IBM Tivoli

IPv6 Introduction and IPv4/IPv6 Coexistence Share User Group Session 3128

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What is IPv6

Updated version of the Internet Protocol (IPv4)

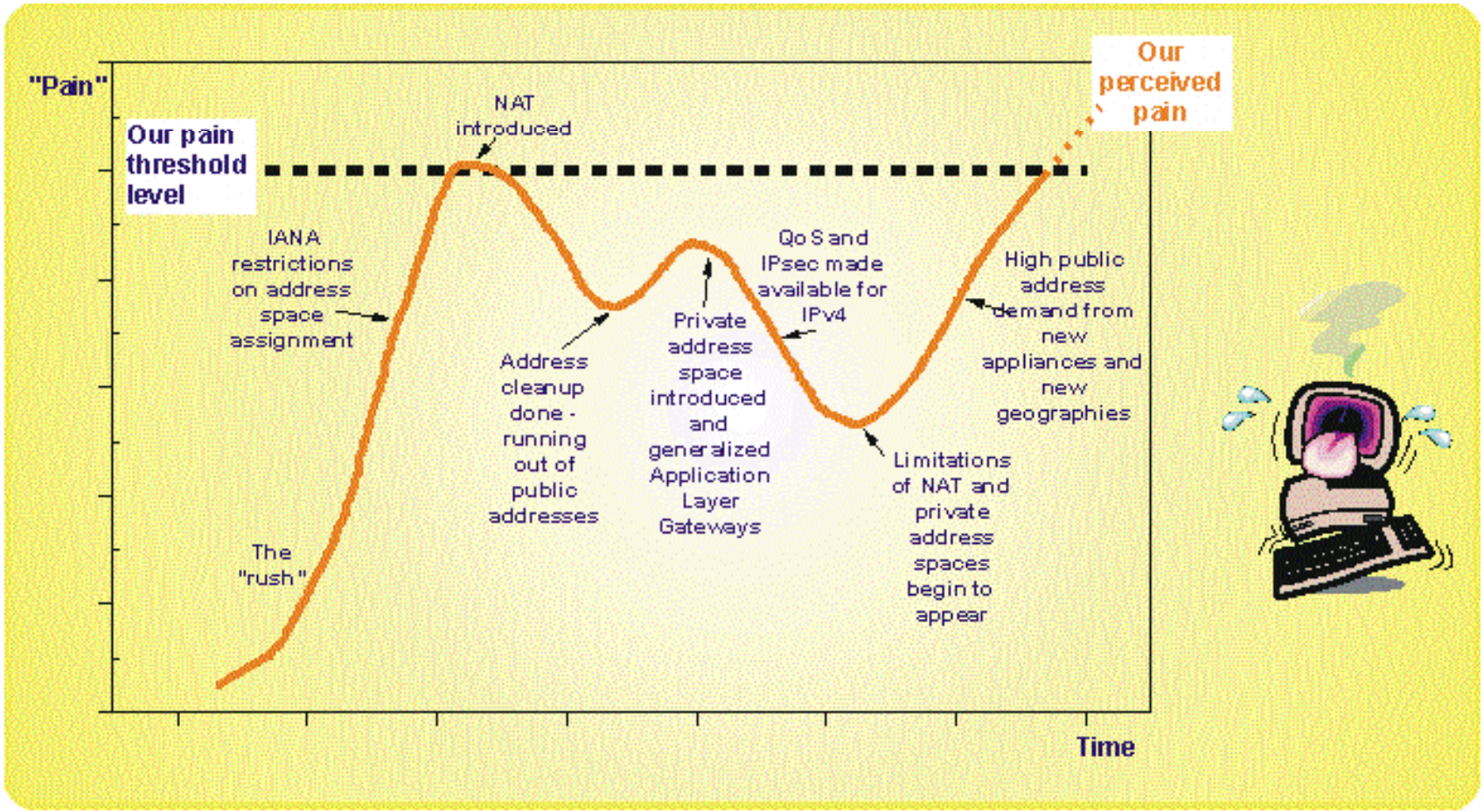
Defined in RFC 1752

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**

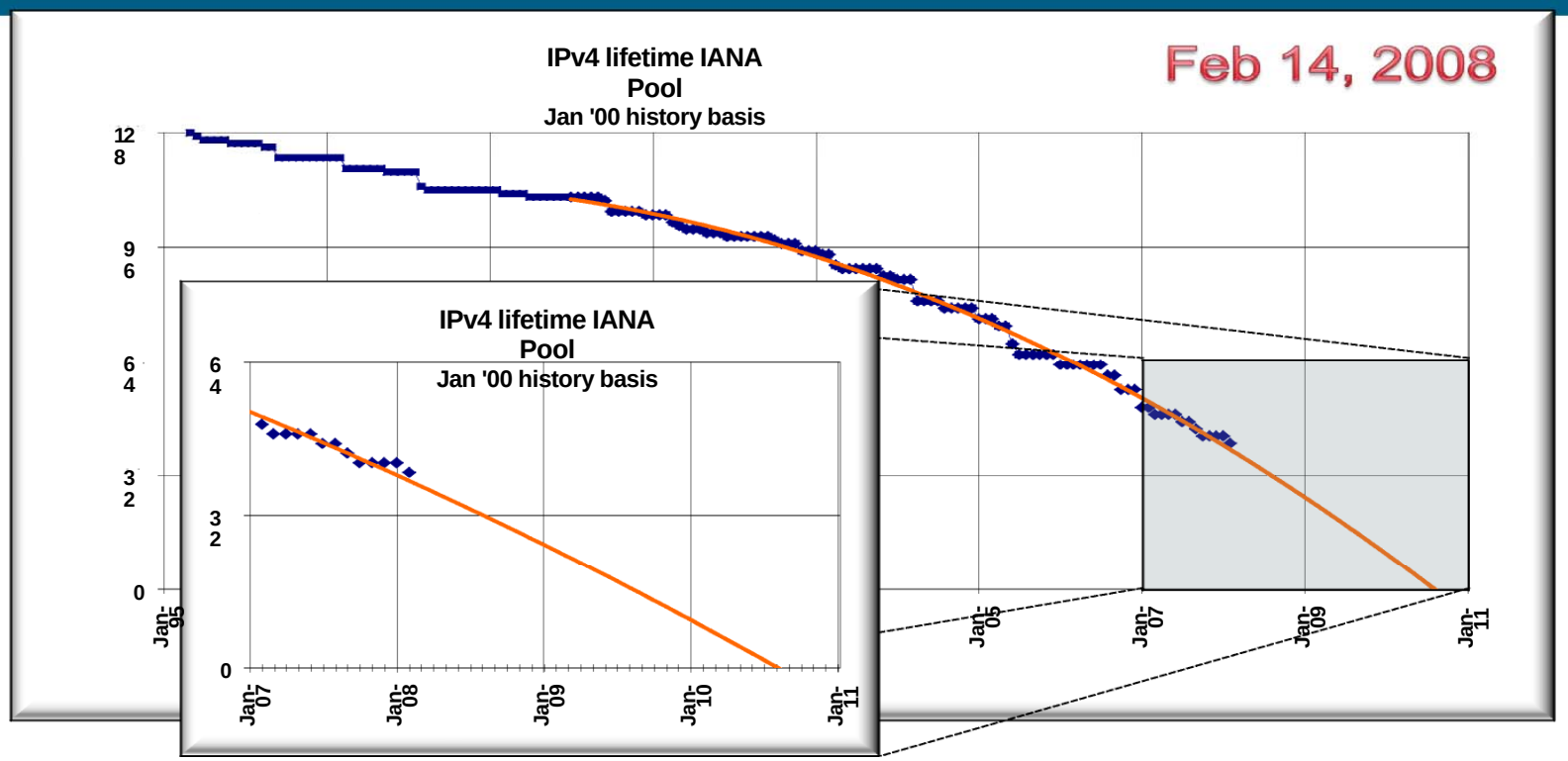
Coexist with IPv4

Why Do We Need More Address Spaces?



April 15, 2009…ARIN Letter Subject: Notice of Internet Protocol version 4 (IPv4) Address Depletion

IPv4 address allocation by /8



Update to: http://www.cisco.com/web/about/ac123/ac147/archived_issues/ipj_8-3/ipj_8-3.pdf

Applications are Changing

- **Growing mobility of users**
  - Internet access from anywhere (car, home, office)
  - Multiple addresses per person
  - Pervasive Computing
- **Continued rapid growth of the Internet**
  - China plans to roll out ~1 billion Internet nodes, starting with a 320 million student educational network
  - Asia/Pacific, and to a lesser extent Europe, missed out on the early IPv4 address allocations
- **Government support**
  - Wide-scale IPv6 promotion underway in Japan, Korea, and Taiwan
