Module 13

IPv6 Addressing

Objectives

1. 2.3 Explain the Properties and characteristics of TCP/IP IPv6

INTRODUCTION TO IPV6

IPv4 Addresses: 32 Bits

1. IPv4 address: 192.168.1.10
   A. Four bytes or octets
   B. 32 bits
   C. Dotted Decimal system
2. In Binary:

   11000000.10101000.00000001.00001010
3. 2^{32} total addresses or about 4 billion

How many Internet users are there globally?

About 40% of the world's population is online…and growing.

IPv6 Addresses: 128 Bits

1. IPv6 address
2. 2001:05c0:1000:000b:0000:0000:0000:66fb
   A. Eight fields
   B. Each 16 bits long
      - 4 hexadecimal characters per field
      - Separated by a colon (:)
3. 128 bits total
4. 2^{128} total addresses:
   A. 340,282,366,920,938,463,463,374,607,431,768,211,456
   B. 340 undecillion, 282 decillion, 366 nonillion, 920 octillion, 938 septillion, 463 sextillion, 463 quintillion, 374 quadrillion, 607 trillion, 431 billion, 768 million, 211 thousand and 456

IPv6 Advantages

1. More efficient address space allocation
2. End-to-end addressing: no NAT
3. Routers do not calculate header checksum
4. Multicasting instead of broadcasting
5. Built-in security mechanisms
6. Single control protocol (ICMPv6)
7. Auto-configuration

Methods of IPv6 Migration

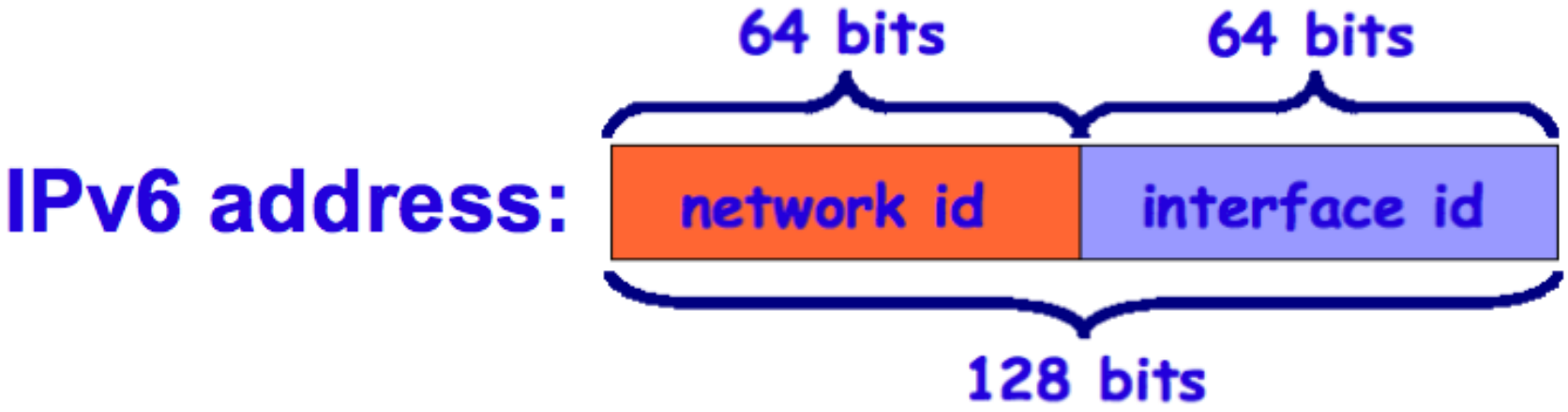
1. Ignore IPv6: Stay on IPv4-only
2. Gateways: Devices that convert IPv6 to IPv4
3. Tunnel: IPv6 over IPv4
4. Dual-Stack: IPv4 and IPv6 together
5. Nirvana: IPv6-only

IPv6 Tunnels

1. Fast and easy to set up
2. Not the best for security or performance
3. Free IPv4-to-IPv6 Tunnels
    A. Gogo6.com
    B. Sixxs.net
    C. Tunnelbroker.com

