Hardware and Software

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IPV6 – Performance, Capacity, Growth

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April 2012

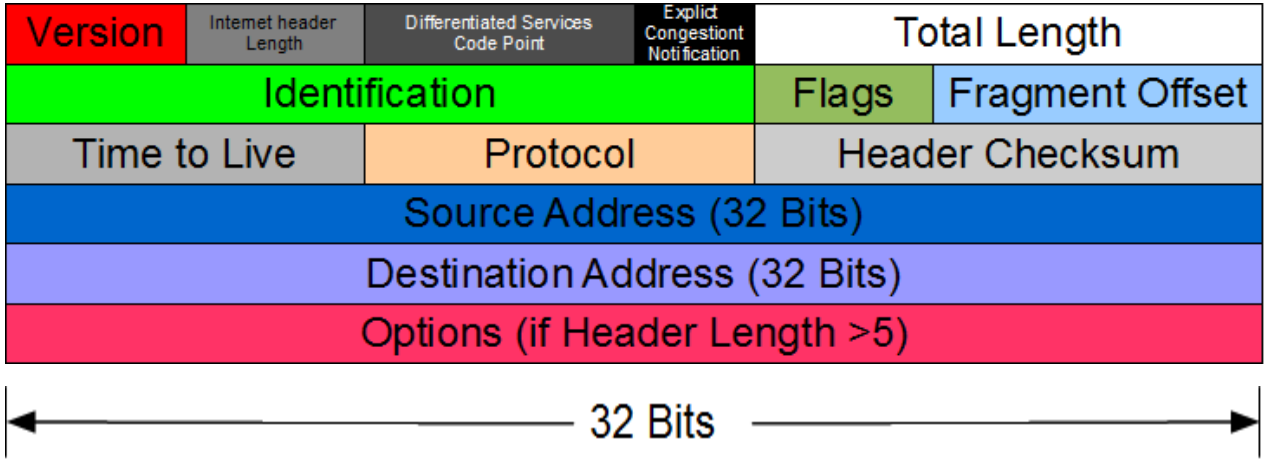
- A brief overview of IPV6
- Why IPV6 (Isn't IPV4 with NAT good enough?)
- Performance and Scale
- Implementation Options/Strategies
- What do we need to do to be ready
- IPV6 World Wide Launch 2012

Image If Every Piece of Paper had an IP address

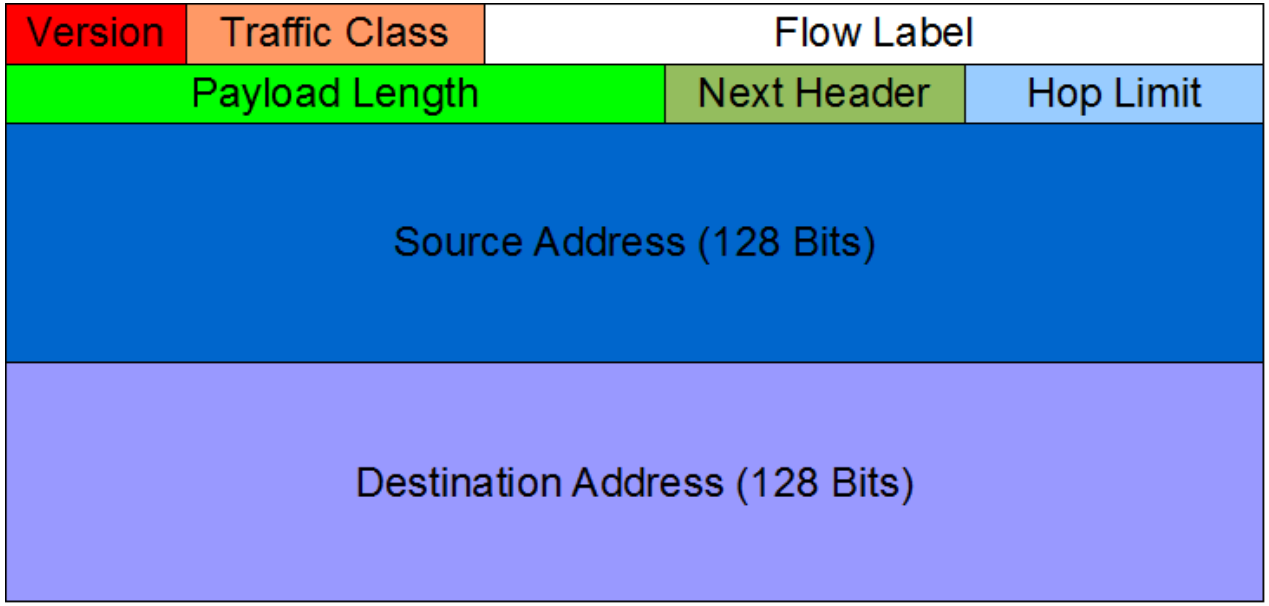
- RFC 2460 (1998)
- IP address size from 32 bits to 128 bits
- Header Format Simplification
- Improved Support for Extensions and Options
  - more efficient forwarding
  - less stringent limits
  - greater flexibility for introducing new options
- More Secure
- More Automation
  - Stateless Address Autoconfiguration (SLAAC)
- More Scalable

