IPv6 Basics
Share San Francisco Session 12152

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What is IPv6

Updated version of the Internet Protocol (IPv4)

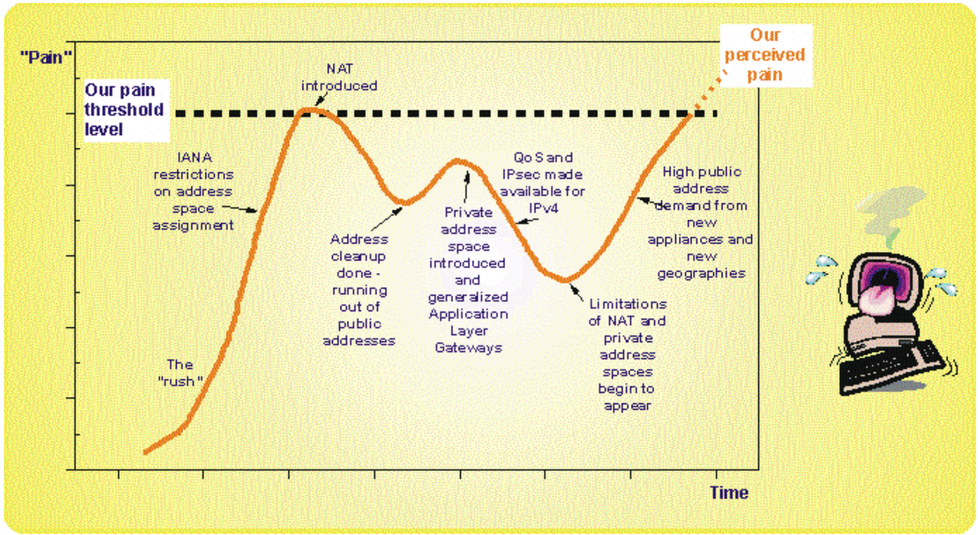
Defined in RFC 1752

New features

- Larger address space
- Encapsulation
- Class of service for audio, video, etc.
- Multicast support
- Authentication
- Encryption
- Automatic configuration/reconfiguration
- Support for non-IP protocols

Coexist with IPv4

Why Do We Need More Address Spaces?

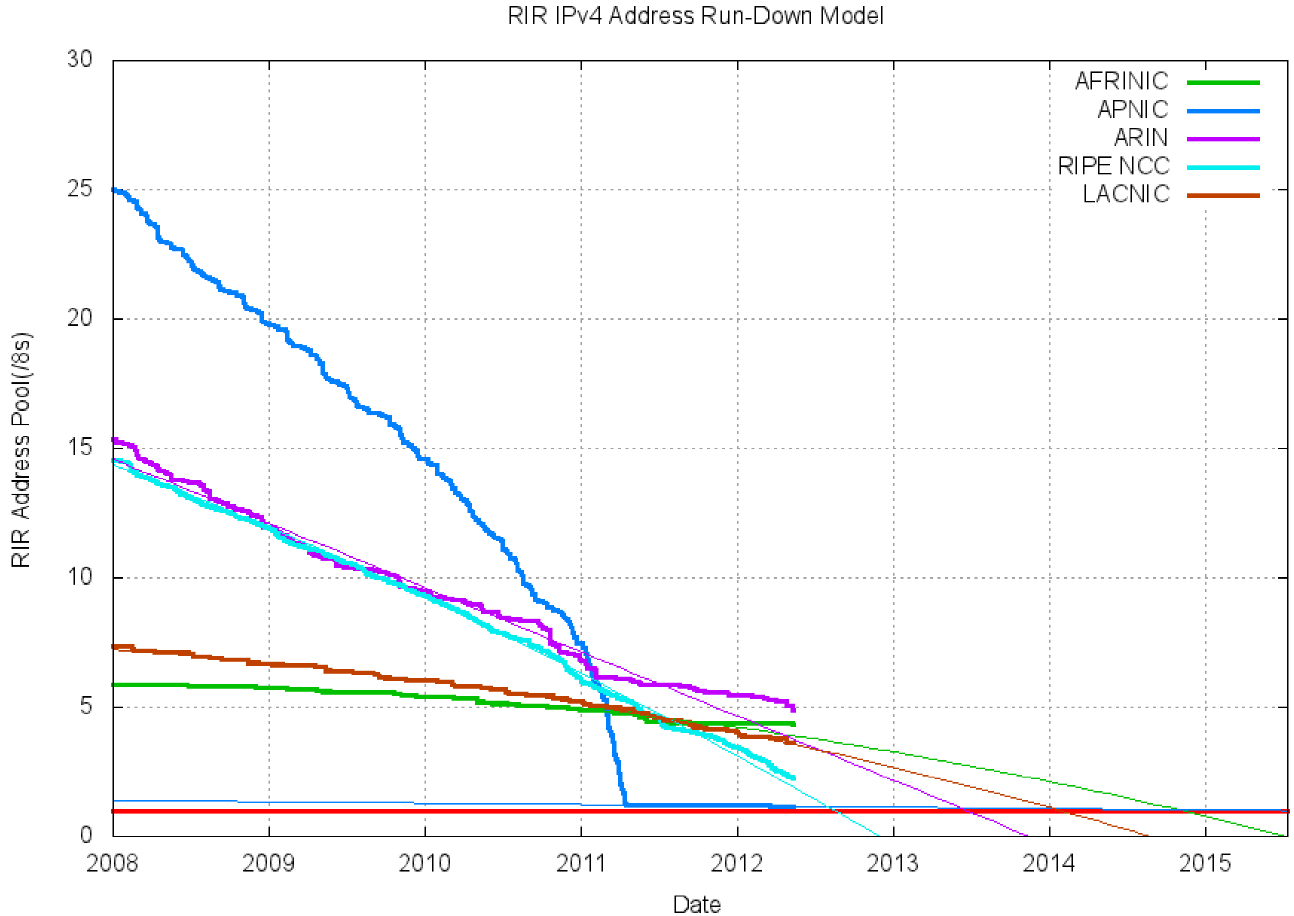


February 2011 – NRO (Number Resource Organization of the IANA) allocated the last IPv4 addresses to RIR

Microsoft paid $7.5M for Nortels 666,624 IPv4 addresses

Trading sites like Tradipv4.com have emerged

IPv4 address allocation by /8



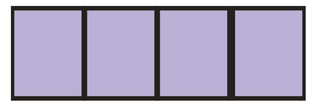
Applications are Changing

IPv6 Technology Scope

IP Service	*IPv4 Solution*	*IPv6 Solution*
Addressing Range	32-bit, Network Address Translation	128-bit, Multiple Scopes
Autoconfiguration	DHCP	Serverless, Reconfiguration, DHCP
Security	IPSec	IPSec Mandated, works End-to-End
Mobility	Mobile IP	Mobile IP with Direct Routing
Quality-of-Service	Differentiated Service, Integrated Service	Differentiated Service, Integrated Service
IP Multicast	IGMP/PIM/Multicast BGP	MLD/PIM/Multicast BGP,Scope Identifier

IPv6 Address Size

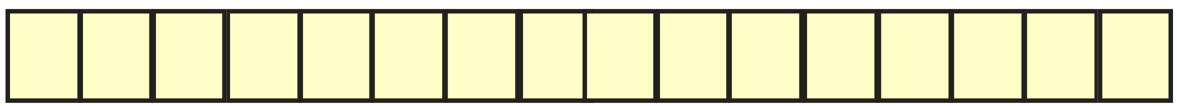
207.217.125.50/24



IPv4
(4 bytes - 32 bits)

2001:0DB8::15:219:D1FF:FE10:74EE/64

C L



IPv6
(16 bytes - 128 bits)

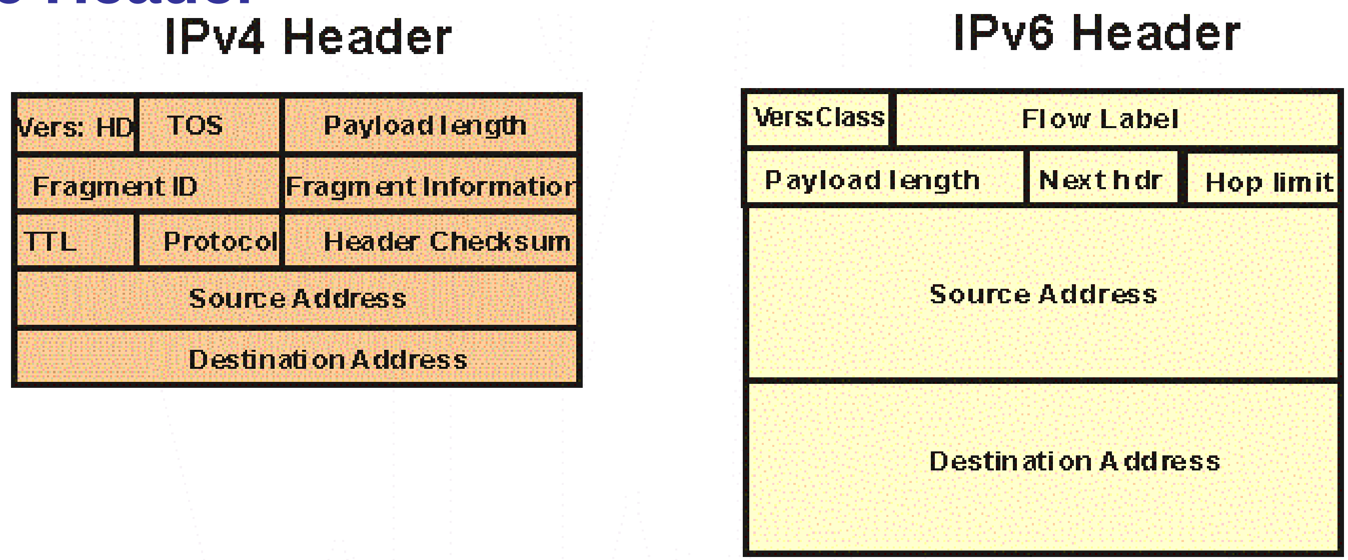
Asia feeling address squeeze fastest due to receiving addresses last

