IPv6 Basics

Share Orlando Session : 9266

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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

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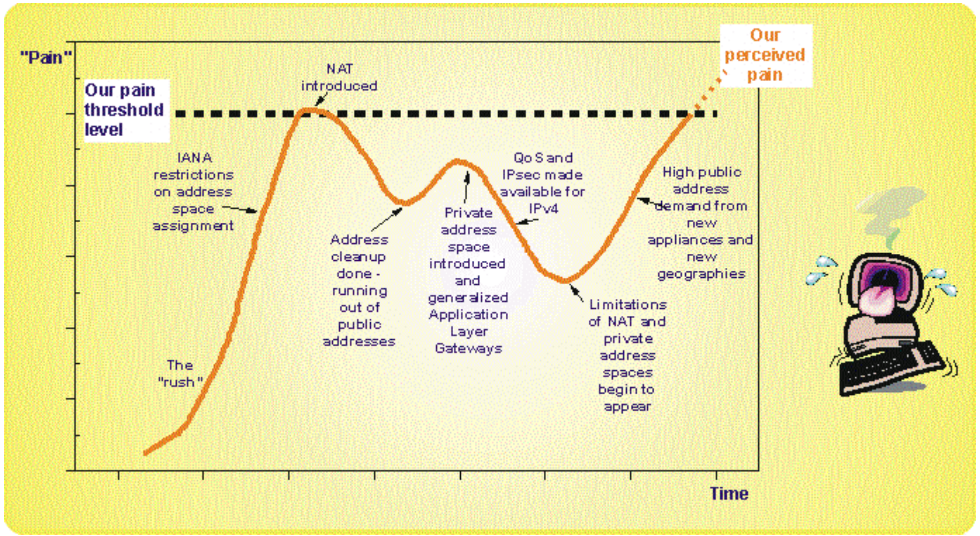
Why Do We Need More Address Spaces?



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

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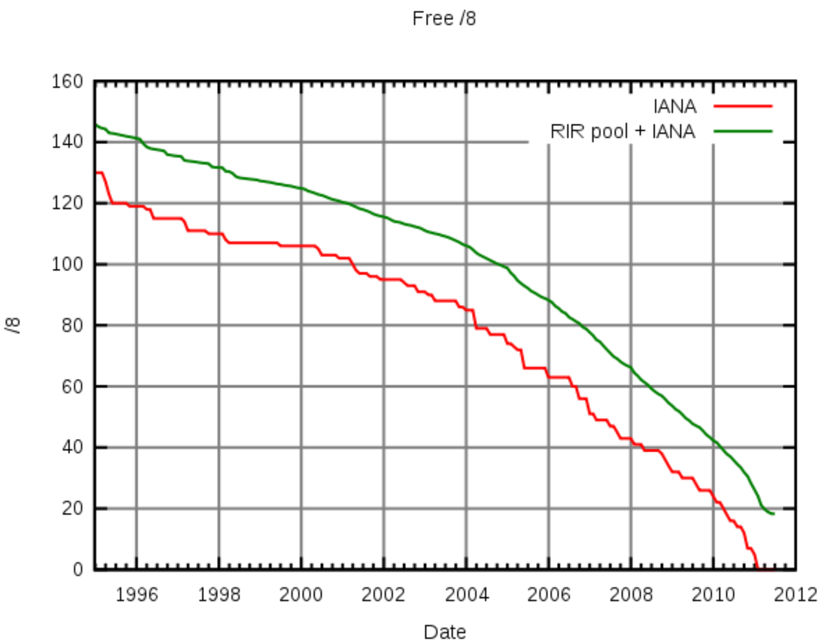
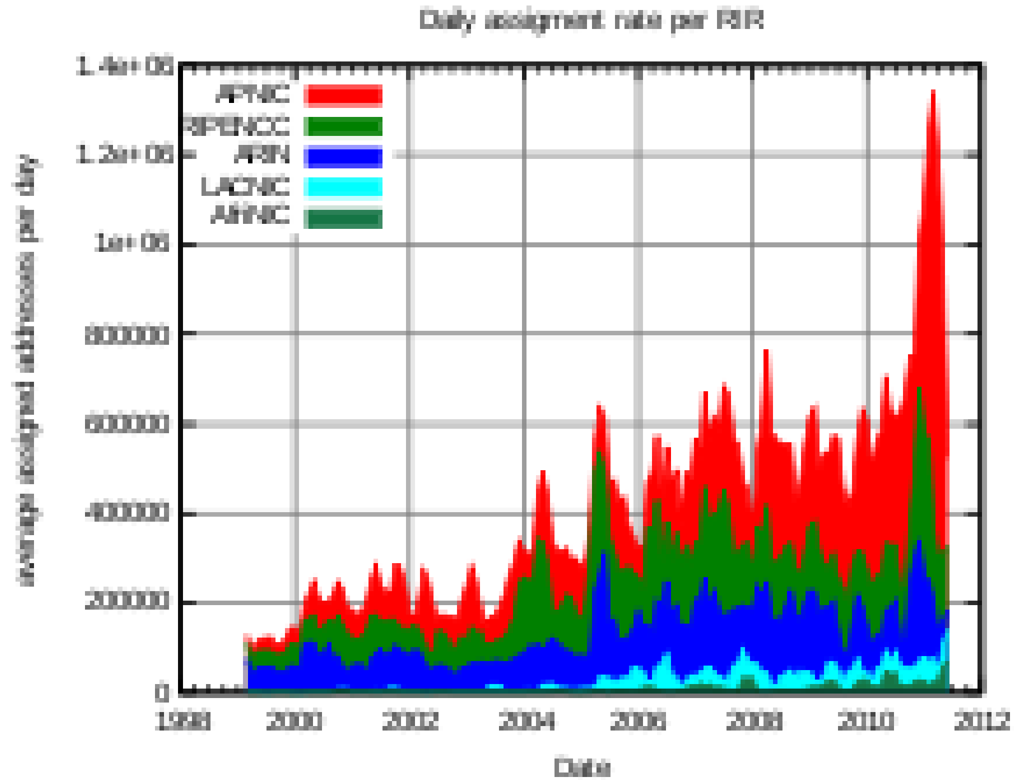
IPv4 address allocation by /8





