
Introduction to IPv6

Structure and function of IPv6 addresses

Network Addresses

Each one needs one!



Let's look at an address

What is this?



1600 Pennsylvania Ave
NW Washington, DC 20500

Private vs. Public Addresses



Public:

1600 Pennsylvania Ave

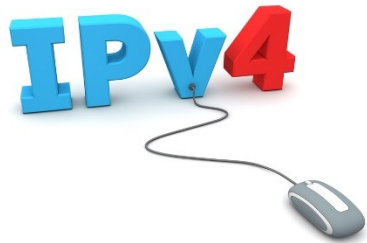
NW, Washington, DC 20500



Private:

P.O. Box 27624
Washington, D.C. 20500

Sample IPv4 Addresses

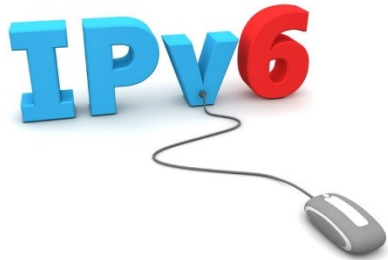


192.168.1.1

10.12.15.201

201.23.5.104

Sample IPv6 Addresses



3FFE:52AB:2:ABC:123:56:DE:1
2001::2:ABC:123
FE80::1234:1
FF01::2
::

Sample Private Addresses

192.168.1.1

- IPv4
- Private

FE80::1234:1

- IPv6
- Private (limited)

Sample Public Addresses

201.23.5.104

- IPv4
- Public

2001::2:ABC:123

- IPv6
- Public

TCP/IP Network

Addresses



192.168.1.100
2001:5c0:8fff:3::100



192.168.1.101
2001:5c0:8fff:3::101



192.168.1.102
2001:5c0:8fff:3::102

Addressing Concepts

Decimal notation (IPv4)

1.2.3.4

Hexadecimal notation (IPv6)

00 - FF

Binary

1 byte = 8 bits

IPv6 Address Representation

IPv4 Address : 32 bits – IPv6 address : 128 bits

- IPv6 address : 8 sections of 4 hex digits (16 bits)
 - 1111:2222:3333:4444:5555:6666:7777:8888
- Zero-compression
 - 1111:2222:0:0:5555:6666:7777:8888
 - 1111:2222::5555:6666:7777:8888
- Prefix length
 - 1111:2222::5555:6666:7777:8888 /64
- Prefix alone
 - 1111:2222:: /64

Important IPv6 Prefix Notations

/8

11111111xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx.
xx.
xx.
xx.

00xx::

FFxx::

/16

1111111111111111xxxxxxxxxxxxxxxxxxxxxxxx.
xx.
xx.
xx.

0000::

FFFF::

/32

1111111111111111.1111111111111111.
xx.
xx.
xx.

0000:0000::

FFFF:FFFF::

/48

1111111111111111.1111111111111111.
1111111111111111xxxxxxxxxxxxxxxxxxxxxxxx.
xx.
xx.

0000:0000:0000::

FFFF:FFFF:FFFF::

/56

1111111111111111.1111111111111111.
1111111111111111.1111111xxxxxxxxxxxx.
xx.
xx.

0000:0000:0000:00xx::

FFFF:FFFF:FFFF:FFxx::

/64

1111111111111111.1111111111111111.
1111111111111111.1111111111111111.
xx.
xx.

0000:0000:0000:0000::

FFFF:FFFF:FFFF:FFFF::

Zero Compression

- IPv6 addresses are zero compressed.
- Double colon can appear only once.
- Zero compression of special addresses.