  - European Commission (EC) encourages IPv6 research, education, and adoption in member countries
  - Government agencies beginning to mandate IPv6 capable technology
- **Convergence of voice, video and data on IP**
  - Need for reliable and scalable architecture
  - "Always-on Connections"
- **New application opportunities**
  - Potentially unlimited number of IP nodes (vehicles, devices, components, individual parts, etc.)
- **Security becomes more and more important**
  - Various optional security features have been patched on top of IPv4
  - **IPv6 has security features defined as part of the base protocol**

Connectivity for ***anyone*** from ***anywhere*** (car, plane, home, office) to ***anything***!

IPv6 promises true end-to-end connectivity for peer-based collaborative solutions.

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.

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.

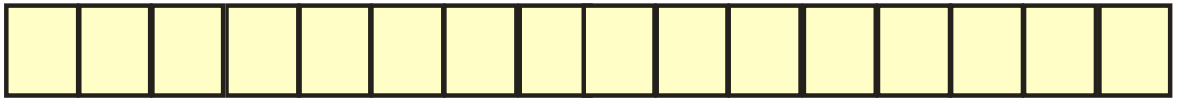
IPv6 Address Size

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)

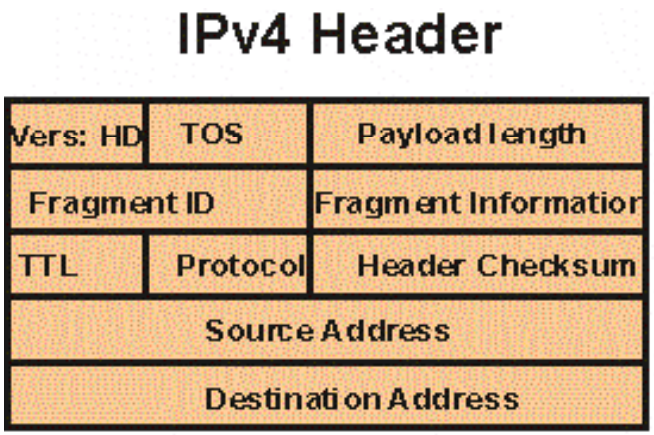
Asia feeling address squeeze fastest due to receiving addresses last

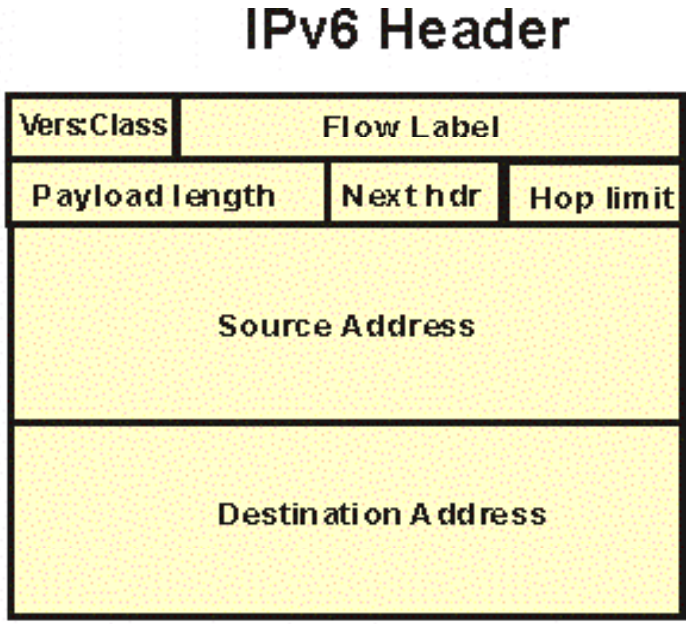
Mobil digital telephony pressuring existing IPv4 network

