# CAP660: Network Administration
# Unit-4: IP Addressing and Subnetting

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# What is an IP Address

- An IP address is an address used to uniquely identify a device on an IP network.
- An IP address is a unique global address for a network interface
- An IPv4 address:
  - is a **32 bit long** identifier
  - Address Space of IPv4 is $2^{32}$ or 4,294,967,296.
  - encodes a **network number**
  - and a **host number**

# Dotted Decimal Notation

- IPv4 addresses are written in a so-called ***dotted decimal* notation**
- Each byte is identified by a decimal number in the range [0 to 255]:
- **Example:**

| 10000000 | 10001111 | 10001001 | 10010000 |
|---|---|---|---|
| 1st Byte | 2nd Byte | 3rd Byte | 4th Byte |
| **= 128** | **= 143** | **= 137** | **= 144** |

**128.143.137.144**

# Network prefix and Host number

- The network prefix identifies a network and the host number identifies a specific host (actually, interface on the network).

| network prefix | host number |
|---|---|

- **How do we know how long the network prefix is?**
  - The network prefix **used** to be implicitly defined (**class-based addressing, A,B,C,D…**)
  - The network prefix now is flexible and is indicated by a **prefix/netmask (classless).**

**Example**: argon.cs.virginia.edu

- IP address is 128.143.137.144
  - Is that enough info to route datagram??? -> No, need netmask or prefix at every IP device (host and router)
- Using Prefix notation IP address is: **`128.143.137.144/16`**
  - Network prefix is 16 bits long
- Network mask is: **`255.255.0.0`** or hex format: **`ffff0000`**

