IPv6 - Benefits and Deployment Issues

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Agenda for Today

- Introduction to IPv6
  – Benefits of IPv6
- Deployment Issues
  – Transitioning
  – A full service?

Networking Today

- Severe shortage of IP addresses
  - Limits growth for existing users
  - Hinders use for new users
- Routing table explosion
- Management nightmare
- No support for new applications
  - Mobility, QoS, etc…
- Drive for commercialisation killed network exp.

What is IPv6

- IETF standard for the next generation IP
  - AKA IPng
- Design goals
  - Address the failings of IPv4
  - Namely:
    - Scalability
    - Efficiency
    - Extensibility

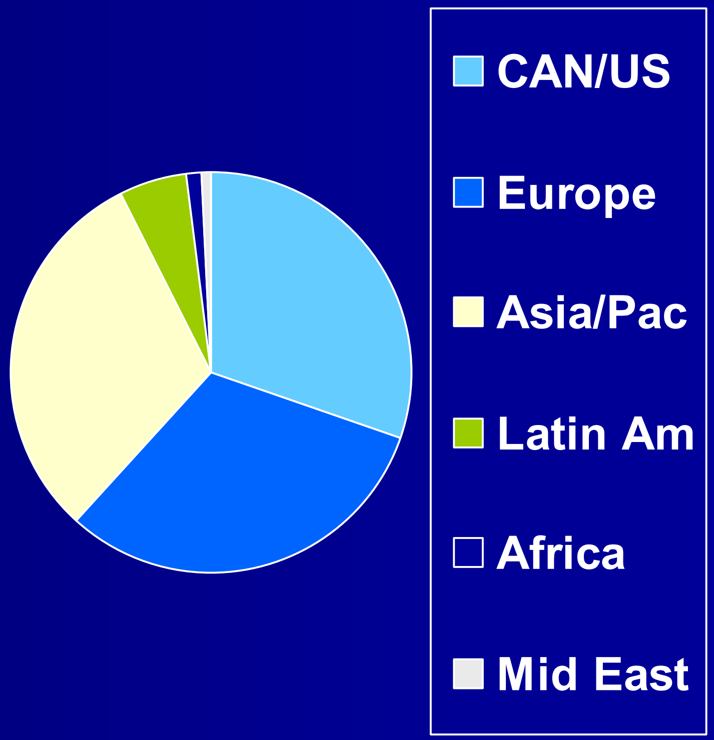
IP and Scalability…

- IPv4 lacks scalability due to addressing
  - 32 bits address space (4.4 Bn addresses)
  - Most addresses allocated to US
- More addresses, please!
  - Individually address all mobile handsets
  - Growth of “always on”, globally addressable devices
  - Peer-to-peer computing, e.g. ICQ, video/VoIP
  - Home networking appliances, pervasive computing devices