ICANN continues to handle overall addressing issues

Shortcuts like dropping L eading zeros or C ontiguous zeros permittec

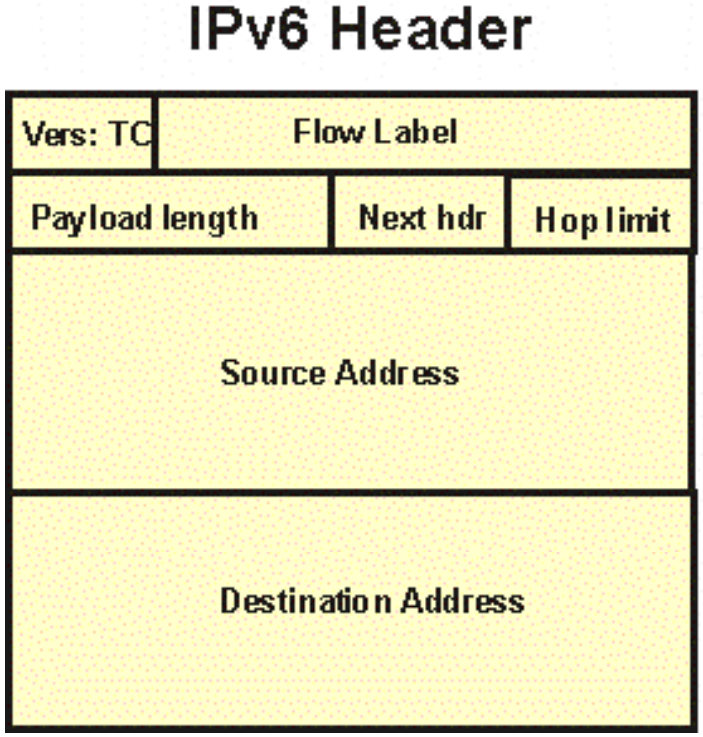
IPv6 Header





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



Identifies datagrams that require special quality of service

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

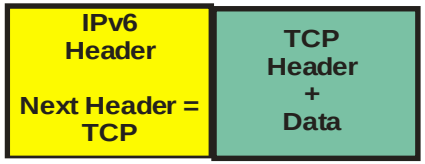
Zero value indicates no flow label

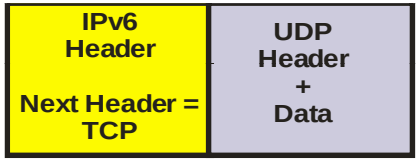
Other protocols like RSVP may provide information for the Flow Label

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

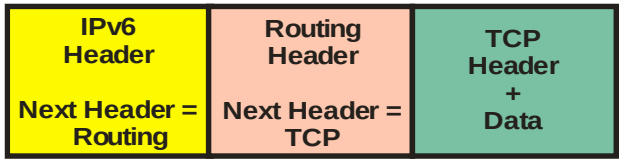
IPv6 Extension Headers

Usual traffic

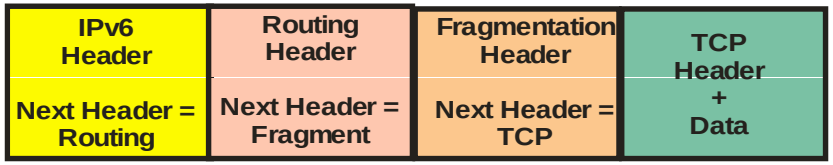




Special routing



If fragmented



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

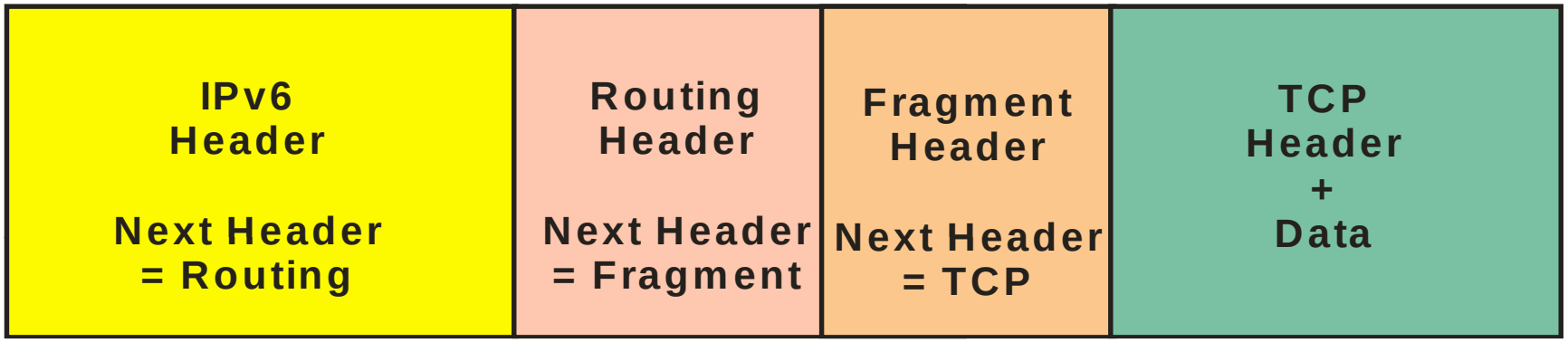
Encapsulating Security Payload = 50
Encryption type and parameters

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

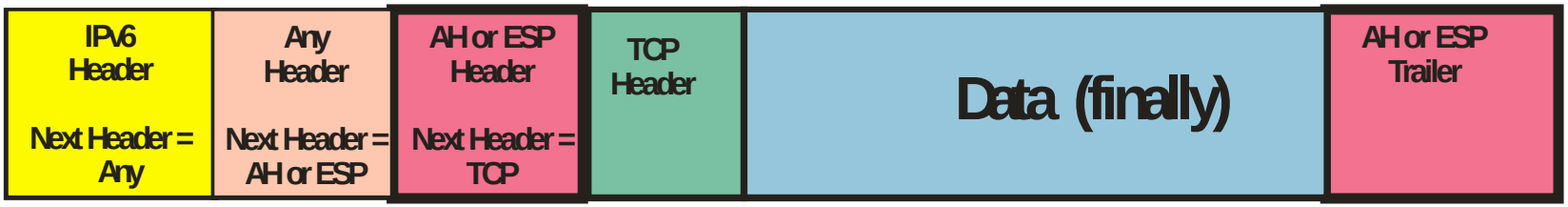


In IPv4 routers handled fragmenting frames

If needed, IPv6 hosts fragment frames

Hosts use:
- Increased guaranteed minimum MTU of 1280
- Path MTU discovery to find maximum fragment size for a path

IPv6 Security



Authentication - AH header
- **Packet authentication and integrity without confidentiality**
- **Algorithm independent – MD5 (Message Digest) 128 bits**
  - **SHA1 (Secure Hash Algorithm) 160 bits**

Data Privacy – ESP header
  - **(Encapsulating Security Payload)**
- **Message, including next header(s), encrypted**
- **Mandatory support of DES-CBC**
  - **(Data Encryption Standard - Cipher Block Chaining) 56 bits**
- **Other processes including AES-CBC**
  - **(Advanced Encryption Standard) 128 bits**
- **May also include authentication, no separate header**