Mobil digital telephony pressuring existing IPv4 network

ICANN continues to handle overall addressing issues

Shortcuts like dropping Leading zeros or Contiguous zeros permittec

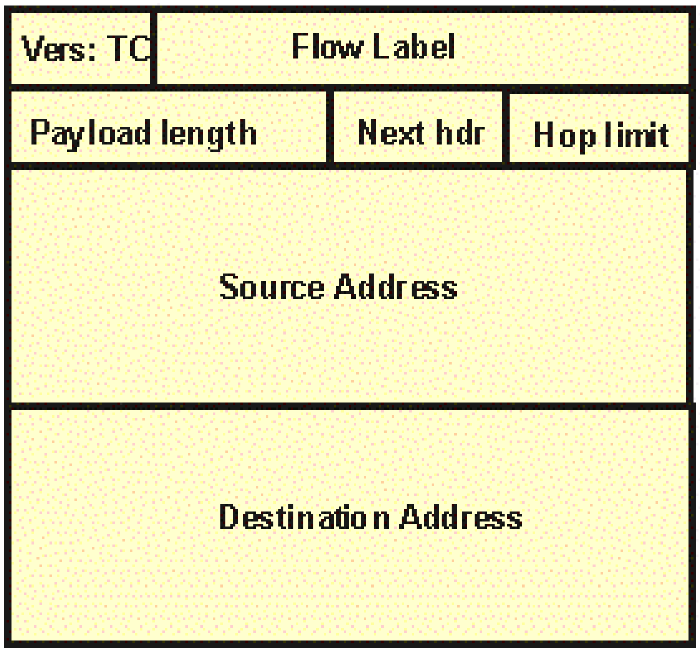
IPv6 Header



IPv4 header is 20 bytes : IPv6 header is 40 bytes
Address increased from 32 to 128 bits
Fragmentation fields moved out of base header
Header checksum
Time to Live replaced with 'Hop Limit'
Protocol replaced with 'Next Header'
TOS replaced with 'Flow Label'
Alignment changed from 32 to 64 bits

IPv6 Flow Label

IPv6 Header



Identifies datagrams that require special quality of service

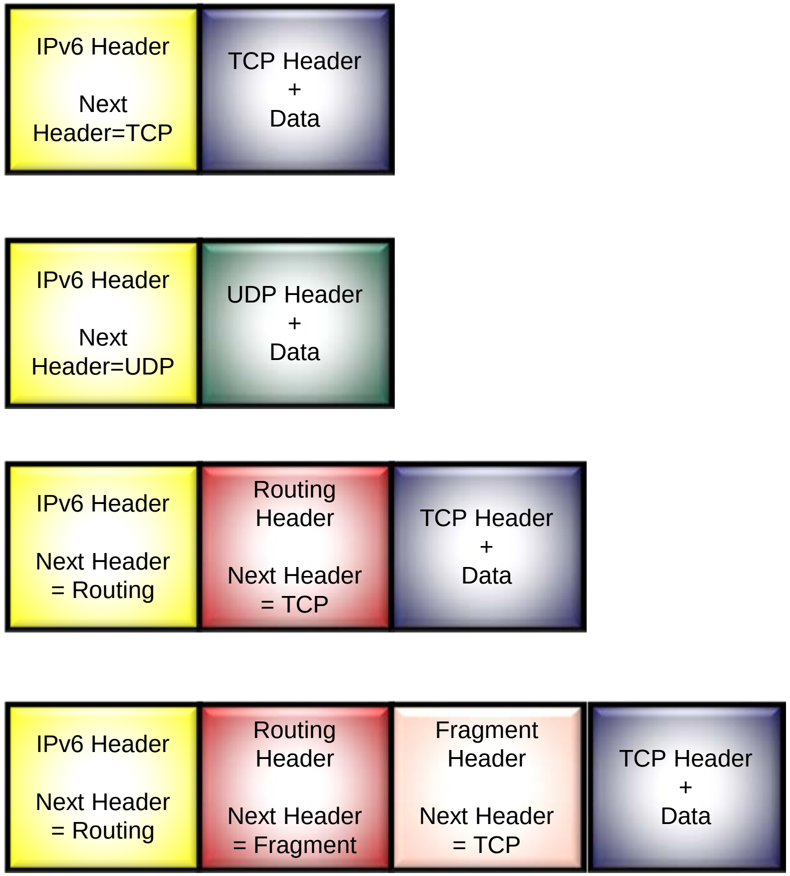
May be used to tie particular traffic to pre-allocated network resources

Zero value indicates no flow label

Other protocols like RSVP may provide information for the Flow Label

TC class identifies delivery of priority packets
- Values 0-7 : TCP flow controlled packets
- Values 8-15 : real time packets

IPv6 Extension Headers



Hop by hop options = 0
Information for all devices in the path

Destination options = 60
Destination information for all devices

Routing = 43
Specify route for a datagram

Fragment = 44
Breaks datagram if MTU exceeded

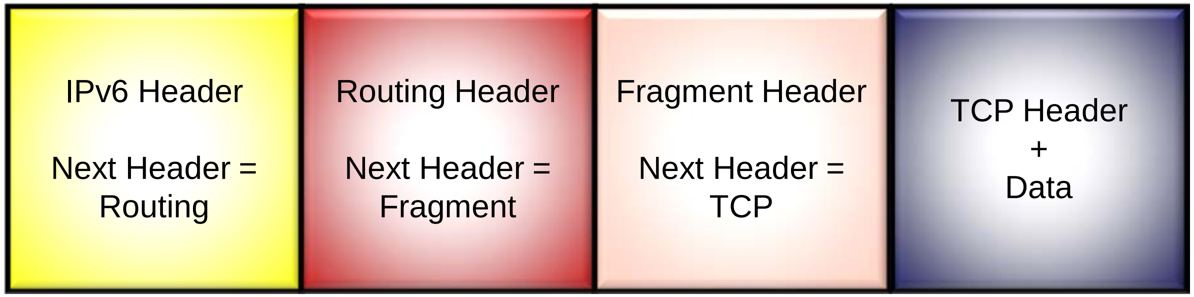
Encapsulating Security Payload = 50
Encryption type and parameters

Authentication = 51
Hash type and parameters

Destination options = 60
Information only for destination host

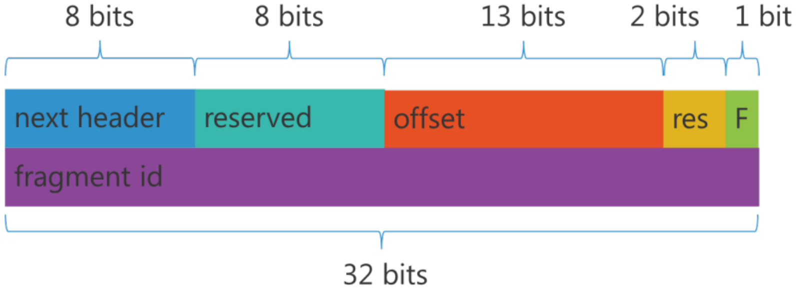
Protocols
TCP = 6, UDP = 17, RSVP = 46, ICMP = 58

IPv6 Fragmentation Header



In IPv4 Routers handled fragmenting frames

If needed, IPv6 hosts fragment frames:
- Increased guaranteed minimum MTU of 1280
- Pat MTU discovery to find maximum fragment size for a path



IPv6 Security

IPv6 Header Next Header = Routing	ESP Header Next Header = TCP	TCP Header + Data	TCP Header + Data	ESP Trailer

Authentication Header (AH)
- Packet authentication and integrity without confidentiality
- Algorithm independent (MD5) (SHA1)

Data Privacy Header (ESP)
- Message including next headers encrypted
- Mandatory support of DES-CBC
- May also include AH with no separate header

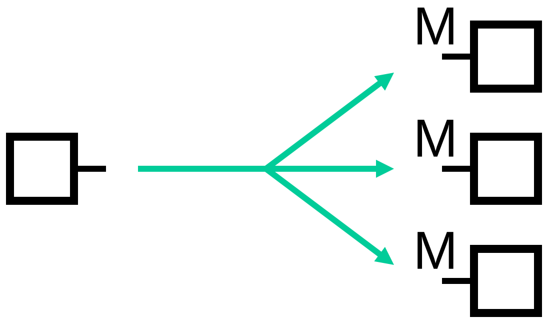
IPv6 Address Types

unicast:

for one-to-one communication

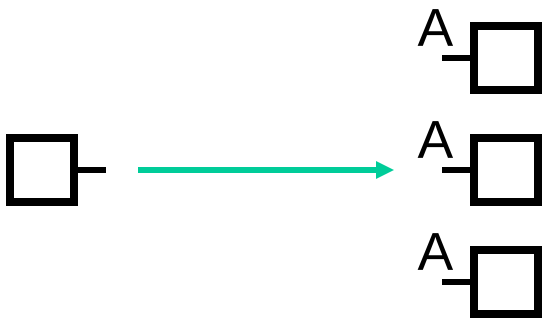
multicast:

for one-to-many communication

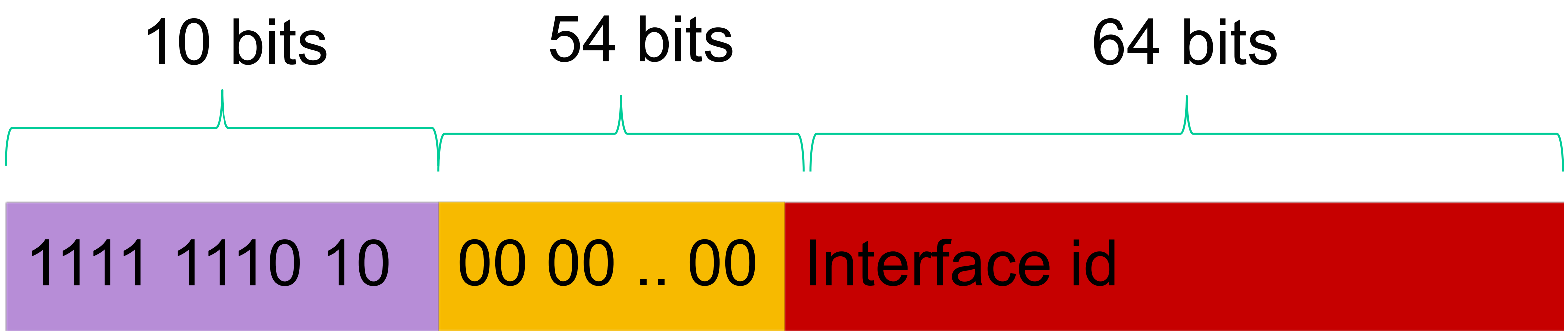


anycast:

for one-to-nearest communication



Link Local Address



- FE80 prefix
- Similar to IPv4 APIPA (169.254.0.0/16)
- Only for on-link communication, not routable
- Used for
  - Auto configured addresses
  - Neighbor discovery process