805B:2D9D:DC28:0:0:FC57:0:0



805B:2D9D:DC28::FC57:0:0

or

805B:2D9D:DC28:0:0:FC57::

FF00:4501:0:0:0:0:0:32

FF00:4501::32

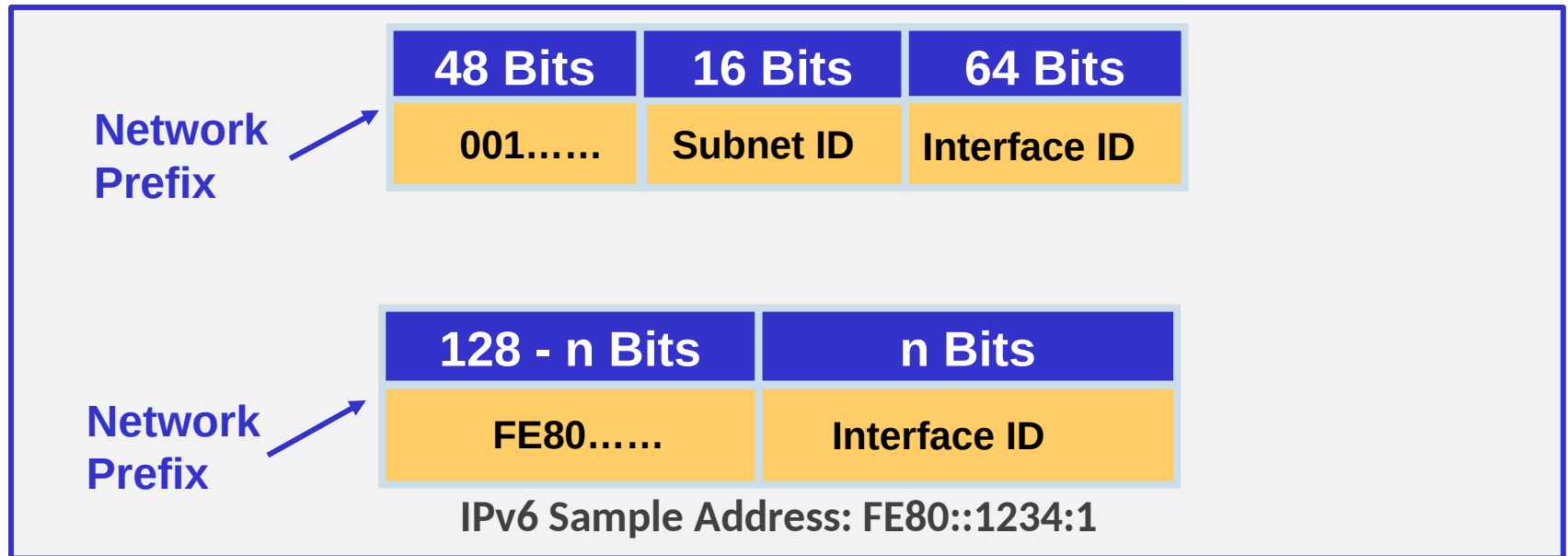
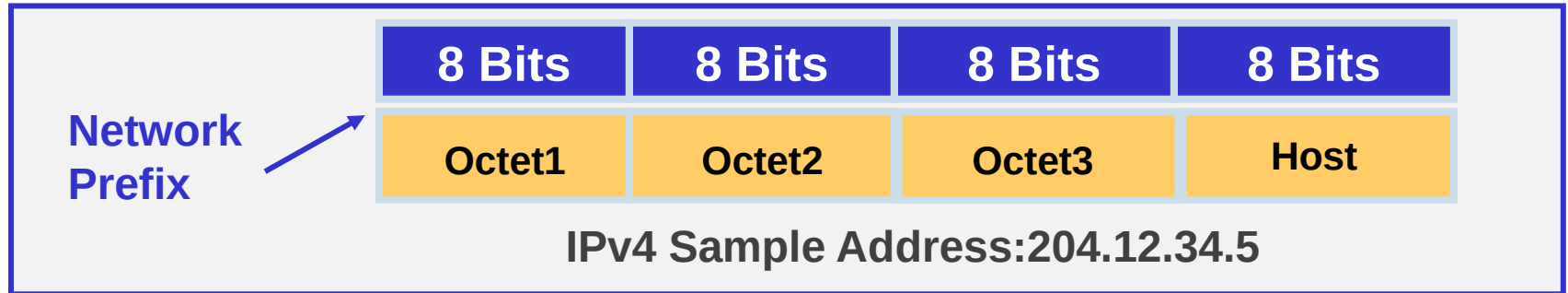
0:0:0:0:0:0:0:1