- Mobility
  - IPv6 Mobile, Triangular Routing
- Option Extensions
- Jumbograms
  - As large as 4294967295 ($2^{32}-1$) octets vs 65535 ($2^{16}-1$) octets
- Privacy Extensions
  - There is debate where this is a good thing
- Multicasting
  - Part of the base spec.

IPV4


Version
Internet header Length
Differentiated Services Code Point
Explict Congestiont Notification
Total Length
Identification
Flags
Fragment Offset
Time to Live
Protocol
Header Checksum
Source Address (32 Bits)
Destination Address (32 Bits)
Options (if Header Length >5)
32 Bits

IPV6


Version
Traffic Class
Flow Label
Payload Length
Next Header
Hop Limit
Source Address (128 Bits)
Destination Address (128 Bits)

192.169.0.15

8 Bits

YYY	YYY	YYY	YYY

4,294,967,296
Unique IP Addresses

fe80::a00:27ff:fe02:1252/10

16 Bits

XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Network Prefix
Describes Network Location

Interface ID
Provides Unique
Identifying Number

340,282,366,920,938,463,374,607,432,768,211,456
Unique IP Addresses

192.169.0.15

8 Bits

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Interface ID
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340,282,366,920,938,463,374,607,432,768,211,456
Unique IP Addresses

3ffe:1900:4545:3:200:f8ff:fe21:67cf

Colons separate 16-bit fields. Leading zeros can be omitted in each field as can be seen above where the field :0003: is written :3:. In addition, a double colon (::) can be used once in an address to replace multiple fields of zeros. For example:

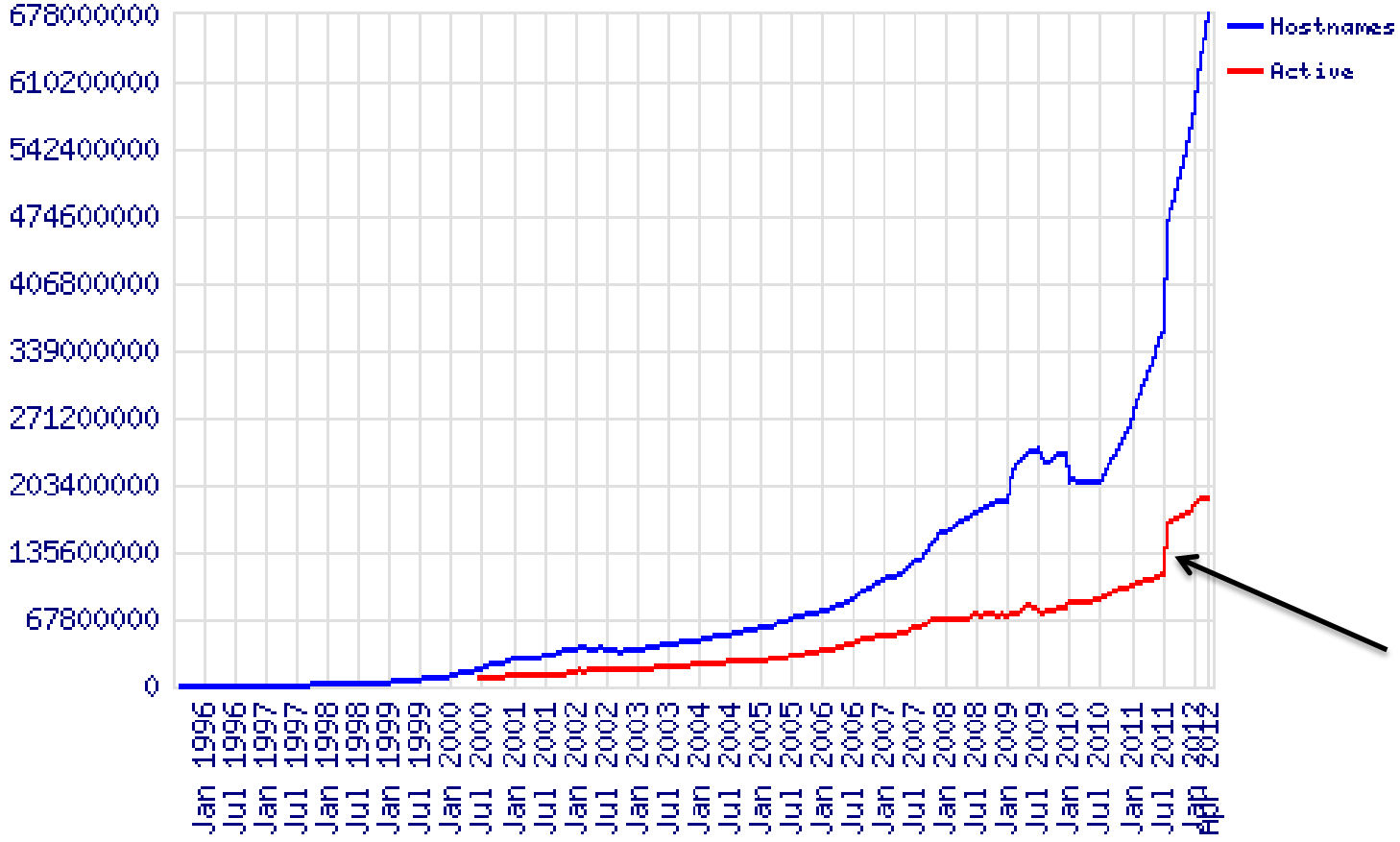
fe80:0:0:0:200:f8ff:fe21:67cf

can be written

fe80::200:f8ff:fe21:67cf

- IPv6 Only
  - Not to common
- Dual IP stack implementation
  - OS Level IPv4-to-IPv6 transition technology.
- IPv4-mapped IPv6 addresses
- Tunneling
  - encapsulates IPv6 packets within IPv4, in effect using IPv4 as a link layer for IPv6
- Automatic tunneling
  - 6to4 is recommended by RFC 3056
  - Teredo is an automatic tunneling technique that uses UDP encapsulation and can allegedly cross multiple NAT boxes
  - IPv6, including 6to4 and Teredo tunneling, are enabled by default in Windows Vista[49] and Windows 7
  - Most Unix systems implement only 6to4, but Teredo can be provided