Multicast Address

8 bits	4 bits	4 bits	8 bits	8 bits	64 bits	32 bits
1111 1111	flags	scope	reserve	plen	net prefix	group prefix

Flags

0: well known address, 1: transient address

Scope

1: Node Local (FF01::1), 2: Link Local (FF02::1)

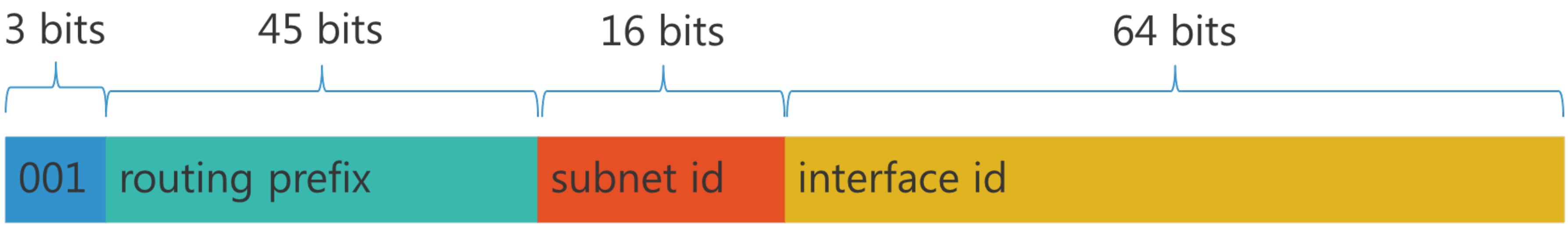
All routers group: FF02::2)

Group ID

1: All nodes, 2: All routers, 101: all NTP servers

- Multicast replaces Broadcast
- All IPv6 nodes must support multicast
- You must enable IGMP snooping

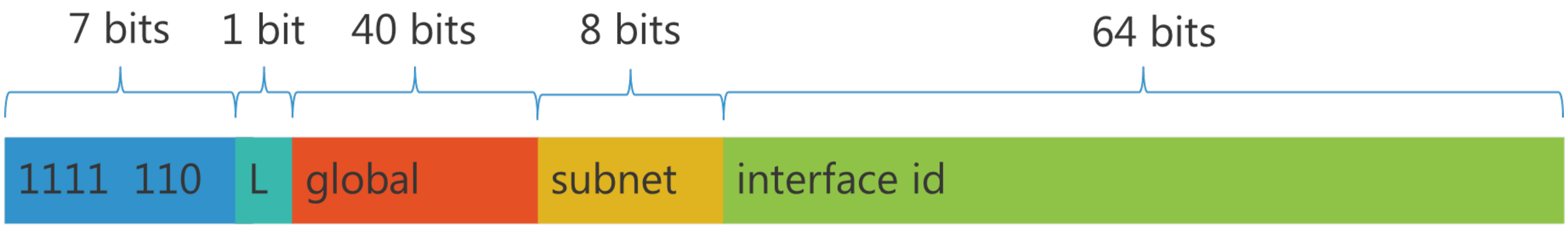
Global Unicast Address



Address Type	Binary Prefix	Prefix
Unspecified	000…0	::/128
Loopback	0000…01	::1/128
ULA	1111 110	FC00::/7
Assigned to RIRs	001	2003:/3
Global Unicast	Everything else!!	

Korea: 2001:0200 – 099F
ATT: 2001:0408/32
Verizon: 2001:0506:0000/48

Unique Local Address (ULA)



- L=1
- FC00::/7 prefix
- Local or site local communications
- Most likely will be unique and not expected to be routable
- Well known, somewhat like the RFC1918