::1

0:0:0:0:0:0:0:0

::

IPv4 / IPv6 Address Structure



IPv6 Address Types

Unicast address:
2001:5c0:8fff:3::3f53



Unicast Host

Anycast address:
2001:5c0:8fff:3::3f53



Anycast Hosts

Multicast address:
ff02::1



Multicast Host Group

Anycast addresses appear the same as unicast addresses

Importance of IPv6 Network Prefix

- First part of network prefix important!
- Example: **2001**:5c0:8fff:3::3f53
- Learn:
 - Can you go out on the internet with it,
 - What devices can you talk to,
 - Is it for special function.

FE80 = Link Local

FFxx = Multicast

2001 = Global Unicast

0000 = Special

Addressing Changes

- No broadcast addressing in IPv6
- IPv6 multicast addressing used

IPv4 Broadcast Addresses

192.168.1.255
255.255.255.255



Addressing Planning

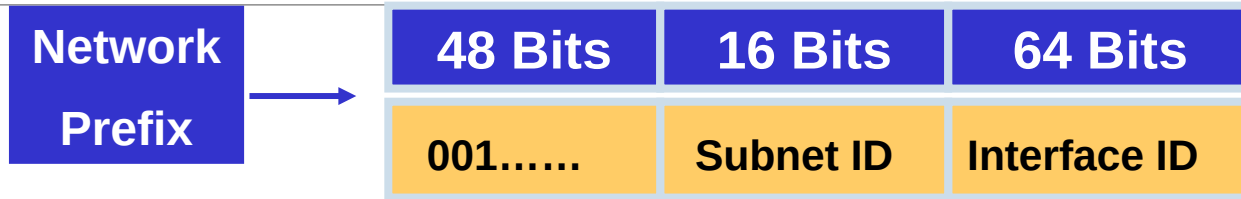
- IPv6 address planning is different from IPv4
- IPv4: 0 address is network, .1 address is gateway, 255 is broadcast (generally)
- IPv4 and IPv6 subnet structure is different
- Basically, you do not lose three addresses per subnet

IPv4 Subnet

192.168.1.1
(network)

192.168.1.255
(broadcast)

Types of Unicast Addresses



Global Unicast Address

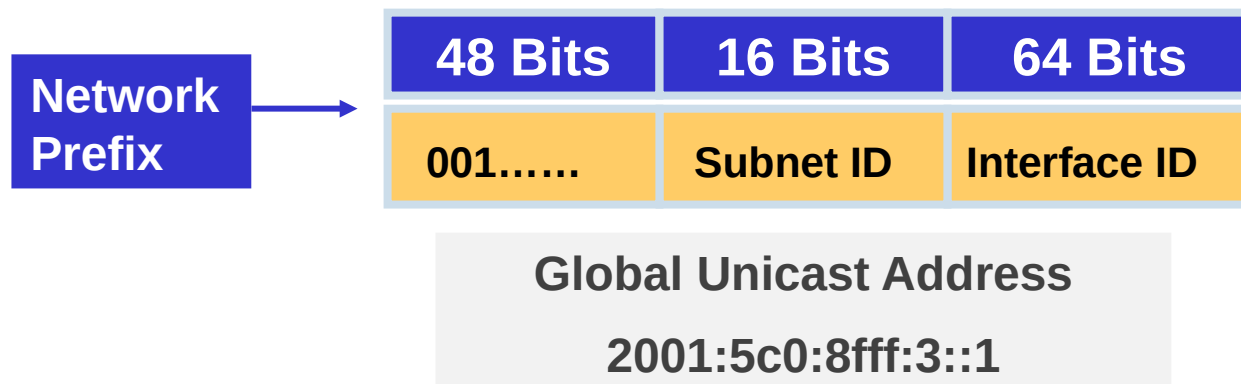
2001:5c0:8fff:3::3f53

Types of IPv6 unicast addresses:

- ↯ global unicast,
- ↯ link-local unicast, and
- ↯ site-local unicast.