  --> **Network id** (IP address **AND** Netmask) is: **`128.143.0.0`**

  --> **Host number** (IP address **AND** inverse of Netmask) is: **`137.144`**

| | |
|---|---|
| **128.143** | **137.144** |

# Classful IP Adressing

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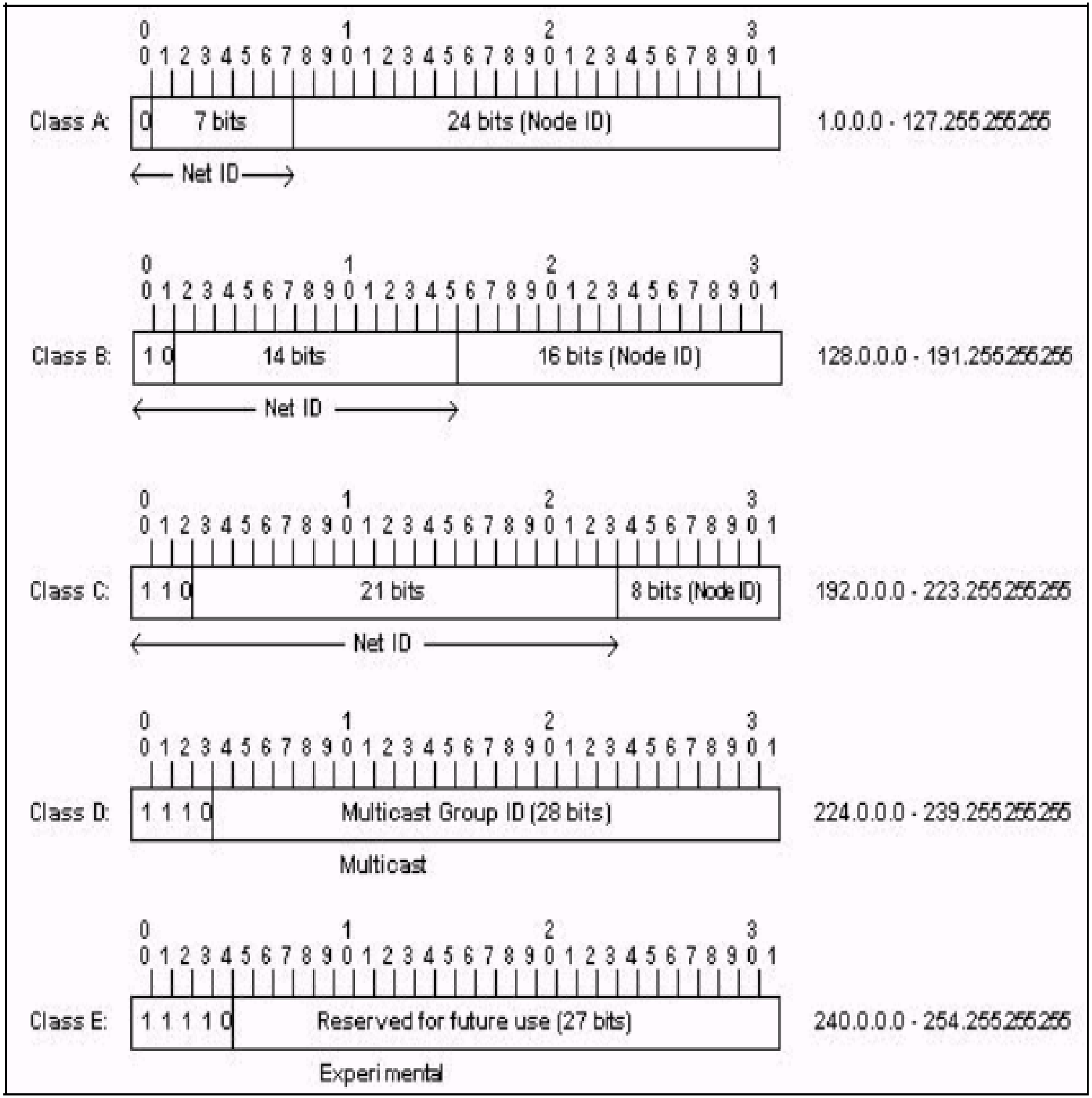
- When Internet addresses were standardized (early 1980s), the Internet address space was divided up into classes:
  - **Class A:** Network prefix is 8 bits long
  - **Class B:** Network prefix is 16 bits long
  - **Class C:** Network prefix is 24 bits long
  - **Class D:** Used for Multicasting
  - **Class E:** Reserved for Scientific Research and Future.

- Each IP address contained a key which identifies the class:
  - **Class A:** IP address starts with "0"
  - **Class B:** IP address starts with "10"
  - **Class C:** IP address starts with "110"
  - **Class D:** IP address starts with "1110"
  - **Class E:** IP address starts with "1111"

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| CLASS | LEADING BITS | NET ID BITS | HOST ID BITS | NO. OF NETWORKS | ADDRESSES PER NETWORK | START ADDRESS | END ADDRESS |
|---|---|---|---|---|---|---|---|
| CLASS A | 0 | 8 | 24 | $2^{7}$ ( 128 ) | $2^{24}$ (16,777,216) | 0.0.0.0 | 127.255.255.255 |
| CLASS B | 10 | 16 | 16 | $2^{14}$ ( 16,384 ) | $2^{16}$ ( 65,536 ) | 128.0.0.0 | 191.255.255.255 |
| CLASS C | 110 | 24 | 8 | $2^{21}$ ( 2,097,152 ) | $2^{8}$ ( 256 ) | 192.0.0.0 | 223.255.255.255 |
| CLASS D | 1110 | NOT DEFINED | NOT DEFINED | NOT DEFINED | NOT DEFINED | 224.0.0.0 | 239.255.255.255 |
| CLASS E | 1111 | NOT DEFINED | NOT DEFINED | NOT DEFINED | NOT DEFINED | 240.0.0.0 | 255.255.255.255 |

# Special Cases

- **0.0.0.0**: default route, used only during Startup
- **127.xx.yy.zz**: loopback, test TCP/IP for IPC on local machine
- **host all 0**: this host
- **host all 1**: limited broadcast (local net)

# Problems with Classful IPv4 Addresses

- The original classful address scheme had a number of problems

**Problem-1: Too few network addresses for large networks**

- Class A and Class B addresses are gone

**Problem-2: Two-layer hierarchy is not appropriate for large networks with Class A and Class B addresses**

**For the Problem 1 and 2**

**Solution-1**: Subnetting

## Problem-3: Inflexible

Assume a company requires 2,000 addresses

- Class A and B addresses are overkill
- Class C address is insufficient (requires 8 Class C addresses)

## Problem 4: Exploding Routing Tables:

Routing on the backbone Internet needs to have an entry for each network address. In 1993, the size of the routing tables started to outgrow the capacity of routers.