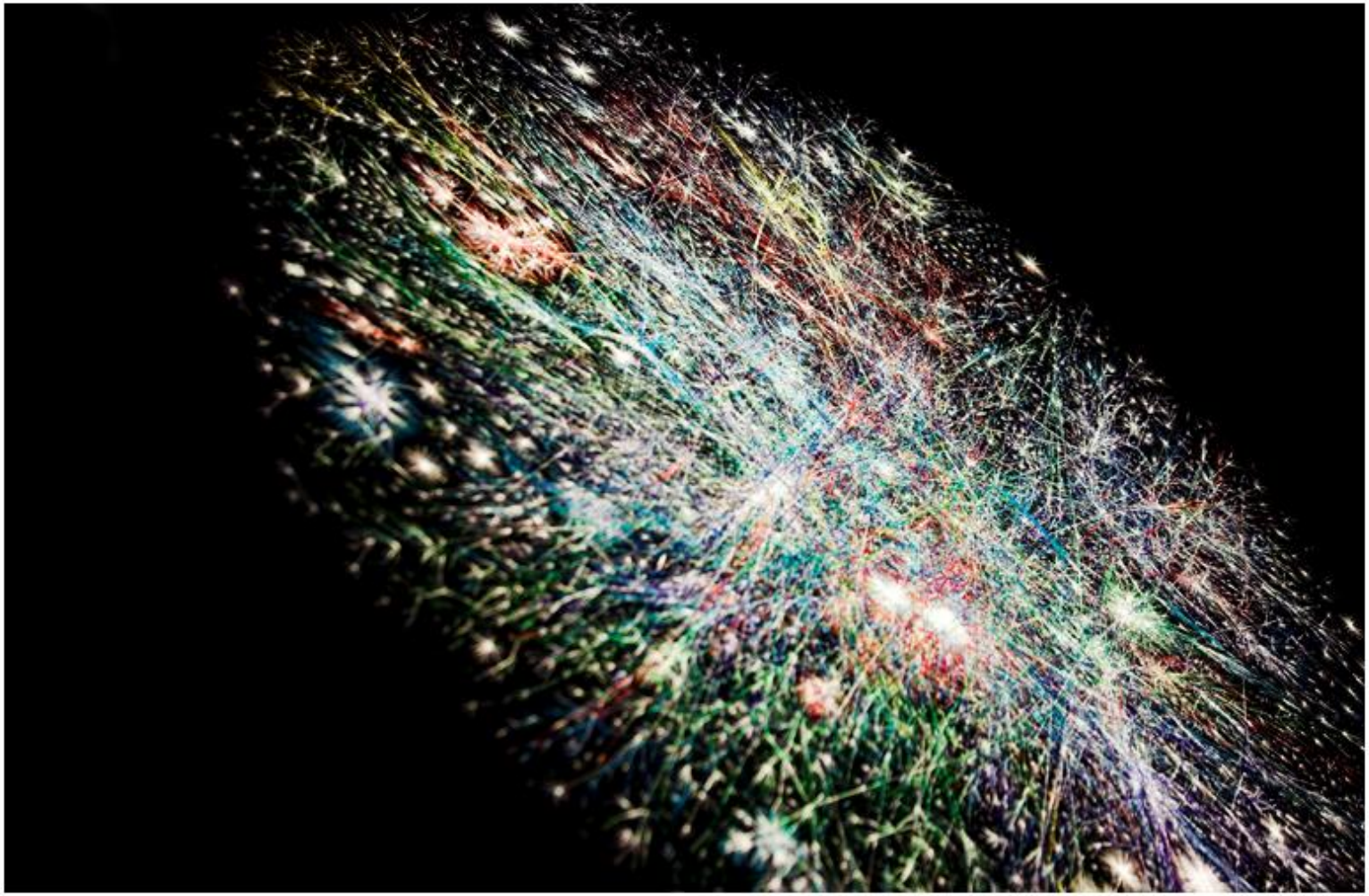
- IPv6 allows flexible addressing and drastically reduces the size of routing tables
- Companies, Organizations, and Countries who manage millions of IP addresses care
- ISPs and Border Gateway Protocol



China Telcom

Source: Netcraft.com

- The **Border Gateway Protocol** (**BGP**) is the protocol backing the core routing decisions on the Internet
- It maintains a table of IP networks or 'prefixes' which designate network reach-ability among autonomous systems (AS)
- Routers in the service provider core networks have to exchange information about several hundred thousand IP prefixes
- The Border Gateway Protocol routing information is usually exchanged between competing business entities -- Internet Service Providers (ISPs) -- in an open, hostile environment (public Internet).
- In BGP terminology, an independent routing domain (which almost always means an ISP) is called an autonomous system (AS).



