IPv6 Cheat Sheet

IPv6 Protocol Header (40 octets)

Bits: 0 — 15 16 — 31

Byte	Fields
1	VER, TRAFFIC CLASS, FLOW LABEL
5	PAYLOAD LENGTH, NEXT HEADER, HOP LIMIT
9–21	SOURCE ADDRESS
25–37	DESTINATION ADDRESS
	PAYLOAD
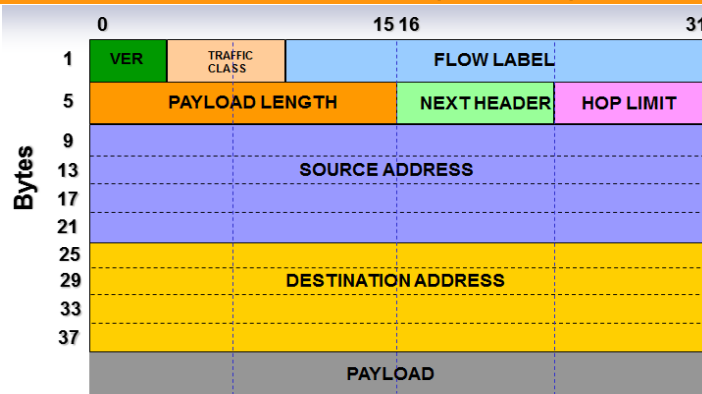
IPv4 Protocol Header (for reference)

Bits: 0 — 15 16 — 31

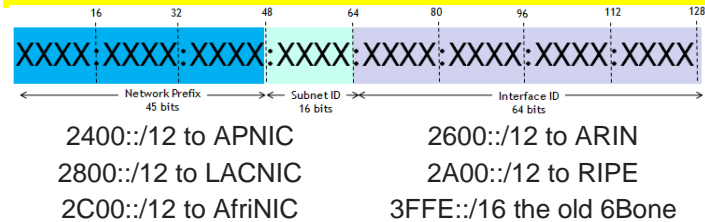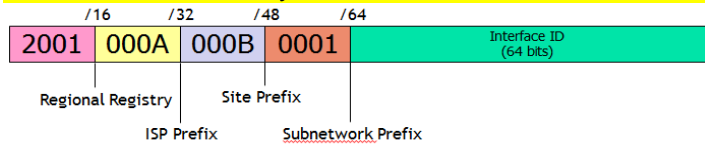| Byte	Fields
1	VER, INTERNET HEADER LENGTH, TYPE OF SVC, TOTAL LENGTH
5	IDENTIFICATION, FLAG, FRAGMENT OFFSET
9	TIME TO LIVE, PROTOCOL, HEADER CHECKSUM
13	SOURCE ADDRESS
17	DESTINATION ADDRESS
21	PADDING AND OPTIONS (usually not be used)
	PAYLOAD
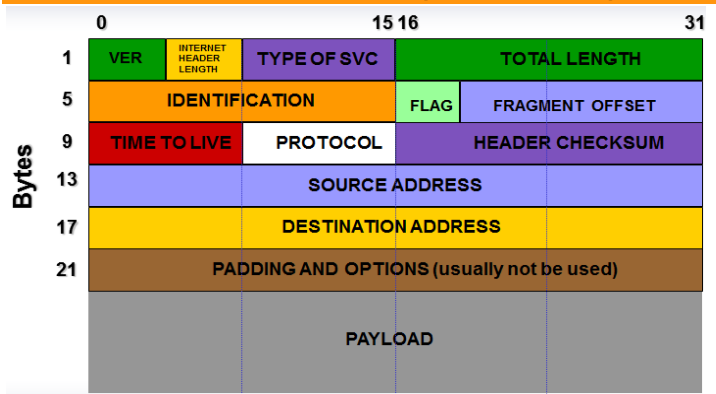
Size of IPv6 address = 128 bits or 2^{128} = 340,282,366,920,938,463,463,374,607,431,768,211,456 addresses

