# IPv6 Basics

## Share Anaheim Session 11156

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# What is IPv6

**Updated version of the Internet Protocol (IPv4)**

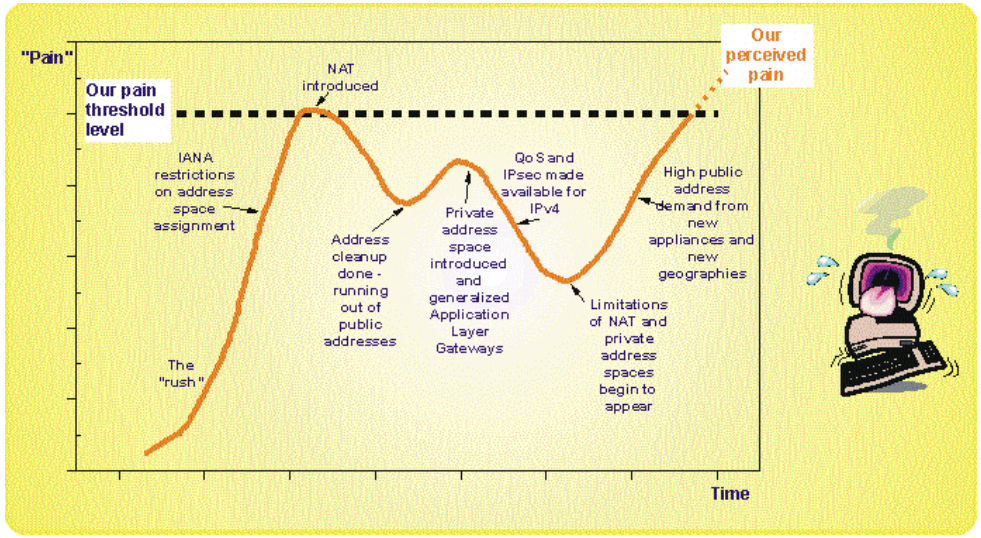
**Defined in RFC 1752**

**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?

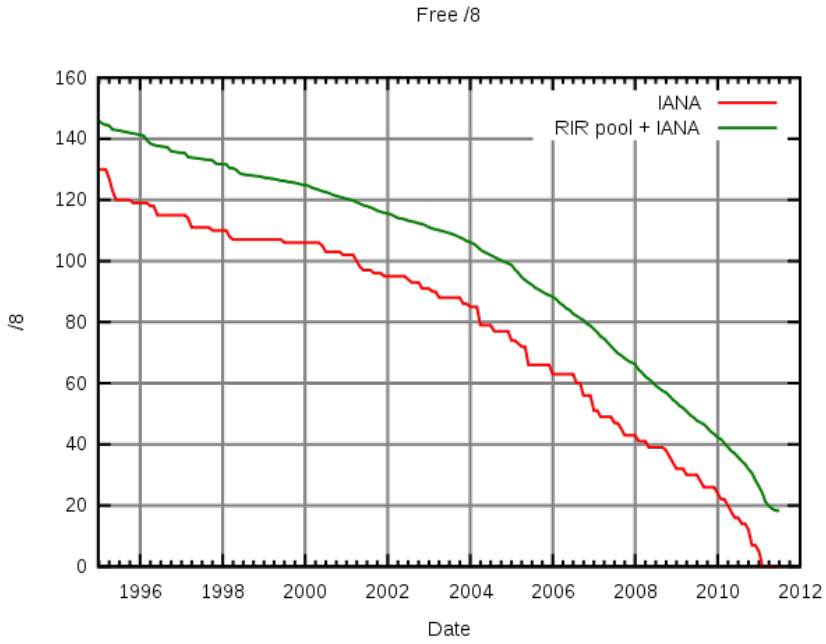


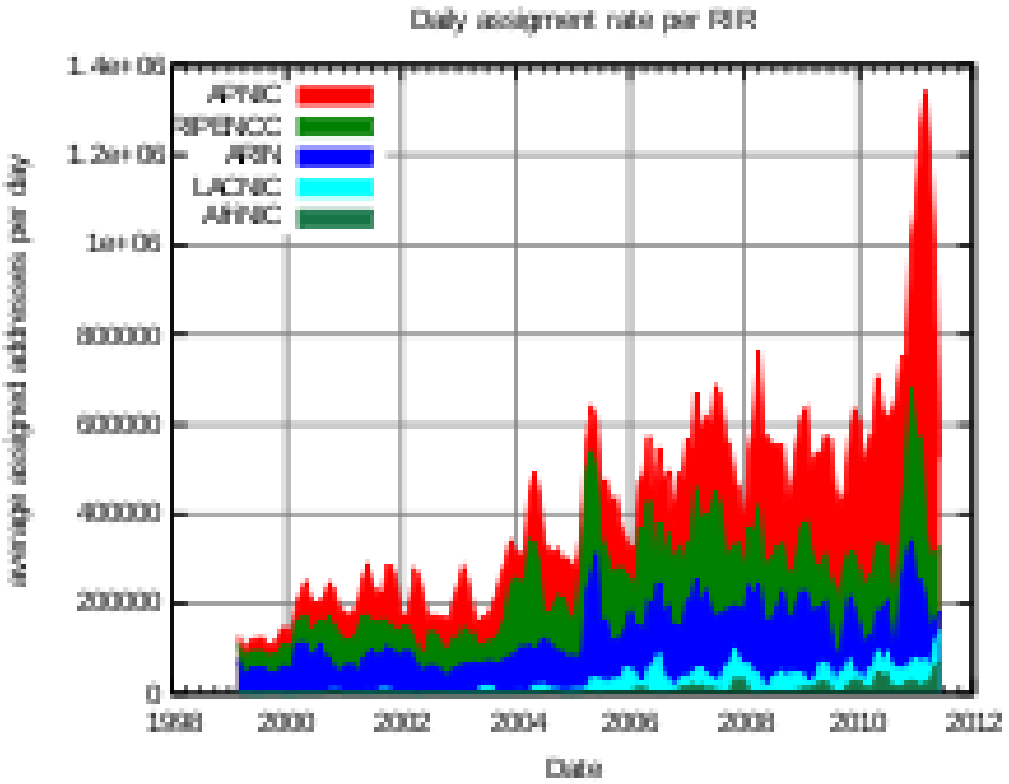

February 2011 – NRO (Number Resource Organization of the IANA) allocated the last IPv4 addresses to RIR

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 |

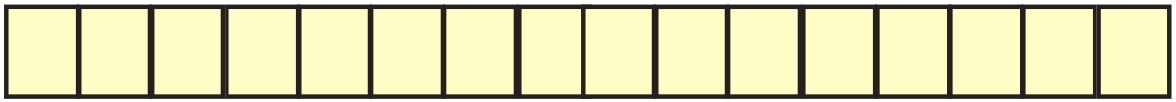
# IPv6 Address Size

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

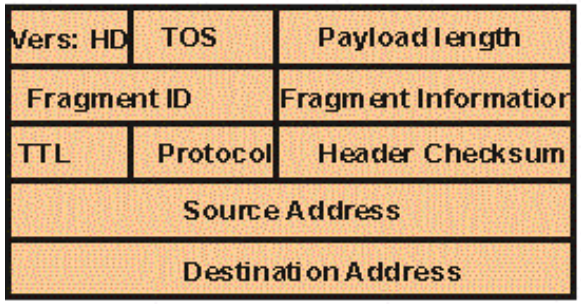
Mobil digital telephony pressuring existing IPv4 network

ICANN continues to handle overall addressing issues

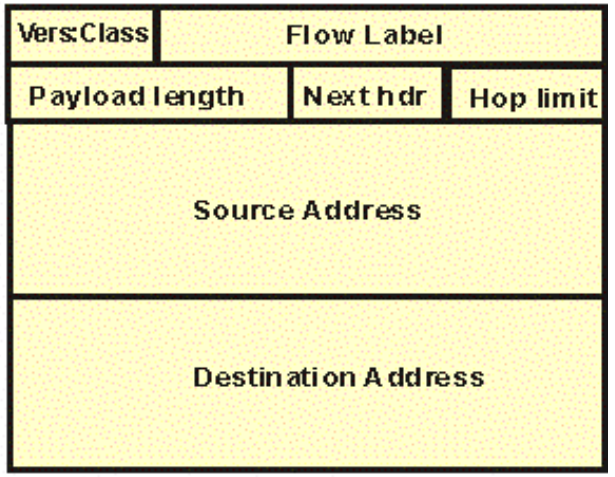
Shortcuts like dropping Leading zeros or Contiguous zeros permitted