IPv6 Address Format

1. The network and host portions on IPv4 are now called the network id and interface id



2. IPv6 addresses are case sensitive and should always written in lower case

IPv6 Address Format

1. Examples of the same address:
   A. 2001:0db8:0000:0000:0008:8000:0000:417a
   B. 2001:db8:0:0:8:8000:0:417a
   C. 2001:db8::8:8000:0:417a
   D. 2001:db8:0:0:8:8000::417a

2. All leading zeroes can be omitted
3. :: can be used once to represent a string of zeroes

IPv6 Address Format

Multiple zeros can be omitted entirely but only once in an address

A. 2001:0000:0000:0000:0000:0000:0000:003f

2001::3f

B. 0:0:0:0:0:0:0:1 **::1** (Loopback Address)

C. 0:0:0:0:0:0:0:0 **::** (Unspecified Address)

D. 2001:0:0:0001:0:0:0:003f (Valid Routable Address)

2001::1:0:0:0:3f or 2001:0:0:1::3f

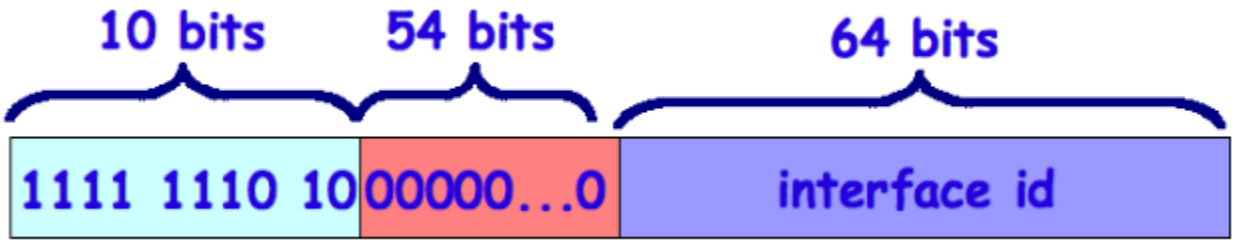
IPv6 - IPv4 Addresses

1. A hybrid format may be used
2. First 5 groups are IPv6, ffff, IPv4 dotted decimal notation
   A. Generic IPv6-IPv4 format: x:x:x:x:x:ffff:d.d.d.d

x=IPv6 address; d=IPv4 address

3. Example of an IPv4 mapped IPv6 address with an IPv4 number on 192.168.0.5:
   A. 0.0.0.0.0.ffff.192.168.0.5 or ::ffff:192.168.0.5

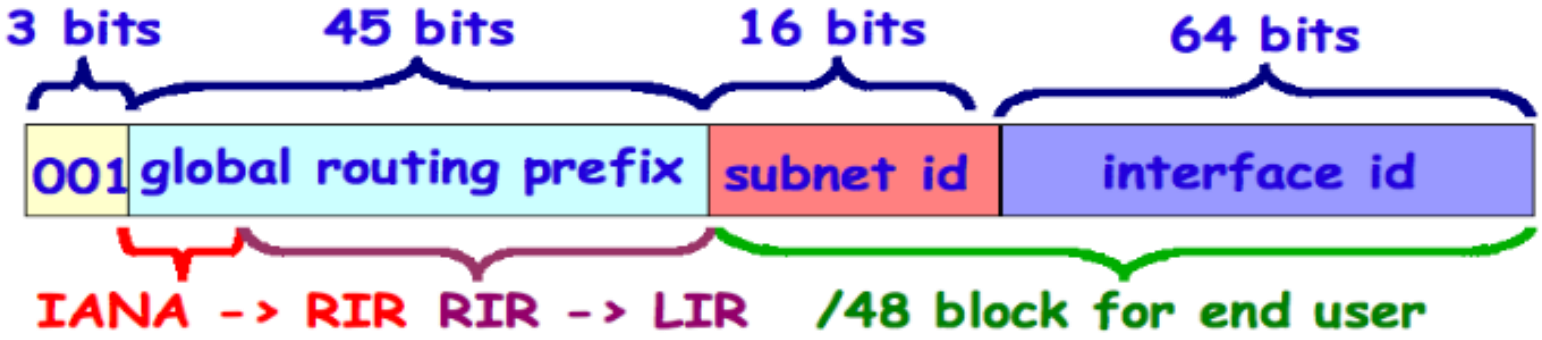
Link-Local Addresses



1. fe80::/10 prefix
2. Same as IPv4 169.254.0.0/16
3. Automatically assigned to an interface
4. Valid in the scope of the given link! Not to be routed!
5. Used for auto-configuration
6. Used for neighbor discovery