Addressing Types

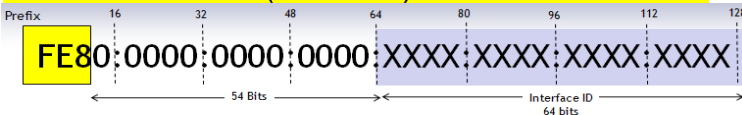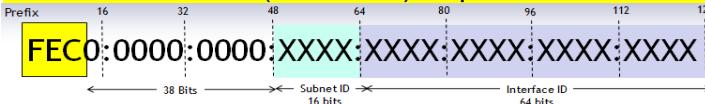**Global Unicast Address:**

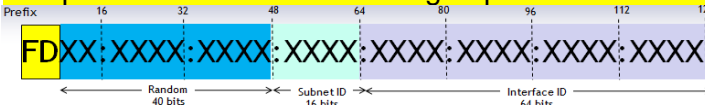XXXX:XXXX:XXXX:XXXX:XXXX:XXXX:XXXX:XXXX

- Network Prefix 45 bits
- Subnet ID 16 bits
- Interface ID 64 bits

2400::/12 to APNIC	2600::/12 to ARIN
2800::/12 to LACNIC	2A00::/12 to RIPE
2C00::/12 to AfriNIC	3FFE::/16 the old 6Bone

Global IPv6 Hierarchy:

/16	/32	/48	/64	
2001	000A	000B	0001	Interface ID (64 bits)

- 2001 = Regional Registry
- 000A = ISP Prefix
- 000B = Site Prefix
- 0001 = Subnetwork Prefix

Link Local Address (FE80::/10):

FE80:0000:0000:0000:XXXX:XXXX:XXXX:XXXX

- 54 Bits
- Interface ID 64 bits

Site Local Address (FEC0::/10) Deprecated:

FEC0:0000:0000:XXXX:XXXX:XXXX:XXXX:XXXX

- 38 Bits
- Subnet ID 16 bits
- Interface ID 64 bits

Unique Local Address: FD00:/8 group shown

FDXX:XXXX:XXXX:XXXX:XXXX:XXXX:XXXX:XXXX

- Random 40 bits
- Subnet ID 16 bits
- Interface ID 64 bits

Documentation Format:

2001:0DB8:0000:0000:0000:0000:CAD5:7D91
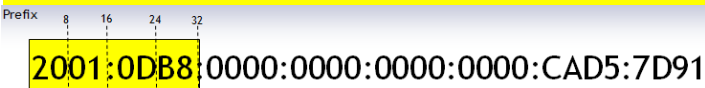
Unspecified Format (::/128): (analogous to "0.0.0.0")

0000:0000:0000:0000:0000:0000:0000:0000
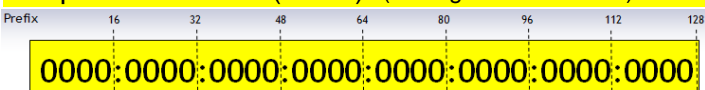
Loopback Address (::1/128): (analogous to "127.0.0.1")

0000:0000:0000:0000:0000:0000:0000:0001
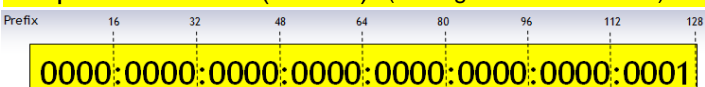
NAT64 64:FF9B::/96
IPv6 Mapped IPv4 Address (::FFFF:A.B.C.D)

Next Header Field Definitions

000	IPv6 Hop-by-Hop Option
002	Internet Group Management Protocol
006	Transmission Control Protocol (TCP)
017	User Datagram Protocol (UDP)
041	IPv6
043	IPv6 Routing Header
044	IPv6 Fragementation Header
046	Reservation Protocol (RSVP)
047	General Routing Encapsulation (GRE)
050	Encapsulation Security Payload (ESP)
051	Authentication Header (AH)
055	IP Mobility (MOBILE)
058	ICMPv6
059	No Next Header
060	IPv6 Destination Options
089	OSPF IGP
094	IP-in-IP Encap. Protocol (IPIP)
103	Protocol Independent Multicast (PIM)
135	Mobility for IPv6 (MIPv6) Header

