CSC 402 – Internet Technology

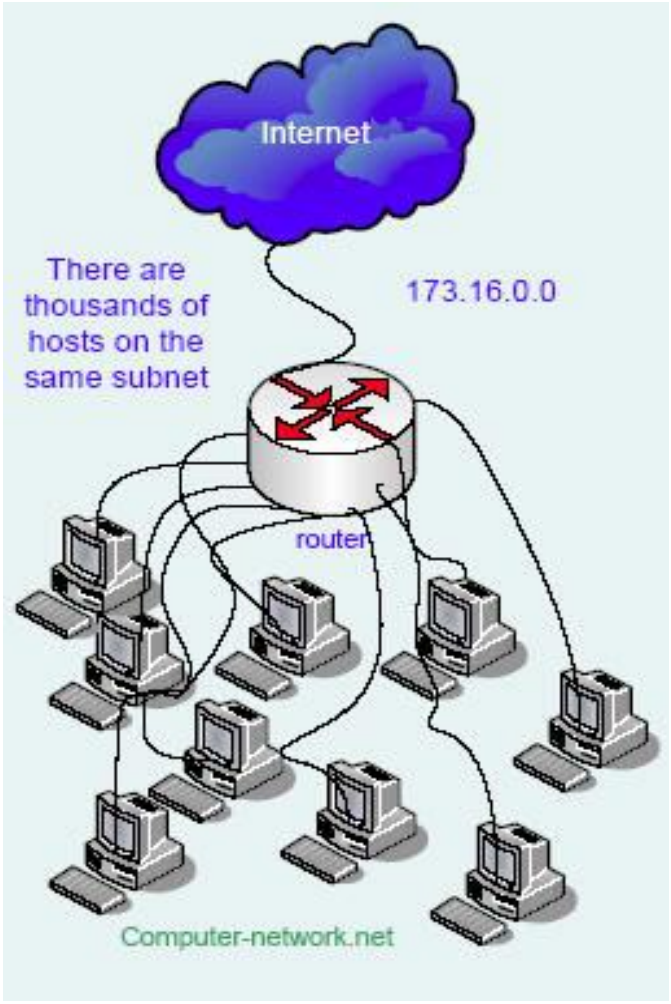
Recap

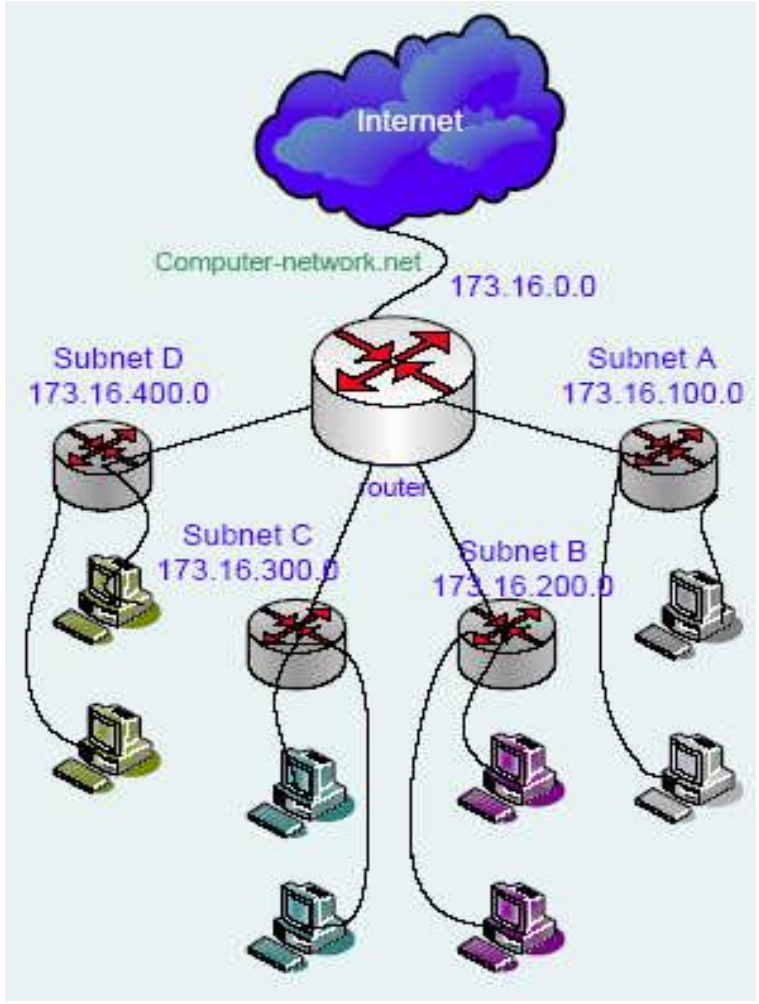
- IP Addressing
- Classful Addressing

Subnet Addressing

- The original classful addressing simply divides a large internetwork into a two-level hierarchy: many networks of different sizes, each of which contains a number of hosts.
  - The system works well for small organizations that may connect all their hosts in a single network.
  - However, it lacks flexibility for large organizations that often have many subnetworks
  - Trying to assign and administer IP addresses to an organization's entire network without any form of internal logical structure is very difficult
- To better meet the administrative and technical requirements of large organizations, the classful addressing was enhanced through the technique known as subnet addressing (aka subnetting), defined in RFC 950.
  - The basic idea of subnetting is to add another hierarchical level called the "subnet"
  - Instead of having just hosts within a network, a three-level hierarchy is thus created: a number of networks, which contain subnets, each of which has a number of hosts.
  - This allows each organization to structure its address space to match its internal physical networks

Subnet Addressing





Subnet Addressing

- In a non-subnetted classful environment, routers use the first byte of the IP address to determine the class of the address, and from this they know which bits are the network ID and which are the host ID.
- In a subnetting environment, this division can be arbitrary for each network.
- To find the subnet ID, the routers need to store additional information about which bits are for the subnet ID and which for the host ID.
- This information is given in the form of 32-bit binary number called a subnet mask.
  - The term ”mask” comes from the binary mathematics concept called ”bit masking”.
  - This is a technique where a special pattern of 1s and 0s can be used in combination with Boolean functions such as AND and OR to select or clear certain bits in a number.
- A subnet mask consists of binary 1s for each bit corresponding of the network ID and subnet ID, and binary 0s for each bit of the host ID.
- A subnet mask is used by applying the Boolean AND function between that mask and the IP address.
- Thus, the bits in the network ID and subnet ID are left intact, while the host ID bits are removed.
- The network mask affects only the local interpretation of local IP numbers (where local means on this particular network segment).
- The network mask is not an IP number - it is used to modify how local IP numbers are interpreted locally.