# IPv6 Header

IPv4 Header

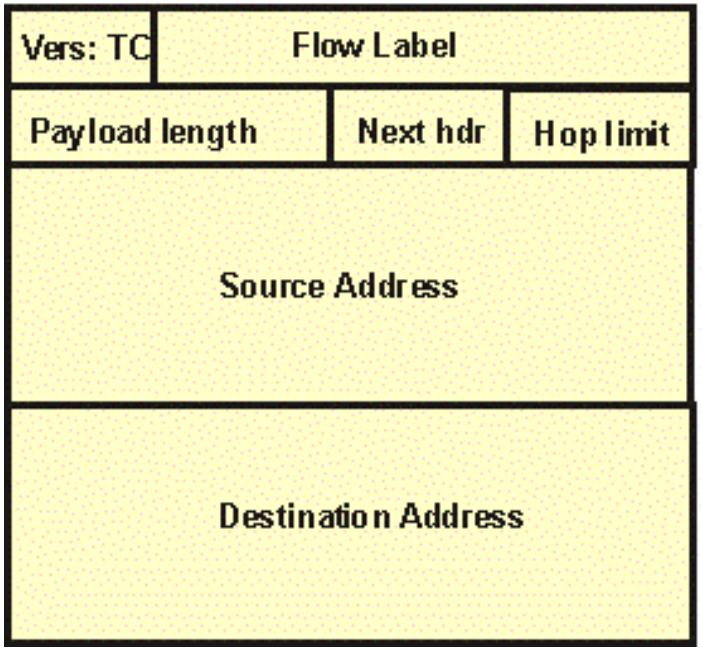



IPv6 Header




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




Identifies datagrams that require special quality of service

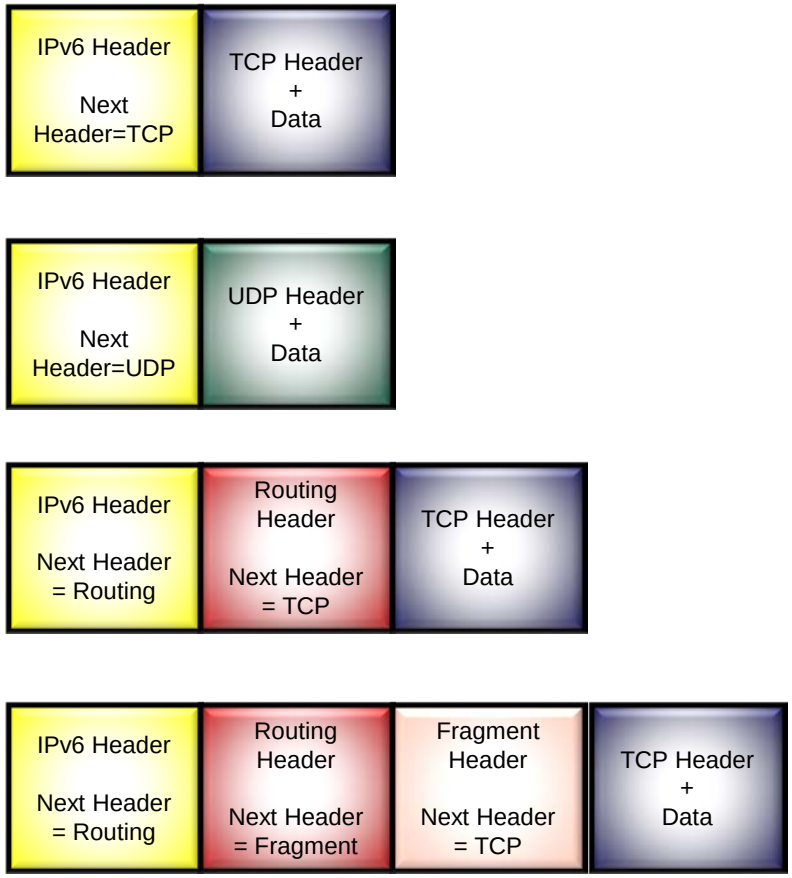
May be used to tie particular traffic to pre-allocated network resources

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**

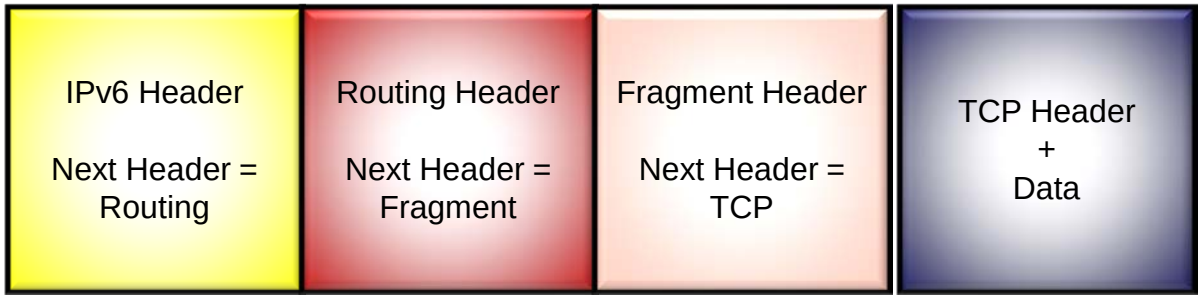
**Encapsulating Security Payload = 50**
**Encryption type and parameters**

**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

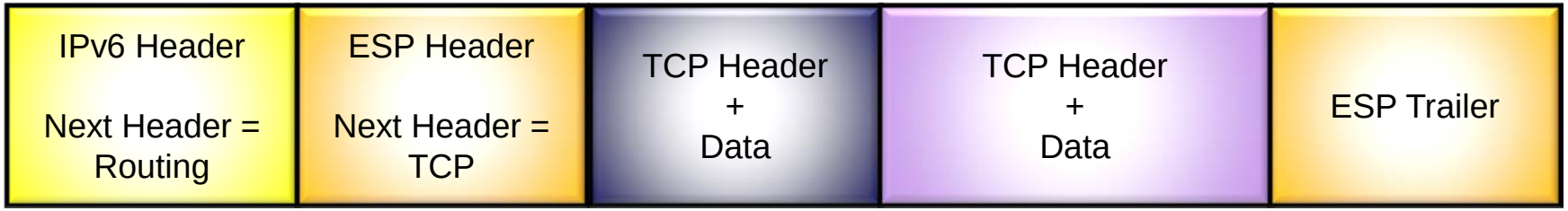
If needed, IPv6 hosts fragment frames

Hosts use:

Increased guaranteed minimum MTU of 1280

Pat MTU discovery to find maximum fragment size for a path

# IPv6 Security




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:

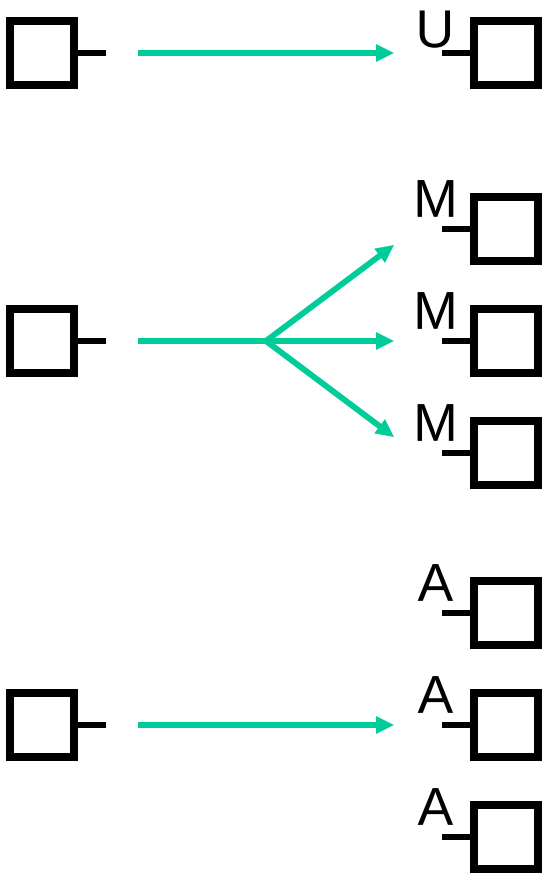
for one-to-one communication

multicast:

for one-to-many communication

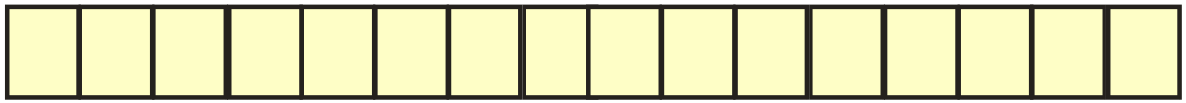
anycast:

for one-to-nearest communication



# IPv6 Address: Site and Link

IPv6



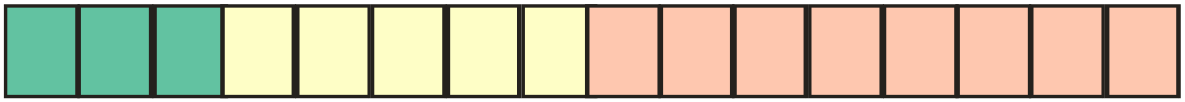
2001:0DB8::15:219:D1FF:FE10:74EE/64

Multicast

Prefix=FF00::/8 112 bit group ID

Unicast

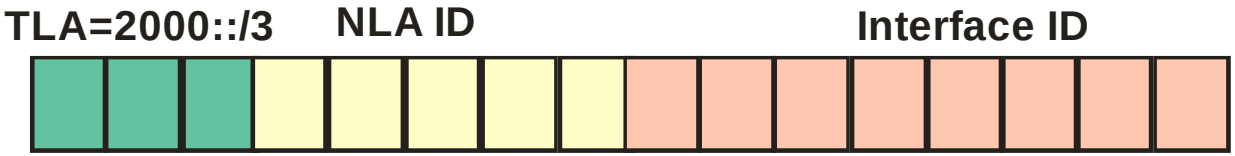
TLA=2000::/3 NLA ID Interface ID



2001:0408/32 ATT
2001:0506:0000/48 Verizon Business
2001:4840/32 Earthlink
2001:49C0/32 IBM
2001:0200--039F 12 ISPs in Korea

FC00::/7 Unique Local – Internet router will discard
FE80::/10 Link Local – Non-routeable

# Global Unicast Address



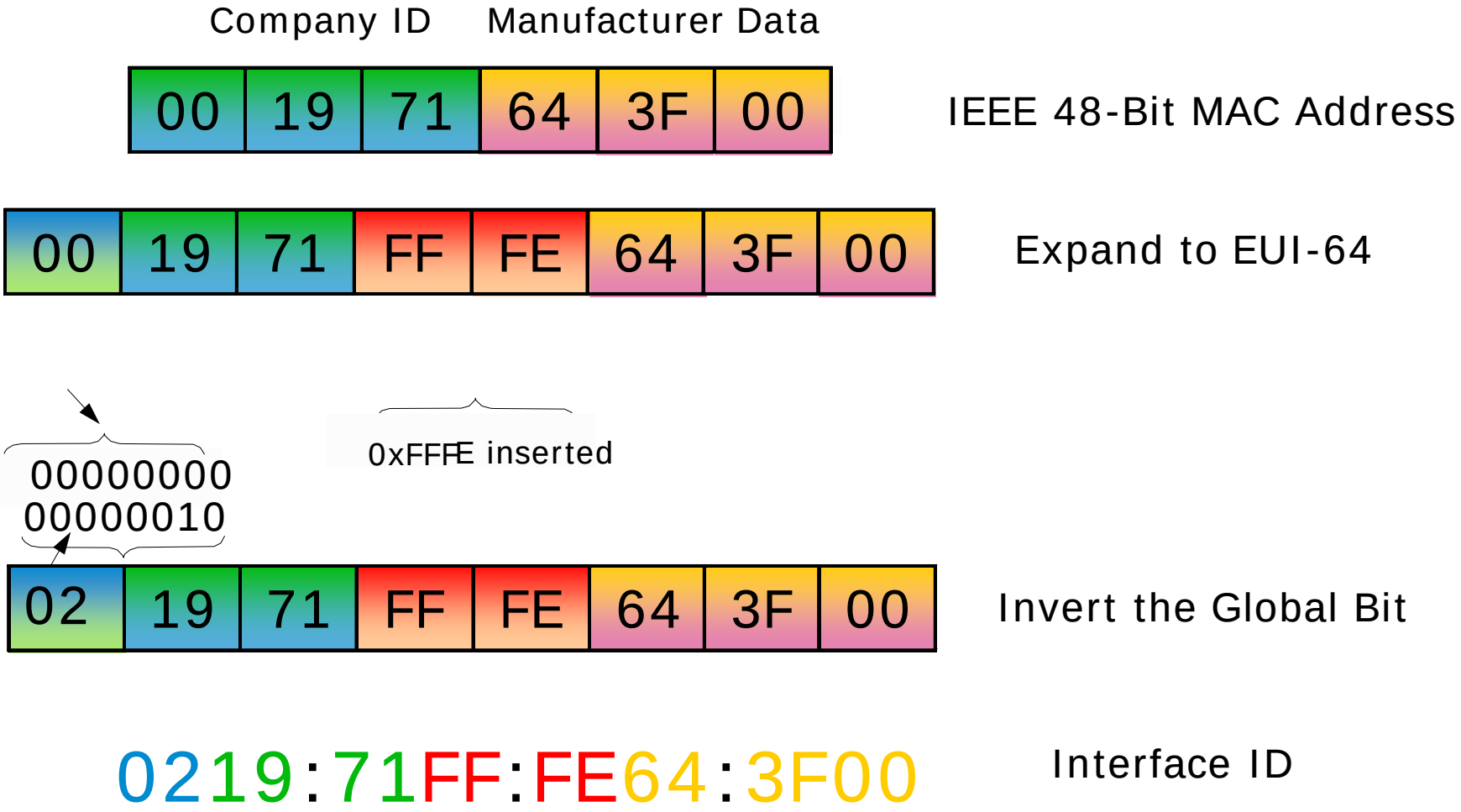

TLA : Top Level Aggregation - 3 bytes (21 bits; First three bits of byte 1 are 001)
IANA allocates address blocks to the regional Internet registries
They allocate portions of their block to national registries or to ISPs

NLA : Next Level Aggregation - 5 bytes
High order part assigned to smaller or regional ISPs, large companies
Holders of an NLA block assign partsof their block to their customers
They assign middle chunks to locations
Low order numbers identify subnets

