
<tr>
<th>Geo-region</th>
<th>Latency [ms]</th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
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<td>median</td>
<td>mean</td>
<td>95th percentile</td>
<td>v4</td>
<td>v6</td>
<td>v4</td>
<td>v6</td>
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<td>North America</td>
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<td>101</td>
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</tbody>
</table>
6to4 tunneling

from: en.wikipedia.org/wiki/6to4

A. Berger
## Native vs. Tunneled Latency

<table>
<thead>
<tr>
<th>Geo-region</th>
<th>Set of Nameservers based on v6 interface</th>
<th>Median Latency [ms]</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>v4</td>
<td>v6</td>
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<td>North America</td>
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<td>225</td>
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</tbody>
</table>
Time History: 8 Months, Latency, North America
Time History: 8 Months, Latency, Europe

![Graph showing latency over 8 months for various categories: v6 latency, v6 tunneled, v4 latency, v6 tunneled, v6 latency, v6 native, v4 latency, v6 native.]
Time History: 3 Days, Latency, Europe

- v6 latency; Europe, v6 tunneled
- v4 latency; Europe, v6 tunneled
- v6 latency; Europe, v6 native
- v4 latency; Europe, v6 native
Time History: 3 Days, Latency, Asia
Time History: 3 Days, Latency, Africa
Probes Between Dual-Stack Akamai Servers

- Deployment of dual-stack servers in:
  - 350 network-city pairs
  - 50 countries
  - all continents (except Antarctica)
- Interfaces are native IPv6
- Measurement taken every minute.
Latency between two Networks at Chicago, USA

Latency [ms]

June 05 June 06 June 07 June 08 June 09 June 10 June 11 June 12

v4 v6
Latency between two Networks at Milan, Italy

Latency [ms]

v4
v6
Packet Loss between Los Angeles and London

Loss [percent]

June 05, June 06, June 07, June 08, June 09, June 10, June 11, June 12

v4 — red line
v6 — green line
Distribution of difference in latency

Fraction

v6 latency minus v4 latency [ms]

Asia_Europe
Europe_NorthAmerica
Asia_NorthAmerica
Distribution of difference in latency
Focus on Australia

Fraction

v6 latency minus v4 latency [ms]

Australia_Europe
Australia_NorthAmerica
Australia_Asia
Distribution of difference in latency
Focus on South America

Fraction

v6 latency minus v4 latency [ms]

Europe_SouthAmerica
Asia_SouthAmerica
NorthAmerica_SouthAmerica
Summary

• Increasing pressure to deploy IPv6

• Compared performance over v6 vs. v4

  - Overall, latency and loss is higher on v6,
  - but not always, or for all locations.
  - Opportunity to select based on performance.
  - Potential for insights into network architecture.