Windows and IPv6

IPv6 is preferred

Nameserver query

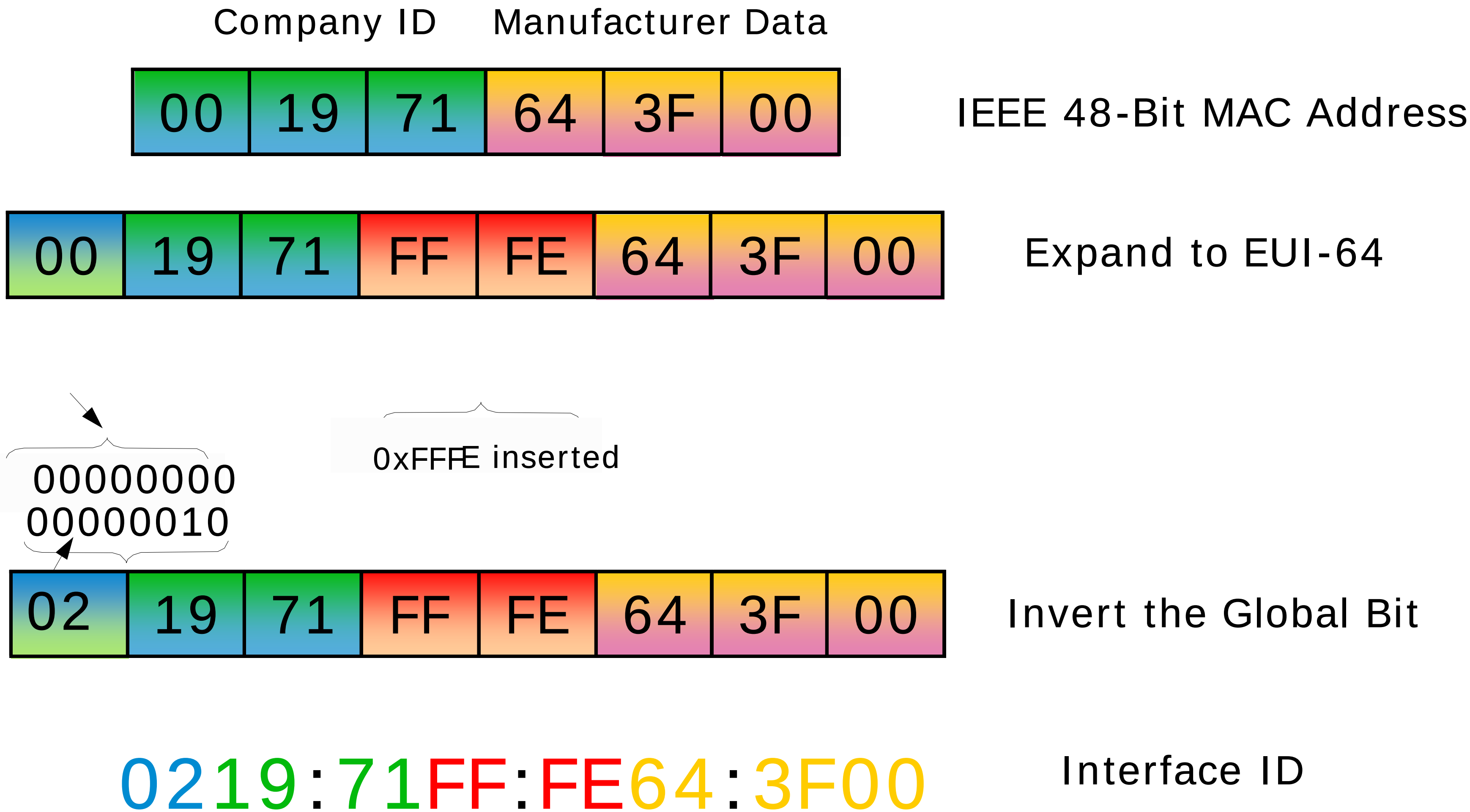
Try to reach IPv6

Try to reach IPv4

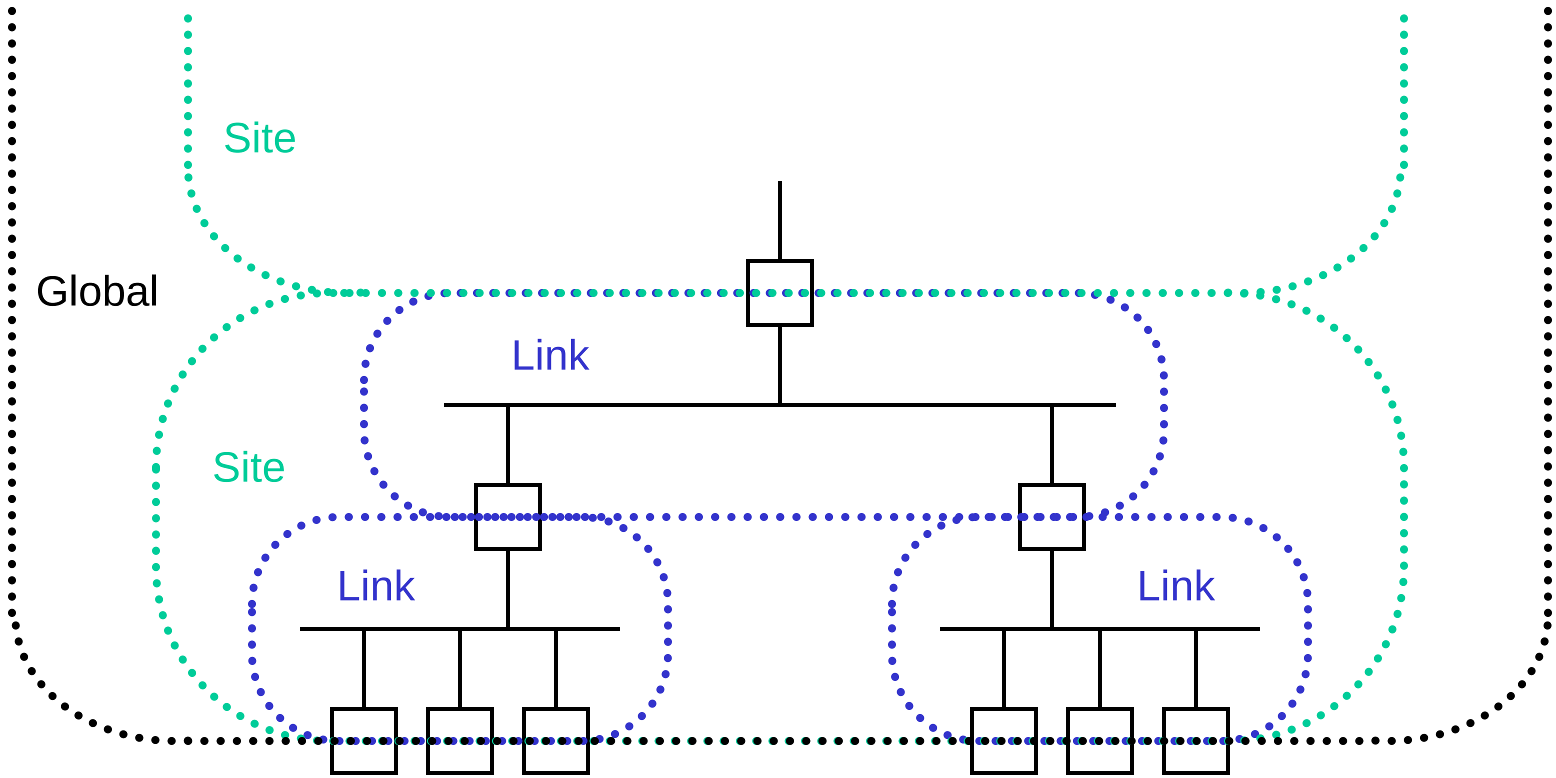
Timeout

```
Wireless LAN adapter Wireless Network Connection 2:

   Media State . . . . . . . . . . . : Media disconnected
   Connection-specific DNS Suffix  . :

Wireless LAN adapter Wireless Network Connection:

   Media State . . . . . . . . . . . : Media disconnected
   Connection-specific DNS Suffix  . :

Ethernet adapter Local Area Connection:

   Connection-specific DNS Suffix  . : hawaii.rr.com
   Link-local IPv6 Address . . . . . : fe80::6947:83b1:88e2:73d4%13
   IPv4 Address. . . . . . . . . . . : 192.168.1.146
   Subnet Mask . . . . . . . . . . . : 255.255.255.0
   Default Gateway . . . . . . . . . : 192.168.1.1

Ethernet adapter Bluetooth Network Connection:

   Media State . . . . . . . . . . . : Media disconnected
   Connection-specific DNS Suffix  . :

Tunnel adapter Teredo Tunneling Pseudo-Interface:

   Connection-specific DNS Suffix  . :
   IPv6 Address. . . . . . . . . . . : 2001:0:4137:9e76:10f7:1e4b:9d69:43f8
   Link-local IPv6 Address . . . . . : fe80::10f7:1e4b:9d69:43f8%15
   Default Gateway . . . . . . . . . : ::

Tunnel adapter isatap.hawaii.rr.com:

   Media State . . . . . . . . . . . : Media disconnected
   Connection-specific DNS Suffix  . : hawaii.rr.com
```

Interface ID from MAC



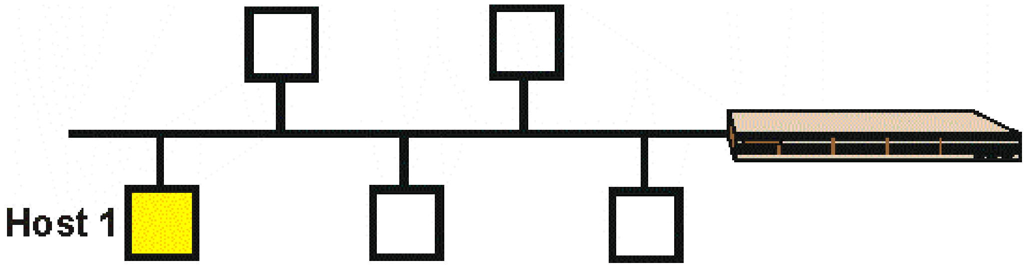
Boundaries



IPv6: Autoconfiguration

- Combination
  - ARP : ICMP router discovery : ICMP redirect
- Neighbor discovery
  - Multicast and unicast datagrams
  - Establishes MAC address on same network
  - ICMPv6 router solicitation
  - ICMPv6 router advertisement
  - ICMPv6 neighbor solicitation
  - ICMPv6 redirect
- ICMPv6 includes IGMP protocol for Multicast IP
  - Reduces impact of finding hosts
- Stateless: router configures a host with IPv6 address
- Stateful: DHCP for IPv6
- Link Local Address: IPv6 connectivity on isolated LANs

IPv6 Auto-configuration



Host 1 comes on line and generates a link local address

Host 1 sends out a query called neighbor discovery to the same address to verify uniqueness.   If there is a positive response a random number generator is used to generate a new address

Host 1 multicasts a router solicitation message to all routers

Routers respond with a router advertisement that contains an aggregatable global address (AGA) prefix and other information

Host 1 automatically configures its global address by appending its interface ID to the AGA

Host 1 can now communicate

Changes Needed to Implement IPv6

Hosts

- Implement IPv6 code in operating system
- TCP/UDP aware of IPv6
- Sockets/Winsock library updates for IPv6
- Domain Name Server updates for IPv6

Domain Name Server (DNS)

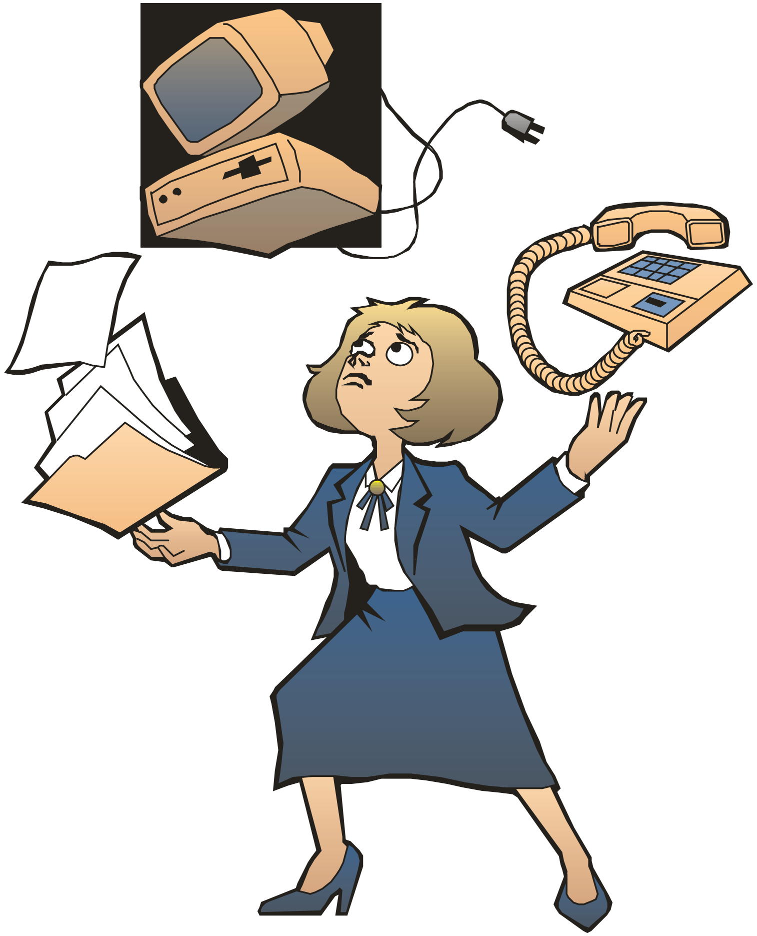
- Many products already support 128 bit addresses
- Uses 'AAAA' records for IPv6
- IP6.INT (in_addr_arpa in IPv4)

Routers

- IPv6 forwarding protocols
- Routing protocols updated to support IPv6
- Management needs to support ICMPv6
- Implement transition mechanisms

IPv6 Protocol Status

- RIPv6 - Same as RIPv2
- OSPFv6 - Updated for IPv6
- EIGRP - Extensions implemented
- IDRP - Recommended for exterior protocol over BGP4
- BGP4+ - Preferred implementation in IPv6 today



Considerations

IPv6 Deployment

customer

- Network impact is minimal, the user is no-perceived.
- IPv6 users visit IPv4 service.
- Enhance the user experience of IPv6

cost

- Weighed between the cost of reconstruct and upgrade, choose the time to introduce
- IPv6 mobile services, dual stack terminal cost, single-stack terminal need large volume of NAT-PT.

service

- Start from closed business, interoperability is undemanding, easy to deploy.
- IPv4/IPv6 will be long-term coexistence.
- Integrated service intercommunication

network

- Reduce impact to the network, consider build a new private network, using an independent IPv6 Gateway to access IPv6 users
- Consider the end-to-end deployment of IPv6.

Applications

NTT Technical Review

- NTT ‘Earthquake Alert Service
  - On detecting P-wave an S-wave alert is delivered
  - IPv6 Multicast is adopted
    - Low delay delivery is achieved
    - IPv4 is not suitable for a push-type service due to NAT
- Sensor Arrays
  - 6LoWPAN (RFC 4919and 4944) based networks
  - Routing over low poer and Lossy Networks
    - Sensors on aging infrastructure
    - Fire sensors
- Chinese Academy of Sciences
  - Integrated wireless, control and precision agriculture technologies linked
    - Accurate watering of farmland
    - Water/soil pollution monitoring

IPv6 Deployment

China Telecom	2009 deploy Experimental IPv6 network, in 2010 commercialized. **T**he Telecommunications Research Institute draft guidance of large-scale IPv6 introduction, Hunan Telecom starts IPv6 test point. In 2010 Shanghai World Expo and Guangzhou Asian Games displayed IPv6.
China mobile	3G mobile broadband deploy IPV6, to resolve the limitation of private network address space. The original IPv4 reserve is very limited, the mobile broadband has more requirements. 2010, China mobile deployed 3G IPv6 commercial services.
China Unicom	2010 commercial-scale test users reached 20,000, China Unicom built a new type IPv6 access network
France Telecom	2009 Q2-Q3 FT deployed Enterprise IPV6, in 2010 deployed the family IPv6 Livebox, the Core network maintains IPv4 temporarily. Poland subnet has strong interest, actively discusses the deployment of IPv6 solution, requests the current network equipment support dual-stack.
Japan	IPv6 large-scale commercial from 2005, package the new concept of next-generation network, provide high-speed network services based on IPv6, leveraging next-generation network evolution, and promote various IPV6 new technologies and new services.
America	The U.S. government required government and Defense departments migrate telecommunication network into IPv6 platform before the summer of 2008. It led that the United States new applied IPv6 addresses reached 14,729 pieces, the world's ranking jumped from No. 11 to No. 1.