Subnet Addressing

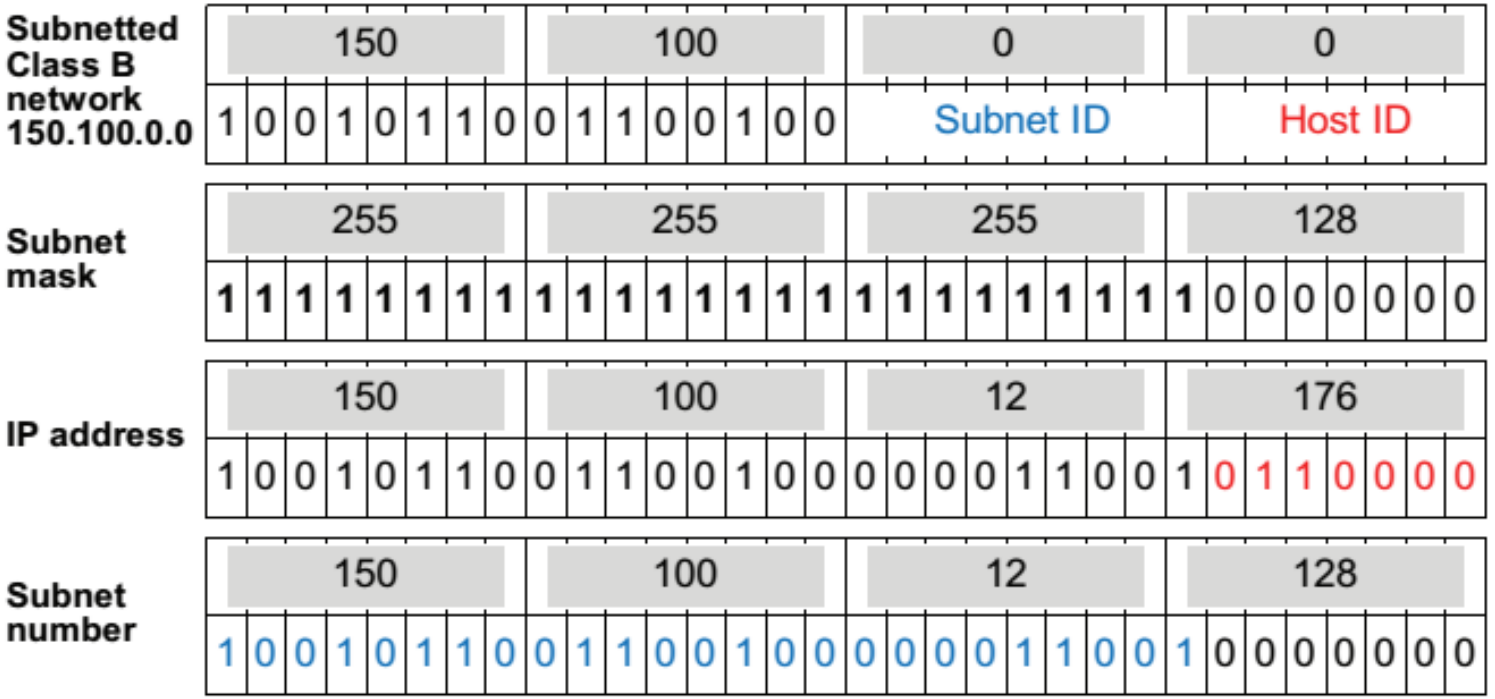
- Subnet Mask:
  - Determines the way an IP address is split into network and hosts portions
- Class A - 0nnnnnnn.hhhhhhhh.hhhhhhhh.hhhhhhhh
  - Subnet Mask = 255.0.0.0; IP Address /8
- Class B - 10nnnnnn.nnnnnnnn.hhhhhhhh.hhhhhhhh
  - Subnet Mask = 255.255.0.0; IP Address /16
- Class C - 100nnnnn.nnnnnnnn.nnnnnnnn.hhhhhhhh
  - Subnet Mask = 255.255.255.0; IP Address /24
- REMEMBER: The important word here is **local**: as far as the world outside the machines and physical networks covered by the sub-netted IP network are concerned, nothing whatsoever has changed - it is still just a single IP network. This is important - sub-networking is a local configuration and is invisible to the rest of the world.

Subnet Addressing

- Consider an organization that has been assigned a Class B address (10XXXXXX) with a network ID of 150.100.0.0.
- Suppose that the organization has many LANs (i.e., subnetworks), each consisting of no more than 100 hosts.
- Then 7 bits are sufficient to uniquely identify each of the 100 hosts in a subnetwork (2^7 – 2 = 126).
  - All 1's are reserved for broadcast ID
  - All 0's are reserved for network ID
- The other 9 bits can be used to identify the subnetworks within the organization.
- Then the subnet mask is 11111111 11111111 11111111 10000000 which corresponds to 255.255.255.128 in dotted-decimal notation or 150.100.0.0/25 in slash notation (the total number of 1s is equal to 25).
- The router can determine the subnet number by performing the bitwise AND operation between subnet mask and the IP address of an incoming packet.

Subnet Addressing

- A packet with a destination IP address of 150.100.12.176 arrives outside the network. The subnet mask is 255.255.255.128
  - Q: Which subnet and host should a router forward this packet to?
  - A: The subnet is 150.100.12.128 and the destination host is 0.0.0.48.



Subnet Addressing

- In essence, a non-subnetted Class A, Class B, and Class C network can be considered as a special case of the more general, custom-subnetted network
- The Linux Documentation Project (website). Retrieved from http://tldp.org/HOWTO/archived/IP-Subnetworking/IP-Subnetworking-6.html

Class	Number of bits for network ID/host ID	Default subnet mask			
		1st Byte	2nd Byte	3rd Byte	4th Byte
A	8 / 24	11111111 (255)	00000000 (0)	00000000 (0)	00000000 (0)
B	16/16	11111111 (255)	11111111 (255)	00000000 (0)	00000000 (0)
C	24/8	11111111 (255)	11111111 (255)	11111111 (255)	00000000 (0)