Users on the Internet – September 2002

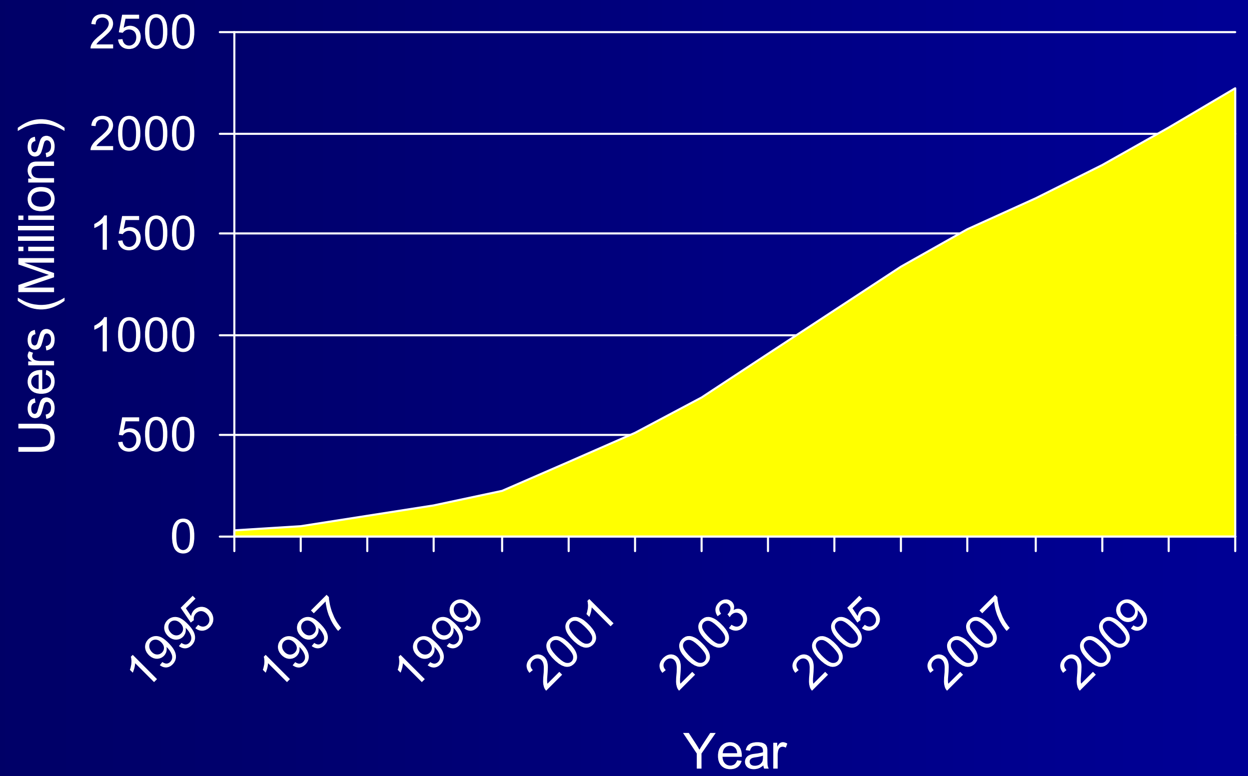
- CAN/US 182.67M
- Europe 190.92M
- Asia/Pac 187.24M
- Latin Am 33.35M
- Africa 6.31M
- Mid-east 5.12M

