Networking

IPv6 Addressing

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- Guiding Question: How does IPv6 address the limitations of IPv4, and what benefits does it provide for the future of networking?

- Students will:
  - Define the structure of an IPv6 address.
  - Define characteristics of IPv6 addressing including format and compression.
  - Identify methods to transition a network from IPv4 to IPv6.

The Internet of Things

Internet of Things (IoT) - A network of physical objects, or "things," embedded with sensors, software, and network connectivity, enabling them to collect and exchange data, allowing for communication and automation.

How many Internet of Things devices do you have?

- Smart phone
- Smart watch
- Smart lightbulbs
- Smart thermostat
- Smart refrigerator
- Doorbell camera
- Smart speakers (Alexa or Echo)

Why IPv6

IPv4 uses 32-bit addresses, resulting in a limited number of unique addresses (around 4.3 billion).

- Number of devices globally in 2025 were estimated to be around 21.5 billion.
- So it is easy to see that 4.3 billion IPv4 addresses are not enough.

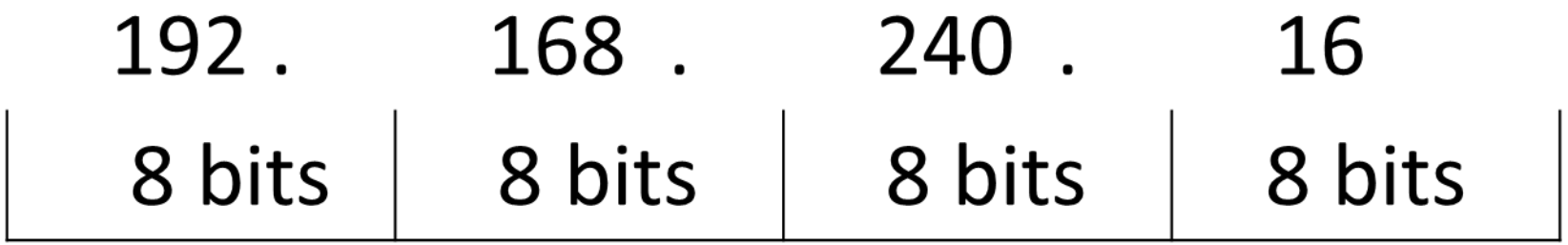
IPv6 was developed to address the inevitable exhaustion of IPv4 addresses.

- IPv6 can provide 340 undecillion addresses.
- This massive increase in addresses ensures that the internet can accommodate the growing number of devices for decades to come.

IPv4 Address Format

OLD way - IPv4:

- Format = 32 bits divided into 4 x 8 bits
- Uses decimal digits with a dot to separate 4 sections
- Uses a subnet mask to indicate the network portion of the IP address. Can be in decimal form or CIDR notation.



IPv6 Address Format

NEW way - IPv6:

- Format = 128 bits divided into 8 x 16 bits.
- Uses hexadecimal digits with a colon as a separator.
- No subnet mask.

3FAA : 0025 : 4E00 : DEAD : BEEF : 1235 : 0001 : 9800

16 bits	16 bits	16 bits	16 bits	16 bits	16 bits	16 bits	16 bits

No Subnet Mask

Without a subnet mask, how do I know what part of the address is the **network** part?

- IPv6 uses **/prefix** notation!
- **Example: /64** means the first 64 bits are the network portion of the address.
- It is called the Prefix Length.
- The host portion of the IPv6 address is called the Interface ID.

Method to Compress IPv6

128-bit addresses are not fun to type, and they are too long to remember.

Good news - there is a method to compress the address:

- **Rule #1** - you can drop any leading zeros in a 16-bit segment
  So . . . 004F . . . becomes . . . 4F
  - This:

    FF00:ACAD:ABCD:003D:1234:0002:0567:CB20
  - Becomes this:

    FF00:ACAD:ABCD:3D:1234:2:567:CB20

Method to Compress IPv6 (cont'd)

- **Rule #2** - Any single contiguous string of zeros can be merged into a double colon.
  So . . . **0000:0000:0000** . . . becomes . . . **::**
- Can only use ONCE in an address!
  - This:

    2001:D2E2:5BA7:0000:0000:9C5D:14D3:BD3F
  - Becomes this:

    2001:D2E2:5BA7::9C5D:14D3:BD3F

Method to Compress IPv6 (cont'd)

Put Rule #1 and Rule #2 together.