IPv6 Address Types

unicast:

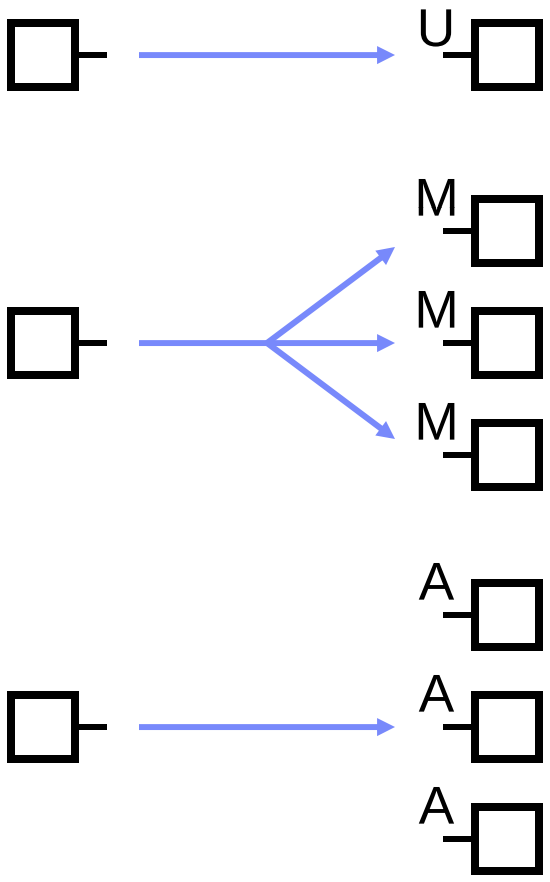
for one-to-one communication

multicast:

for one-to-many communication

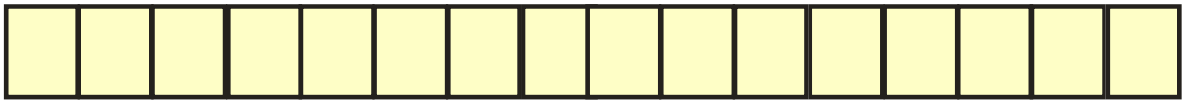
anycast:

for one-to-nearest communication



IPv6 Address: Site and Link

IPv6



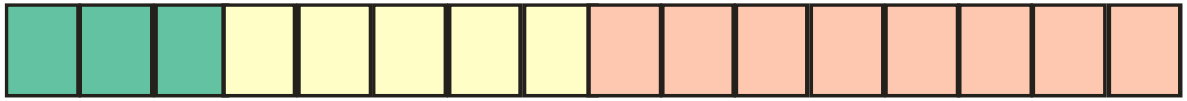
2001:0DB8::15:219:D1FF:FE10:74EE/64

Multicast

Prefix=FF00::/8 112 bit group ID

Unicast

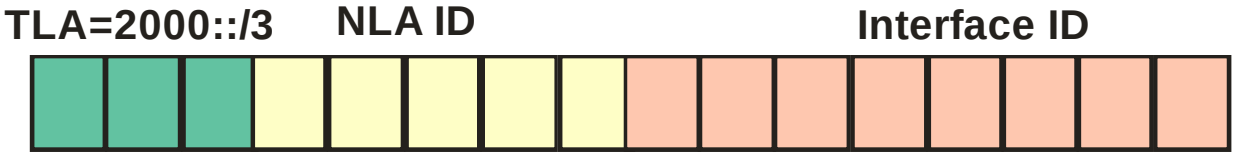
TLA=2000::/3 NLA ID Interface ID



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



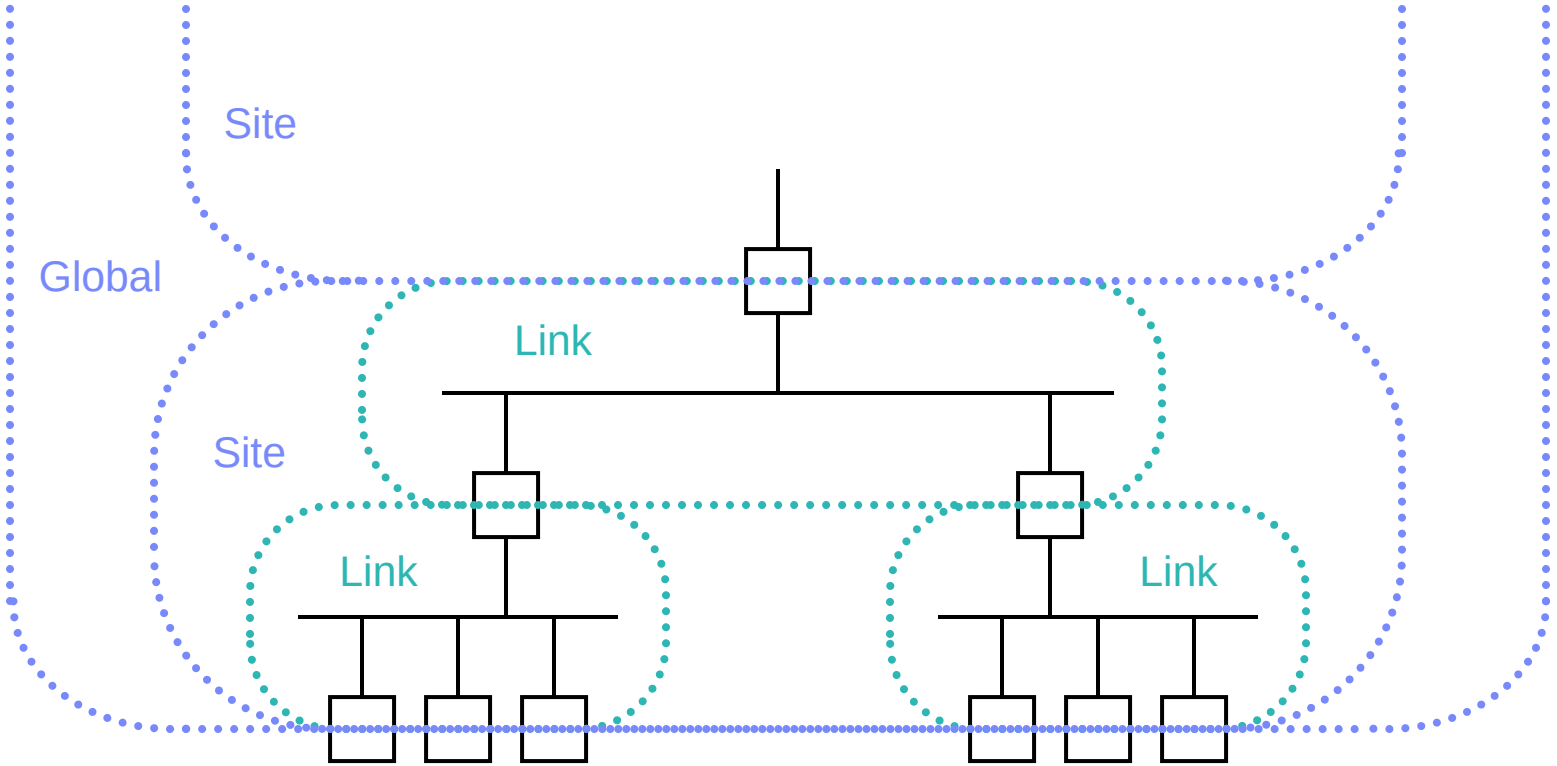
TLA : Top Level Aggregation - 3 bytes (21 bits; First three bits of byte 1 are 001)
- IANA allocates address blocks to the regional Internet registries
- They allocate portions of their block to national registries or to ISPs

