Disadvantages of IPv4 and IPv6 Solutions

Disadvantages of IPv4

- Not enough IPv4 addresses
  - Approximately 4.3 billion public IP addresses
  - 7.8 billion world population
  - Multiple devices per user (computers, tablets, smart phones, smart TVs, home automation, etc.)
- Less Efficient Routing (compared to IPv6)
- Security is Optional
  - Encrypted data is optional

IPv6 Solutions

- Plethora of Addresses
  - 128-bit binary address space compared to 32-bit for IPv4
  - 340 trillion trillion trillion addresses
  - 5×10^{28} addresses for each person on the planet
- Simplified Internet Routing Tables
  - IPv6 packet header enables more efficient routing:
    - Fixed at 40 Bytes versus IPv4 “Variable Length” Packet Header for Optional Fields
- Easier & Automated Configuration Compared to IPv4
  - Stateless Auto-Configuration
  - No need for a DHCP server
- Security is Required
  - Internet Protocol Security (IPSec) is required
    - Source IP can be authenticated
    - Data in transit is encrypted

IPv4 versus IPv6

	IPv4	IPv6
Deployed	1981	1999
Address Size	32-Bit	128-Bit
Number of Addresses	2^{32} = 4,294,967,296	2^{128} = 340,282,366,920,938,463,463,374,607,431,768,211,456
Addressing	Class-Based	Classless

Why is IPv4 Still Around?

- Subnetting / CIDR
- Use of Private IP Addresses
- Network Address Translation (NAT)

IPv6 Addressing

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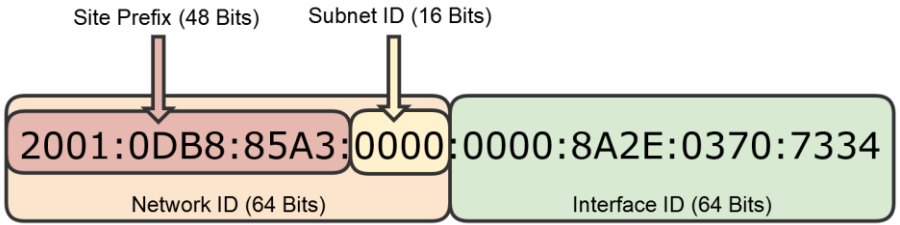
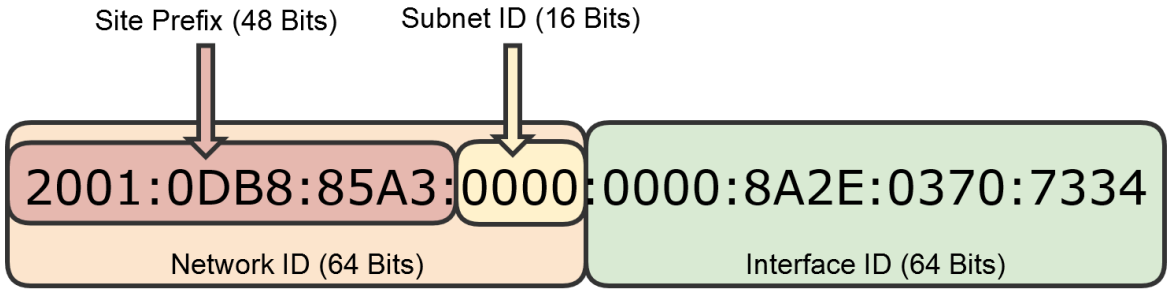
IPv6 Addressing



- 128-bit address composed of eight 16-bit hexadecimal blocks, separated by colons
- Each number or letter is 4 binary bits.
- They are shown in hexadecimal to simply the address:
  - 128 digits in binary format
  - Up to 64 digits in decimal format.
- Example:
  - **Hexadecimal**: 85A3
  - **Binary**: 1000 0101 1010 0011
  - **Decimal**: 8 5 10 3

Decimal (Base 10)	Binary (Base 2)	Hexadecimal (Base 16)
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

The Network and Interface IDs



- 128-bit address composed of eight 16-bit hexadecimal blocks, separated by colons
- **Network ID**
  - Site Prefix: Used for routing over the Internet.
  - Subnet ID: Used for subnets on internal networks.
- **Interface ID**
  - The host portion of the address, that's automatically configured from the MAC address or manually configured in EUI-64 format.