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Applications are Changing

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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

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Why IPv4 is not Sustainable Long Term

- Trading smaller and smaller blocks will cause the global IPv4 routing table to explode.
- Small blocks make it difficult for large service providers to acquire enough space to sustain the business needs.
- The IPv4 address shortage will disproportionately harm the access providers relative to the content providers due to their imbalanced needs for additional addresses.
- If content providers require growth beyond the availability of IPv4, they can deploy IPv6, and then wait for the access providers to connect the content customers.
- Shortage driven IPv4 address block hijackings will become routine, which in turn will result in the routing table being politicized.

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Parallel Connections Problems

- Google Maps opens ~ 70 parallel connections
- iTunes store has been shown to open as many as 300 parallel connections
- IPv4/nat multiplexes multiple users through the port range, so 64k divided by 300 parallel connections results in ~200 customers per ISP based NAT address (assuming each customer is only allowed to run one simultaneous instance of iTunes or similar apps).
- Services generally don‘t allow connections from the same host to span multiple public side addresses, so use of more ports on another address will cause the application to fail.
- Reuse of port pairs can‘t be guaranteed with a high rate of churn in the port pool, so the likelihood of matching src/dst port pairs to popular sites will expose the probability of TCP sequence number overlap between unrelated connections.

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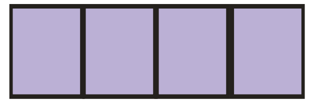
IPv6 Address Size

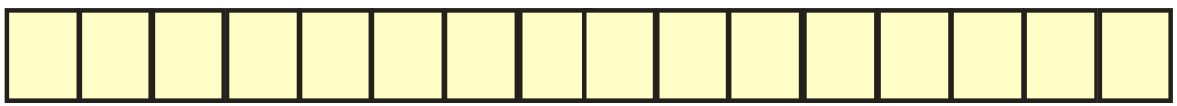
207.217.125.50/24



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

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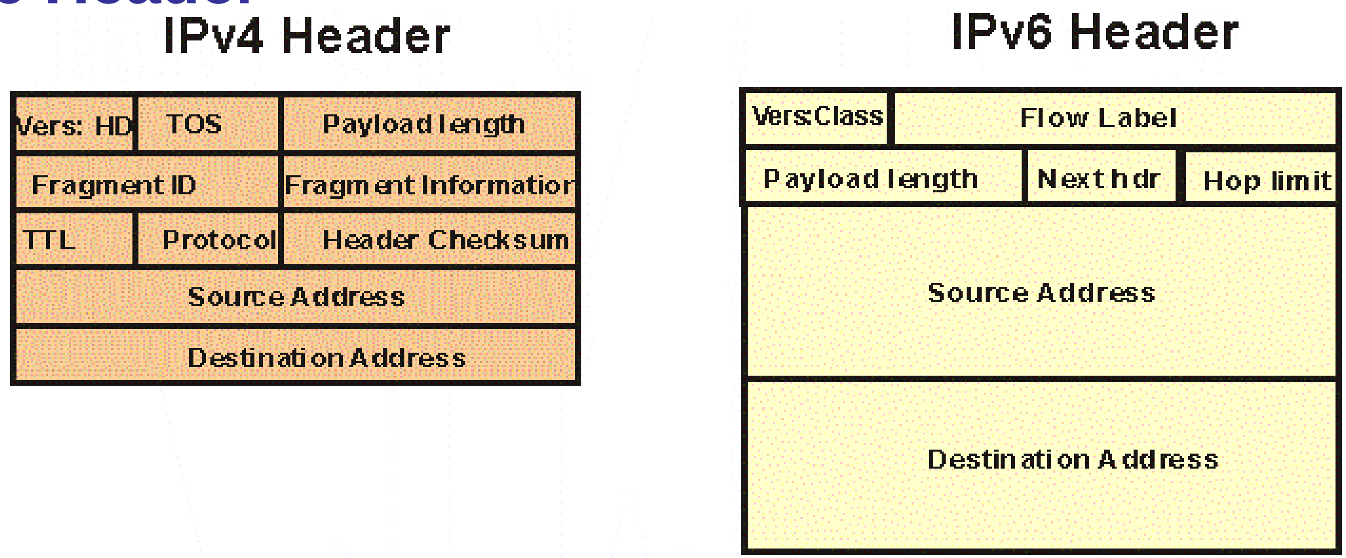
IPv6 Header



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

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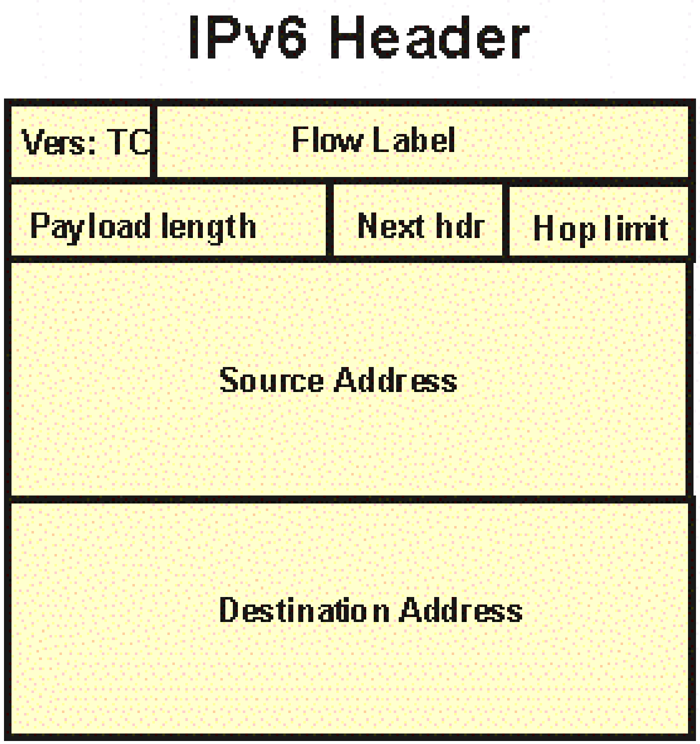
IPv6 Flow Label