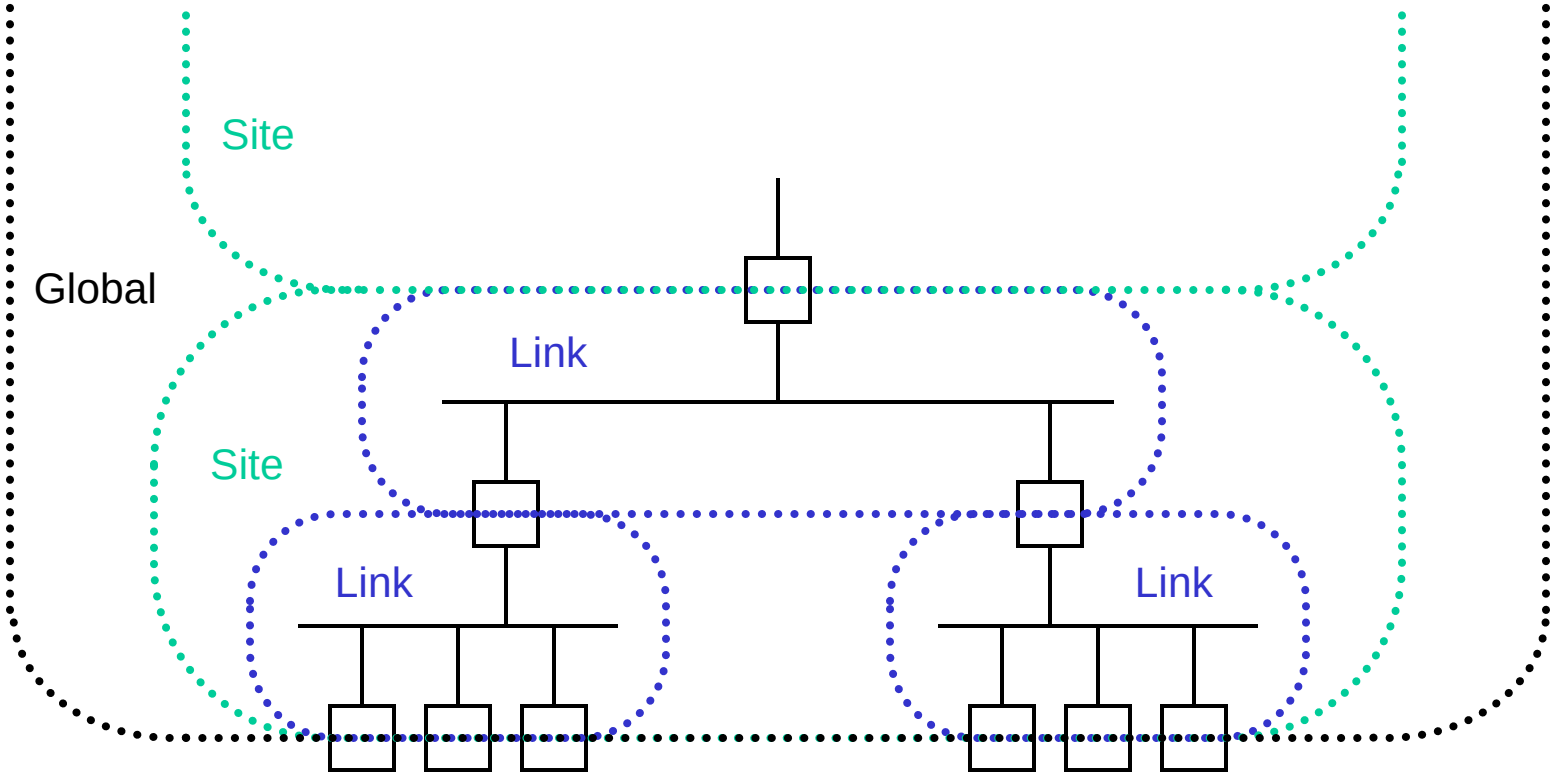
Interface ID : host interface (64 bits)
Assigned by the owning organization
IEEE has defined a 64 bit NIC address known as EUI-64
NIC driver for IPv6 will convert 48 bit NIC to 64 bit NIC

Structure greatly reduces the entries in the routing table....only one entry needed in a US router to define all the networks in a region or country

# 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**

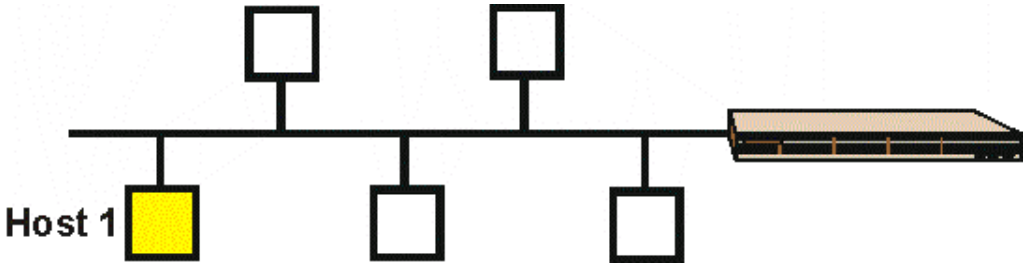
**Reduces impact of finding hosts**

**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)

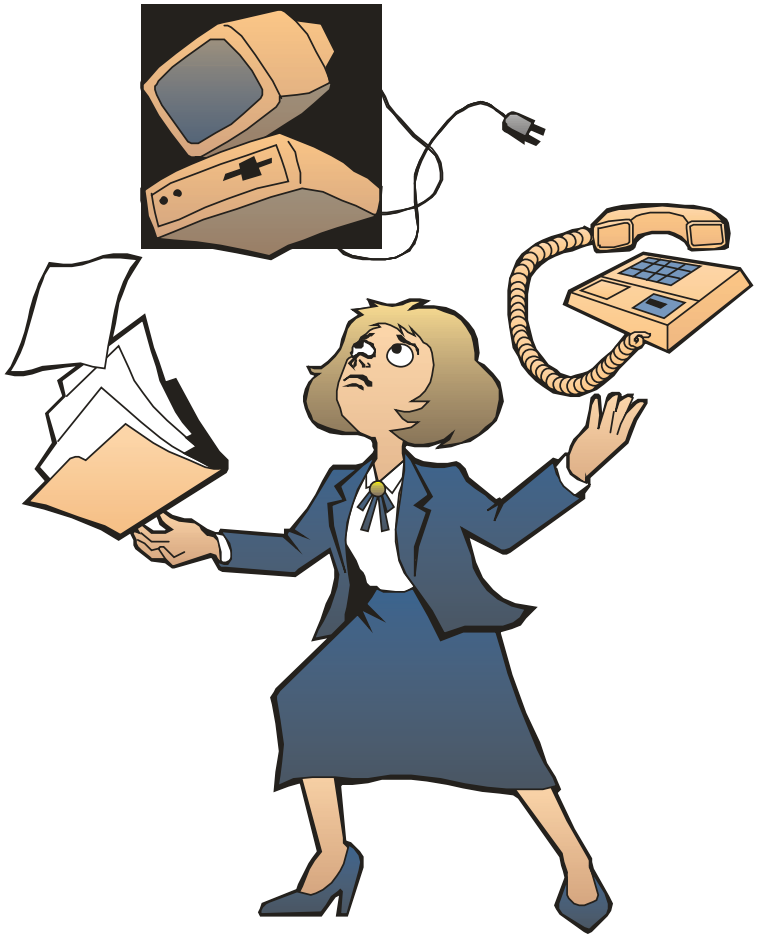
- Many products already support 128 bit addresses
- Uses ‘AAAA’ records for IPv6
- IP6.INT (in_addr_arpa in IPv4)

## 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



# Applications


- 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

# NTT and IPv6

**1996:** NTT Labs started one of the world's largest global IPv6 research networks

**1998:** Verio begins participation in PAIX native IPv6 IX

**1999:** NTT Com begins IPv6 tunneling trial for Japanese customers

**2000:** Verio obtains IPv6 sTLA from ARIN

**2001:** NTT Com pioneers worlds first IPv6 connectivity services on a commercial basis

**2002:** World Communications Awards (WCA) awards NTT Communications with "Best Technology Foresight" for its IPv6 Global products