Global Unicast

1. A global-unicast IPv6 address starts with binary 001 or 2000::/3
2. Assigned to a single interface



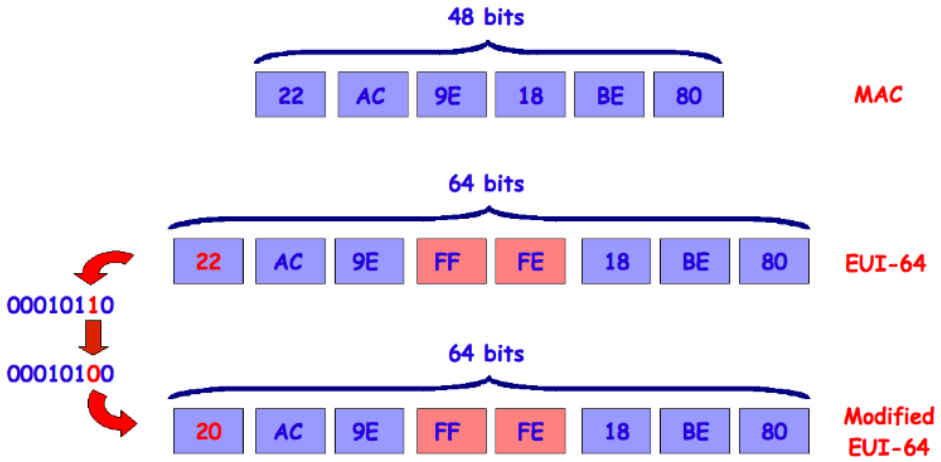
Interface Configurations

1. Manual configuration
2. Autoconfiguration (EUI-64)
3. DHCPv6
4. Pseudo-random interface ID
5. Cryptographically generated ID

Extended Unique Identifier (EUI-64)

1. Interface MAC 00-40-63-ca-9a-20
2. IPv6 Interface ID (EUI-64)

   ::40:63ff:feca:9a20

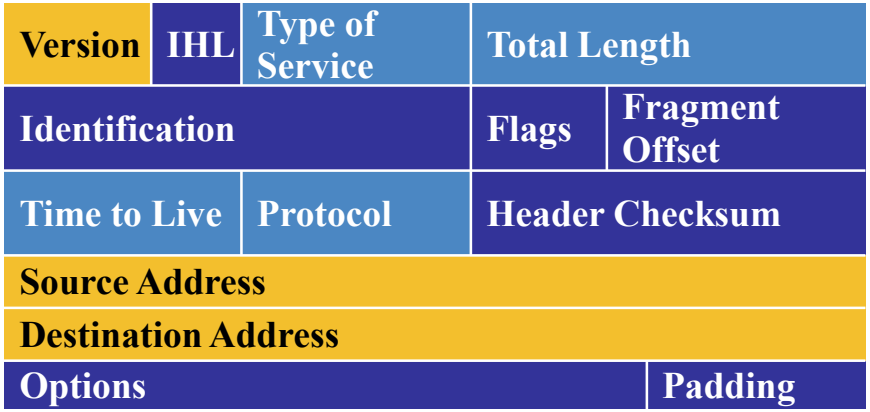


3. Link local

   fe80::40:63ff:feca:9a20

IPv4 and IPv6 Header Comparison

IPv4 Header



IPv6 Header

Legend

- Field's Name Kept from IPv4 to IPv6
- Fields Not Kept in IPv6
- Name and Position Changed in IPv6
- New Field in IPv6

- Fixed Length
- No checksum
- Payload length instead of Total Length
- "TTL" field replaces by "Hop Limit"

