CSC 402 – Internet Technology

Recap

- IPv4 Packet Structure (Continued)
- Additional Terminologies
- IPv6
- IPv6 Packet Structure
- IPv6 Header
- IPv6 Flow Label
- IPv6 Migration Techniques
- IPv6 Addressing
- Unicast Addressing
- From IPv4 to IPv6
- Tunneling

IP Addressing

- In the Internet, a unique address is assigned to each node.
- A node (such as a router) may have multiple network interfaces with each interface connected to a different network.
  - An analogy of this situation is a house having multiple doors facing different streets.
- In this situation, an IP address is associated with the network interface rather than with the node.
  - Analogy, an address is assigned to each door of a house rather than to the house itself.
  - For a node with a single network interface (typically, a host), we can safely think of the IP address as the identity of the node.
- An IPv4 address has a fixed length of 32 bits
  - Thus, the total address space of IPv4 is 2^32 = 4,294,967,296 addresses.
  - However, not all of these addresses can be used, for a variety of reasons.

IP Addressing

- IP addresses are hierarchical.
- The address structure was originally defined to have a two-level hierarchy: network ID and host ID.
  - The network ID (aka net ID) identifies the network the host is connected to.
  - Consequently, all hosts connected to the same network have the same network ID.
  - The host ID identifies the network connection to the host rather than the actual host.
- An implication of this hierarchical structure is that a router can forward packets based on the network ID only, thereby shortening the size of the routing table significantly.
- The host ID is assigned by the network administrator.
- The network ID for an organization may be assigned by the **Internet Service Provider** (ISP).
- An ISP in turn requests a network ID from its **Regional Internet Registry** (RIR).

IP Addressing

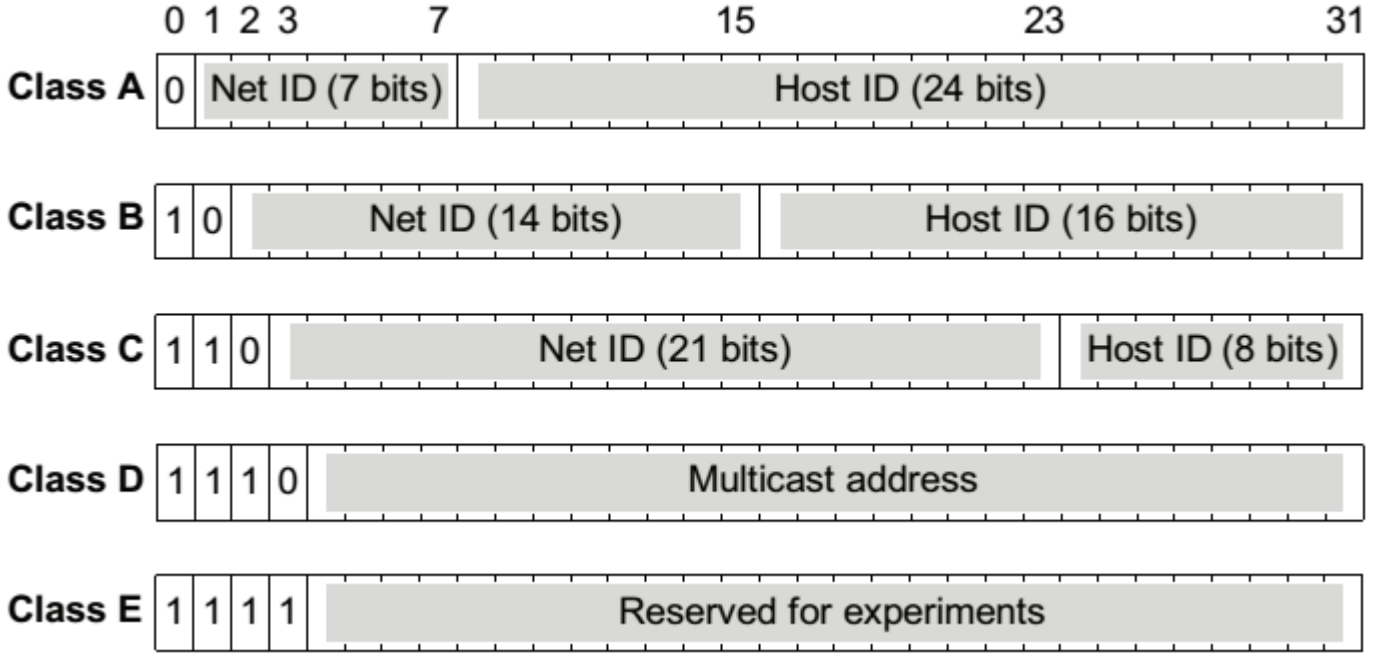
- There are currently 5 Regional Internet Registries (RIRs) in operation:
  - R´eseaux IP Europ´eens Network Coordination Centre (RIPE NCC) for Europe, the Middle East, and Central Asia.
  - American Registry for Internet Numbers (ARIN) for North America
  - Asia-Pacific Network Information Centre (APNIC) for Asia and the Pacific region.
  - Latin American and Caribbean Internet Address Registry (LACNIC) for Latin America and the Caribbean region.
  - African Network Information Centre (AfriNIC) for Africa.