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

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

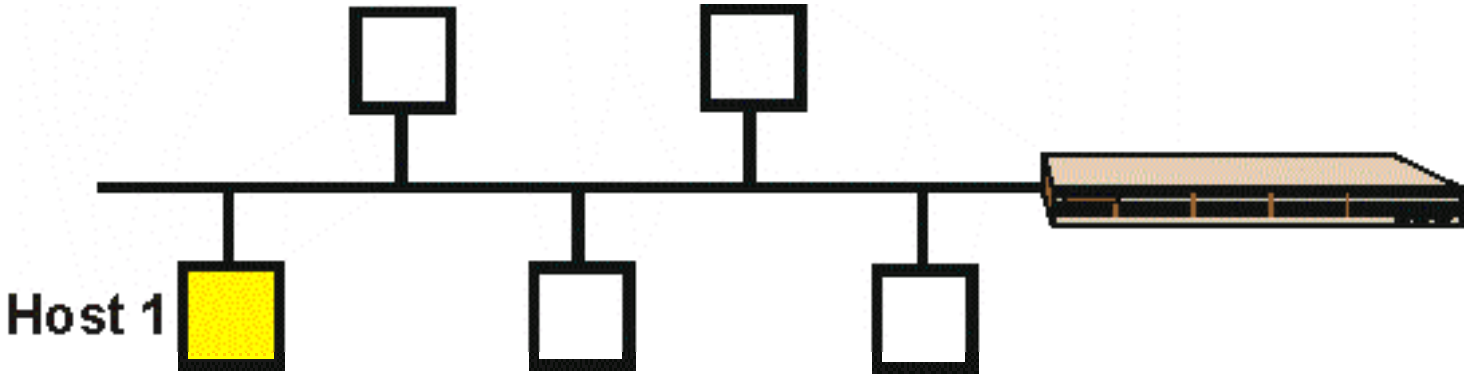
- **Reduces impact of finding hosts**

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)

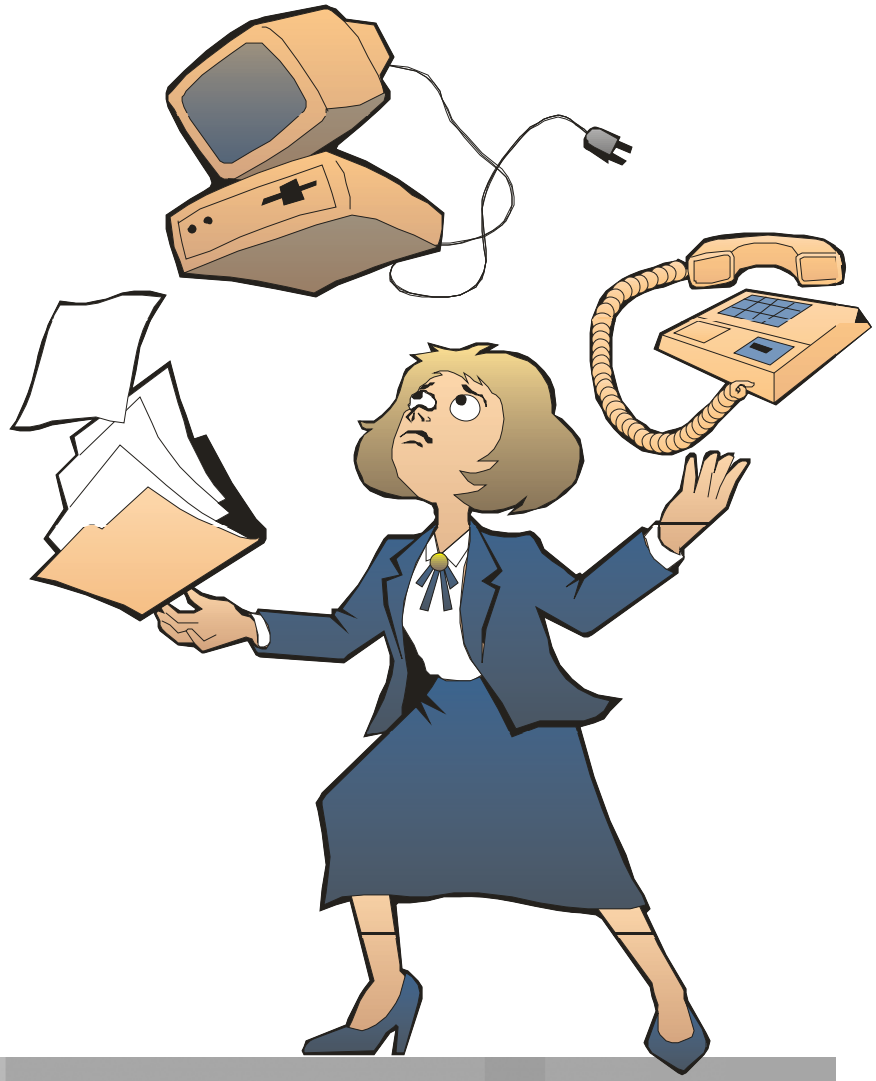
- **Many products already support 128 bit addresses**
- **Uses 'AAAA' records for IPv6**
- **IP6.INT (in_addr_arpa in IPv4)**

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 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

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

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
- IreInd's national research network leverages the IPv6 netwrok

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

- Google engineers say it was not expensive and required only a small team of developers to enable all of the company's applications to support IPv6, a long-anticipated upgrade to the Internet's main communications protocol. (Network World March 2009)
- We can provide all Google services over IPv6," said Google network engineer Lorenzo Colitti during a panel discussion held here Tuesday at a meeting of the Internet Engineering Task Force (IETF). Production January 2009
- Business Case: Colitti said the business case for IPv6 is that new devices such as set-top boxes will increasingly support IPv6. In addition, IPv6 will reduce the infrastructure and support costs associated with the alternative to IPv6, which is multiple layers of network address translators (NATs) being installed on the Internet
- Colitti warned that IPv6 traffic "will appear overnight," as Google experienced in March when its IPv6 traffic grew three-fold after Google Maps was IPv6-enabled.