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

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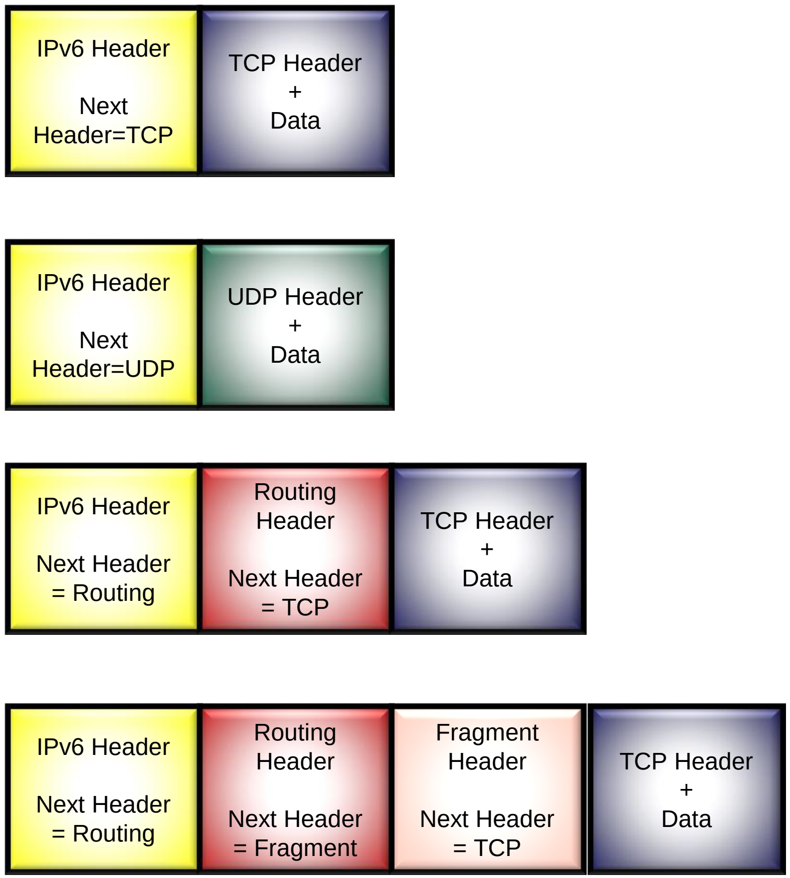
IPv6 Extension Headers



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

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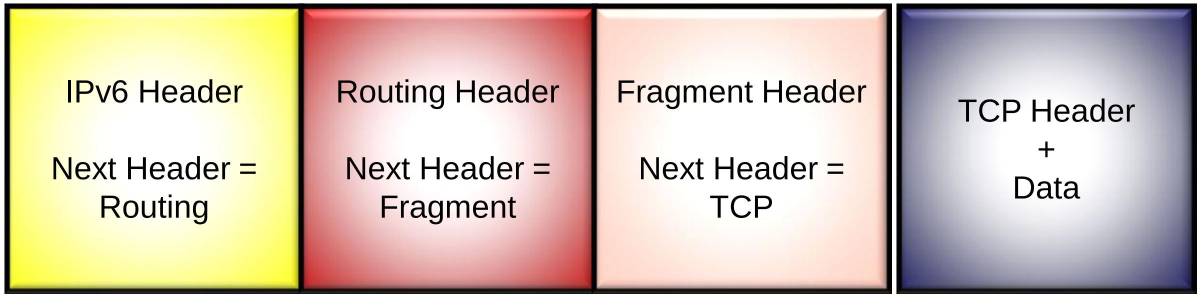
IPv6 Fragmentation Header



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

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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
- Alogrithm 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

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IPv6 Address Types

unicast:

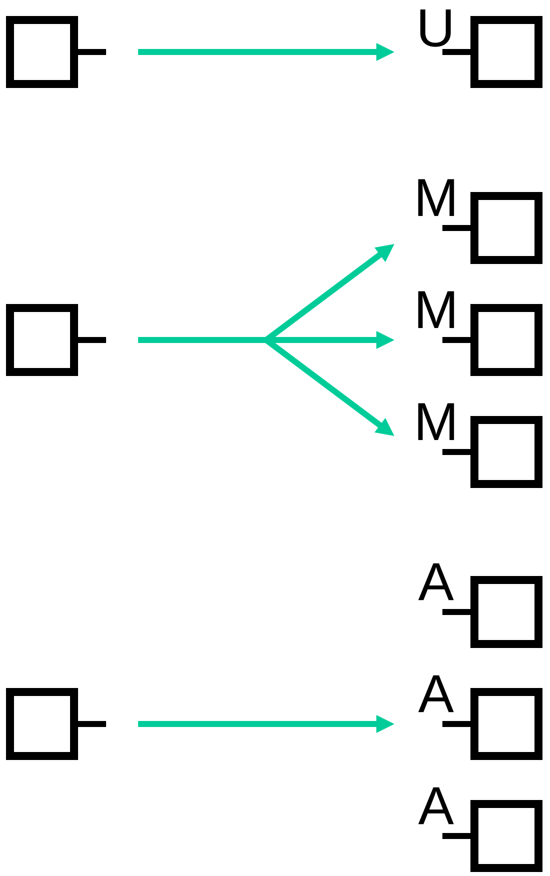
for one-to-one communication

multicast:

for one-to-many communication

anycast:

for one-to-nearest communication



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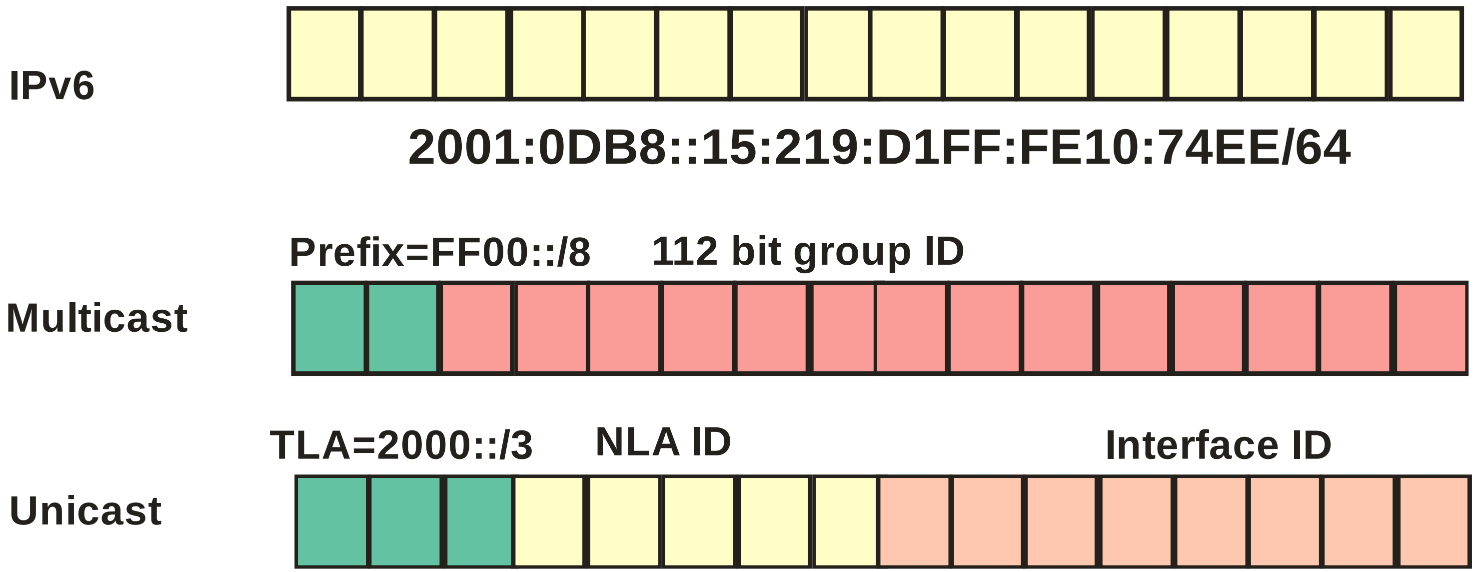
IPv6 Address: Site and Link



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

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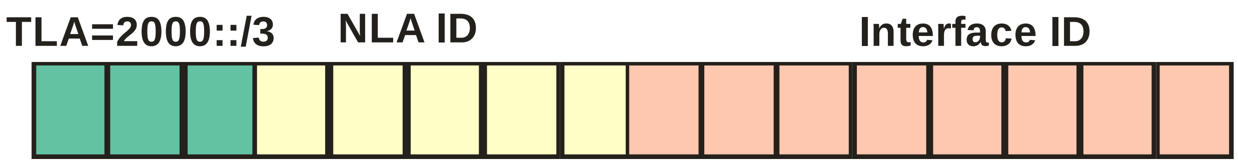
Global Unicast Address