NTT and IPv6

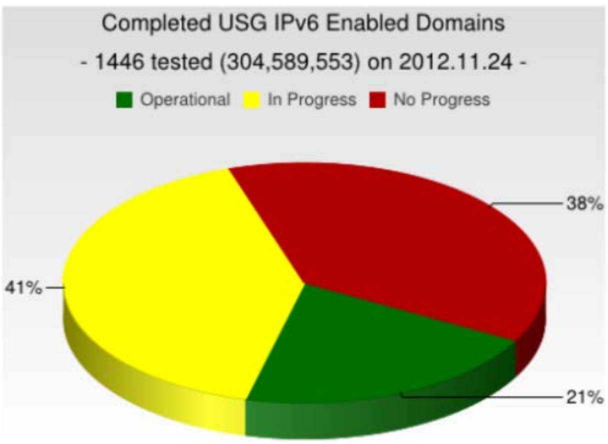
1.Latency Statistics(ms)

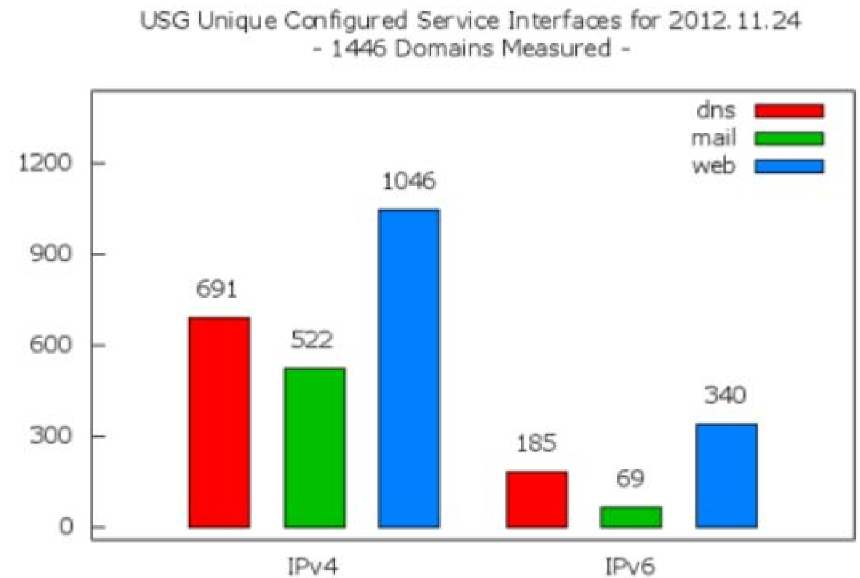
Month	Intra-Japan (25ms)	Intra-Asia (95ms)	Intra-US (60ms)	Intra-Europe (35ms)	Trans-Atlantic (90ms)	US-Japan (130ms)	Japan-Europe (300ms)
Oct 2012	10.39	51.17	44.30	23.26	72.31	105.49	262.25
Nov 2012	9.68	52.53	44.17	23.36	72.01	103.24	262.07
Dec 2012	10.18	57.55	43.88	23.39	71.99	93.63	224.09

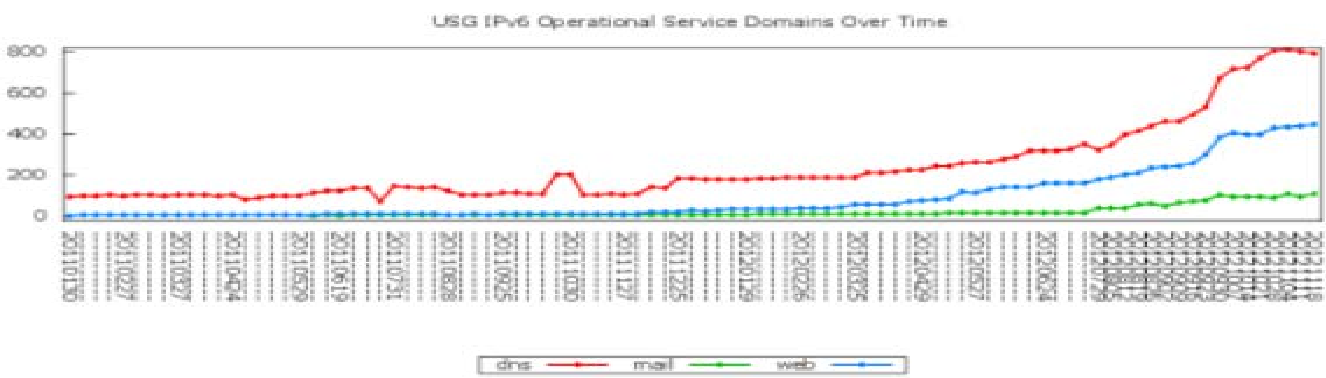
2.Packet Loss Statistics(%)

Month	Intra-Japan	Intra-US	Trans-Atlantic	Japan-US	Intra-Asia	Intra-Europe	Japan-Europe
Oct 2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov 2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec 2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00

IPv6 and the US Government







Global Crossing

- October 2005 IPv6 natively deployed
- End-to-end security, auto-configuration and mobile IP networking enable next generation of Internet services and applications.
- Meets enhanced requirements of government purveyors and systems integrators as they comply with federal mandates.
- IPv6 simplifies mobile IP networking with improved routing and security capabilities
- MPLS VPN is fully IPv6
- Ireland's national research network leverages the IPv6 network

- As a leading provider of IPv6 enablement, Global Crossing has been helping customers configure IPv6 across their networks for the past 10 years. As a sign of continuing commitment to successful IPv6 implementations, Global Crossing has dedicated its team of IPv6 experts to answering questions of enterprises in the process of IPv6 deployment. Interact with the Global Crossing team by:

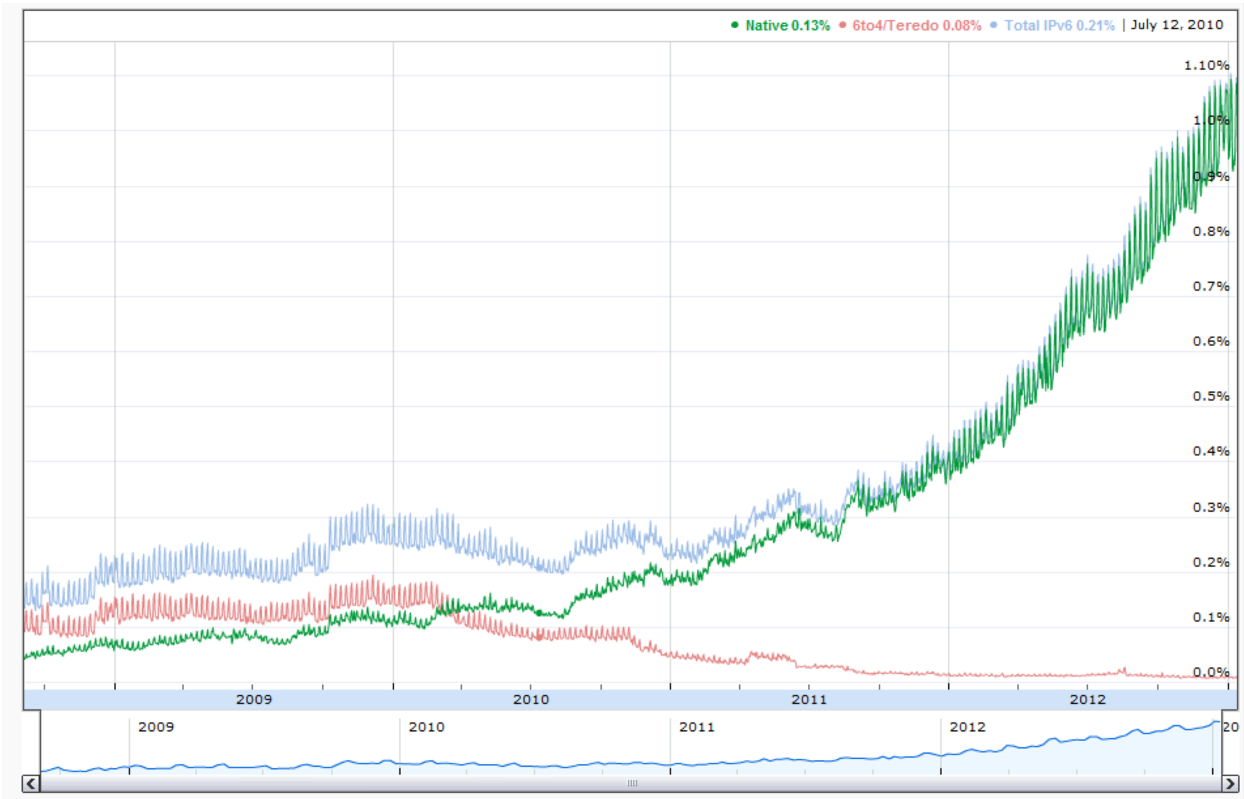
Comcast and IPv6

- 100 Million IP Addresses (doesn't include Digital voice/data)
- Exhaused NET 10 (RFC1918) for managing cable modems
  - This space exhaused in 2005
- In the control plane all devices need to be remotely managed so NAT is not an option
- Move to IPv6 will not happen overnight
  - Ask ARIN for address spaces every time they can justify it
  - Use already located non-globally routed IPv4 address space
  - Subdivide the network into independently managed domains…loss of global visibility
- Deployment Plans
  - Started in 2005
  - Start with control plane for the management and operation of edge devices
  - Dual stack t the core, IPv6 t the edges