- February 04, 2011 – The IANA (Internet Assigned Numbers Authority – www.iana.org) has allocated the last IP address blocks from the IPv4 central address pool.
- March 25, 2011 - Microsoft buys 666,624 IPv4 addresses from Nortel for $7.5 million ($11.00 per)
- April 21, 2011 – Tradeipv4.com – IPv4 Trading $4/
- December 4, 2011 - Bankrupt Borders sells 65,536 IP addresses at $12 a pop
  - Cerner Healthcare has agreed to pay $786,432 for the rights to a /16 block of IPv4 addresses

- Neighbor Discovery
  - Router discovery. This allows hosts to identify local routers.
  - Address resolution. This allows nodes to resolve a link-layer address for a corresponding next-hop address (a replacement for Address Resolution Protocol [ARP]).
  - Address auto-configuration. This allows hosts to automatically configure site-local and global addresses.
- Neighbor Discovery uses Internet Control Message Protocol for IPv6 (ICMPv6) messages that include:
  - Router advertisement
  - Router solicitation
  - Neighbor solicitation
  - Neighbor advertisement
  - Redirect. Sent by routers to indicate a better next-hop address to a particular destination for a sending node.

IPv6 Security

IPv4

- Designed to work in a friendly environment
- Well know security practices
- Complex Header is Compute Intensive
- Many Available and Know exploits
- Lots of Human (Manual) Intervention
- Reputation Databases

IPv6

- Designed to work in a hostile environment
- New Security concepts and considerations
- Simplified Header is lighter on Compute
- Fewer Know Exploits
- More Automation
- Not as many

- IPSEC is integral (Originally Mandatory)
- Unique Address (End-to-End Transparency)
- Authentication Header (AH)
- Encrypted Security Payload (ESP)
- Less Human Intervention
  - Less Mis-configuration
- Link-Local Address (LLA)
  - No Malicious Traffic can be remotely sent to the LLA

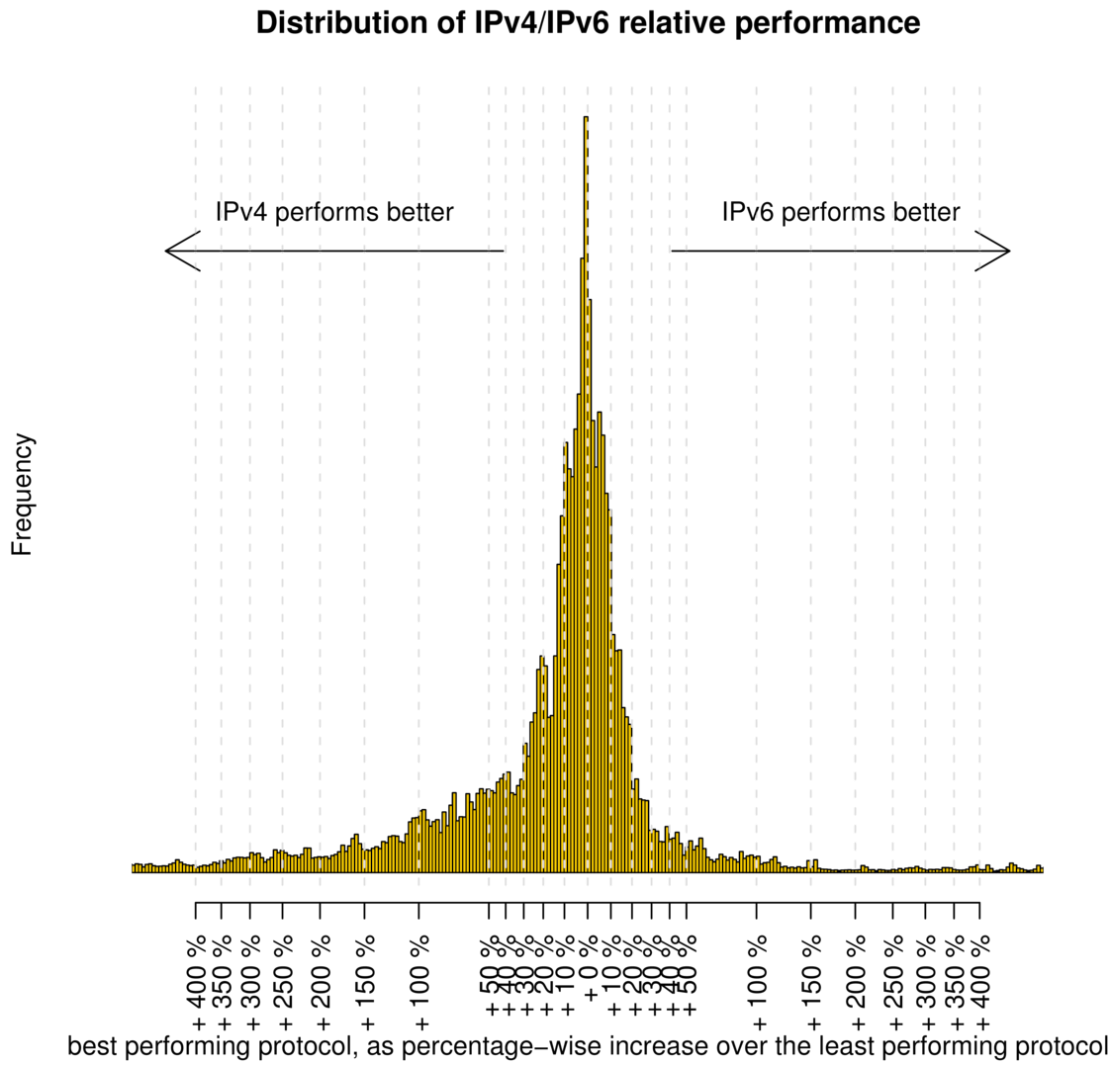
- Latent Threat - IPv6 Dual Stack is Automatic
  - (Mis-Configured or just plain NOT Configured)
- Neighbourhood Discovery (ND) spoofing Attacks
- Spoofing (If AH is not used)
- Network Denial of Service
- Privacy Extensions (NAT-like)
- Network Address Port Translation
  - Security Architecture and Methods
- Tunnels (Injection and Sniffing - If no IPSEC)
- Black-hats are Leading - White-hats are learning