- This **2001:D2E2:0004:BEEF:0000:0000:00C3:4200**
- Becomes this: **2001:D2E2:4:BEEF::C3:4200**
- We can end up with some unusual results:
  - **0000:0000:0000:0000:0000:0000:0000:0042**
  - Will be compressed to **::42**

Practice Compressing IPv6

FE80:0000:0000:0000:2000:0AFF:FEA7:0F7C

Rule #1:

_____

Rule #2:

_____

Both Rules:

_____

2031:0000:130F:0000:0000:09C0:876A:130B

Rule #1:

_____

Rule #2:

_____

Both Rules:

_____

FF01:0000:0000:0000:0000:0000:0000:0001

Rule #1:

_____

Rule #2:

_____

Both Rules:

_____

2001:0DB8:0000:0000:0000:FF00:0042:8329

Rule #1:

_____

Rule #2:

_____

Both Rules:

_____

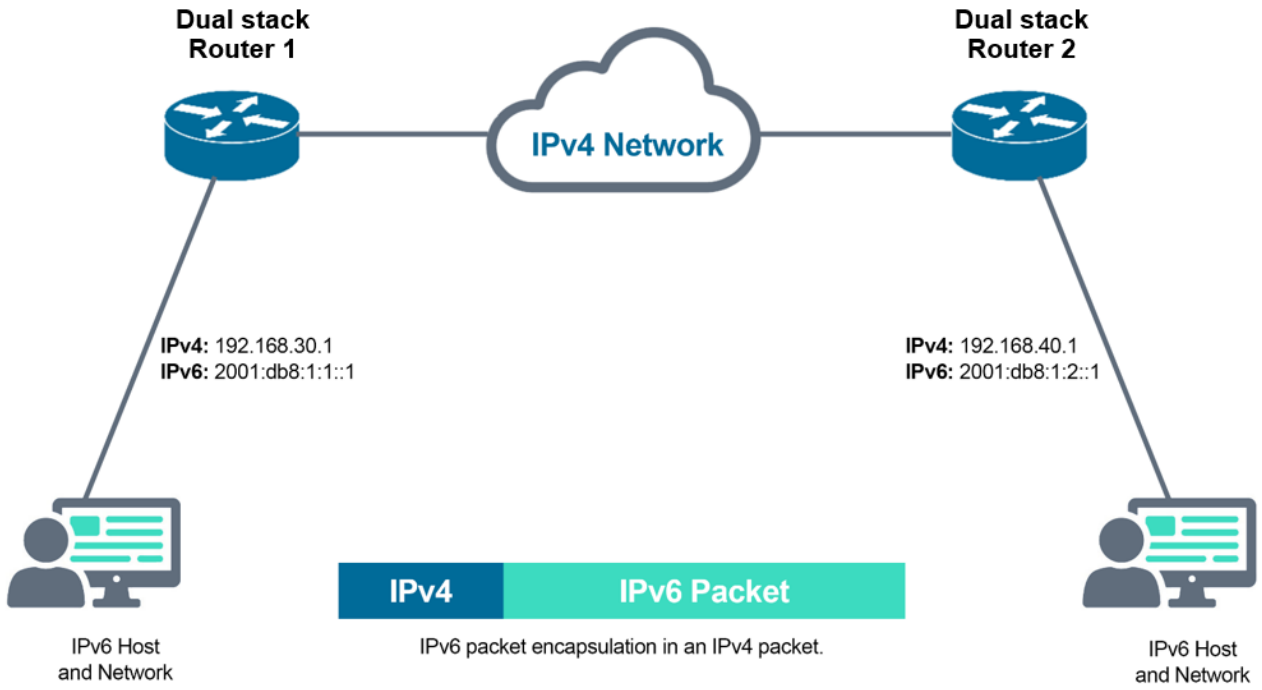
NDP Instead of ARP

- Remember that a packet needs both a MAC addresses and an IP address to send a packet directly to another host.
- To discover each other's MAC addresses:
  - In an IPv4 network hosts will broadcast an ARP (Address Resolution Protocol) packet. (Broadcast = 1 to all)
  - In an IPv6 network, hosts will multicast an NDP (Neighbor Discovery Protocol) packet. (Multicast = 1 to many)

Communicating Between IPv4 & IPv6

Tunneling - Used to allow communication between networks using different IP versions. Both methods are legacy and no longer work in a Windows environment.

- **6to4 Tunneling** – An IPv6 packet is encapsulated in an IPv4 packet and carried across the IPv4 network.
- **4in6 Tunneling** – An IPv4 packet is encapsulated in an IPv6 packet and carried across the IPv6 network.



Communicating Between IPv4 & IPv6

Dual Stack Configuration – A computer's Ethernet adapter can have two IP addresses, one for IPv4 and one for IPv6.

- **IPv4 Works as Usual:** If a program uses IPv4, it will connect to the network with the IPv4 address, just like always.
- **IPv6 for Newer Applications:** If a program prefers IPv6, it will use the IPv6 address instead. IPv6 can offer better security and faster connections in some cases.
- Using both versions together makes it easier to switch to IPv6 while still supporting older systems that use IPv4.