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

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Interface ID from MAC

Company ID | Manufacturer Data

00	19	71	64	3F	00

IEEE 48-Bit MAC Address

00	19	71	FF	FE	64	3F	00

Expand to EUI-64

00000000

00000010

0xFFFE inserted

02	19	71	FF	FE	64	3F	00

Invert the Global Bit

0219:71FF:FE64:3F00

Interface ID

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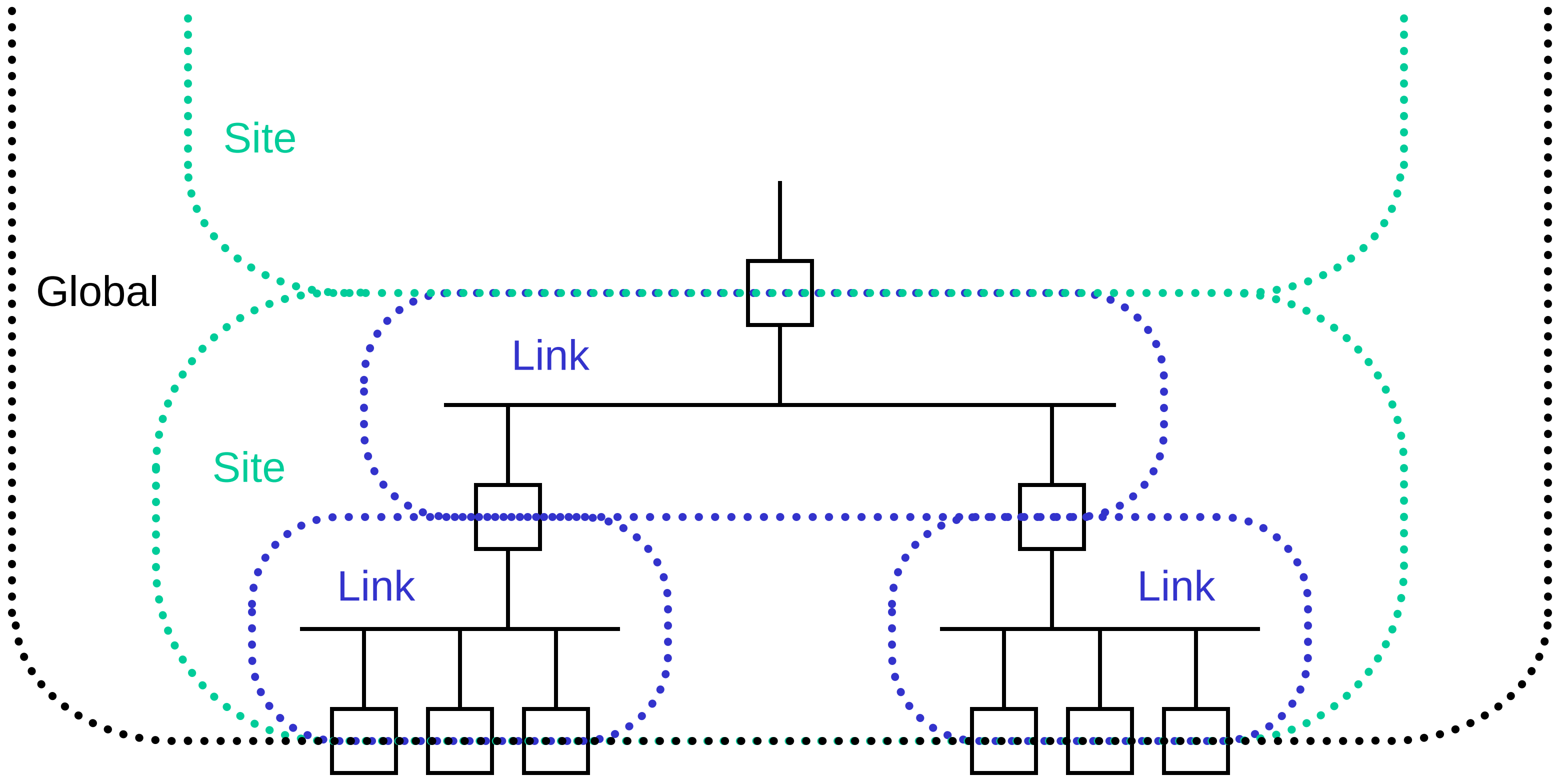
Boundaries



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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

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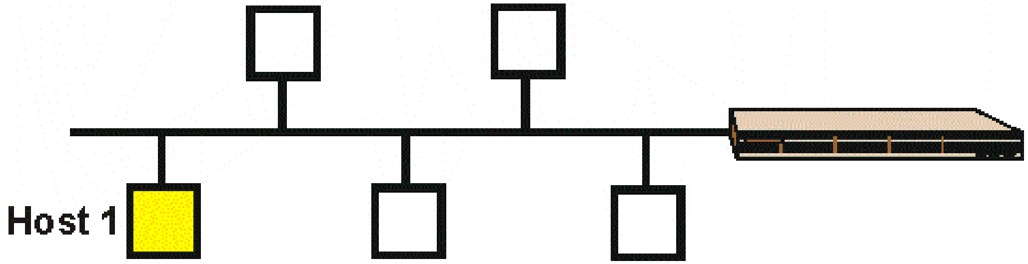
IPv6 Auto-configuration



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

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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)

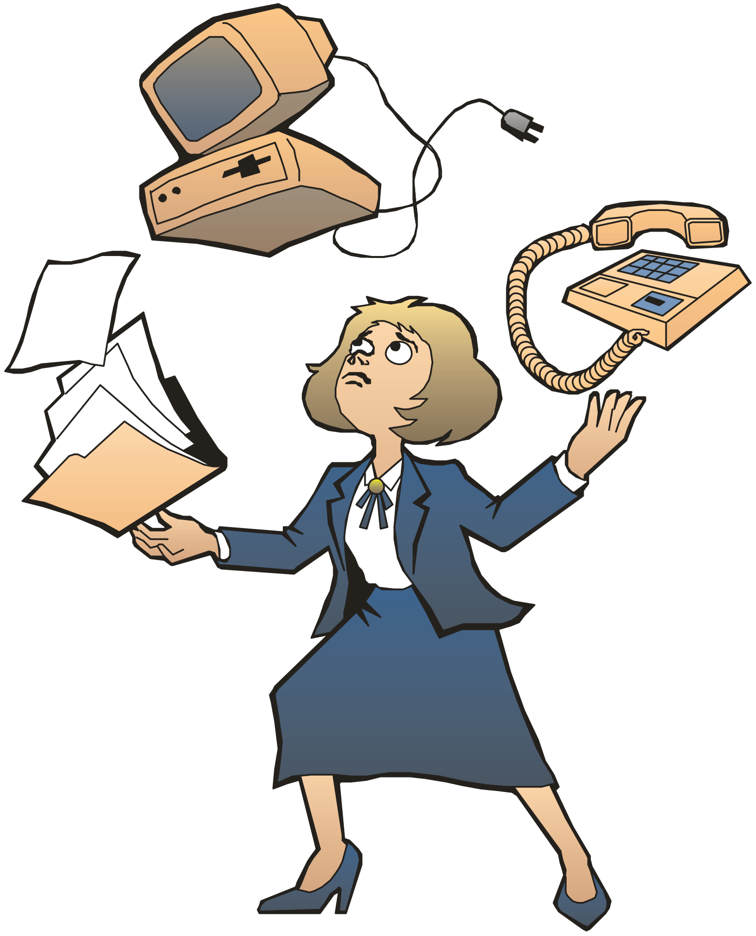
- Many products already support 128 bit addresses
- Uses ‘AAAA’ records for IPv6
- IP6.INT (in_addr_arpa in IPv4)

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



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Applications

NTT 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 Netwroks
    - 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

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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

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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:

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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