- Total 605.6 M



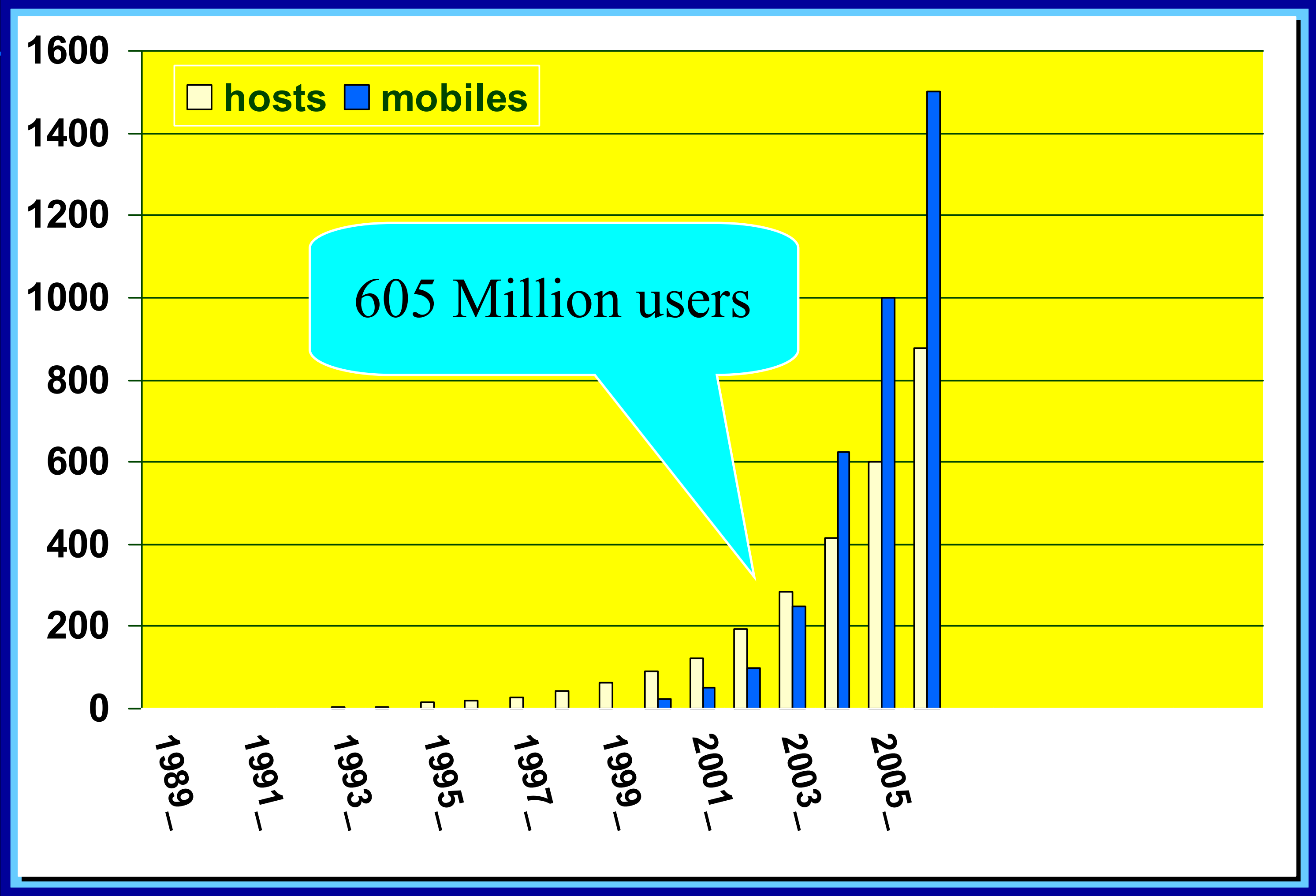
Thanks to Vint Cerf, WorldCom, and *www.nua.com*

Internet User Trends



Source: Nua Internet Surveys + Vint Cerf predictions

More Predictions...



Source: Cerf, based on www.nw.com, Jun 2000 + Ericsson

IPv6 – Size Matters…

- Extended address space
  - 128 bits long
  - Unicast, Multicast or Anycast formats
  - Written in hex notation as 16-bit integers
    - E.g. 2001:630:80:0:0:0:0:1

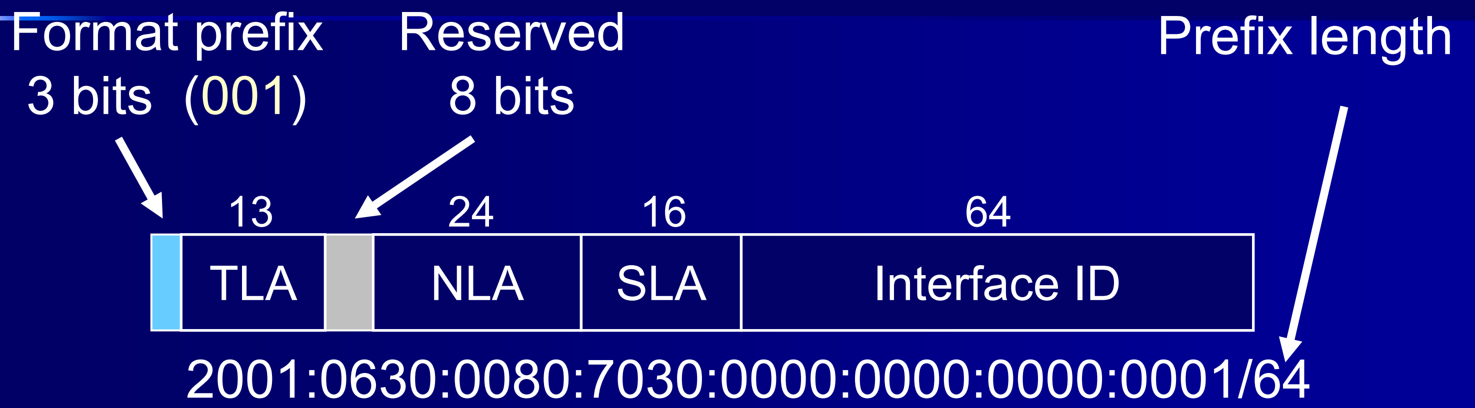
  - 3.4×10^{38} Addresses
  - 6.7×10^{23} Addresses / m^2 on the earth