## For the Problem 3 and 4

**Solution-2:** Classless Interdomain Routing (CIDR)

**Problem-5: The Internet is going to outgrow the 32-bit addresses**

**Solution-3:** IP Version 6

# Subnetting

- Sub netting is the process of taking a single Network address and creating further smaller Network IDs from it, called Subnets (Sub Networks).
- In the process of sub netting, bits can be borrowed from the host portion of an IP Address, the borrowed bits are added to the Subnet Mask of that IP address.
- The main goal behind sub netting a given network address is to create our required number of smaller network IDs and to achieve our desired number of hosts per subnet ID.

# Subnetting a Class C IP Address

- The basic Subnetting process starts from below mentioned questions:
  - How many subnets are required?
  - How many hosts per subnet are required?
  - Compute the effective subnets?
  - Compute the valid host IP Addresses?
- The anatomy of a typical Class C address is:
  - N.N.N.H with subnet mask 255.255.255.0 or /24
  - Default number of Network bits=24
  - Default number of Host bits = 8

**Example:** An organisation want to setup an IT infrastructure to support 45 system in the office. Network 192.168.10.0/24 is available for allocation, but the IP address assigning authority want to assign a subnet to this organisation that will cater its need. Find out how many subnets can be created to support required number of hosts, calculate the ranges of all the subnets.

**Solution:**

**Step-1:** Identify the required number of host bits to support 45 nodes

| Host Bits (n) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| Hosts (2^n) | 1 | 2 | 4 | 8 | 16 | 32 | 64 | 128 |

Find which host number can accommodate the required number of hosts. As per the table it is 64, so the required number of host bits

$$H = 6$$

**Step-2:** Now find the number of Host bits borrowed by the network id from host id or converted number of network bits

**N = Default Host bits – H**

**= 8 – 6 = 2**

**Step3:** Now find the total number of network bits in network id of the required subnet

**TN = Default Network Bits + N**

**= 24 + 2 =26** **(i.e. /26)**

**Step-4:** Now find the subnet mask of the required subnets

11111111.11111111.11111111.11000000

255 . 255 . 255 . 192

So the calculated subnet mask is 255.255.255.192 /26

**Step-5:** Total number of subnets $= 2^N = 2^2 = 4$

**Step-6:** Total number of

Host/Subnet $= 2^H = 2^6 = 64$

## **Step-7:** Find the range of Subnets

| Subnet Block | Network Id | Start IP | End IP | Broadcast Id |
|---|---|---|---|---|
| I | 192.168.10.0 | 192.168.10.1 | 192.168.10.62 | 192.168.10.63 |
| II | 192.168.10.64 | 192.168.10.65 | 192.168.10.126 | 192.168.10.127 |
| III | 192.168.10.128 | 192.168.10.129 | 192.168.10.190 | 192.168.10.191 |
| IV | 192.168.10.192 | 192.168.10.193 | 192.168.10.254 | 192.168.10.255 |

**Note:**

1. **Network id of the 1st subnet block is 192.168.10.0**
2. To calculate the network id of the next block, we need to calculate the difference between default subnet mask and calculated subnet mask.

   Default SM: 255.255.255.0

   Calculated SM: 255.255.255.192
3. Check for the variation in values starting from last octate. There is a variation in last octate.
4. Find the difference 256-192 = 64
5. Add the result in the octate where variation was found.

# Thanks