IPv6 Transition Methods

Tunneling

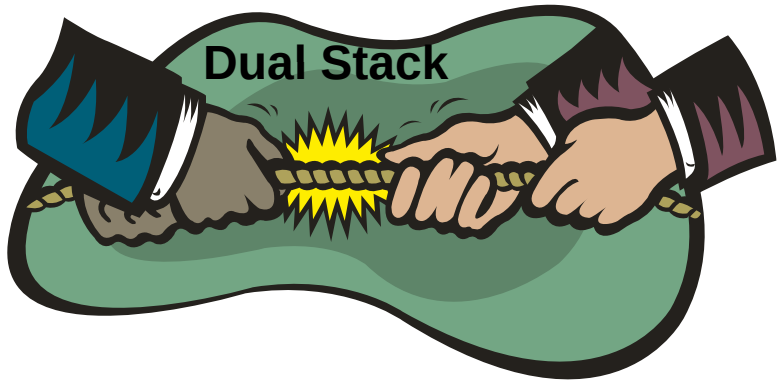
IPv6 only systems communicate across an IPv4 network

New “6to4” protocol from IETF

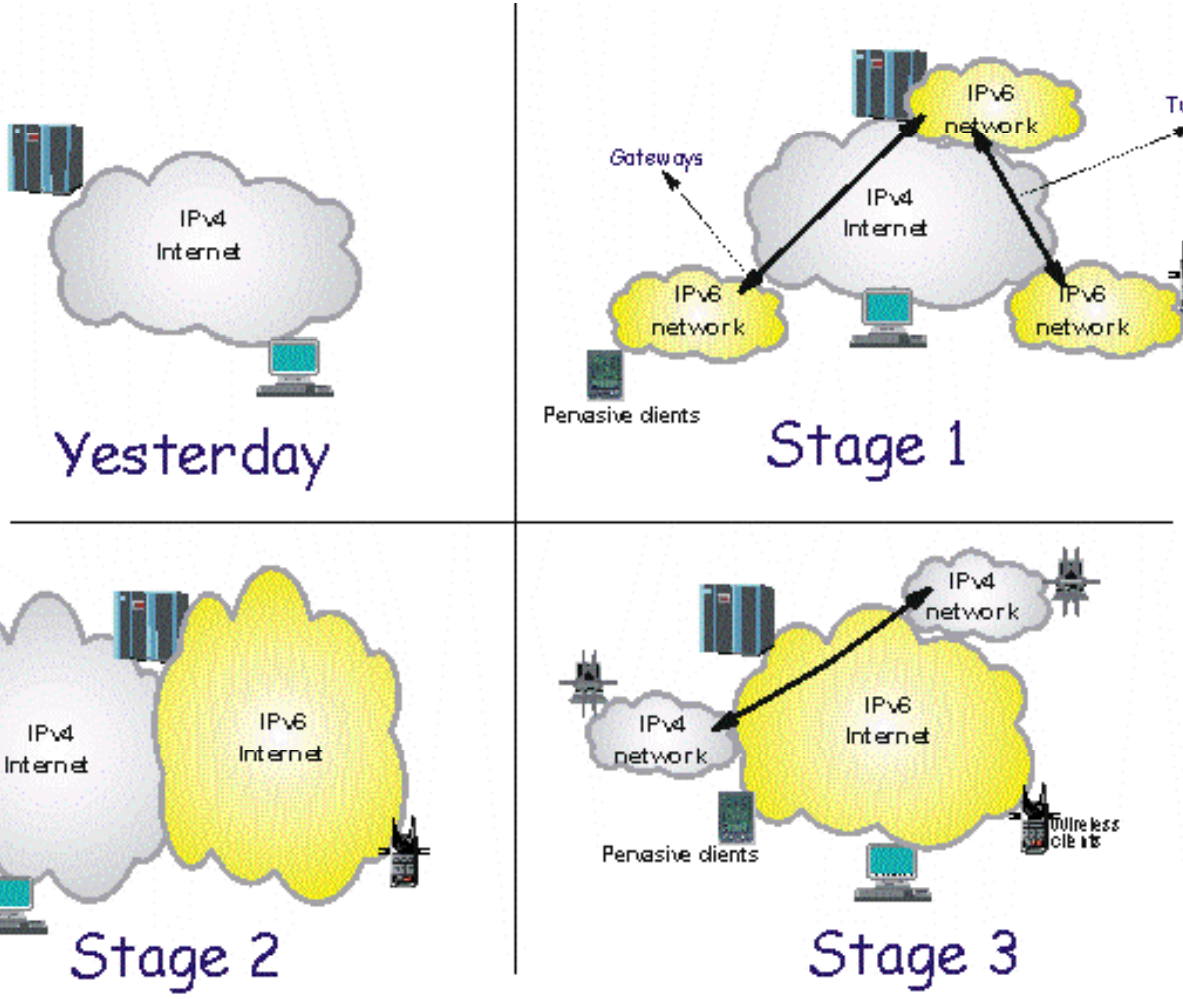
Header translation

IPv6 system communicates with an IPv4 system

(header conversion, transport relay, application proxy)



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.