**2003:** NTT/VERIO launches IPv6 Native, Tunneling, and Dual Stack commercial service in North America

**2003:** Communications Solutions magazine names NTT/VERIO IPv6 Gateway Services "Product of the Year"

**2004:** NTT IPv6 Native and Dual Stack services available around the globe

**2004:** NTT Com wins the World Communications Awards "Best New Service" award for IPv6/IPv4 Global Dual Service

**2005:** Dual stack Virtual Private Server released. First ISP to offer an IPv6 managed firewall service

**10/2006** – Launched the NTT Communications IPv6 Transition Consultancy

**2/2007** – Awarded GSA Schedule 70 contract for IPv6 IP transit



# NTT/Verio IPv6 Backbone

# 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:

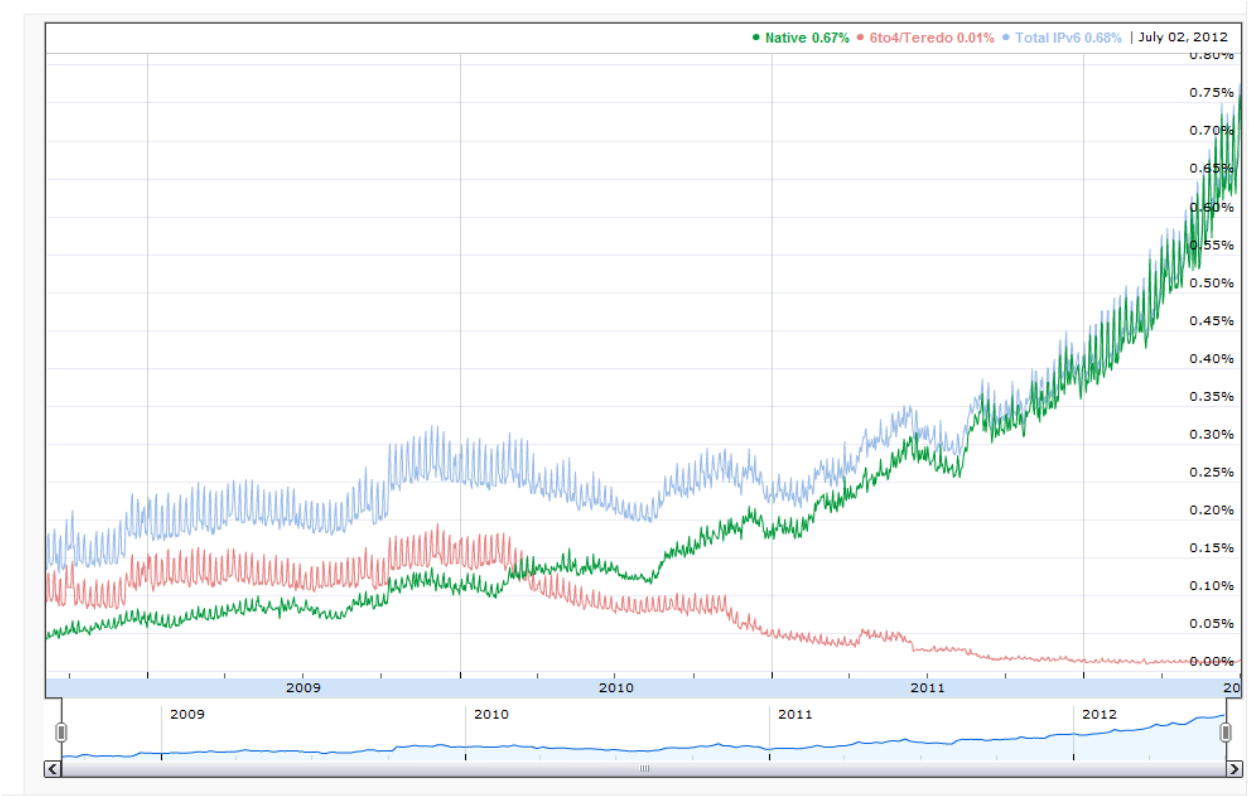
# Comcast and IPv6

- 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

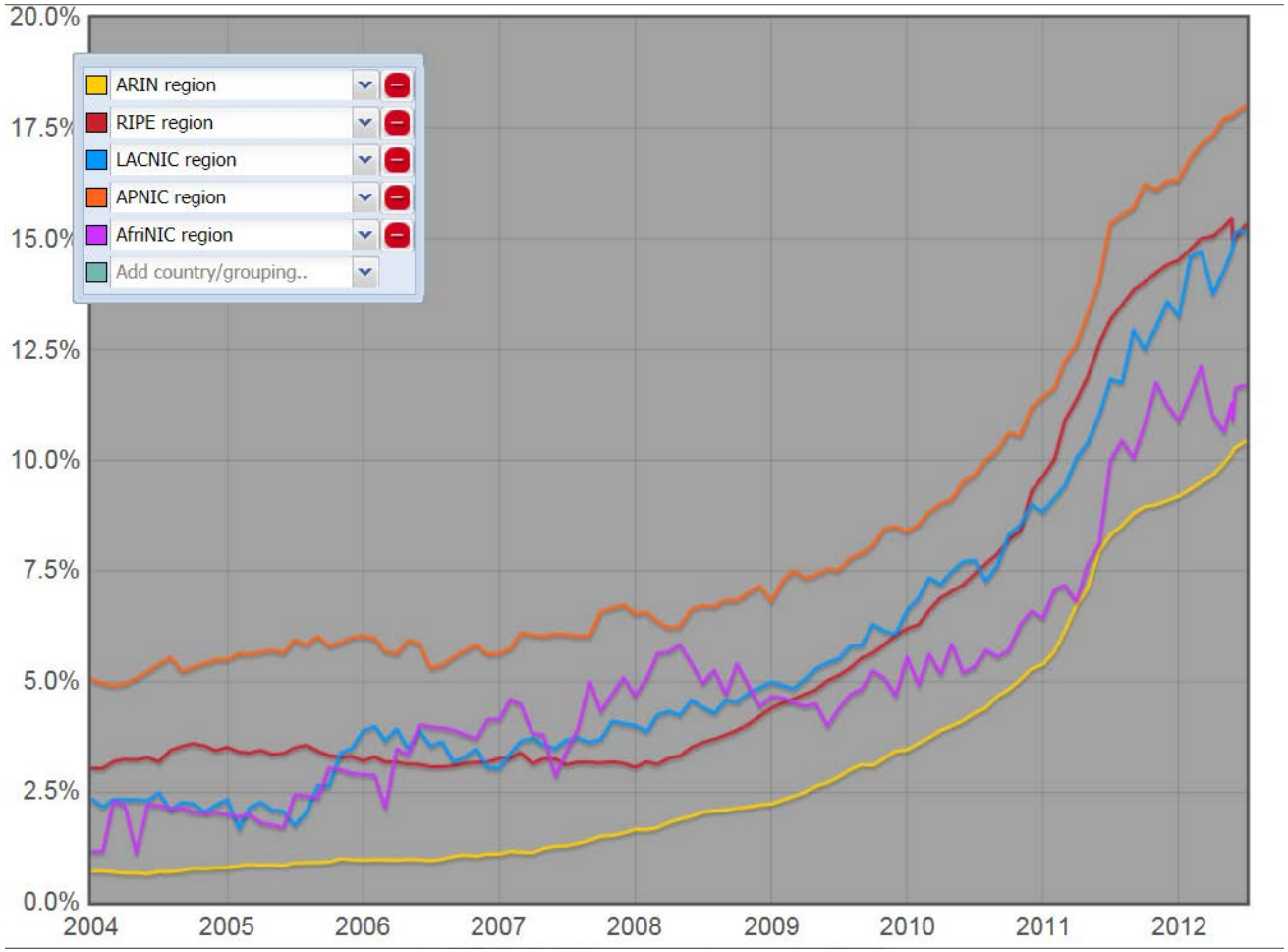
- http://www.google.com/intl/en/ipv6/
- **Access Google services over IPv6**
- At Google, we believe that IPv6 is essential to the continued health and openness of the Internet – and that by allowing all devices on a network to talk to each other directly, IPv6 will enable innovation and allow the Internet's 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.