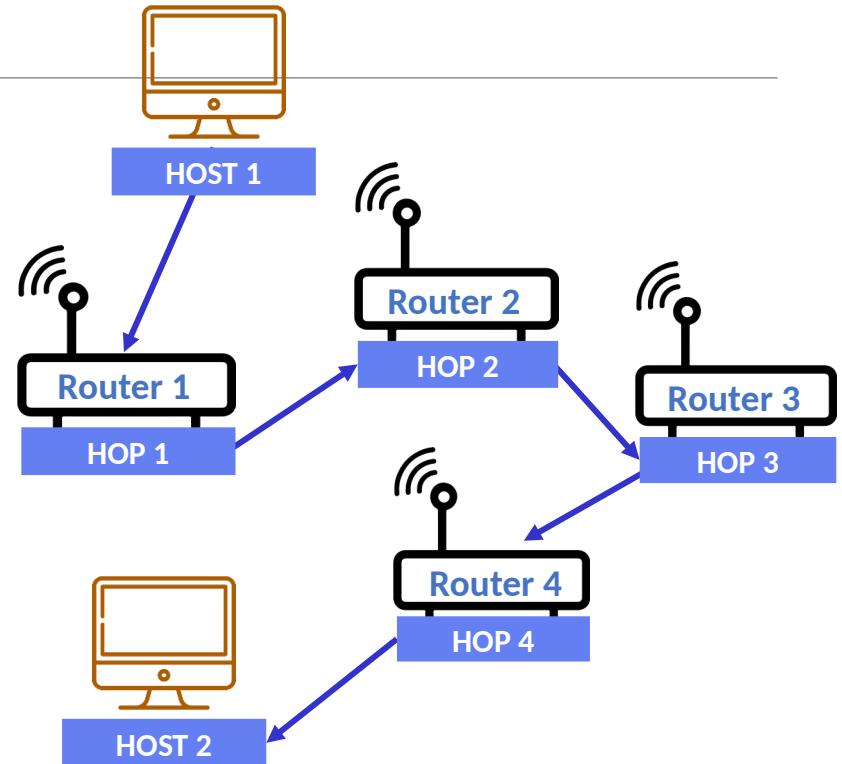
IPv6 Global Unicast Address

- Global unicast address: 48-bit network prefix, 16-bit subnet ID, 64-bit interface ID
- Router interface: 64 bits
- Current global unicast address allocation: 2000::/3 (binary 001)



IPv6 Global Unicast Address

- IPv6 global unicast address (like) IPv4 global unicast address
- Plan network in hierarchy
- Limit routing table entries



Windows IP Configuration

Ethernet adapter Ethernet:

Media State : Media disconnected
Connection-specific DNS Suffix . :

Wireless LAN adapter Local Area Connection* 2:

Media State : Media disconnected
Connection-specific DNS Suffix . :

Wireless LAN adapter Local Area Connection* 13:

Media State : Media disconnected
Connection-specific DNS Suffix . :

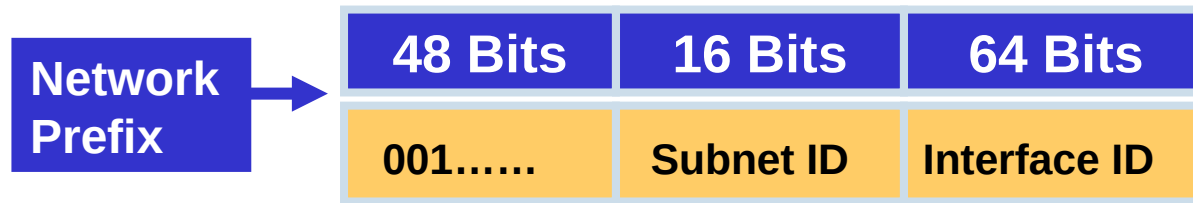
Wireless LAN adapter Wi-Fi:

Connection-specific DNS Suffix . :
IPv6 Address. : 2601:642:c201:bd::478d
IPv6 Address. : 2601:642:c201:bd:fced:f576:4c8d:11f7
Temporary IPv6 Address. : 2601:642:c201:bd:c5f4:62a3:c9cd:500b
Link-local IPv6 Address : fe80::fced:f576:4c8d:11f7%9
IPv4 Address. : 10.0.0.118
Subnet Mask : 255.255.255.0
Default Gateway : fe80::5a19:f8ff:fef4:a74e%9
10.0.0.1

Ethernet adapter Bluetooth Network Connection:

Media State : Media disconnected
Connection-specific DNS Suffix . :

Global Unicast Network Prefix



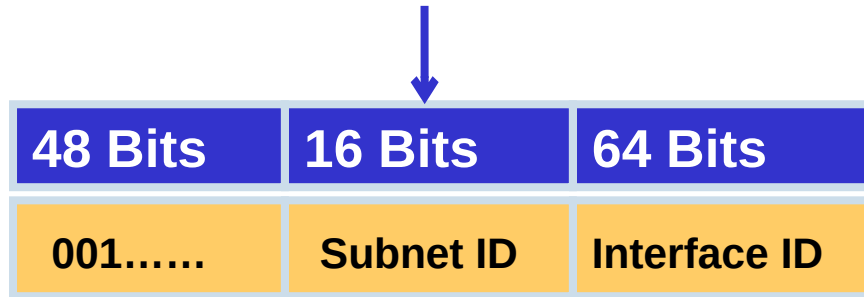
Global Unicast Address

2001:5c0:8fff:3::3f53

- Network Prefix: First part of an IPv6 address.
- Best practices: 48 bits

Global Unicast Subnet Prefix

- Subnet prefix: standard is 16 bits
- 65,535 subnets



Global Unicast Address
2001:5c0:8fff:0003::35f3

Global Unicast Interface ID (IID)

- IID is for an interface
- IID must be unique
- IID: standard is 64 bits



48 Bits	16 Bits	64 Bits
001.....	Subnet ID	Interface ID

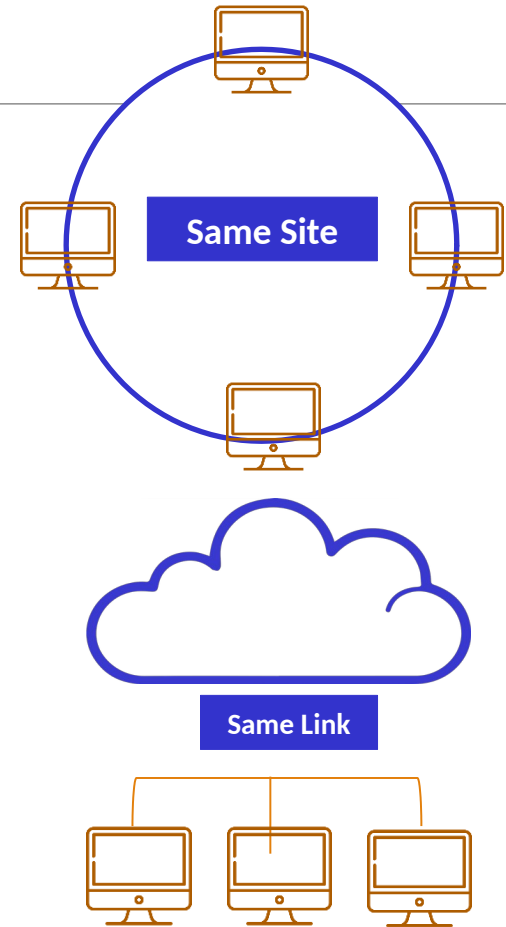
Global Unicast Address

2001:5c0:8fff:3::3f53

IPv6 Private Addresses

- Link-local or site-local
- Never routed outside a company or link
- Start with hex FE then 8 to F (1111 1110 1)
- Most common: FE80 (link-local)

FE8n – FEFn = Private Addresses



Link-Local Unicast Address

- IPv6 devices always have link-local address
- IPv6 devices use link-local to communicate with 'on-link' devices
- IPv6 routers must not forward link-local packets

10 Bits	54 Bits	64 Bits
1111111010	zeroes	Interface ID

Sample Link-Local Address

fe80::211:d8ff:fe39:292b

Link-Local Address Explained

- Why do you need link-local addresses?
- How do you get a link-local address?