IPv6 Multicast

FF LS XXXX:XXXX:XXXX:XXXX:XXXX:XXXX:XXXX:XXXX

- Reserved 16 bits
- plen 16 bits
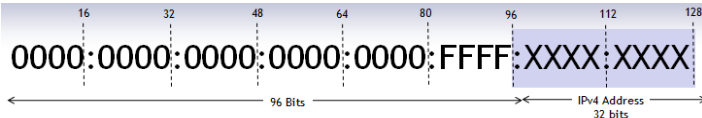- Network Prefix 64 bits
- Group ID 32 bits
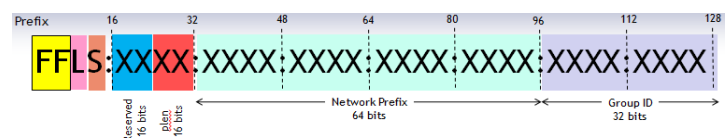
Scope Field 0 = Reserved, 1 = Node/Infc. Local
2 = Link Local, 3 = Subnet Local
4 = Admin Local, 5 = Site Local
8 = Organization Local, E = Global

Flag Bits (L): Format is "0RPT" where
T, =1 "well known", =0 "transient"
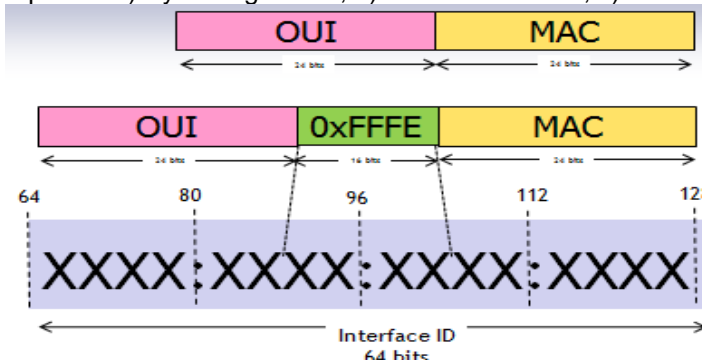R, =1 Embedded RP, =0 not
P, =1 based on unicast, =0 not

plen = length of the network prefix, locally administered

Well Known IPv6 Multicast Addresses

IPv6 Address Structure

`0000:0000:0000:0000:0000:FFFF:XXXX:XXXX`

96 Bits | IPv4 Address 32 bits

IPv6 Interface Addresses

Options: a) By Configuration, b) Psuedo Random, c) EUI:

OUI (24 bits) | MAC (24 bits)

OUI (24 bits) | 0xFFFE (16 bits) | MAC (24 bits)
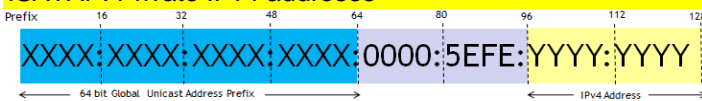
`XXXX:XXXX:XXXX:XXXX`
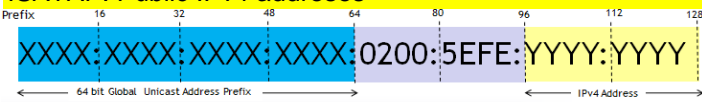
Interface ID 64 bits

Note: Also flips 7th bit (Universal/Local flag) to 1

Example: 00d0.5873.4cf1 becomes FE80::2D0:58FF:FE73:4CF1
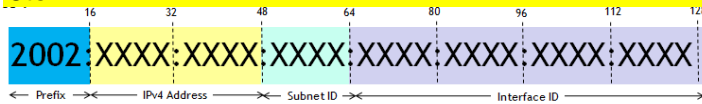
IPv6 Tunnel Interface Addresses

ISATAP: Private IPv4 addreses

`XXXX:XXXX:XXXX:XXXX:0000:5EFE:YYYY:YYYY`

64 bit Global Unicast Address Prefix | IPv4 Address 32 bits

ISATAP: Public IPv4 addreses

`XXXX:XXXX:XXXX:XXXX:0200:5EFE:YYYY:YYYY`

64 bit Global Unicast Address Prefix | IPv4 Address 32 bits

6to4:

`2002:XXXX:XXXX:XXXX:XXXX:XXXX:XXXX:XXXX`

Prefix | IPv4 Address 32 bits | Subnet ID 16 bits | Interface ID 64 bits

Teredo Tunnels: 2001:0000::/32

Ethertype Reference

0800 = IPv4	86DD = IPv6
0806 = ARP	8847 = MPLS Unicast
8035 = Reverse ARP	8848 = MPLS Multicast
8863 = PPoE (Discovery)	8864 = PPoE (PPP sess)

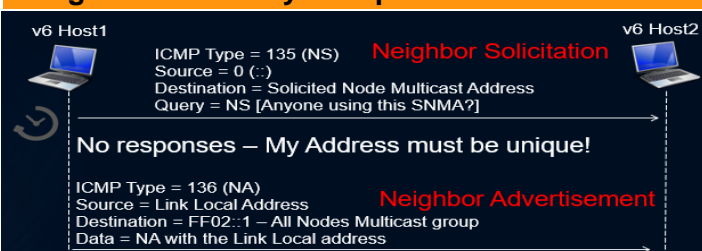## Stateless Address Autoconfiguration (SLAAC)

Originally in RFC 2462, updated by RFC 4862
"Stateless" because it begins from a "dead start" with
no information (or "state") at all for the host to work with
, and has no need for a DHCP server
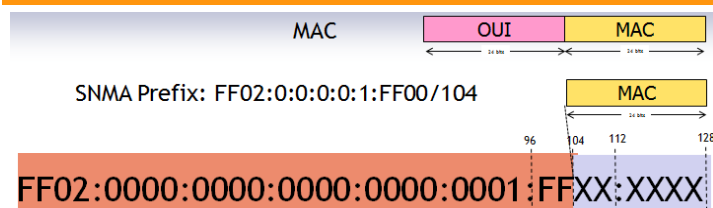Host autonomously configures its own Link-Local addr.
Router solicitations are sent by booting nodes to
request Router Advertisements (RAs) for Prefix

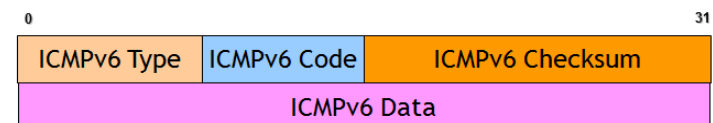## Neighbor Discovery & Duplicate Address Detect

v6 Host1 | Neighbor Solicitation | v6 Host2
ICMP Type = 135 (NS)
Source = 0 (::)
Destination = Solicited Node Multicast Address
Query = NS [Anyone using this SNMA?]

No responses – My Address must be unique!

ICMP Type = 136 (NA) Neighbor Advertisement
Source = Link Local Address
Destination = FF02::1 – All Nodes Multicast group
Data = NA with the Link Local address

Multicast Addresses

FF01::1	All nodes on Local Node/Infc.
FF02::1	All nodes on Link Local (analogous to 224.0.0.1)
FF01::2	All Routers on Local Node/Infc.
FF02::2	All Routers on Link Local
FF05::2	All Routers on Local Site
FF02::4	All DVMRP Routers on Link Local
FF02::5	All OSPF IGP Routers on Link Local
FF02::6	All OSPF DRouters on Link Local
FF02::9	All RIP Routers on Link Local
FF02::A	All EIGRPv6 Routers on Link Local
FF02::D	All PIM Routers on Link Local
FF02::12	All VRRPv3 Routers on Link Local
FF02::16	All MLDv2 Routers on Link Local
FF02::1:2	All DHCP agents on Link Local
FF05::1:3	All DHCP servers on Local Site
FF05::16	All MLDv2 Routers on Link Local
FF01::101	All NTP servers on sender's host
FF02::101	All NTP servers on sender's link
FF05::101	All NTP servers on sender's site
FF0E::101	All NTP servers on the Internet