# IPv6 Day




**Google Statistics on IPv6 continuous usage since they went live**

# IPv6 Networks Advertised



# IPv6 Transition Methods

**Tunneling**

**IPv6 only systems communicate across an IPv4 network**

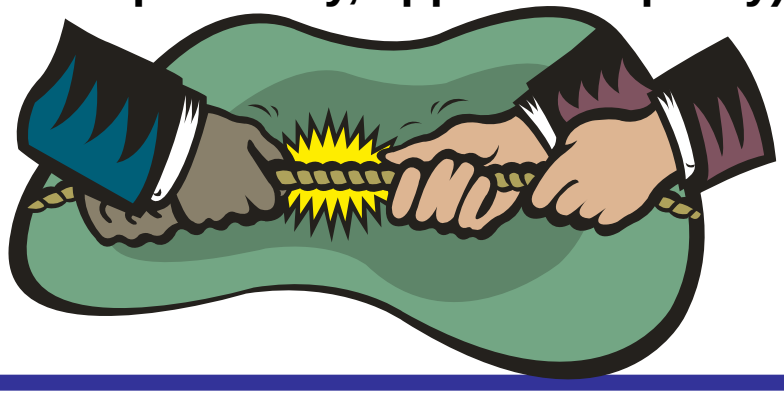
**New “6to4” protocol from IETF**

**Header translation**

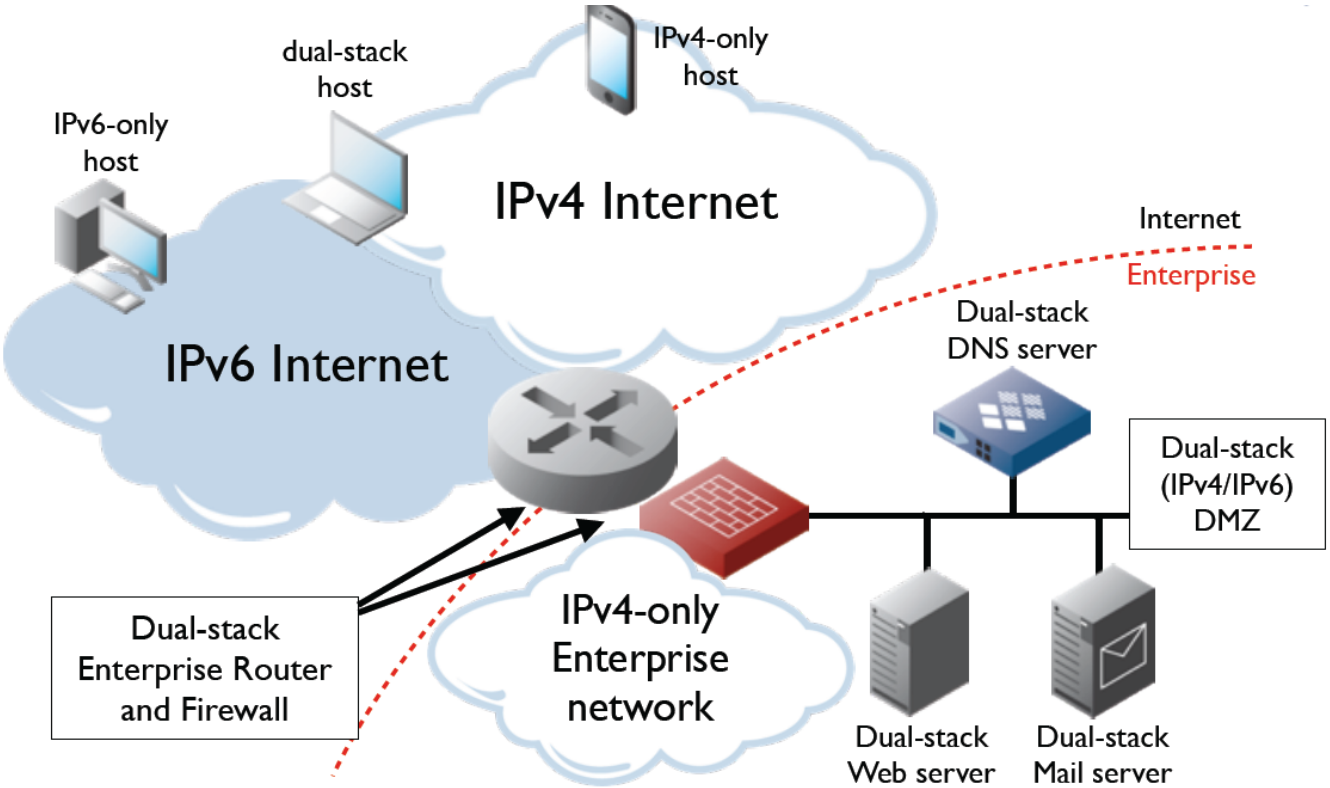
**IPv6 system communicates with an IPv4 system**