IPv6 Addressing Model

- Addresses are assigned to interfaces
- Interfaces can have multiple addresses
- Addresses have scope: *link local*, *site local*, *global*

- Addresses are formed through the combination of:
  – Routing Prefix – *where you are connected to*
  – Interface ID – *who you are*

Aggregatable Addresses



TLA	Top Level Aggregation identifier
NLA	Next Level Aggregation identifier
SLA	Site Level Aggregation identifier

IPv6 terminology can drop a single string of all 0s…

2001:630:80:7030::1/64

2001:630:80:7030::/64

loopback ::1 **unspecified ::0** **IPv4 Compatible ::148.88.8.6**

IPv6 General Concepts

- Improved routing techniques
  - Aggregated routing entries designed to reduce routing table sizes
- Multicast supported as native communication mode
- Authentication and privacy capabilities
  - Authentication header
  - Transport + Tunnel Mode

Efficient Header Construction

- IPv4 contains many redundant features…
  - Variable length IP header options
  - IP header checksum
- …some inefficient ones…
  - Packet fragmentation
- … and some omitted
  - Packet classification
- All of which impact network performance

IP: Head to Head

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 Version|  IHL  |Type of Service|          Total Length
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
          Identification        |Flags|      Fragment Offset
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   Time to Live |    Protocol    |         Header Checksum
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        Source Address
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                     Destination Address
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                     Options                    |    Padding
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

IP: Head to Head

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 Version| Traffic Class |           Flow Label
-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
         Payload Length         |  Next Header  |   Hop Limit
-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
+                                                               +
+                                                               +
                         Source Address
+                                                               +
+                                                               +
-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
+                                                               +
+                                                               +
                      Destination Address
+                                                               +
+                                                               +
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

What’s missing?

- The IPv6 protocol header is streamlined for the common-case…
  - Fixed format header (no options)
  - No **checksum** - left to transport and data link layers, no need to check/recalculate each hop
  - No fragmentation (except at source)
    - Agree path **MTU** at the source using **Path MTU discovery**

What's new

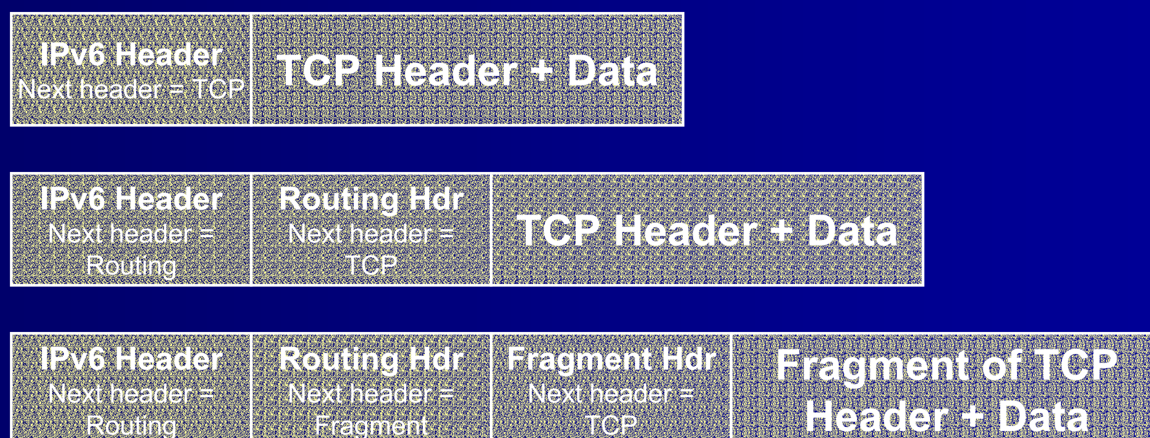
- Revised fields
  - **Payload length** vs. **Total length**
  - **Next Header** vs. **Protocol type**
  - **Hop Limit** vs. **TTL**
- New fields
  - **Traffic Class**:
    - To support differentiated services (e.g. prioritised best effort queuing)
  - **Flow Label**:
    - Along with source address, allows identification of packets which are part of a 'flow'