- On 8 June, 2011, top websites and Internet service providers around the world, including Google, Facebook, Yahoo!, Akamai and Limelight Networks joined together with more than 1000 other participating websites in World IPv6 Day for a successful global-scale trial of IPv6. By providing a coordinated 24-hour “test flight”, the event helped demonstrate that major websites around the world are well-positioned for the move to a global IPv6-enabled Internet, enabling its continued exponential growth

- On IPv6 Day Yahoo saw about 140ms performance improvement to 6to4 users
- TCP Connection Setup is often faster on IPv6
- Adding Dual Stack did not degrade IPv4 (Checkpoint)
- Although it was not too difficult to do, the Performance gain was not on par with the amount of work required

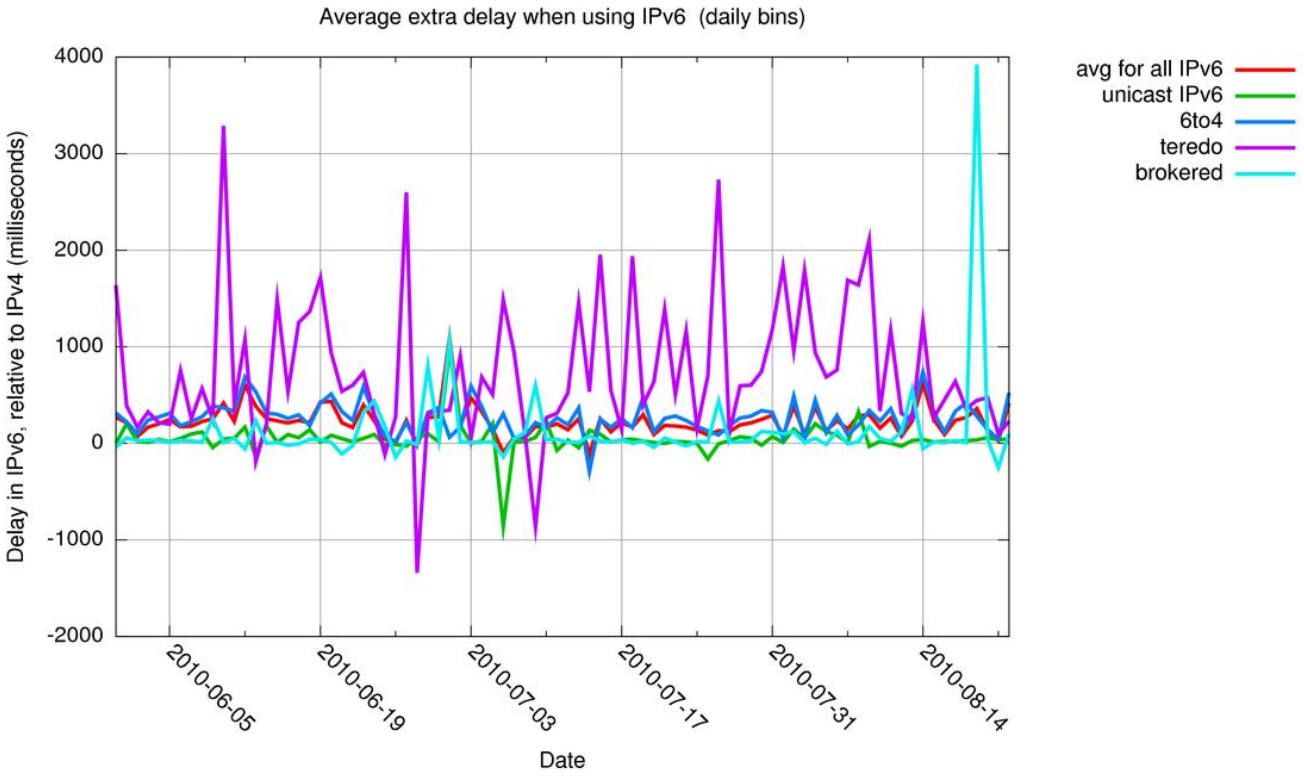
World IPv6 Day Testing www.ripe.net

- Ripe measured the performance of IPv4 and IPv6 between 40 vantage points and 46 World IPv6 Day participants.
- If one has to pick a winner, then the old protocol, IPv4, would win,
- But IPv6 often shows comparable or better performance.



World IPv6 Day Testing
www.ripe.net

This graph shows IPv6 performance as measured to www.ripe.net. These measurements show performance of native IPv6 on average being very close to IPv4.



- At Some points IPv4 is executed/process in Hardware
  - Offload Engines e.g.
- Poorly managed experimental IPv6 sites are one of the major hurdles to the perceived quality of the IPv6 Internet
- Experimental results show that even “native” networks reach more than 60% of all IPv6 prefixes through tunnels
- Testing is showing that CPU usage is essentially the same for a dual stack environment as compared to an IPv4 only environment, indicating that dual stack does not impact CPU usage

- Organized by the Internet Society, World IPv6 Launch on 6 June 2012 is intended to motivate organizations across the industry – including ISPs, hardware makers, and web companies – to prepare for and permanently enable IPv6 on their products and services as IPv4 address space runs out.
- http://test-ipv6.com/

- IPv6 is Important
- Dual Stack will be with us for a long time
- When IPv6 content is common place it its better to have Native IPv6
- The case for IPv6 is not performance
- We need to be diligent with Security (as always)
  - IPv6 is an opportunity to do it right and do it better

- http://www.worldipv6day.org/embeds/index.html
- IPv6 Theory, Protocol, and Practice - Pete Loshin
- http://searchtelecom.techtarget.com/feature/BGP-essentials-The-protocol-that-makes-the-Internet-work
- http://tools.ietf.org/html/rfc4271
- https://labs.ripe.net/Members/emileaben/measuring-world-ipv6-day-comparing-ipv4-and-ipv6-performance
- http://www.cs.princeton.edu/~yiwang/papers/iscc05.pdf
- http://www.worldipv6day.org
- www.netcraft.com

- www.cisco.com/web/strategy/docs/gov/IPv6perf_wp1f.pdf