Solicited Node Multicast Addresses

MAC | OUI | MAC

SNMA Prefix: FF02:0:0:0:0:1:FF00/104

MAC

`FF02:0000:0000:0000:0000:0001:FFXX:XXXX`

ICMPv6

0			31
ICMPv6 Type	ICMPv6 Code	ICMPv6 Checksum	
ICMPv6 Data			

ICMPv6 Error Messages
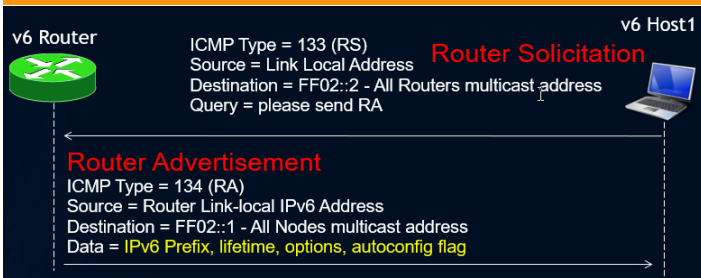
Type = 0-127 Error Messages
Type = 1   Destination Unreachable
   Code = 0 No route to destination
   Code = 1 Administratively Prohibited
   Code = 2 (unassigned)
   Code = 3 Address Unreachable
   Code = 4 Port Unreachable
Type = 2   Packet Too Big
Type = 3   Time Exceeded
   Code = 0 Hop Limit Exceeded
   Code = 1 Fragment Reass. Time Exceeded
Type = 4   Parameter Problem
   Code = 0 Errored Header Field
   Code = 1 Unrecognized Next Header
   Code = 2 Unrecognized IPv6 Option

ICMPv6 Informational Messages

Type = 128-255 are Informational Messages
Type = 128   Echo Request (Ping)
Type = 129   Echo Reply
Type = 130   Multicast Listener Query

Neighbor Discover replaces ARP

Router Solicitation & Router Advertisement

v6 Router

Router Solicitation
ICMP Type = 133 (RS)
Source = Link Local Address
Destination = FF02::2 - All Routers multicast address
Query = please send RA

v6 Host1

Router Advertisement
ICMP Type = 134 (RA)
Source = Router Link-local IPv6 Address
Destination = FF02::1 - All Nodes multicast address
Data = IPv6 Prefix, lifetime, options, autoconfig flag

Stateful Address Config. - DHCPv6

DHCPv6 Server #1 — DHCPv6 Client — DHCPv6 Server #2

SOLICIT
DHCPv6 client Selects Server
ADVERTISE
ADVERTISE
REQUEST
REPLY
Use this IPv6 Address/Lifetime
RENEW
REPLY
Use this IPv6 Address/Lifetime
RELEASE
At shutdown, client releases address

DHCP Client Port = UDP port 546
DHCP Server Port = UDP port 547
Each client and server has a DHCP Unique Id. (DUID)
DUID can have multiple Identity Associations (IAs)

Security: Preventing Scanning from Outside

```
ipv6 access list blockscan
    deny ipv6 any fec0::/10
    deny ipv6 any ff02::/16
    permit ipv6 any ff0e::/16
    deny ipv6 any ff00::/8
    permit ipv6 any any
```

