# Network Programming:
# *A Programmer's View of the Internet:*
# 1. *IP Addresses*

# IPv4 and IPv6

- **The original Internet Protocol, with its 32-bit addresses, is known as *Internet Protocol Version 4* (IPv4)**

- **1996: Internet Engineering Task Force (IETF) introduced *Internet Protocol Version 6* (IPv6) with 128-bit addresses**
  - Successor to IPv4
  - IPv5 never went public

- **As of 2020, majority of Internet traffic still carried by IPv4**
  - Only 30% of users access Google services using IPv6
  - Up from 5% in 2015, and 0.2% in 2010!
  - India: 48%; USA: 41%; Canada: 28%; Russia: 5%; 0.2% in Africa

# IP Addresses

- **32/128 bit IP addresses are stored in an *IP address struct***
  - IP addresses are always stored in memory in *network byte order* (big-endian byte order)
  - True in general for any integer transferred in a packet header from one machine to another.
    - E.g., the port number used to identify an Internet connection.

```
/* Internet address structures */
struct in_addr {
    uint32_t  s_addr; /* network byte order (big-endian) */
};

struct in6_addr {
    uint16_t s_addr[8]; /* each 16-bit value in
                           network byte order (big-endian) */
}
```

# On Notation

- **By convention, each byte in a 32-bit IPv4 address is represented by its decimal value, separated by a period (*dotted decimal*)**
  - IP address: `0x8CC00E6A = 140.192.14.106`

- **For 128-bit IPv6 addresses, hexadecimal, blocks of two bytes**
  - `{0xFFE0, 0x0000, 0x03AA, 0x17AB, 0xFFFF, 0x0000, 0x0000, 0x0001}`

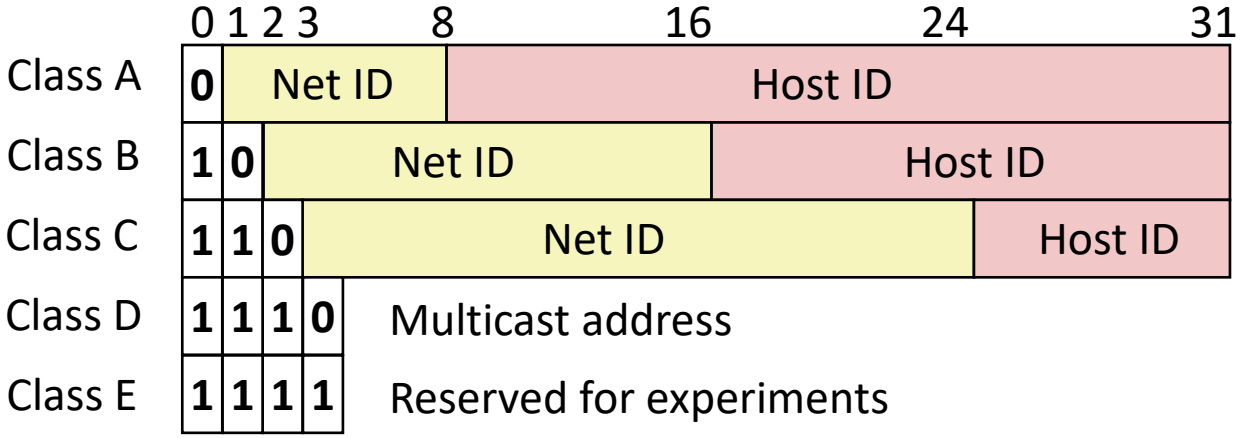
    `=`

    `ffe0:0:3aa:17ab:ffff:0:0:1`

- **Use `getaddrinfo` and `getnameinfo` functions (described later) to convert between IP addresses and dotted decimal/hexadecimal format.**

# IPv4 Address Structure

- **IPv4 Address space divided into classes:**

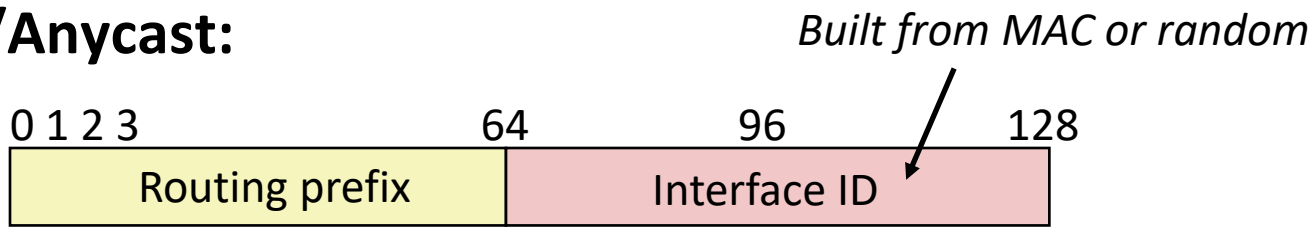



- **Network ID (routing prefix) written in form `w.x.y.z/n`**
  - `n` = number of *bits* in prefix, allow for classless routing (CIDR)
  - E.g., DePaul written as 140.192.0.0/16 (Class B)
- **Unrouted (private) IP addresses**

  10.0.0.0/8  172.16.0.0/12  192.168.0.0/16  127.0.0.0/8
- **Broadcast addresses: ending in 255**

# IPv6 Address Structure

- **Address has 128 bits, written in hexadecimal**
  - fe80:1234:5678:9abc:def0:1234:5678:9abc (8 quartets of 16 bits each)
  - Shorthands: leading 0's in quartets omitted, and :: is just 0's
    - fe80::1 = ffe80:0000:0000:0000:0000:0000:0000:0001
    - fe80:: = fe80:0000:0000:0000:0000:0000:0000:0000
- **Three types (scope): Unicast, Anycast, Multicast**
- **Unicast/Anycast:**




  - ::ffff:0:0/96 is IPv4-mapped IPv6 addresses; fc00::/7 for local nets
  - Unicast if one device, anycast otherwise
- **Multicast:**
  - No broadcast in IPv6, a device joins a ff00::/8 address (using messages)