**Who am I? IPv6 Stateless
autoconfiguration**



FE8n - FEBn = Link Local

Site-Local Unicast Addresses

- IPv4 site-local private addresses = 10.0.0.0/8 or 192.168.0.0/16
- Site-local address + NAT used for topology hiding
- **IPv6 site-local unicast deprecated**
- Site scope multicast still available



FECn - FEFn = Site Local

IPv6 Reserved Addresses

- Defined by the IETF

Includes:

- Unspecified,
- Loopback and
- IPv4 Embedded addresses

:: /8 = Reserved

See:

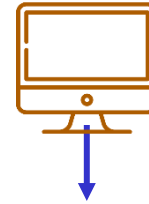
<http://www.iana.org/assignments/ipv6-address-space/ipv6-address-space.xml>

IPv6 Unspecified Address

- Who am I?
- IPv6 *unspecified address*.
- Stateless Autoconfiguration
- Represented as ::

0000 = Unspecified (::)

Who am I? (IPv4)
DHCP



Who am I? (IPv6)
Stateless Autoconfiguration

```

164 ADCD      PACKET  00000004 08:14:04.416323 Packet Trace
    From Interface : ETH1                Device: LCS Ethernet      Full=342
    Tod Clock      : 2006/01/06 08:14:04.416317      Intfx: 4
    Sequence #     : 0                    Flags: Pkt
    IpHeader: Version : 4                Header Length: 20
    Tos            : 00                  QOS: Routine Normal Service
    Packet Length  : 342                ID Number: 0000
    Fragment       :                    Offset: 0
    TTL            : 128 ←
    Source         : 0.0.0.0
    Destination    : 255.255.255.255
    Protocol: UDP                      CheckSum: 3998 FFFF
  
```

UDP

```
Source Port      : 68          (bootpc)    Destination Port: 67          (bootps)
Datagram Length : 322                CheckSum: 93B0 FFFF
BOOTP Opcode    : REQUEST            HW Type: ETHERNET 10M   HW Length: 6
HOP Count       : 0                  Trans ID: 1047706584   Seconds: 0
Client IP        : 0.0.0.0           Your IP: 0.0.0.0
Server IP        : 0.0.0.0           Gateway: 0.0.0.0
Client HW Addr   : 0013D38D61FB000000000000000000000000000000000000 Flags: 0
Server Host Name:
Boot FileName    :
Vendor Info      : 638253633501033D07010013D38D61FB3204C0A801650C0C42617272792D636F
Vendor Info      : 6D7061715110000000042617272792D636F6D7061712E3C084D53465420352E30
DHCPMSG         : DhcpREQUEST
CLIENTID        : 7 010013D38D61FB
REQIPADDR        : 192.168.1.101 ←
HOSTNAME         : Barry-compaq
DHCPDDNS        : 16 000000042617272792D636F6D7061712E
CLASSID         : MSFT 5.0
PARMLIST         : 11 options
```


IPv6 Stateless Autoconfiguration

The image shows a Wireshark packet capture interface. The filter bar at the top is set to 'icmpv6'. The packet list shows several ICMPv6 messages, with packet 40 (Neighbor solicitation) highlighted. The packet details pane shows the structure of this packet, with a red circle around the source IP address '192.168.1.102' in the Ethernet II section and a red arrow pointing to the target address 'fe80::213:d3ff:fe8d:61fb' in the ICMPv6 section.