RFC4941/RFC8981: IPv6 Temporary Addresses

```
C:\Users\amwal>netsh interface ipv6 show privacy
Querying active state...

Temporary Address Parameters
----------------------------------------
Use Temporary Addresses             : enabled
Duplicate Address Detection Attempts: 3
Maximum Valid Lifetime              : 7d
Maximum Preferred Lifetime          : 1d
Regenerate Time                     : 5s
Maximum Random Time                 : 10m
Random Time                         : 53s

C:\Users\amwal>
```

```
awalding@ubuntu:~$ sysctl -a | grep 'temp' | more
sysctl: permission denied on key 'fs.protected_hardlinks'
sysctl: permission denied on key 'fs.protected_symlinks'
sysctl: permission denied on key 'kernel.cad_pid'
sysctl: permission denied on key 'kernel.unprivileged_userns_apparmor_policy'
sysctl: permission denied on key 'kernel.usermodehelper.bset'
sysctl: permission denied on key 'kernel.usermodehelper.inheritable'
sysctl: permission denied on key 'net.core.bpf_jit_harden'
sysctl: permission denied on key 'net.core.bpf_jit_kallsyms'
sysctl: permission denied on key 'net.ipv4.tcp_fastopen_key'
sysctl: permission denied on key 'net.ipv6.conf.all.stable_secret'
sysctl: permission denied on key 'net.ipv6.conf.default.stable_secret'
sysctl: permission denied on key 'net.ipv6.conf.ens33.stable_secret'
sysctl: permission denied on key 'net.ipv6.conf.lo.stable_secret'
sysctl: permission denied on key 'vm.mmap_rnd_bits'
sysctl: permission denied on key 'vm.mmap_rnd_compat_bits'
sysctl: permission denied on key 'vm.stat_refresh'
net.ipv6.conf.all.temp_prefered_lft = 86400
net.ipv6.conf.all.temp_valid_lft = 604800
net.ipv6.conf.all.use_tempaddr = 2
net.ipv6.conf.default.temp_prefered_lft = 86400
net.ipv6.conf.default.temp_valid_lft = 604800
net.ipv6.conf.default.use_tempaddr = 2
net.ipv6.conf.ens33.temp_prefered_lft = 86400
net.ipv6.conf.ens33.temp_valid_lft = 604800
net.ipv6.conf.ens33.use_tempaddr = 2
net.ipv6.conf.lo.temp_prefered_lft = 86400
net.ipv6.conf.lo.temp_valid_lft = 604800
net.ipv6.conf.lo.use_tempaddr = -1
awalding@ubuntu:~$
```

Type = 131   Multicast Listener Report
Type = 132   Multicast Listener Done
Type = 133   Router Solicitation
Type = 134   Router Advertisement
Type = 135   Neighbor Solicitation
Type = 136   Neighbor Advertisement
Type = 137   Redirect Message
Type = 138   Router Renumbering
Type = 139   Node Information Query
Type = 140   Node Information Response
Type = 143   Version 2 Multicast Listener Report
Type = 144   Home Agent Address Discovery Request
Type = 145   Home Agent Address Discovery Reply
Type = 146   Mobile Prefix Solicitation
Type = 147   Mobile Prefix Advertisement
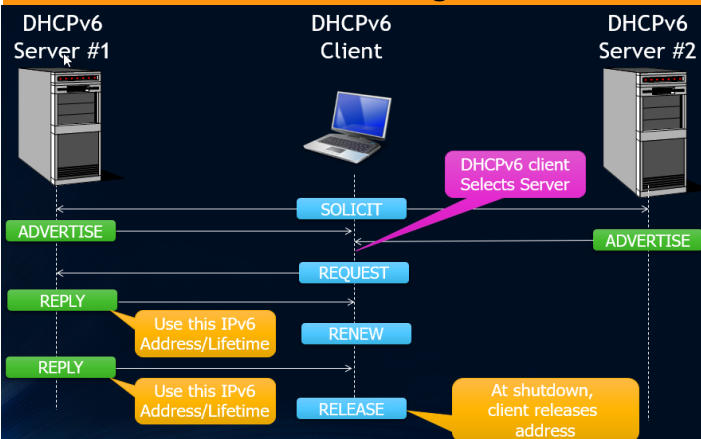
ICMPv6 Flags

Station Parameters	Stateless Autoconfig.	Stateless DHCP	Stateful DHCP
Prefix/Length	From the Router Advertisement M=0 and O=0	From the Router Advertisement M=0 and O=1	From the Router Advertisement M=1 and O=1
Interface Identifier	Auto Configuration	Auto Configuration	From DHCPv6 Server
DNS, NTP address, etc.	Manual Configuration	From DHCPv6 Server	From DHCPv6 Server

CellStream IPv6 Courses

[Hands On IPv6 Course - 2.5 day ILT](#)
[IPv6 101 - 2 day ILT or Web Based Delivery](#)
[IPv6 201 (Advanced) - 2 day ILT or Web Based Del.](#)

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