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

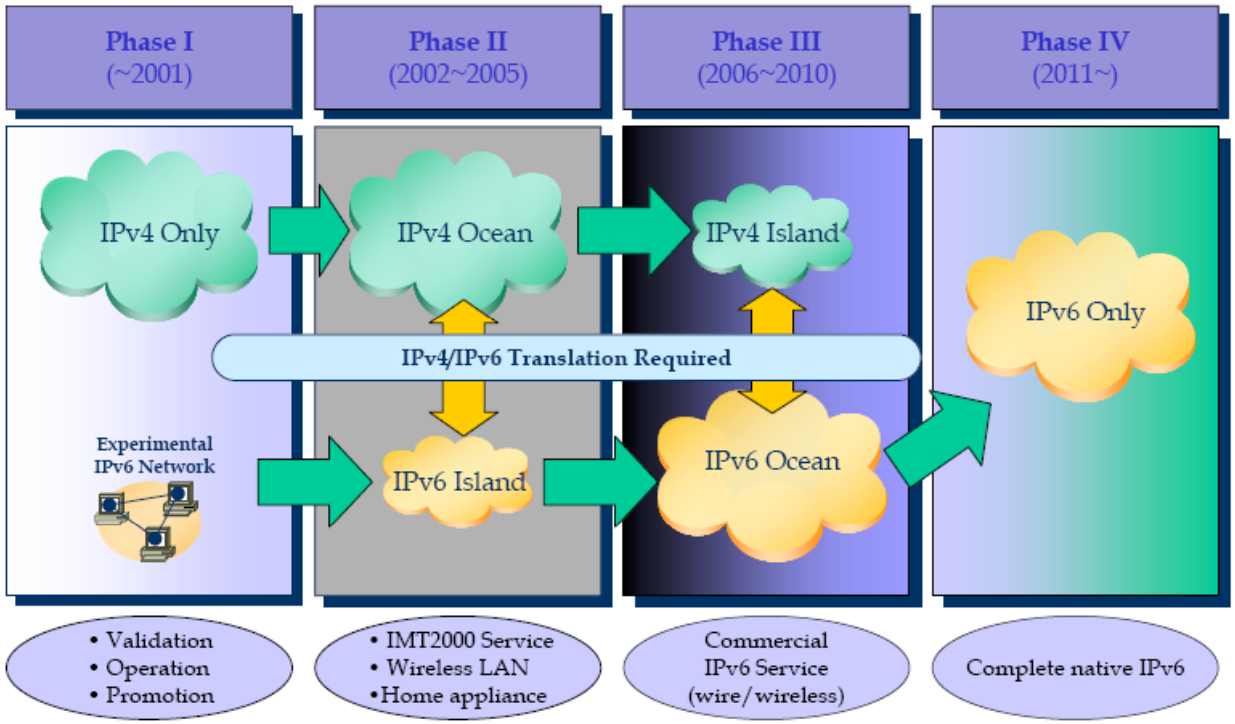
Promoting New Services

- 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 – 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

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

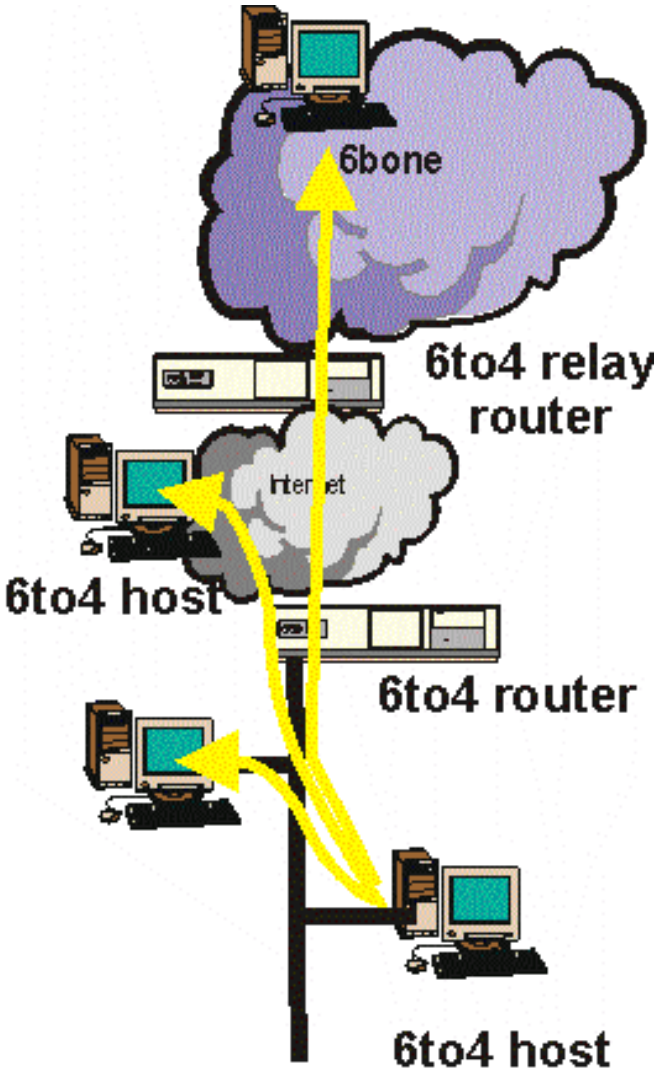
2002:wwxx:yyzz:[Subnet]:{Interface ID}

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

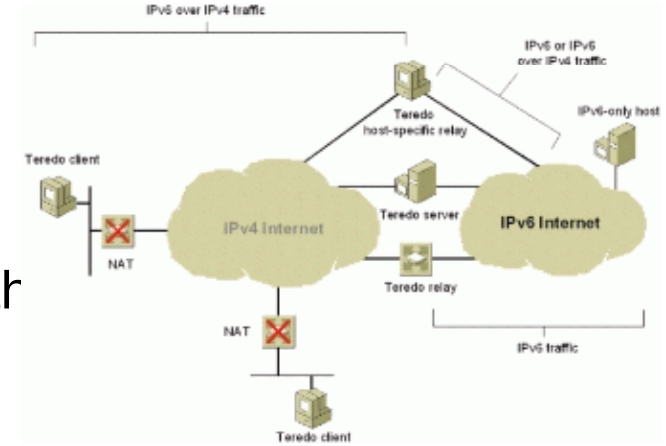
6to4 router - an IPv4/IPv6 router that forwards 6to4 traffic between 6to4 hosts within a site or 6to4 relay routers on the IPv4 Internet

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::