Filter: icmpv6

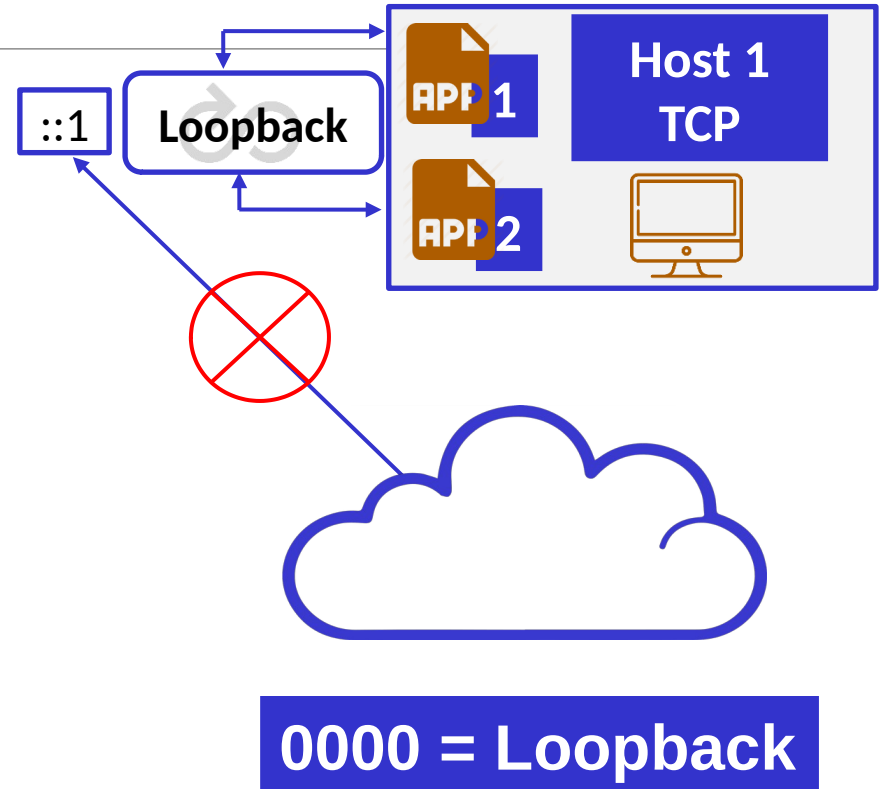
No.	Time	Source	Destination	Protocol	Info
38	19.885381	fe80::213:d3ff:fe8d:61fb	ff02::1:ff8d:61fb	ICMPv6	Multicast listener report
39	19.885395	fe80::213:d3ff:fe8d:61fb	ff02::2	ICMPv6	Router solicitation
40	19.885416	::	ff02::1:ff8d:61fb	ICMPv6	Neighbor solicitation
43	21.885387	fe80::213:d3ff:fe8d:61fb	ff02::1:ff8d:61fb	ICMPv6	Multicast listener report
46	23.885313	fe80::213:d3ff:fe8d:61fb	ff02::2	ICMPv6	Router solicitation
52	27.885227	fe80::213:d3ff:fe8d:61fb	ff02::2	ICMPv6	Router solicitation

Frame 40 (78 bytes on wire (78 bytes captured) on interface 0)

- Ethernet II, Src: 192.168.1.102 (00:13:d3:8d:61:fb), Dst: IPv6-Neighbor-Discovery_ff:8d:61:fb (33:33:ff:8d:61:fb)
Destination: IPv6-Neighbor-Discovery_ff:8d:61:fb (33:33:ff:8d:61:fb)
Source: 192.168.1.102 (00:13:d3:8d:61:fb)
Type: IPv6 (0x86dd)
- Internet Protocol Version 6
Version: 6
Traffic class: 0x00
Flow label: 0x00000
Payload length: 24
Next header: ICMPv6 (0x3a)
Hop limit: 255
Source address: ::
Destination address: ff02::1:ff8d:61fb
- Internet Control Message Protocol v6
Type: 135 (Neighbor solicitation)
Code: 0
Checksum: 0xe302 [correct]
Target: fe80::213:d3ff:fe8d:61fb