Extensible headers

- Custom headers for specialist functionality…
  - Fragmentation Headers
  - Routing Headers
  - Destination Options
  - Hop by Hop Headers
  - Authentication and ESP

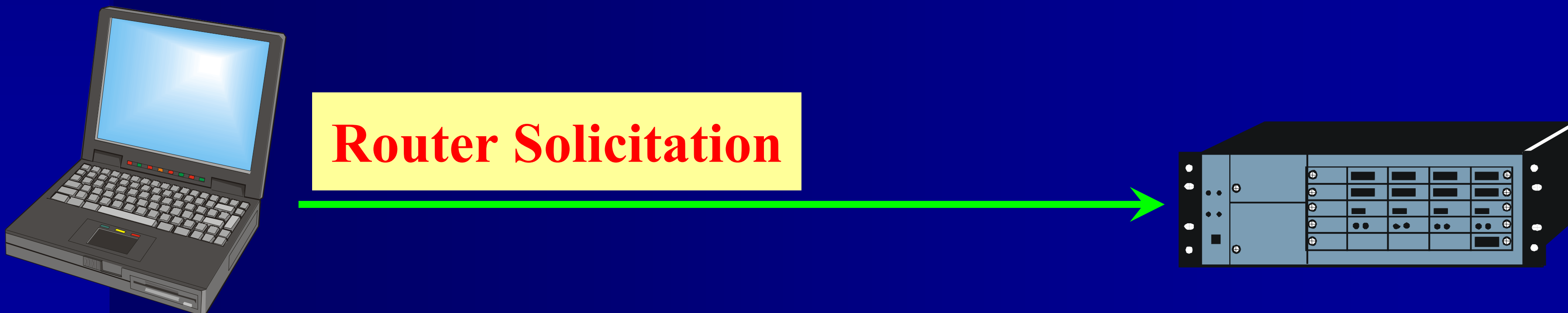
IPv6 Extension Headers

- In IPv6, Options are daisy-chained in extension headers…



Autoconfiguration

- Plug 'n' Play Networking…
  - IPv6 host requires three pieces of info
    - IPv6 Address
    - IPv6 Network
    - IPv6 Gateway
  - Router Solicitation and Advertisement…



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Autoconfiguration

- Host builds IPv6 address from prefix
  - Using EUI-64 identifier of interface
  - Or padded MAC address…
  - In two frame message exchange

Deployment Issues: Transitioning to IPv6…

Contrary to popular belief, IPv6 is not backward compatible…

Compatibility Issues

- Introduce IPv6 connectivity into the IPv4 world
- IPv6 hosts must be able to communicate with each other across IPv4 nets
- As native IPv6 networks become commonplace
  - IPv4 hosts will need to communicate with each other across IPv6 networks
  - IPv6 hosts will need to communicate with IPv4 hosts
- What about dual stacks?

Plugging it Together…

- Three broad categories
  - Tunnelling (6to4, 6over4, Tunnel brokers, Teredo, ISATAP)
    - Allowing hosts that support IPv6 to talk IPv6 to other IPv6 hosts
  - Translation (SIIT, NAT-PT, SOCKS, BIS)
    - Translation between the two
  - Dual Stack (DSTM)

Dual IP Stacks

- Simplest method: Both stacks in parallel in hosts and routers
- Upgrade routers, and host OS
  - Host upgrade can be gradual
- Application support:
  - Existing applications continue to run
  - IPv6 applications (experimental or not…) can be introduced
  - Interoperation of v4 and v6 is another issue
    - Applications to be modified to handle both?