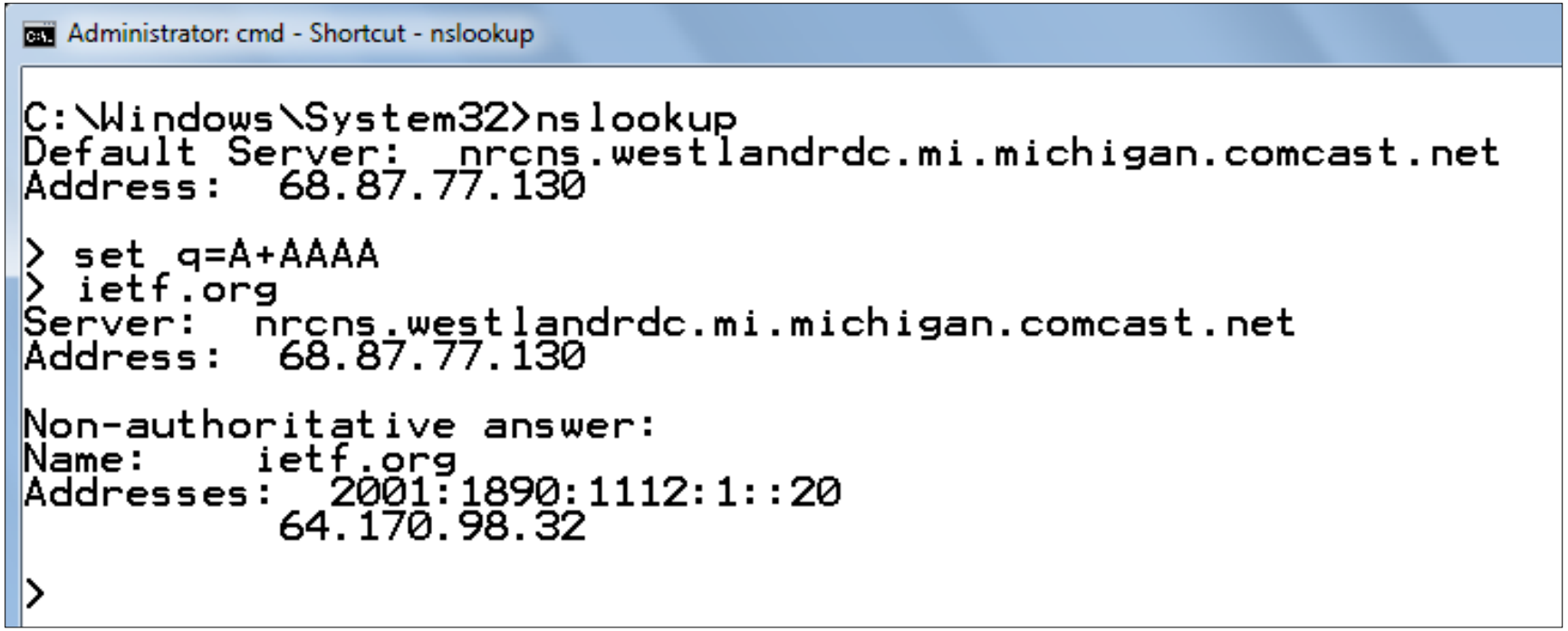
Control Protocols

1. IPv4 Control Protocols:
    A. ARP
    B. ICMP
    C. IGMP
2. IPv6 Control Protocol:
    A. ICMPv6

IPv6 & DNS

1. “**A**” record is used for IPv4
2. New “**AAAA**” record introduced for IPv6
3. Not all ISP support it yet

AAAA Records in DNS



Command prompt > nslookup > set q=A+AAAA Return and then the url

Important Address Types

1. The type of an IPv6 address is identified by the high-order bits of the address

Address Type	IPv6 Notation
Unspecified	::/128
Loopback	:1/128
Multicast	ff00::/8
Link-local unicast	fe80::/10
Site-local unicast	fec0::/10
Global unicast	2000::/3

2. Interfaces normally have two addresses, or more

IPv6 Address Types

Prefix	Designation and Explanation	IPv4 Equivalent
::/128	**Unspecified** This address may only be used as a source address by an initializing host before it has learned its own address.	0.0.0.0
::1/128	**Loopback** This address is used when a host talks to itself over IPv6. This often happens when one program sends data to another.	127.0.0.1
::ffff/96 Example: ::ffff:192.0.2.47	**IPv4-Mapped** These addresses are used to embed IPv4 addresses in an IPv6 address. One use for this is in a dual stack transition scenario where IPv4 addresses can be mapped into an IPv6 address.	There is no equivalent. However, the mapped IPv4 address can be looked up in the relevant RIR's Whois database.