Loopback Address

- IPv6 loopback address is 0:0:0:0:0:0:0:1 (::1)
- Acts like IPv4 loopback.
 - Can't be assigned to physical interface.
 - Used by local applications
 - Can't travel outside node
 - Can't be forwarded by router



IPv4 Addresses in IPv6

- From reserved space (0000::/8)
- IPv4 Mapped (Embedded) IPv6 Addresses.
- Last 32 bits = IPv4 address
- Shown in IPv4 notation
- May see on IBM mainframe applications

80 Bits	16 Bits	32 Bits
Zeroes	FFFF	IPv4 Address

IPv4 Mapped IPv6 Address

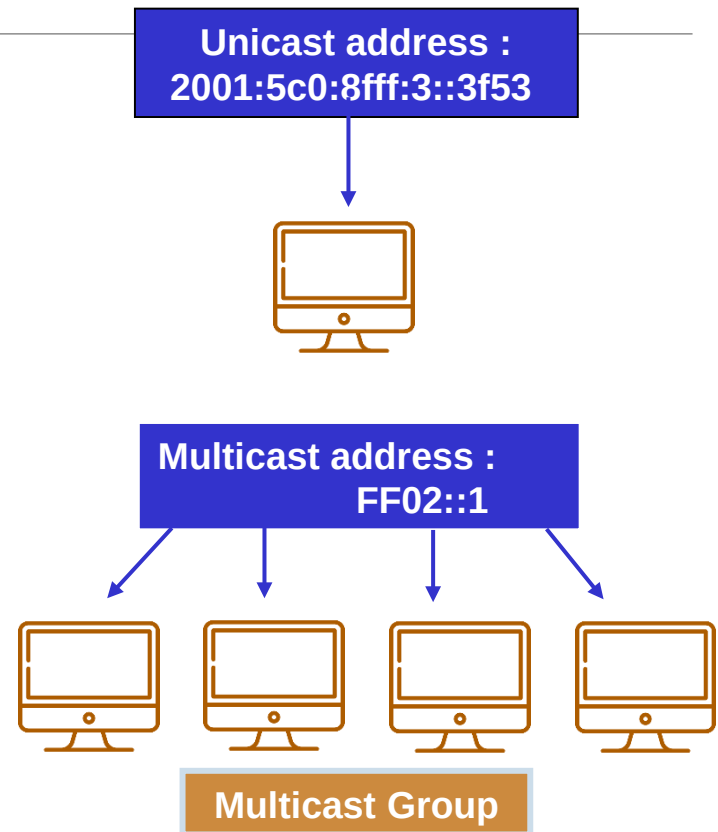
::ffff:192.168.0.1

~~IPv4 Compatible IPv6 Address~~

~~::192.168.0.1~~

IPv6 Multicast

- In IPv6, multicasting used widely
- Multicast is like a newsletter subscription.
- Devices belong to a multicast group
- IPv4 multicast uses Class D range: (224.xx.xx.xx – 239.xx.xx.xx)



IPv6 Multicast Scope

- IPv6 multicast addresses start with FF.
- Last 4 bits is scope. (Ex. FF01, FF02, etc).
- FF01:: means on same interface
- FF02:: means on same link
- FF05:: means in the same site
- FF0E:: means in the Internet.

(From RFC 4291)

Common IPv6 Multicast Groups

- Multicast addresses are registered with the Internet Assigned Numbers Authority (IANA).

See:

<http://www.iana.org/assignments/ipv6-multicast-addresses/ipv6-multicast-addresses.xml>

<u>IPv6 multicast address</u>	<u>Description</u>
FF02::1	The all-nodes address
FF02::2	The all-routers address
FF02::5	The all-Open Shortest Path First (OSPF) routers address
FF02::6	The all-OSPF designated routers address

IPv6 Address Summary

- IPv6 is more than a bigger address!
- Many changes to protocol.

2001:5c0:8fff:fffe::1

2001::11:22:33:44

ff02::1



fe80::211:d8ff:fe39:292b

fe80::192:168:1:100

fe80::169.254.1.100

Questions?