Google and IPv6

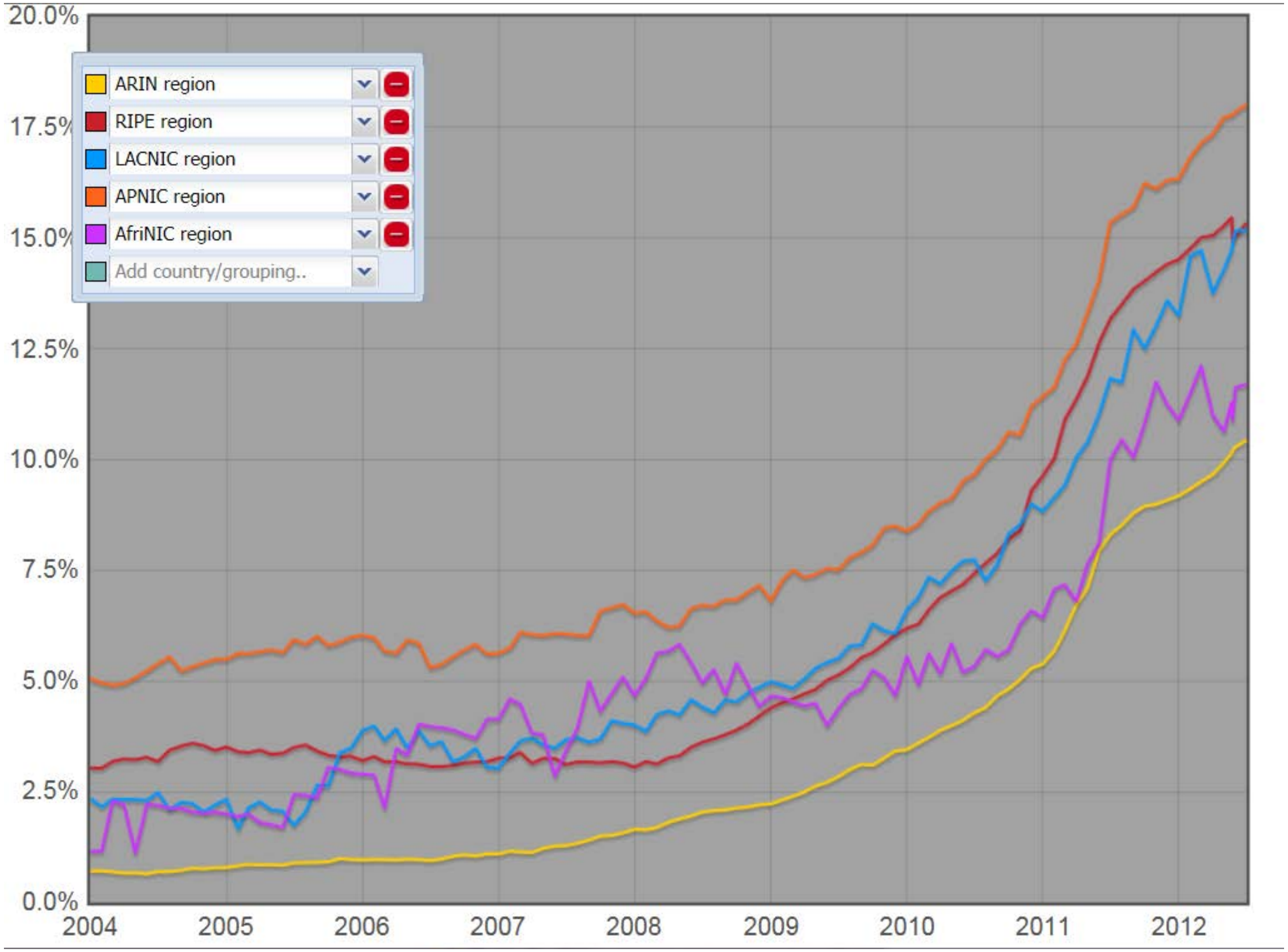
- http://www.google.com/intl/en/ipv6/
- **Access Google services over IPv6**
- At Google, we believe that IPv6 is essential to the continued health and openness of the Internet – and that by allowing all devices on a network to talk to each other directly, IPv6 will enable innovation and allow the Internet's continued growth. Typical Google users do not need to do anything to prepare for IPv6, but we are working with network operators to support the transition.
- In March 2008, we began offering Google search over IPv6 on IPv6-only websites like ipv6.google.com (IPv6 connection required), but other Google products were not generally available over IPv6.
- That's why we created Google over IPv6. If you operate a network that supports IPv6, we may be able to enable Google over IPv6, letting you give users seamless access to most Google services over IPv6 simply by going to the same websites they usually use, such as www.google.com.

Google IPv6 Statistics



Google Statistics on IPv6 continuous usage
http://www.google.com/ipv6/statistics.html#

IPv6 Networks Advertised



IPv6 Transition Methods

Tunneling

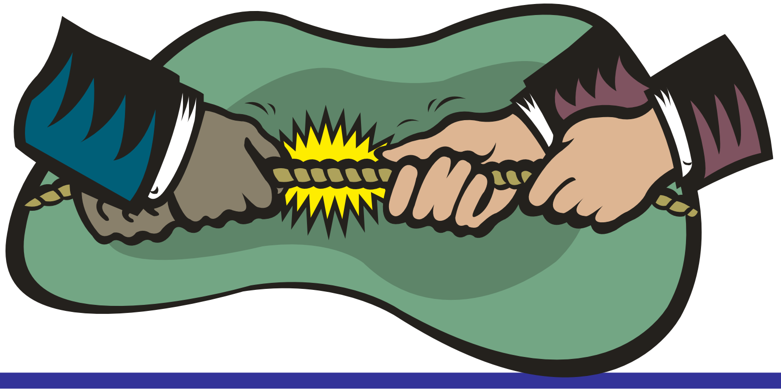
IPv6 only systems communicate across an IPv4 network

Header translation

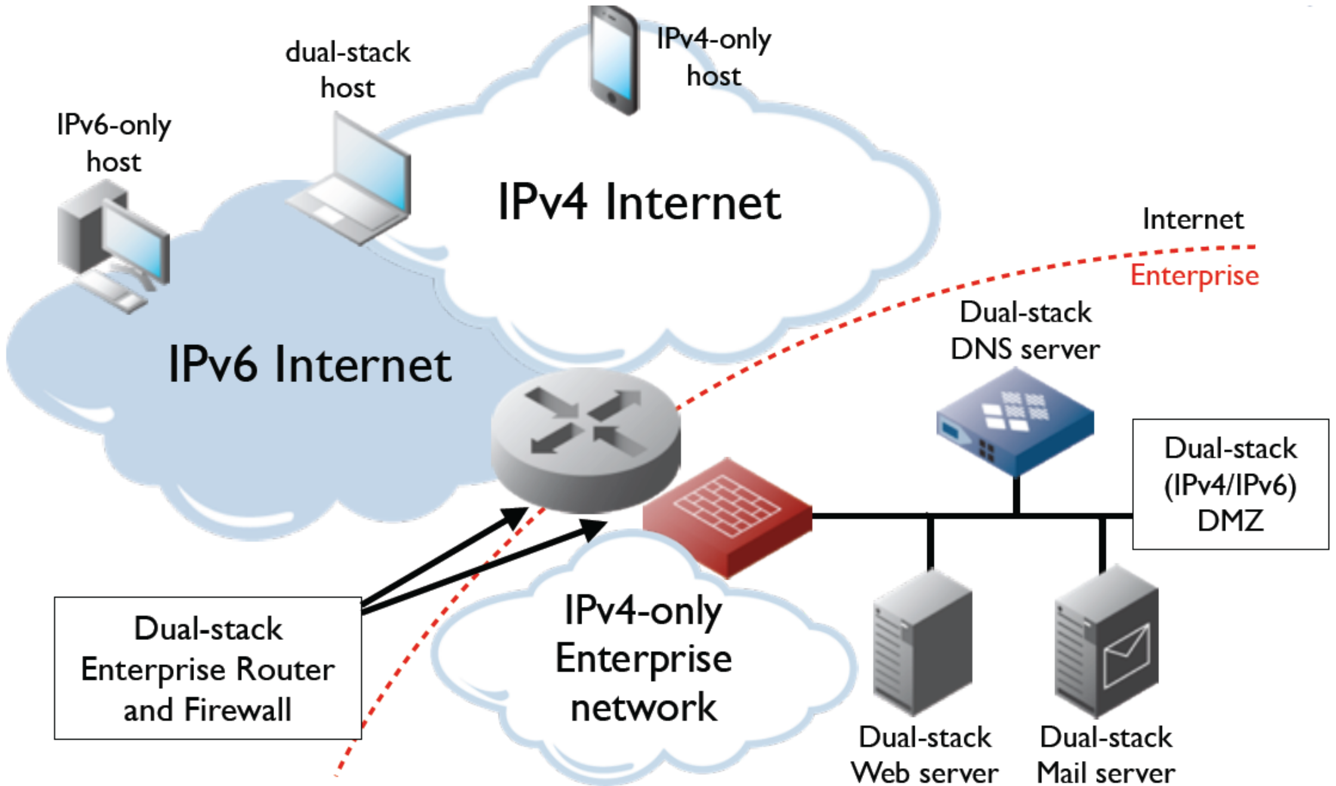
IPv6 system communicates with an IPv4 system

(header conversion, transport relay, application proxy)