IPv6 Address Types

Prefix	Designation and Explanation	IPv4 Equivalent
fc00::/7 Example fdf8:f53b:82e4::53	**Unique Local Addresses (ULAs)** These addresses are reserved for local use in home and enterprise environments and are not public address space. These addresses night not be unique, and there is no formal address registration. Packets with these addresses in the source or destination fields are not intended to be routed on the public Internet but are intended to be routed within the enterprise or organization	Private address space: 10.0.0.0 172.16.0.0 192.168.0.0

IPv6 Address Types

Prefix	Designation and Explanation	IPv4 Equivalent
fe80::/10 Example: fe80::200:5aee:feaa:20a2	**Link-Local Addresses** These addresses are used on a single link or a non-routed common access network such as an Ethernet LAN. They do not need to be unique outside of that link. Link-local addresses may appear as the source or destination of an IPv6 packet. Router must not forward IPv6 packets if the source or destination contains a link-local address	169.254.0.0/16

IPv6 Address Type

Prefix	Designation and Explanation	IPv4 Equivalent
2001:0000::/32 Example: 2001:0000:4136:e378: 8000:63bf:3fff:fdd2	**Teredo** This is a mapped address allowing IPv6 tunneling through IPv4 NATs. The address is formed using the Teredo prefix, the server's unique IPv4 address, flags describing the type of NAT, the obfuscated client port and the client IPv4 address, which is probably a private address. It is possible to reserve the process and identify the IPv4 address of the relay server, which can then be looked up in the relevant RIR's Whois database.	No equivalent

IPv6 Address Types

Prefix	Designation and Explanation	IPv4 Equivalent
2001:0002::/48 Example: 2001:0002:6c::430	**Benchmarking** These addresses are reserved for use in documentation. They should not be used as source or destination addresses.	198.18.0.0/15
2001:0010::/28 Example: 2001:10:240:ab::a	**Orchid** These addresses are used for a fixed-term experiment. They should only be visible on an end-to-end basis and routers should not see packets using them as source or destination addresses.	No equivalent
2002::/16 Example: 2002:cb0a:3cdd:1::1	**6to4** A 6to4 gateway adds its IPv4 address to this 2002::/16, creating a unique /48 prefix. As the IPv4 address of the gateway router is used to compose the IPv6 prefix, it is possible to reverse the process and identify the IPv4 address, which can then be looked up in the relevant RIR's Whois database.	No equivalent

IPv6 Address Types

Prefix	Designation and Explanation	IPv4 Equivalent
2001:db8::/32 Example: 2001:db8:8:4::2	**Documentation** These addresses are used in examples and documentation. They should never be sourced or destination addresses.	192.0.2.0/24 198.51.100.0/24 203.0.113.0/24
2000::/3	**Global Unicast** Other than the exceptions documentd in this table, the operators of networks using these addresses can be found using the Whois servers of the RIRs listed in the registry.	No equivalent
ff00::/8 Example: ff01:0:0:0:0:0:0:2	**Multicast** These addresses are used to identify nulticast groups. They should only be used as destination addresses, never as source addresses.	224.0.0.0/4

Main Address Types

IPv6 addresses can be:

1. **Unicast** – One-to-One address
   A. Identifies a single interface
   B. Used by the Link-Local and global unicast addresses
2. **Multicast** – One-to-Many address
   A. Identifies multiple interfaces
   B. Delivered to all interfaces that are identified by the address
   C. Always begins with FF (1111 1111)
   D. Cannot be used as source addresses

Main Address Types

IPv6 addresses (continued):

3. **Anycast** – One-to-Nearest address
   A. Identifies multiple interfaces
   B. Delivered to the single interface that is nearest in terms of routing distance
   C. Routing infrastructure must be aware of the interfaces that are assigned anycast addresses and their distances in terms of routing
   D. Assigning a unicast address to more than one interface makes a unicast address an anycast address

Summary

In this module we discussed:

1. The differences between IPv4 and IPv6
2. IPv6 migration
3. IPv6 address formats
4. Header and control protocols
5. DNS records changes
6. Types of IPv6 address
7. Unicast, Multicast, and Anycast addresses