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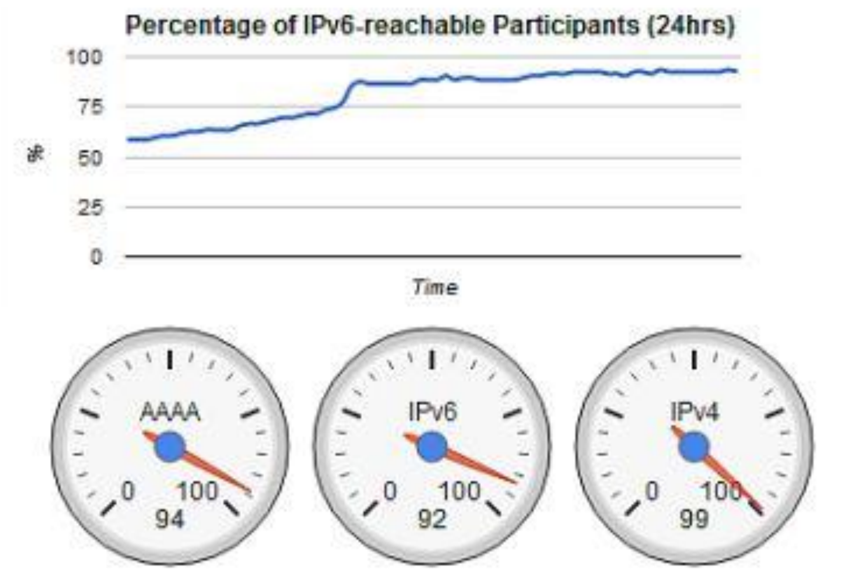
Google and IPv6

- 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

The Internet Society is testing the availability and reachability of World IPv6 Day participants from our servers in the UK. The dials below indicate the percentages of participants announcing IPv6 DNS records, reachable from ISOC over IPv6, and reachable from ISOC over IPv4.



Last updated: Wed Jun 8 23:48:13 UTC 2011.

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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

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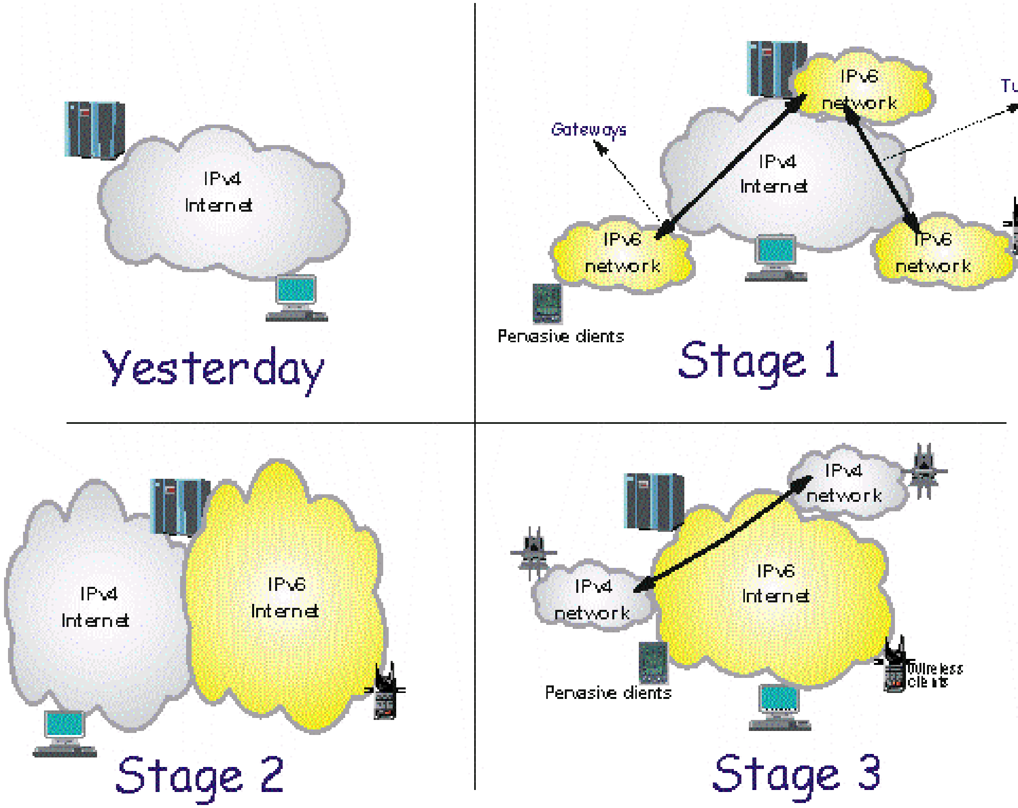
IPv6 Transition Paths



About 2% of the Internet is today IPv6-based (October 2003)

There may be a stage 4 with only IPv6, but it will take some years to get there.