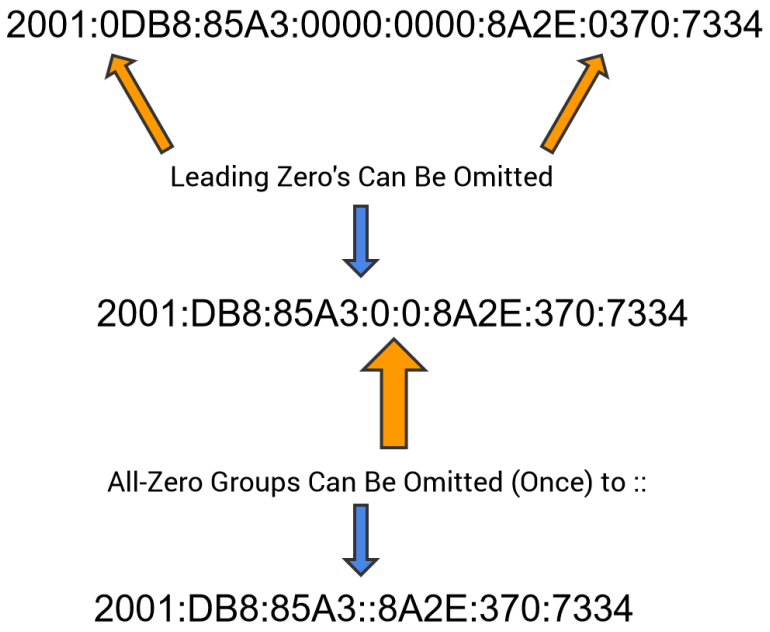
IPv6 Address Simplification

We can simplify by omitting leading 0's

- 0DB8 → DB8
- 0000 → 0

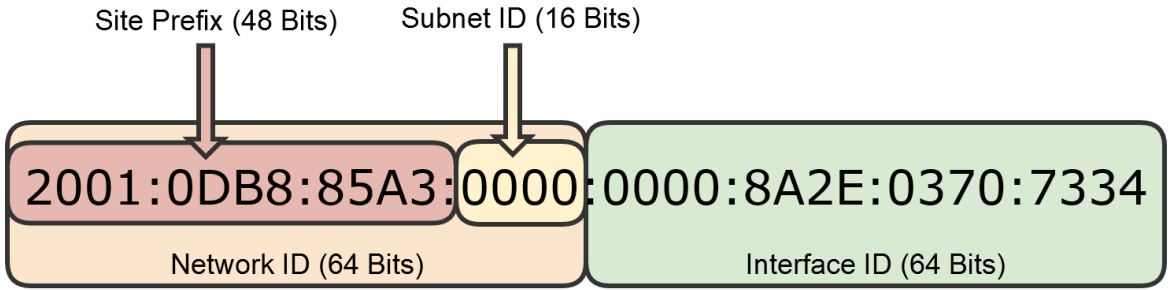
Can also compress contiguous blocks of 0's into double colon "::" once per address.

- :0000:0000: → ::



IPv6 CIDR

- We can use CIDR notation with IPv6 addresses, similar to IPv4
  - FE80::8A:0:8398:85A3/64
- This tells us:
  - **Network ID (64-bits):** FE80:0000:0000:0000
  - **Interface ID (64-bits):** 008A:0000:8398:85A3
- A standard IPv6 subnet can have 2^{64} IPv6 addresses:
  - 18,446,744,073,709,551,616 IPv6 Addresses



IPv6 Transmission Types

IPv6 Transmission Types

- **Unicast (One-to-One) Communication**
  - One-to-one communication, just like with IPv4.
- **Multicast (One-to-Many) Communication**
  - IPv6 doesn't use broadcast transmissions (one-to-all).
  - IPv6 multicast replaced broadcast communications.
  - Sends to multi-cast group members.
- **Anycast (One-to-One-of-Many) Communication**
  - Identifies multiple interfaces, but a packet of data is delivered to the nearest network interfaces (used in routing).

Types of IPv6 Addresses

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IPv6 Unicast (One-to-One) Addresses

Global Addresses

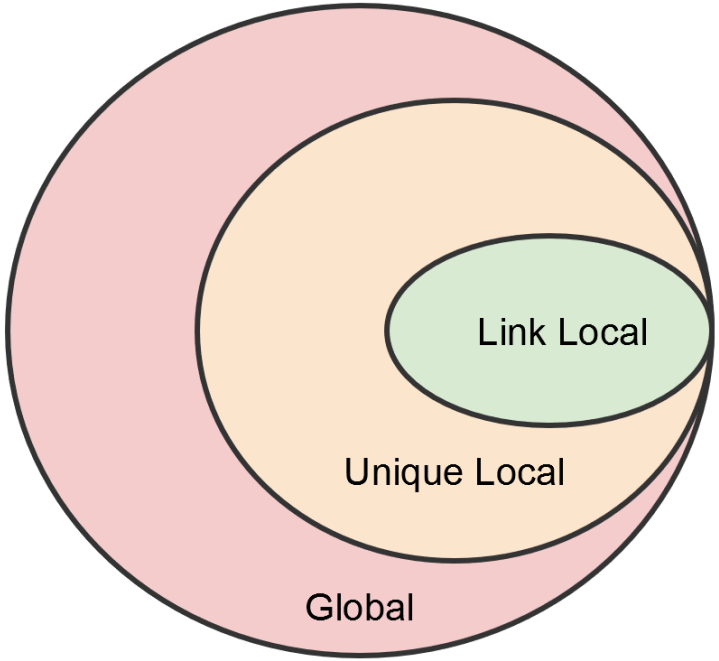
- Similar to Public IPv4 Addresses
- Globally Routable over the Internet
- 2000 Prefix