Dual IP Stacks (2)

- Issues
  - Solution does not scale:
    - New IPv6 hosts that need IPv4 compatibility will quickly eat up IPv4 address space
    - Two IP routing tables will place a burden on routers
  - Entire path dual stack?
  - No real stimulus for moving to IPv6

Dual Stack Transition Mechanism (DSTM)

- Addresses problem of new dual stack hosts exhausting sparse IPv4 address space
- Allows IPv6 hosts to temporarily acquire an IPv4 global address
  - Uses a DHCPv6 server within each domain
  - Assigns IPv4 address on temporary basis
- In instances where IPv6 hosts remain online, temporary assignment becomes permanent… i.e. does not eradicate the problem altogether

Tunnelling

- Common mechanism, where one protocol is encapsulated in another
- IPv6 over IPv4 tunnelling
  - Used to transport IPv6 packets over networks that can only understand IPv4
  - Normally the most common transition mechanism adopted in early stages
  - 6BONE is an example of a virtual overlay network of interconnected IPv6 over IPv4 tunnels
  - Can work in a variety of ways: *host to router, router to router, router to host, host to host*

Tunnelling (2)

- IPv6 over IPv4 tunnels are classified as either *configured* or *automatic*, depending on the way the IPv4 address of the endpoint is determined
- Approaches
  - **6to4** – popular, automatic, router to router
  - **6over4** – single site, relies on IPv4 multicast
  - **Teredo** – connectivity to v4 hosts behind NAT
  - **ISATAP** – site based, where v6 host and gateway is separated
  - **Tunnel brokers** – (web-based) mechanism for obtaining a tunnel

Translation Tools

- Translation necessary for IPv6-only and IPv4-only hosts to communicate, should be done near network edge
- Translates packets from one protocol to another, taking form of header processing
- Can take place at a number of layers
  - IP layer
  - Transport layer
  - Application layer

Translation Tools (2)

- Series of tools available
  - **SIIT** – translates between IPv4 and IPv6 headers using a translation algorithm located in the network
  - **NAT-PT**– maintains a pool of unique v4 add. that it dynamically allocates to v6 nodes
  - **BIS** – takes NAT-PT with SIIT functionality and moves it to the OS protocol stack within each host
  - **SOCKS** – application layer IPv6/IPv4 gateway based on SOCKS, translating between two terminated v4 and v6 connections

The IPv6 Operations IETF Working Group (v6ops)

- Ngtrans group closed, replaced by v6ops
  - More “operationally oriented” wg
  - Operating the “combined net” + avoiding a division
  - Develop guidelines:
    - Operation of shared v4/v6 Internet
    - How to deploy v6 into both v4-only and new installations
- Why?
  - V6 is deploying today
  - V6 has been hiding in a corner of the IETF
- Timescales: Oct 2002 – Aug 2003

Deployment Issues:

A full service?

The bigger questions

- How long will deployment take?
  - 2 addressing modes co-existing
  - 5/ 10 / 15 years?
- What support do we have now?
  - Hosts
  - Routers
  - Applications
  - ISPs
  - *(see Tim and Duncan presentation later)*

A Full IPv6 Service?

- Production service needs commercial code
  - Stability, reliability issues
  - On backbone
    - Possible now
    - Hardware-enabled?
  - Applications
    - Perhaps some way off yet

A Full IPv6 Service? (2)

- Do we have a significant driver?
  - Less demand where IPv4 address space seen as being sufficient
  - Users will not demand "IPv6" but demand IPv6-based applications
  - IPv4 address exhaustion?
  - Major network infrastructure deployment (e.g., 3G)
- Significant research activities in UK and Europe
  - Universities, NRENs, Consortiums
- UK IPv6 Task Force

Thank you…

Questions?