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AES aesclever.com

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

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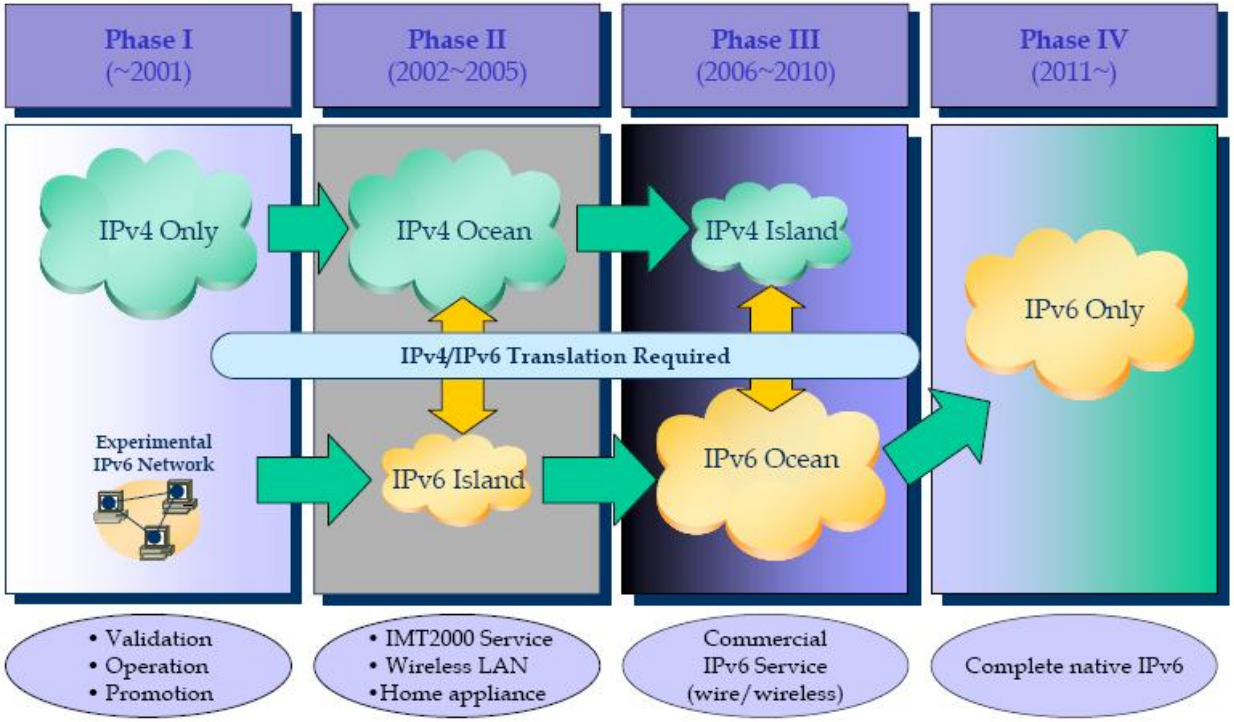
IPv6 Transition Roadmap – Leading Korean ISP



Expanded with country wide support services

6NGIX provides exchange among ISPs

Korea dvanced Network providing IPv6 for orgnizations now

By end of 2009 3 new ISPs moving to IPv6 backbones

Public Sector transition planned for 2011

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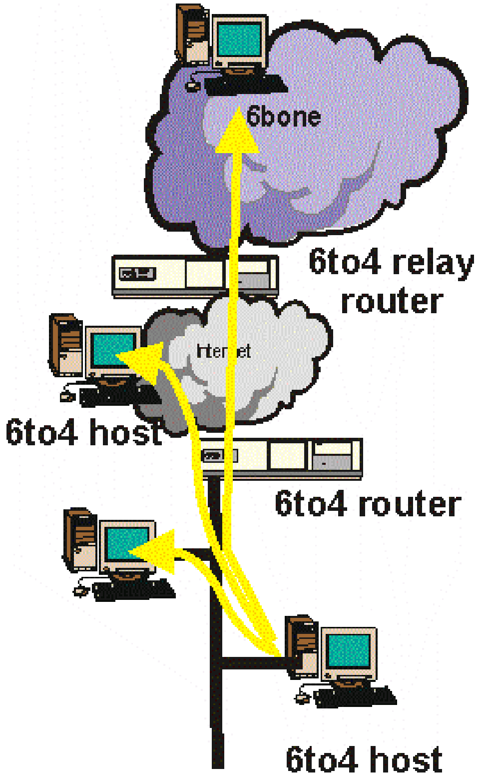
6to4 Tunneling

- 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::



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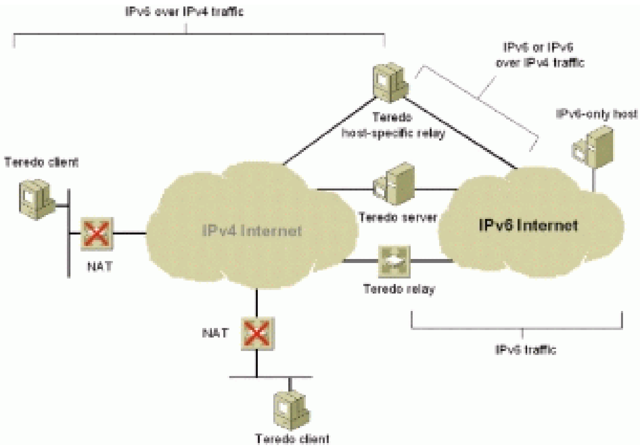
Teredo

- 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.



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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