Subnet Addressing

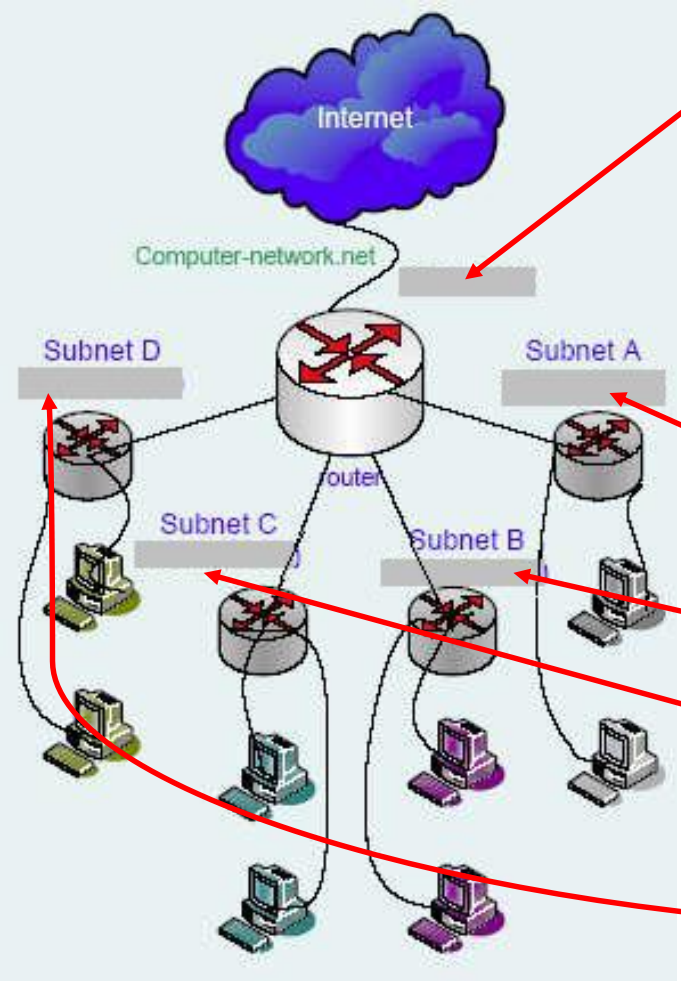
Advantages

- Better match to physical network structure
  - Hosts can be grouped into subnets that reflect the way they are actually structured in the organization's physical network.
- Flexibility
  - The number of subnets and number of hosts per subnet can be customized for each organization.
- Invisibility to public Internet
  - The internal division of a network into subnets is visible only within the organization; to the rest of the Internet the organization is just one big, flat network.
  - Any changes made to the internal structure are not visible outside the organization
- No growth of router table entries
  - Since the subnet structure exists only within the organization, routers outside that organization know nothing about it.
  - Only routers inside the organization need to worry about routing between subnets.

Disadvantages

- Doesn't allocate IP address proportionately per subnet
- Limited by the number of IP address
- Need to buy hardware such as routers
- Costs (monetary) – Reliable network equipment such as routers, switches, hubs, bridges, etc are very pricey. They have come down in price over the last few years, but the good stuff is still expensive.
- Support – Subnetting and network management in general requires an experienced network administrator. This adds to the overall cost as well (esp. regarding resource).

Subnet Addressing



IP address 192.168.5.130 and Subnet mask = 255.255.255.0

192.168.5.0 = Network ID (24 Network ID and 8 Host ID)

To prepare 4 Subnets with 62 hosts/subnet

Borrow 2 bits (for 4 subnets) from host byte

Subnet Mask = 255.255.255.192

= /26 because 2^6 = 64 and we have 62 hosts

Subnet A -> 192.168.5.1/26 to 192.168.5.62/26

Subnet B -> 192.168.5.65/26 to 192.168.5.126/26

Subnet C -> 192.168.5.129/26 to 192.168.5.190/26

Subnet D -> 192.168.5.193/26 to 192.168.5.254/26

Subnet Design

- Requirements analysis
  - What Class is our IP address block?
  - How many physical subnets are on the network today?
  - Do we expect adding any more physical networks in the nearest future, and if so, how many?
  - How many hosts do we have in the largest of our subnets today?
  - How many hosts do we expect having in the largest subnet in the nearest future?
- Deciding how many bits to use for the subnet ID and host ID
  - On the one hand, each bit taken from the host ID for the subnet ID doubles the number of subnets that are possible in the network.
  - But on the other hand, each bit taken from the host ID for the subnet ID approximately halves the number of hosts that are possible in a subnet
- Determining the custom subnet mask
- Determining subnet addresses
- Determining host addresses for each subnet