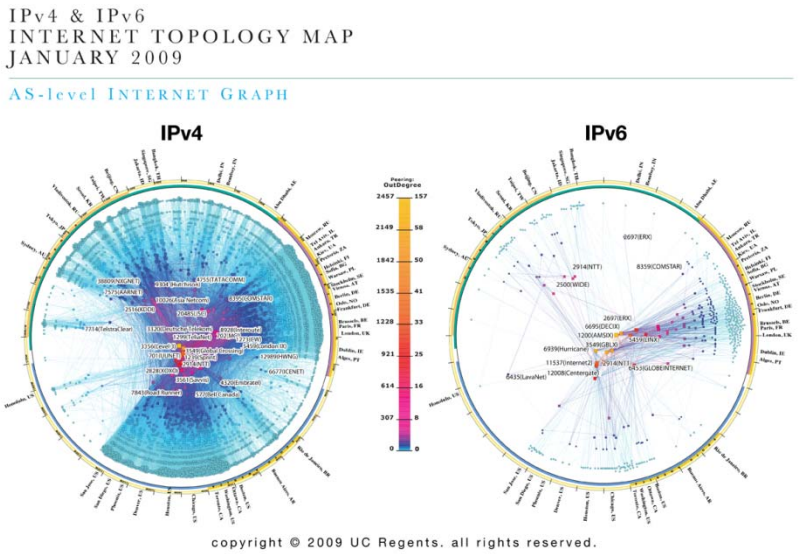


Teredo



- 6to4 tunnels requires the tunnel end point to be public IPv4 address…..so for many that means th NAT device…Many NAT devices cannot be 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

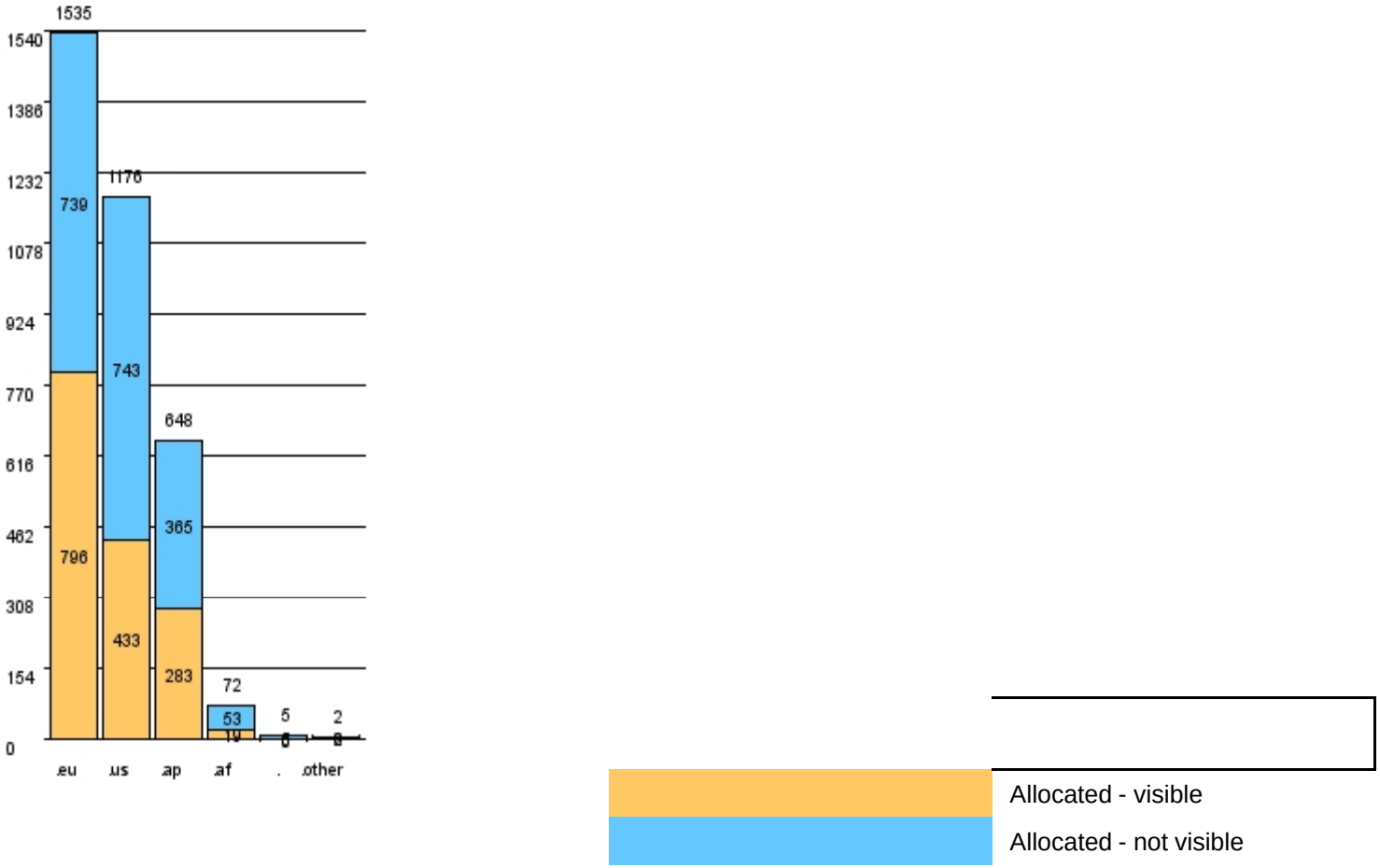
SIIT (Stateless IP/ICMP Translation)

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 Penetration Worldwide



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 Milestones

- 2007 May 15 ARIN tables policy of IPv6 addresses for large contiguous blocks. Discontinue IPv4 allocations for this purpose http://www.arin.net/announcements/2007/20070521.html
- 2007 Oct 24 Japan Emergency Earthquake Alert Service launched, based on IPv6 http://www.ntt.com/release/2007NEWS/0010/1023.html
- 2008 Feb 04 IANA add the AAAA records for IPv6 addresses to the four root servers. Now possible for two internet hosts to communicate without IPv4 DNS http://en.wikipedia.org/wiki/IPv6
- 2008 Mar 12 Google launches an IPv6 web interface to its search engine at the URL http://ipv6.google.com http://en.wikipedia.org/wiki/IPv6
- 2008 Apr 30 IPv6Now launches first Australian commercial IPv6 Tunnel Service with SLAs http://www.ipv6now.com.au/transition.php
- 2008 May 28 European Commission announced initiative for 25% users to adopt IPv6 by 2010 http://ec.europa.eu/information_society/policy/ipv6/index_en.htm
- 2008 Jun 18 IPv6Now web hosting services become available on dual-stack IPv4/IPv6 servers http://www.ipv6now.com.au/innovation.php
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धन्यवाद
Hindi

多謝
Traditional Chinese

ขอบคุณ
Thai

Спасибо
Russian

Gracias
Spanish

Thank
English

You

Obrigado
Brazilian Portuguese

شكراً
Arabic

多谢
Simplified Chinese

Danke
German

Grazie
Italian

Merci
French

நன்றி
Tamil

ありがとうございました
Japanese

감사합니다
Korean

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