

Module Twelve

CSG1105 Applied Communications

- 1990 prediction was that Class B addresses would be exhausted by 1994
- Multiple Class C addresses assigned rather than new Class B
- CIDR aggregation and NAT/PAT used to extend the life of IPv4
- Routing table sizes a problem

- 1992/1993 Multiple proposals for IPng
 - ▶ CATNIP - Common Architecture for the Internet
 - ▶ SIPP - Simple Internet Protocol Plus
 - ▶ TUBA - TCP and UDP with Big Addresses
- None Accepted as they stood
- SIPP proposal modified, resubmitted
- Accepted as basis for IPv6 [rfc1752]

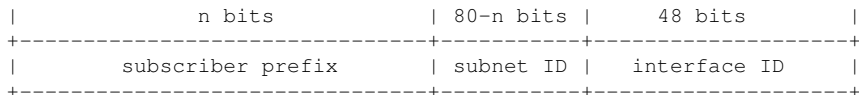
- IPv6 designed as evolution of IPv4
 - ▶ Expanded Routing and Addressing
 - ▶ Header format simplification
 - ▶ Improved support for options
 - ▶ Quality-of-Service Capabilities
 - ▶ Authentication and Privacy Capabilities

- IPv6 address 128 bits allowing 8×10^{17} to 2×10^{33} interfaces
- Three types of address [rfc1884]
 - ▶ Unicast An identifier for a single interface
 - ▶ Anycast An identifier for a set of interfaces, delivered to “nearest” interface
 - ▶ Multicast An identifier for a set of interfaces, delivered to all interfaces

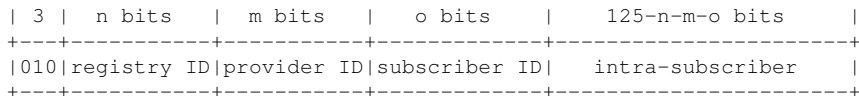
- Too many digits for dotted decimal like IPv6
- Hex form x:x:x:x:x:x:x:x (x is 16 bits) eg 0800:0:0:0:0:00A0:2408:D421
- “::” represents one or more 16 bit zeros eg 0800::A0:2408:D421, ::1 (loopback)
- Can embed IPv4 addresses eg ::128.1.52.1
- Breaks literal URLs

- Variable length Format Prefix [rfc1884]
 - ▶ 0000 0000 unspecified, loopback, IPv4
 - ▶ 0000 001 Reserved for NSAP allocation
 - ▶ 0000 010 Reserved for IPX allocation
 - ▶ 010 Provider-based Unicast
 - ▶ 100 Geographic-based Unicast
 - ▶ 1111 1110 10 Link Local Use
 - ▶ 1111 1110 11 Site Local Use
 - ▶ 1111 1111 Multicast

- Similar to CIDR IPv4 addresses using bitwise contiguous masks



Unicast address using IEEE 802 MAC interface Address



Provider-Based Unicast Address

- Interface may determine own address
- Stateful - using DHCPv6
- Stateless - uses router advertisements plus interface address (eg ethernet) to generate link-local or site-local address

- Simpler header structure than IPv4
- Some IPv4 header fields dropped, others moved to extension headers
- Reduced per case processing by router
- Flow Label is a new field for Quality-of-Service options for real-time data

```
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|Version| Prio. |                               Flow Label                               |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|          Payload Length          | Next Header | Hop Limit |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|
+                               Source Address                               +
|
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|
+                               Destination Address                               +
|
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
```

- Hop-by-Hop options
- Routing
- Fragment
- Destination Options
- Authentication [rfc1826]
- Encapsulating Security Payload [rfc1827]
- Full details of the extension headers may be found in [rfc1883]

- Authentication & Encapsulating Security Payload Headers
- Both headers independent of algorithm
- MD5 originally proposed as standard for Authentication Header
- DES CBC originally proposed as standard for Encapsulating Security Header
- Now, multiple options for both

- Routing IPv6 similar to IPv4 with CIDR
- Uses methods such as OSPF, RIP etc
- Policy Based Routing: anycast address used to construct source-routed path based on provider's prefix
- Mobile Routing

- Study Group, SIT developing methods to allow gradual phased introduction
- Mechanisms allow infinite coexistence of IPv4 with IPv6
- Individual hosts and routers may be upgraded without requiring renumbering
- IPv4-only, Dual-Stack and IPv6-only

- IPv6 tunnelling over IPv4 Internet
- Automatic tunnelling using “IPv4-compatible IPv6 addresses”



- Used where destination is dual-stack IPv4/IPv6

- Configured tunnelling using “IPv4-mapped IPv6 address”



- Used to represent the address of IPv4 only Node
- Header translation under study

- Many existing standards to be revised for IPv6'
 - ▶ DNS - [rfc1886]
 - ▶ ICMP - [rfc1885]
 - ▶ Many others considered including methods for transmission of IPv6 over ethernet, token ring, FDDI and PPP. Some now deprecated as technology has been obsoleted and new alternatives introduced

- Berkeley Sockets API extensions to enable use with IPv6
 - ▶ New data structure to carry IPv6 addresses
 - ▶ New name to address translation library functions
 - ▶ New address conversion functions
 - ▶ New setsockopt() options
- Philosophy “access to IPv6 features, min. change, compatibility with IPv4”

- IPv6 became a draft standard in 1997
- Many implementations created based on draft standard
- It became a ratified standard in 2017
- Private IPs, NAT/PAT and CIDR have delayed push for IPv6 as it was cheaper to kludge than to migrate

- Following stats from

<https://www.internetsociety.org/resources/2018/state-of-ipv6-deployment-2018/>

- ▶ **Over 25% of all Internet-connected networks advertise IPv6 connectivity.**
- ▶ Google reports **49 countries deliver more than 5% of traffic over IPv6**, with new countries joining all the time.
- ▶ Google reports **24 countries whose IPv6 traffic exceeds 15%.**