IP Addressing

- When TCP/IP is used only within an intranet, the local network administrator may wish to assign the network ID on its own.
  - However, the address will not be recognized by a host on the global Internet.
  - Thus, not recommended.
- There are 3 main categories of IP addressing schemes:
  - Classful (aka conventional) addressing.
  - Subnet addressing (regular subnetting and VLSM).
  - Classless addressing (Classless Inter Domain Routing, CIDR).

Classful Addressing

- In the classful addressing , the IP address structure is divided into 5 address classes: A, B, C, D, and E.
- Classes are identified by the most significant bits on the address.



Classful Addressing

- This encoding provides some flexibility in assigning addresses to hosts and allows a mix of network sizes on the Internet.
- In particular, the 3 network classes are best suited for the following conditions:
  - Class A: Few networks, each with many hosts.
  - Class B: Medium number of networks, each with a medium number of hosts.
  - Class C: Many networks, each with a few hosts.
- An ID that contains all 1s or all 0s has a special purpose:
  - All 0s: when the network ID or host ID bits are replaced by all 0s, it means ”this”.
  - All 1s: when the network ID or host ID bits are replaced by all 1s, it means ”all”.
- It is possible for a host not to know its IP address immediately after being booted up
  - In this case, the host may transmit packets with all 0s in the source address in an attempt to find out its own IP address.
- To simplify the reading by humans, IP addresses are usually written in dotted-decimal notation
- The address is broken into 4 bytes with each byte being represented by a decimal number and separated by a dot.

Classful Addressing

Address	Meaning and function
Network ID = 0s	The device with the given host ID on this network
Host ID = 0s	The network with the given network ID
Entire address = 0s (0.0.0.0)	Used in the BOOTP and DHCP during initialization or to represent the default route
Network ID = 1s	All networks
Host ID = 1s	Broadcast to all devices on the specified network; sometimes called a network-limited broadcast or subnet-limited broadcast (must be forwarded)
Entire address = 1s (255.255.255.255)	Broadcast to all devices on the current network; sometimes called an “all 1s broadcast” or limited broadcast (never forwarded to other networks)

Classful Addressing

- Tip: use a Calculator (View ⇒ Scientific) to perform binary (Bin) ⇔ decimal (Dec) conversion.
- E.g., the IP address of www.somewebsite.dw.np: 10000010 11100110 00000001 1000010 can be written as 130.230.1.66 in dotted-decimal notation.
- $X_7X_6X_5X_4X_3X_2X_1X_0 \Rightarrow X_7*2^7 + X_6*2^6 + X_5*2^5 + X_4*2^4 + X_3*2^3 + X_2*2^2 + X_1*2^1 + X_0*2^0$
- $10000010 \Rightarrow 1*2^7+0*2^6+0*2^5+0*2^4+0*2^3+0*2^2+1*2^1+0*2^0 = 1 * 2^7 + 1 * 2^1 = 128 + 2 = 130$

Classful Addressing

- (*) The network ID of all 0s is used for default routing and is not assigned to a particular network.
- (**) The network ID of all 1s (range of addresses from 127.0.0.0 to 127.255.255.255) is reserved for loopback and is not assigned to a particular network.