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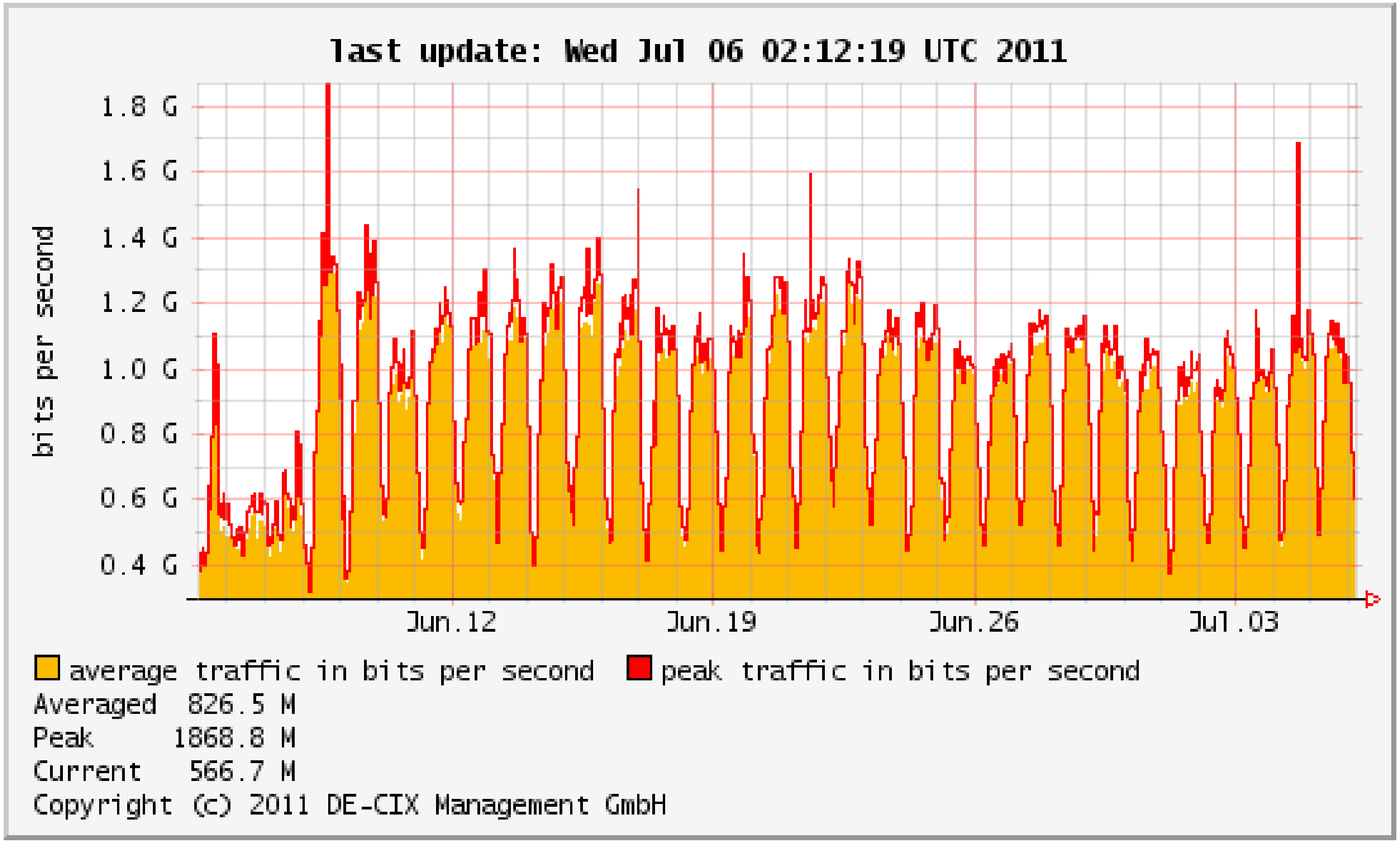
IPv6 Penetration Germany



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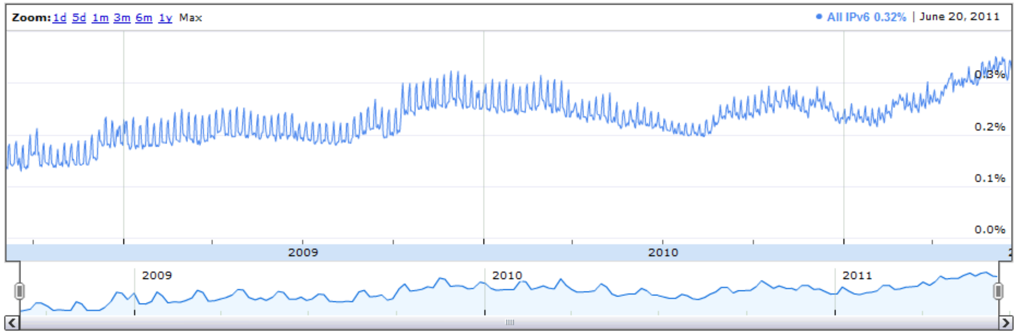
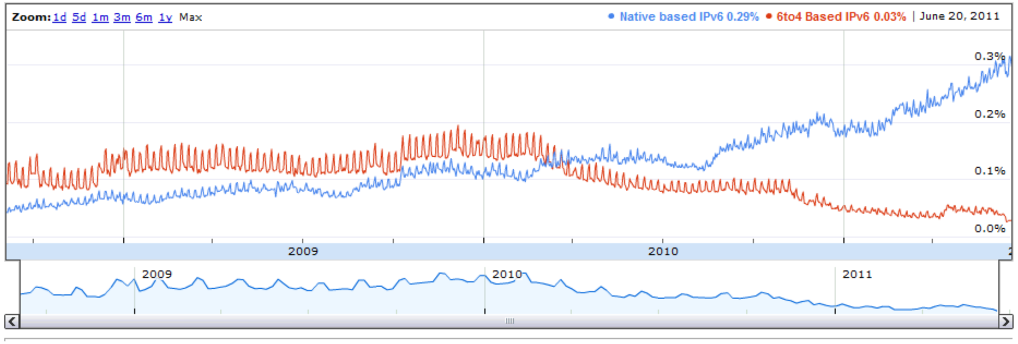
Google IPv6 Statistics



This is the Native IPv6 vs. 6to4/Teredo graph and shows what connectivity method is used by users. More connectivity is now native than before.



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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**

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धन्यवाद
Hindi
Hindi

Tr 多謝

Thai ขอบคุณ

Спасибо
Russian

Gracias
Spanish

Thank
English
You

Obrigado
Brazilian Portuguese

شكرا
Arabic

多谢
Simplified Chinese

Danke
German

Grazie
Italian

Merci
French

நன்றி
Tamil
Tamil

ありがとうございました
Japanese

감사합니다
Korean

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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

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AES Sessions at Share

Aug 8, 2011: 1:30-2:30 9288: Keeping Your Network at Peak Performance as You Virtualize the Data Center
Aug 10, 2011: 8:00-9:00 9266: IPv6 Basics
Aug 10, 2011: 4:30-5:30 9270: Managing an IPv6 Network
Aug 11, 2011: 3:00-4:00 9273: CSI Maui: Forensics in The Case of the Attacked Browsers
Aug 11, 2011: 11:00-12:00 9277: Implementing IPv6 on Windows and Linux Desktop
Aug 11, 2011: 1:30-2:30 9290: **Network Problem Diagnosis with OSA Examples**
Aug 12, 2011: 8:00-9:00 9308: TCP/IP Performance Management in a Virtualized Environment

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