Dual Stack

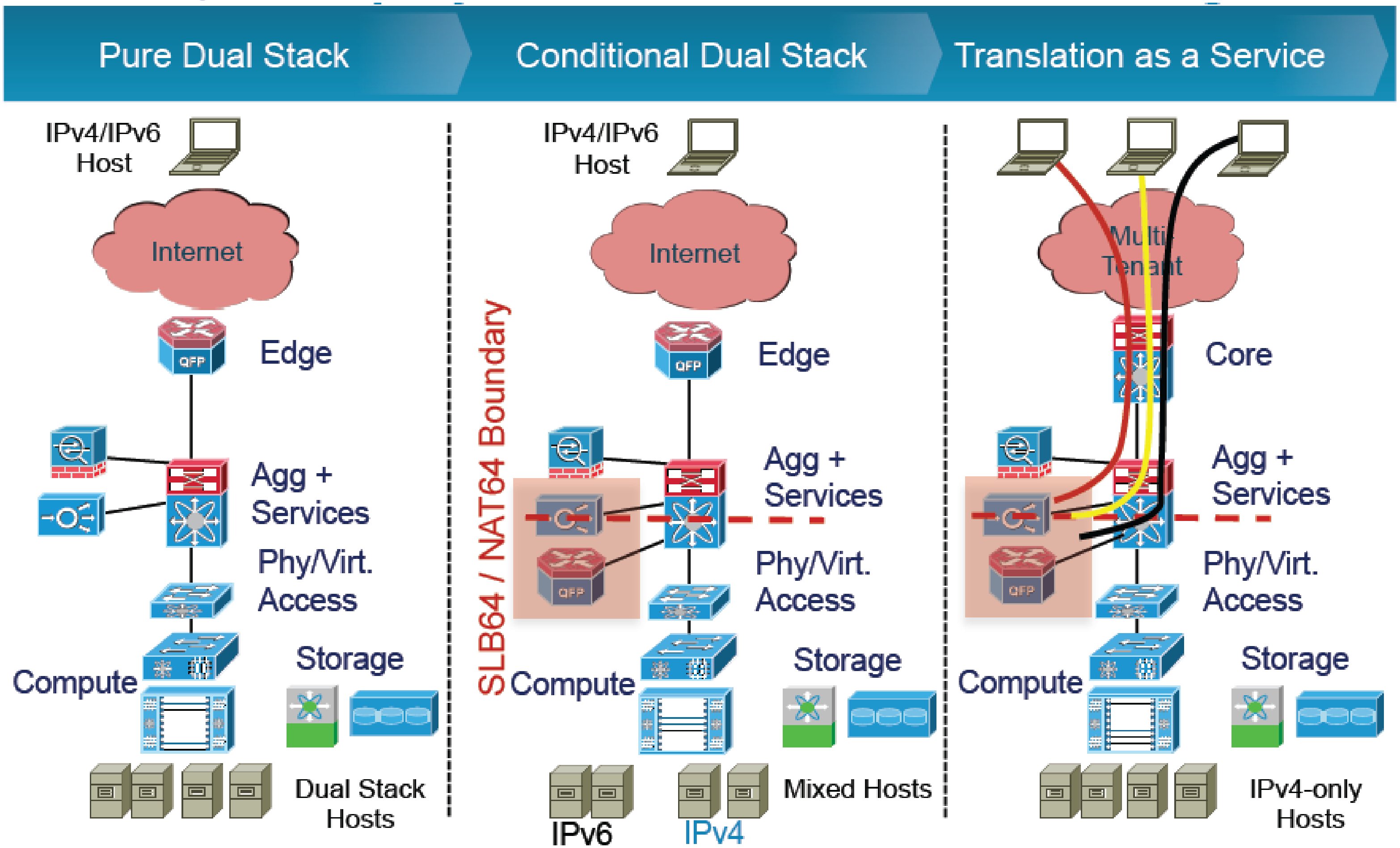


Enterprise Content



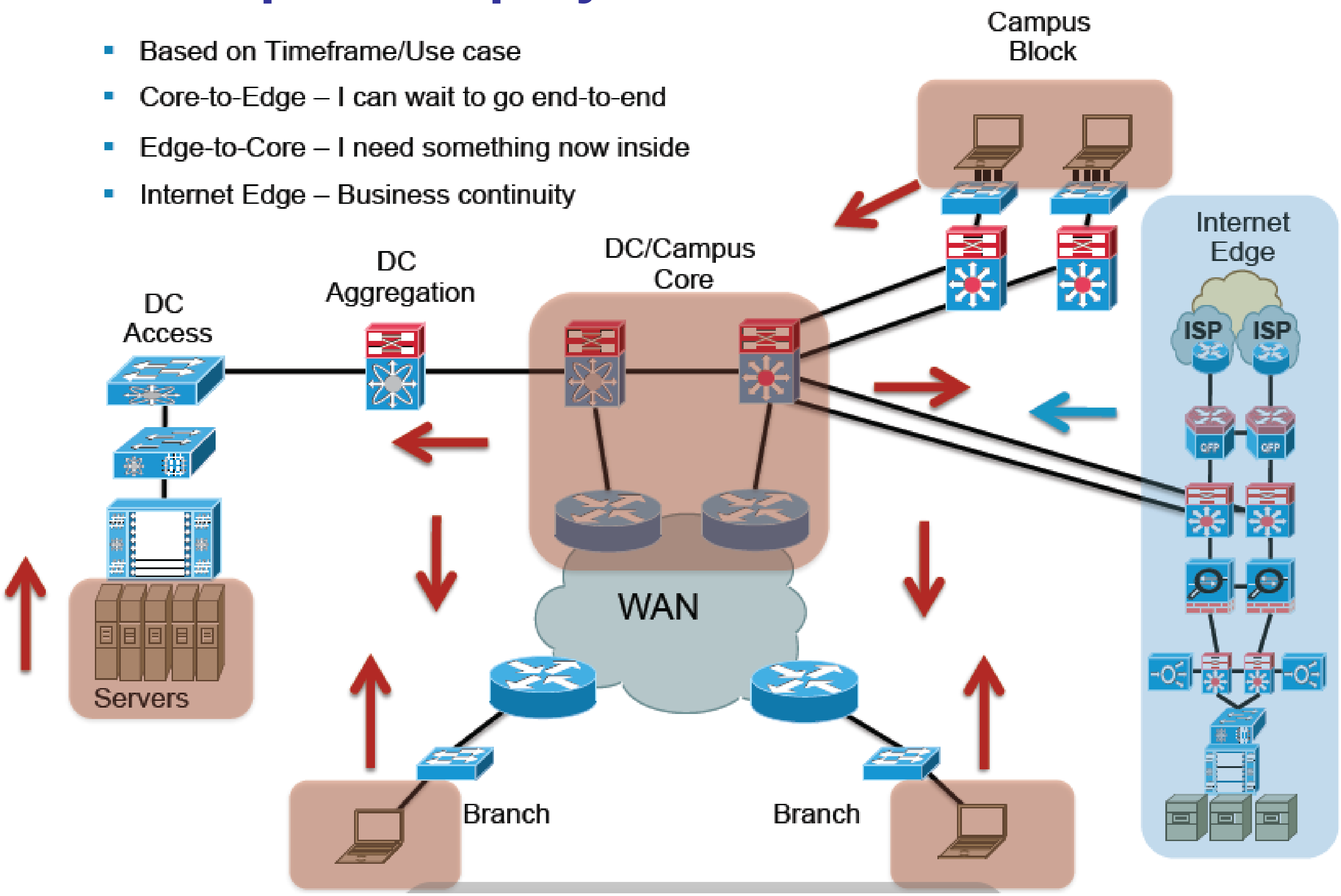
Availability of enterprise content over IPv6

IPv6 Edge Deployment



IPv6 Enterprise Deployment

- Based on Timeframe/Use case
- Core-to-Edge – I can wait to go end-to-end
- Edge-to-Core – I need something now inside
- Internet Edge – Business continuity



Why IPv6 in Korea?

Prepare IPv4 Address Depletion

- Usage ratio of assigned IP addresses : 96.2% (Mar. 2006)
- More IP addresses to be needed for the future IT839 Strategy

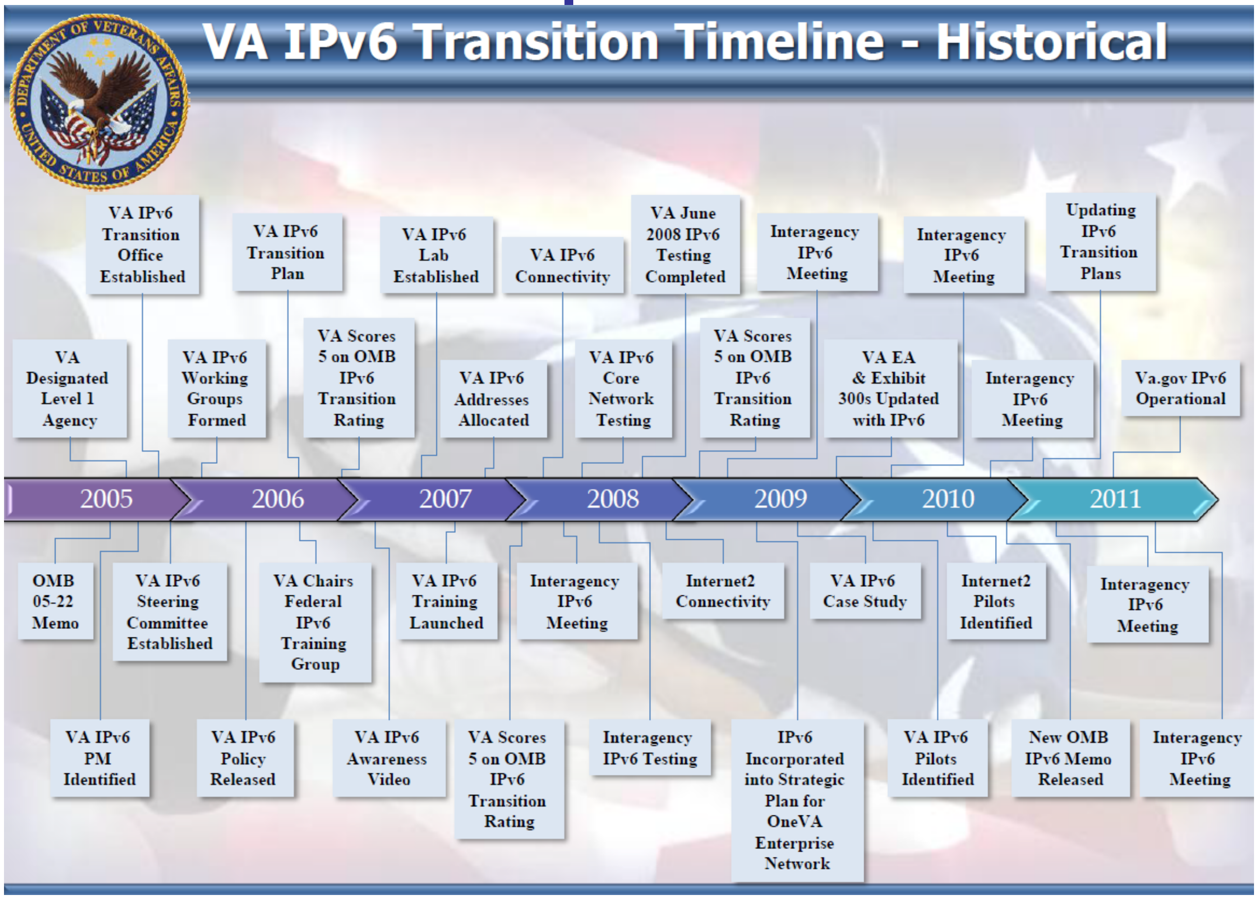
Promoting New Services

- IPv6 based Home Network Service
- IPv6 Service over 2.3 GHz based WiBro
- IPv6 based VoIP Service
- IPv6 based Telematics Service, and many others

IT839 New Growth Engine

- A master plan for the IT industry
- Effort to gain more growth momentum from the IT sectors

IPv6 Transition Roadmap – US VA



Planned IPv4 decommission is 2015 ???