Class	1st Byte	Lowest value of 1st Byte	Highest value of 1st byte	Decimal range of 1st byte	Theoretical IP address range
A	0XXXXXXX	00000001 (*)	01111110 (**)	1 to 126	1.0.0.0 to 126.255.255.255
B	10XXXXXX	10000000	10111111	128 to 191	128.0.0.0 to 191.255.255.255
C	110XXXXX	11000000	11011111	192 to 223	192.0.0.0 to 223.255.255.255
D	1110XXXX	11100000	11101111	224 to 239	224.0.0.0 to 239.255.255.255
E	1111XXXX	11110000	11111111	240 to 255	240.0.0.0 to 255.255.255.255

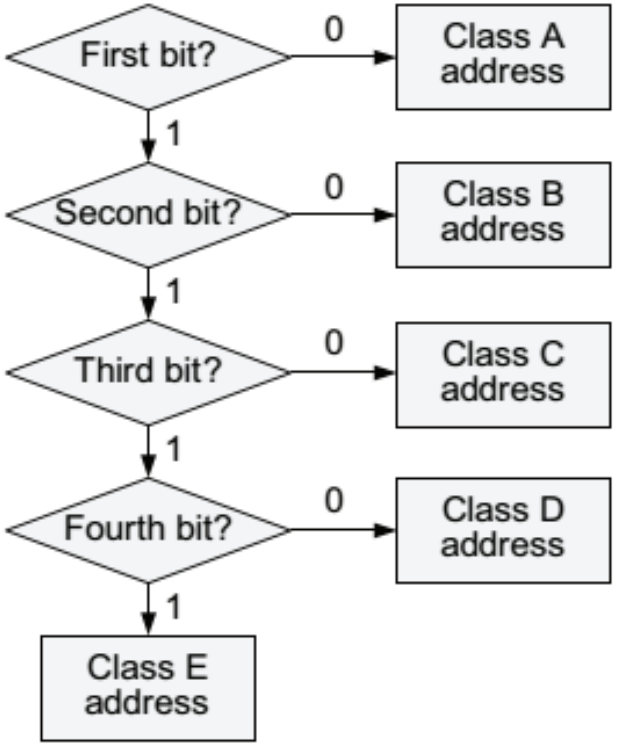
Classful Addressing

- (*) 2 of the Class A network IDs (0 and 127) are reserved
- (**) For each network ID, 2 host IDs cannot be used: the host ID with all 0s and the host ID with all 1s.

Class	Number of bits for net ID / host ID	Usable number of net ID bits	Number of possible net IDs	Number of host IDs per net ID	Fraction of the address space
A	8 / 24	8 – 1 = 7	2^7 – 2 = 126 (*)	2^24 – 2 = 6,777,214(**)	1/2
B	16/16	16 – 2 = 14	2^14 = 16,384	2^16 – 2 = 65,534 (**)	1/4
C	24/8	24 – 3 = 21	2^21 = 2,097,152	2^8 – 2 = 254 (**)	1/8
D	24/8	24 – 3 = 21	2^21 = 2,097,152	2^8 – 2 = 254 (**)	1/16
E	24/8	24 – 3 = 21	2^21 = 2,097,152	2^8 – 2 = 254 (**)	1/16

Classful Addressing

- Class determination algorithm for classful IP addresses



Classful Addressing

- A set of specific ranges of IP addresses have been set aside for use in private networks (RFC 1918).
- These addresses are used within internetworks that do not connect directly to the Internet, for example, home networks.
- These addresses are considered unregistered and routers in the Internet must discard packets with these addresses.
- A range of specific addresses has been defined for each IP class:
  - Range 1: 10.0.0.0 to 10.255.255.255
  - Range 2: 172.16.0.0 to 172.31.255.255
  - Range 3: 192.168.0.0 to 192.168.255.255

Classful Addressing

Advantages

- Simplicity and clarity.
- There are only a few classes to choose from and it is very simple to understand how the addresses are split up.
- Some flexibility
  - 3 levels of granularity match the sizes of large, medium-sized, and small organizations reasonably well.
- Reserved addresses
  - Certain addresses are reserved for special purposes.
- Routing ease
  - The class of the address is encoded right into the address to make it easy for routers to know what part of any address is the network ID and what part is the host ID.

Disadvantages

- Low granularity
  - Consider the difference in size between Class C and Class B networks – a jump from 254 hosts up to over 65,000
- Inefficient use of address space
  - The existence of only 3 block sizes (Classes A, B, and C) leads to waste of limited IP address space
- Lack of internal address flexibility
  - Big organizations are assigned large, ”monolithic” blocks of addresses that do not match well the structure of their underlying internal networks
- Rapid growth of router table entries
  - As the Internet growth, more and more entries are required for routers to handle the routing of IP packets
- To overcome all these shortcoming, we need to get rid of the classes completely in favor of classless addressing

Classful Addressing

- Division of IP addresses into classes