**(header conversion, transport relay, application proxy)**

**Dual Stack**

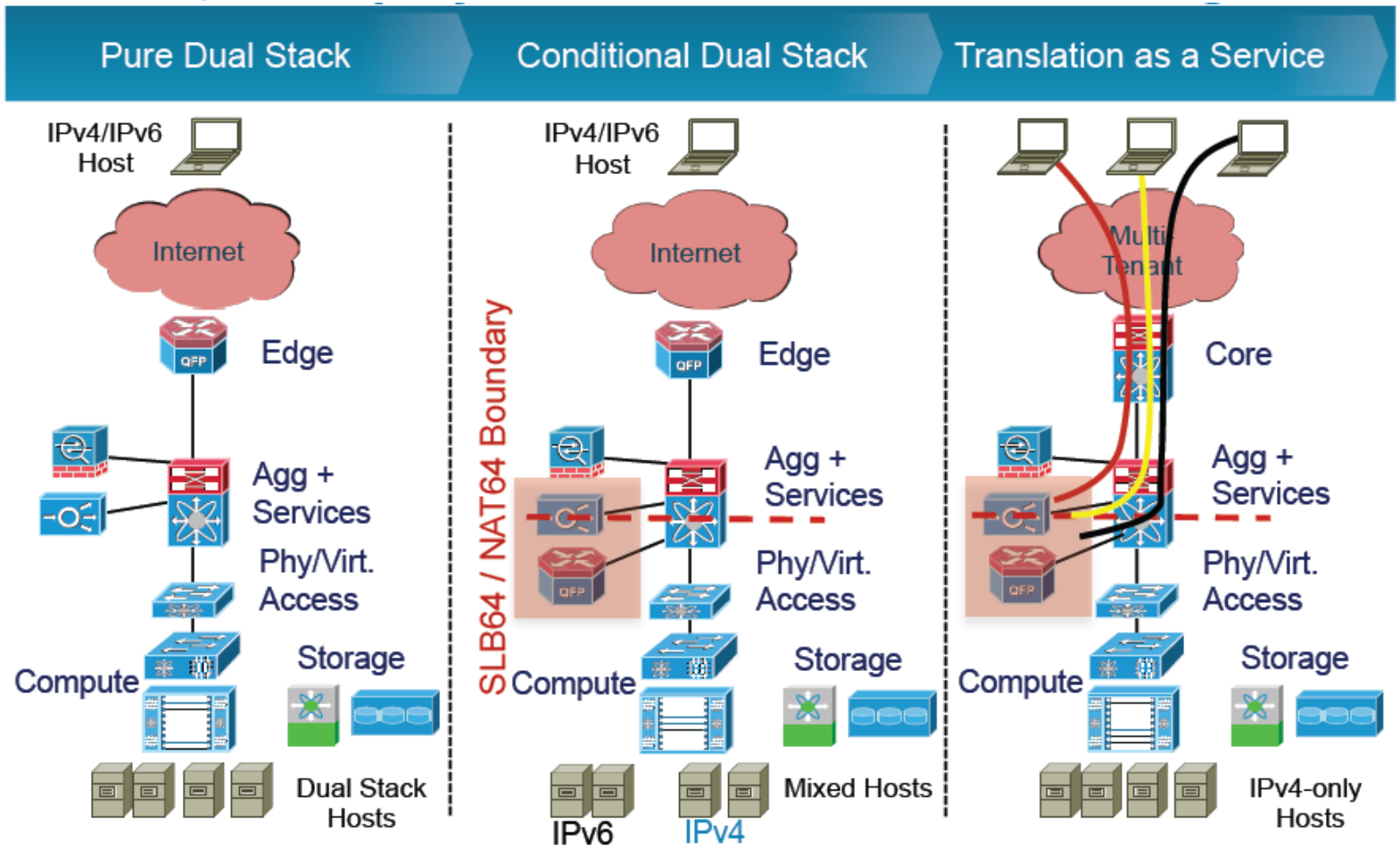


# Enterprise Content



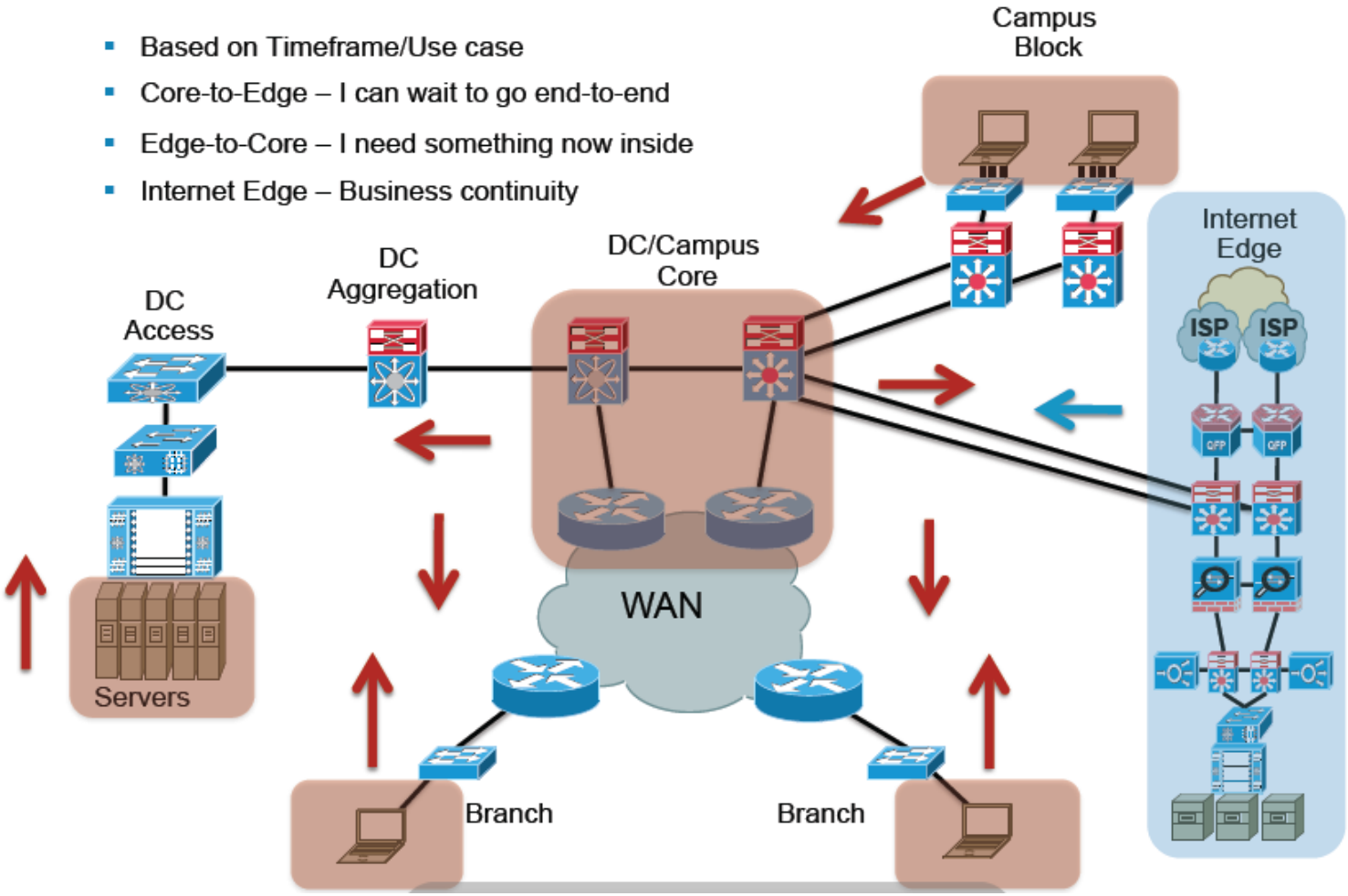

Availability of enterprise content over IPv6

# 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

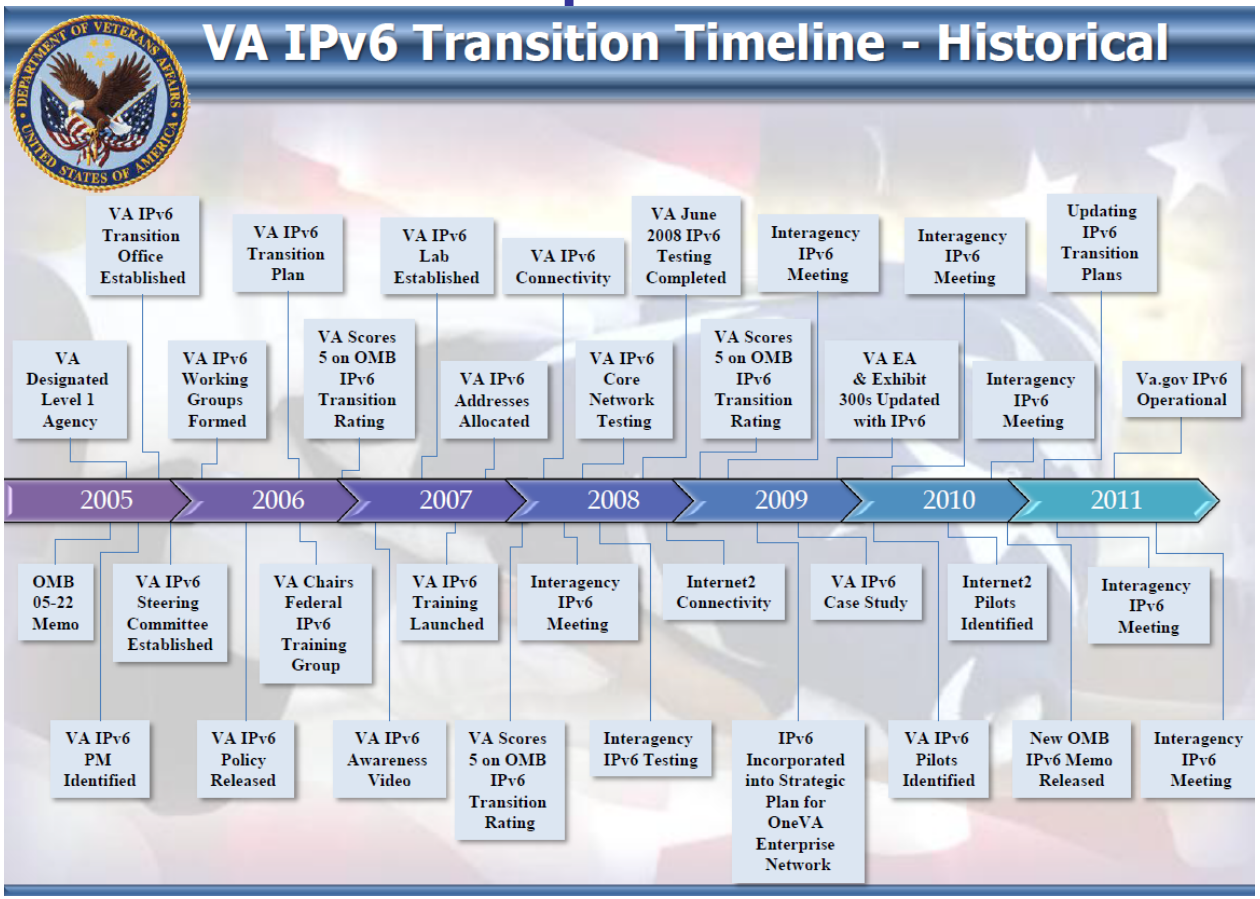
**Promoting New Services**

- 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

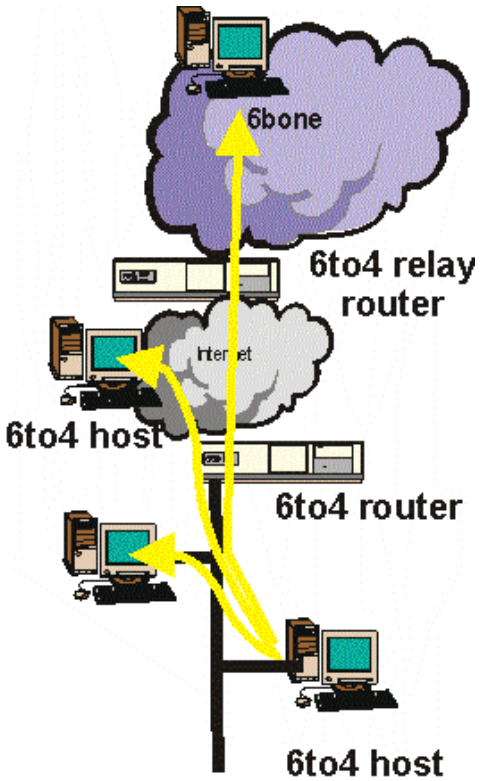
2002:wwxx:yyzz:[Subnet]:{Interface ID}

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

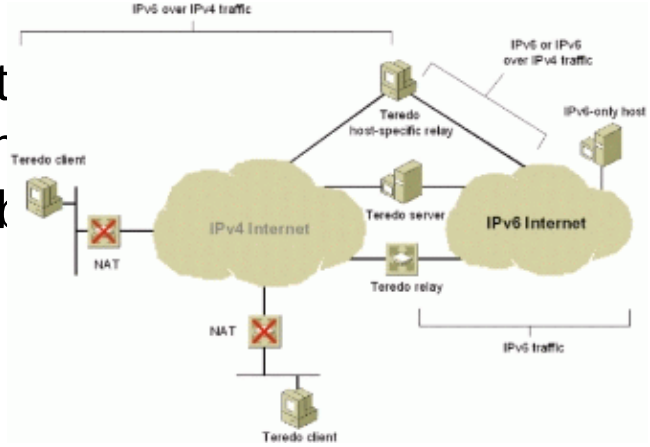
6to4 router - an IPv4/IPv6 router that forwards 6to4 traffic between 6to4 hosts within a site or 6to4 relay routers on the IPv4 Internet

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)**

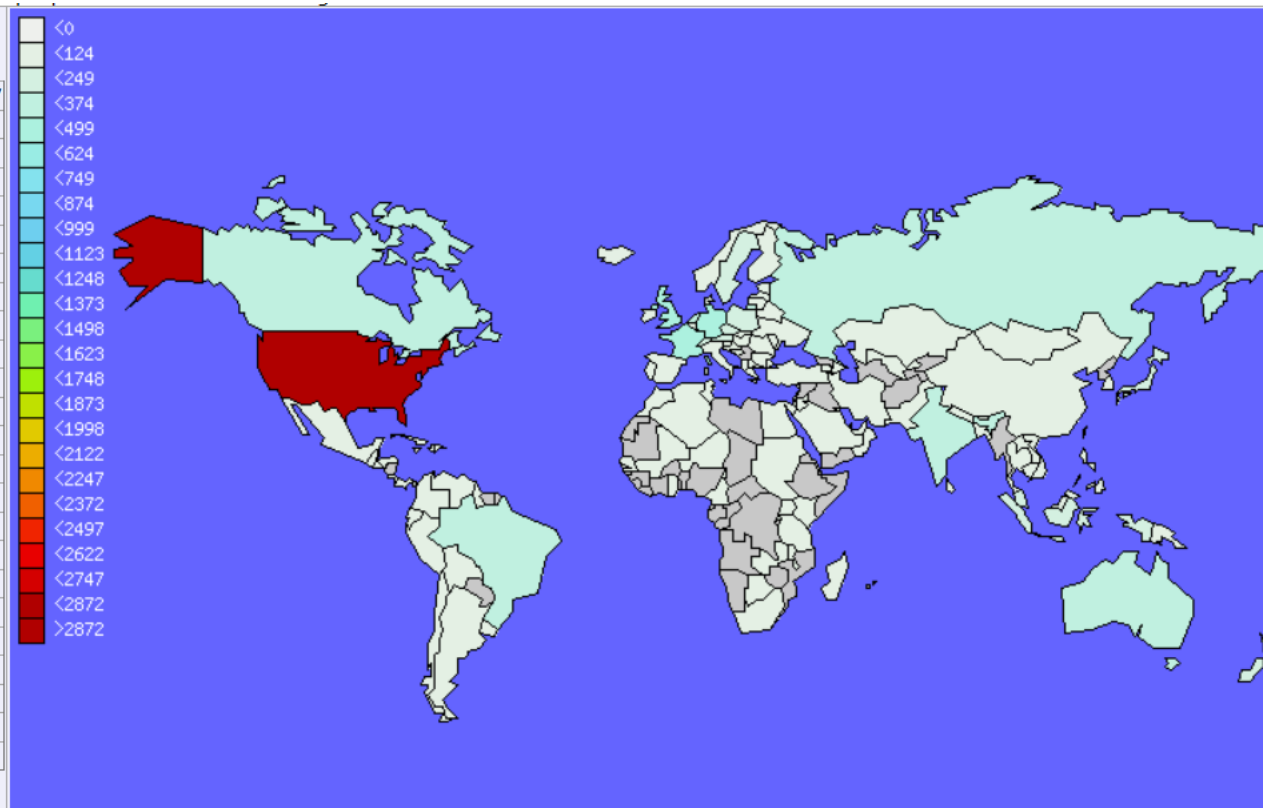
IP packets and ICMP messages are translated between IPv4 and IPv6 with temporary assignments of IPv4 addresses creating a one-one mapping

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 |
| 12 | Indonesia | 259 |
| 13 | Japan | 240 |
| 14 | Sweden | 239 |
| 15 | Czech Republic | 171 |
| 16 | Poland | 170 |
| 17 | Switzerland | 162 |
| 18 | New Zealand | 144 |
| 19 | Singapore | 137 |
| 20 | Austria | 131 |
| 21 | Hong Kong | 129 |
| 22 | Korea, Republic of | 110 |
| 23 | Ukraine | 110 |
| 24 | Norway | 106 |



# 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

http://www.ietf.org/