Unique Local Addresses

- Similar to Private IPv4 Addresses
- Internally routable, but not routable over the Internet.
- FC00 or FD00 Prefix

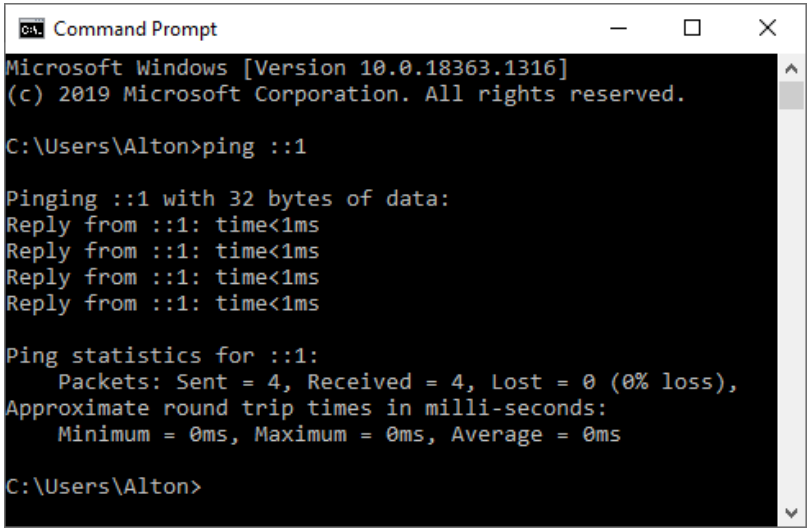
Link-Local Addresses

- IPv6 Equivalent to IPv4 APIPA Addresses
- Can be assigned automatically or statically.
- Not routable internally or over the Internet.
- FE80 Prefix



IPv6 loopback Addresses

- **Loopback Address**
  - ::1



IPv4 to IPv6 Translation & Compatibility

IPv4 to IPv6 Transition

- IPv6 is not natively backward compatible with IPv4.
- To aid in the transition, as well as to allow IPv4 and IPv6 to co-exist, there are two transition technologies you need to know:
  - Dual IP Stack
  - Tunneling

IPv4 to IPv6 Compatibility

Dual IP Stack

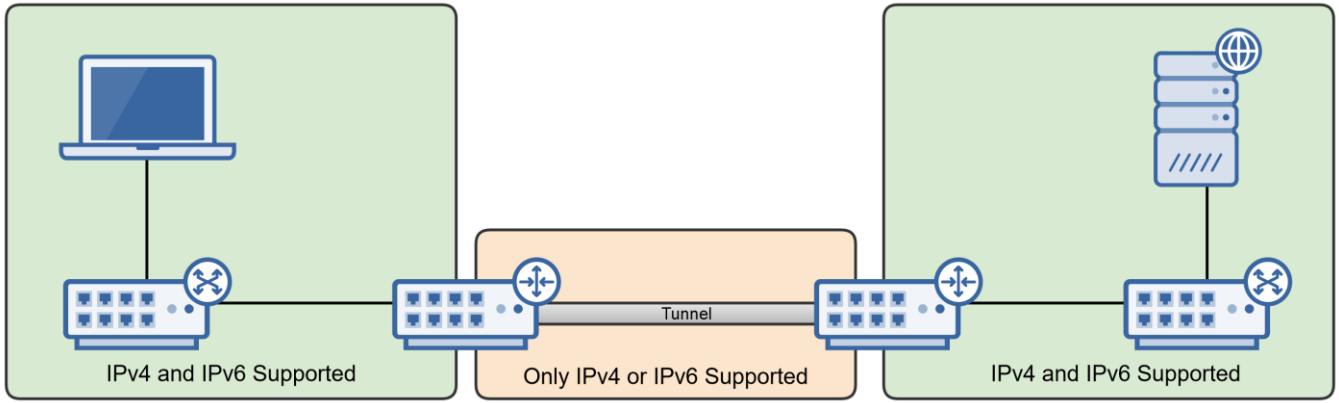
- When both IPv4 and IPv6 protocols co-exist within an operating system.
- Can be used independently or together.

Tunneling

- Tunneling is when we encapsulate IPv4 into IPv6 data and vice versa:
  - 4to6
  - 6in4
  - Teredo
  - Miredo

Tunneling Protocols

- **4to6:** Encapsulates IPv4 data into an IPv6 Tunnel
- **6in4:** Encapsulates IPv6 data into an IPv4 Tunnel and can traverse IPv4 NAT.
- **Teredo:** Microsoft Windows IPv6 tunneling protocol similar to 6in4 that supports NAT.
- **Miredo:** A Linux and Unix-based open-source version of Teredo.



IPv6 Neighbor Discovery Protocol

IPv6 Neighbor Discovery Protocol (NDP)

Neighbor Solicitation and Advertisement

- When an IPv6-enabled system joins a network, it sends out a multicast “neighbor solicitation” to all other IPv6 systems.
- All other IPv6 systems on the network will respond with a “neighbor advertisement.”