6to4 Tunneling

IPv6 traffic tunneled to go through an IPv4 network
- www.sixxs.net – Worldwide tunnel broker

Address - 2002:wwxx:yyzz::/48
- wwxx:yyzz is both the NLA and the colon-hexadecimal representation of an IPv4 address assigned to the site or host

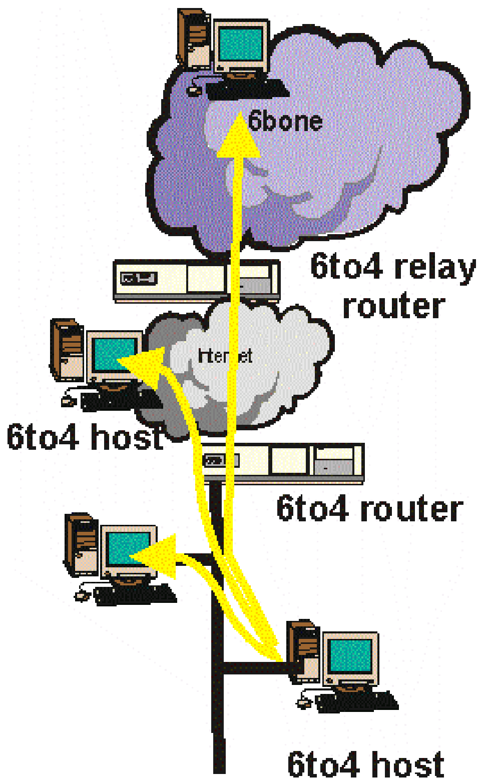
2002:wwxx:yyzz:[Subnet]:{Interface ID}

6to4 host - an IPv6 host that is configured
- with at least one 6to4 address

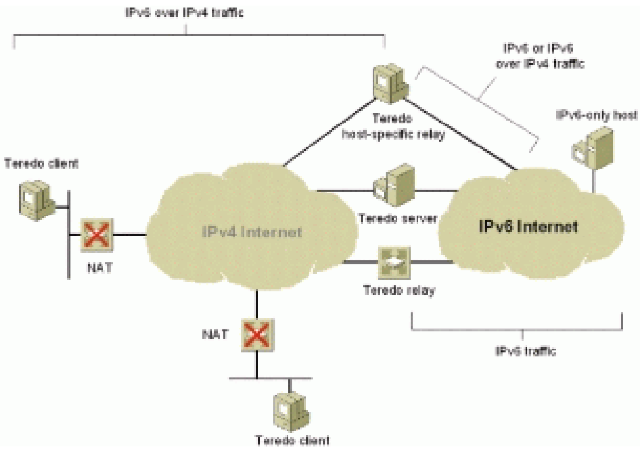
6to4 router - an IPv4/IPv6 router that forwards
- 6to4 traffic between 6to4 hosts within a site or 6to4 relay routers on the IPv4 Internet

6to4 relay router - an IPv4/IPv6 router that
- forwards 6to4 addressed traffic between 6to4 routers on the IPv4 Internet and hosts on IPv6 networks

Anycast 2002:C058:6301::



Teredo



- 6to4 tunnels requires the tunnel end point public IPv4 address…..so for many that m NAT device…Many NAT devices cannot b upgraded
- Teredo encapsulates IPv6 in UDP/IPv4 datagrams.
  - Diagnoses UDP over IPv4 (UDPv4) connectivity and discovers the kind of NAT
  - assigns a globally-routable unique IPv6 address to each host using it;
  - encapsulates IPv6 packets inside UDPv4 datagrams for transmission over an IPv4 network (this includes NAT traversal);
  - routes traffic between Teredo hosts and native (or otherwise non-Teredo) IPv6 hosts.

IPv6 Translations

NAT-PT (Network Address Translation and Protocol Translation)

Translates by mapping each IPv6 address onto one from a pool of IPv4 addresses

Upside: easy to implement and understand

Downside: Limits simultaneous access to multiple services with a network

Breaks end-end networking

Single point of failure

NAPT-PT (Network Address Translation plus Port Translation)

Protocol gateway translates the IPv4/IPv6 network addresses and also maps port across boundaries

Upside: Easy to implement, adds support for more simultaneous sessions

Downside: Breaks end-end networking, single point of failure

SIIT (Stateless IP/ICMP Translation)

IP packets and ICMP messages are translated between IPv4 and IPv6 with temporary assignments of IPv4 addresses creating a one-one mapping

Upside: Does not require state detail to be maintained

Downside: Does not save on IP addresses, single point of failure

IPv6 BGP Weathermap – Prefixes per Country

1		United States	3067
2		Germany	477
3		France	402
4		United Kingdom	399
5		Australia	388
6		EU	375
7		Brazil	349
8		Russian Federation	341
9		India	333
10		Netherlands	328
11		Canada	304
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19		Singapore	137
20		Austria	131
21		Hong Kong	129
22		Korea, Republic of	110
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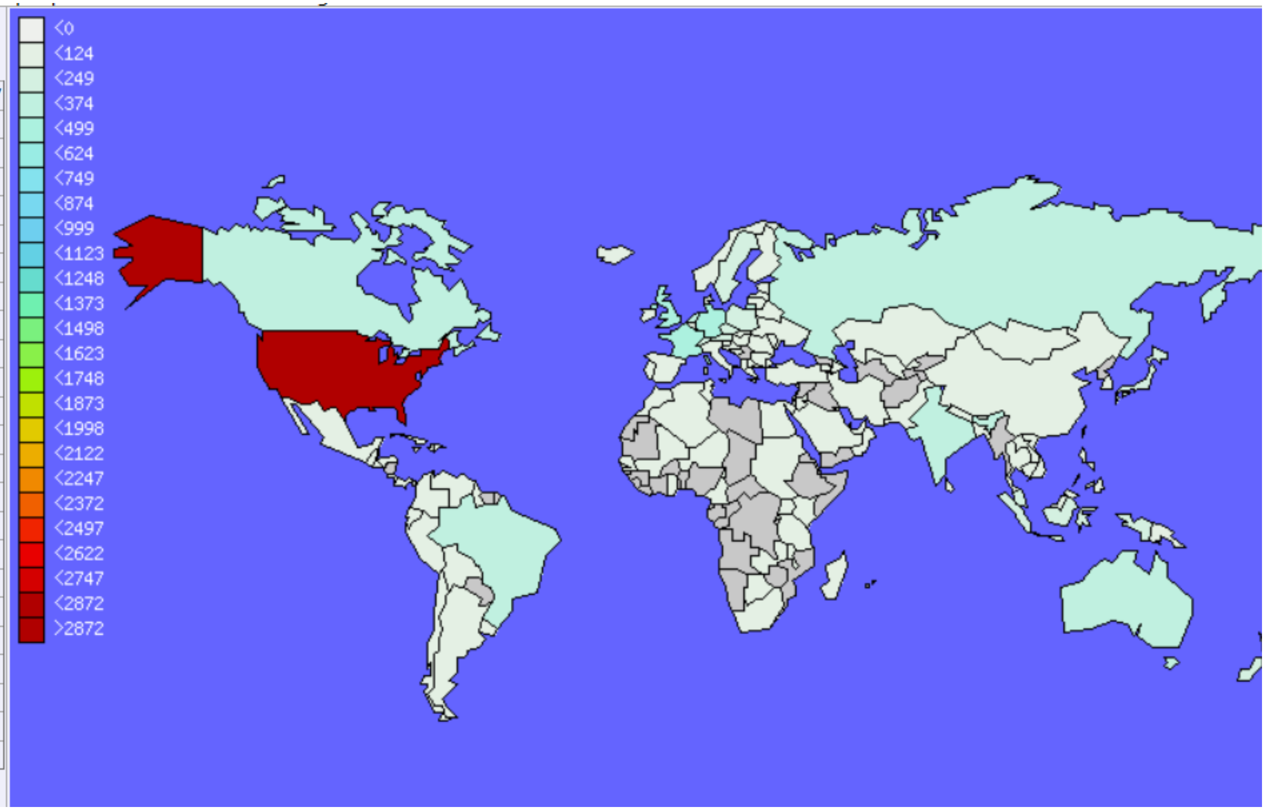

IPv6 Migration Plans

- Define topology and functions on hosts, routers, and service machines
- Upgrade DNS, DHCP, ARP servers to handle IPv6 addresses
- Introduce dual stack systems that support IPv4 and IPv6
- Configure to Internet using IPv6
- Rely on tunnels to connect IPv6 islands separated by IPv4 networks
- Gradually remove IPv4 from systems
- Work closely with ISP for connections to the Internet

IPv6 References

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AES Sessions

Session	Title	Day	Time	Room
12152	IPv6 Basics	Tuesday February 5	1:30 PM	Golden Gate 4
12777	Network Problem Diagnosis with Packet Traces	Wednesday February 6	9:30 AM	Golden Gate 3
12778	Performance Factors in Cloud Computing	Wednesday February 6	11:00 AM	Golden Gate 4
12150	I'm Running IPv6 How Do I Access?	Wednesday February 6	3:00 PM	Golden Gate 4
12158	Managing an IPv6 Network	Thursday February 7	11:00 AM	Golden Gate 4
12149	Kick Start your IPv6 Skills using your home network	Friday February 8	8:00 AM	Golden Gate 4
12153	IPv6 Deep Dive	Friday February 8	9:30 AM	Golden Gate 4

Vielen Dank

ありがとうございました

Köszönettel

Спасибо

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شكراً

Bedankt

Gracias

شكرا

Ευχαριστώ

THANK YOU

Merci

Díky

धन्यवाद

Grazie

Danke

Hvala

תודה

Merci

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Teşekkürler

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