**http://playground.sun.com/pub/ipng/html/ipng-main.html**

**http://www.getipv6.info/index.php/IPv6_Presentations_and_Documentshttp://www.6ren.net**

**http://www.ipv6forum.com**

**http://arin.net**

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**http://www.ipv6.org**

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**http://www.research.microsoft.com/msripv6**

http://www.ipv6.org.uk

New Internet Protocol - Prentice Hall - ISBN 0-13-241936-x

IPNG and the TCP/IP Protocols - John Wiley and Sons - ISBN-0-471-13088-5

IPv6 The New Internet Protocol - ISBN-0-13-24-241936

IPNG Internet Protocol Next Generation - ISBN-0-201-63395-7

Internetworking IPv6 with Cisco Routers - ISBN 0-07-022831-1

# AES Sessions

| Session | Title | Day | Time | Room |
|---|---|---|---|---|
| 11918 | Performance Factors in Cloud Computing | Tuesday August 7 | 3:00 PM | Grand Ballroom Salon A |
| 11156 | IPv6 Basics | Wednesday August 8 | 8:00 AM | Grand Ballroom Salon A |
| 11895 | Network Problem Diagnosis with Packet Traces | Wednesday August 8 | 9:30 AM | Platinum Ballroom Salon 9 |
| 11165 | I'm Running IPv6 How Do I Access? | Wednesday August 8 | 4:30 PM | Grand Ballroom Salon A |
| 11164 | IPv6 Deep Dive | Thursday August 9 | 3:00 PM | Grand Ballroom Salon A |
| 11161 | Managing an IPv6 Network | Friday August 10 | 8:00 AM | Grand Ballroom Salon A |
| 11162 | Home Networking with IPv6 | Friday August 10 | 11:00 AM | Grand Ballroom Salon A |


# QUESTIONS?


Obrigado Спасибо





شكراً






Grazie

Danke



ありがとうございました

ขอบคุณ

Merci


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