Network Device and Configuration

Chapter One

Overview of Ip Address and Subnetting

Feb 2024

Basics of IPv4

- An IP address is a logical address of a computer, which is expressed as a four 8-bit group of bits (a total of 32 bits) separated by periods.
- Each 8-bit group of bits can be represented by a 4-digit decimal that spans between 0 and 255.
- For example 196.27.22.42 is a typical IP address of the DNS server of the Ethiopian Telecommunication Corporation (ETC).
- The total number of distinct addresses one can have from this 32 bit addressing scheme is $2^{32} = 4,294,967,296$.

Structure of IP address

- An IP address is simply a series of 32 binary bits (ones and zeros). It is very difficult for humans to read a binary IP address.
- For this reason, the 32 bits are grouped into four 8-bit bytes called octets. An IP address in this format is hard for humans to read, write and remember.
- To make the IP address easier to understand, each octet is presented as its decimal value, separated by a decimal point or period. This is referred to as dotted-decimal notation.
- When a host is configured with an IP address, it is entered as a dotted decimal number such as 192.168.1.5.
- Imagine if you had to enter the 32-bit binary equivalent of this-11000000101010000000000100000101.

Network Classes

- Because a computer's IP address must uniquely identify not only the computer but also the network the computer is attached to, the IP address is split between a network identifier (net id) part and a host identifier (host id) part.
- The class of the address determines how many bits of the IP address are reserved for network identification and how many are reserved for host identification.

Network Classes

CLASSES	Network ranges	No. of possible networks	Hosts per Network	Default subnet mask
A	1 –126	126(2power 7-2)	16,777,214	255.0.0.0
B	128-191	16,382 (2^{14})	65,534 (2^{16}-2)	255.255.0.0
C	192-223	2,097,150 (2^{21})	254 (2^{8}-2)	255.255.255.0
D	224-239			
E	240-255			

Special Ip Addresses

- In the Internet addressing architecture, the Internet Engineering Task Force (IETF) and the Internet Assigned Numbers Authority (IANA) have reserved various Internet Protocol (IP) addresses for special purposes.
- Some of the special IPv4 addresses are:

Special Ip Addresses

IP addresses	also called	Description
0.0.0.0	Default route	
10.0.0.0-10.255.255.255	Private IP address	Used for local communications within a private network
127.0.0.0-127.255.255.255	Loopback address	Used for loopback addresses to the local host In telecommunications, loopback is a method used to perform transmission tests of the lines at the switching centre.
169.254.0.0-169.254.255.255	APIPA (Automatic Private IP Addressing)	Assigned automatically if the host does not get an IP from a DHCP server provided that the device is set to obtain an IP address automatically
172.16.0.0-172.31.255.255	Private IP Address	Used for local communications within a private network
192.168.0.0-192.168.255.255	Private IP Address	Used for local communications within a private network
224-239	Class D	Reserved for multicast assignments
240-255	Class E	Reserved for future use
Network Addresses and Broadcast Addresses in a subnet.		

Types of Ip Addresses

Private IP Address

- A private IP address, such as a home or office network, is assigned to a device on a local network and is used to identify the device within that network.
- Private IP addresses are not accessible outside the network and only for internal use.
- The most common private IP address ranges are 192.168.0.0 to 192.168.255.255, 172.16.0.0 to 172.31.255.255, and 10.0.0.0 to 10.255.255.255.

Types of Ip Addresses

Public Ip Address

- A public IP address is assigned to a device directly connected to the internet and is used to identify the device on the internet.
- Public IP addresses are unique and can be accessed from anywhere. Public IP addresses are typically assigned by internet service providers (ISPs) and can be either static (permanent) or dynamic (assigned temporarily).

IP Address Assignment

- IP addresses can be assigned for devices either statically or dynamically.

Static IP Address Assignment

- With a static assignment, the network administrator must manually configure the network information for a host.
- At a minimum, this includes the host IP address, subnet mask and default gateway.

Advantages and Disadvantages of Static IP address

Advantages

- Address does not change - good for web servers, email servers and other Internet servers.
- Use DNS to map domain name to IP address, and use domain name to address the static IP address. Similar can be achieved with Dynamic DNS for dynamic IP address, but it is not as clean as the static IP address.

Disadvantages

- Expensive than dynamic IP address - ISPs generally charge additional fee for static IP addresses.
- Need additional security - Since same IP is assigned to a machine, hackers try brute force attack on the machine over period of time.

IP address Assignment

Dynamic IP Address Assignment

- Rather than have the network administrator assign IP addresses for each workstation, it is easier to have IP addresses assigned automatically.
- This is done using a protocol known as Dynamic Host Configuration Protocol (DHCP).
- DHCP provides a mechanism for the automatic assignment of addressing information such as IP address, subnet mask, default gateway, and other configuration information.

Advantages and Disadvantages of Dynamic IP address

Advantages

- Cheaper than static IP, address.
- Changing IP address gives more privacy.

Disadvantage

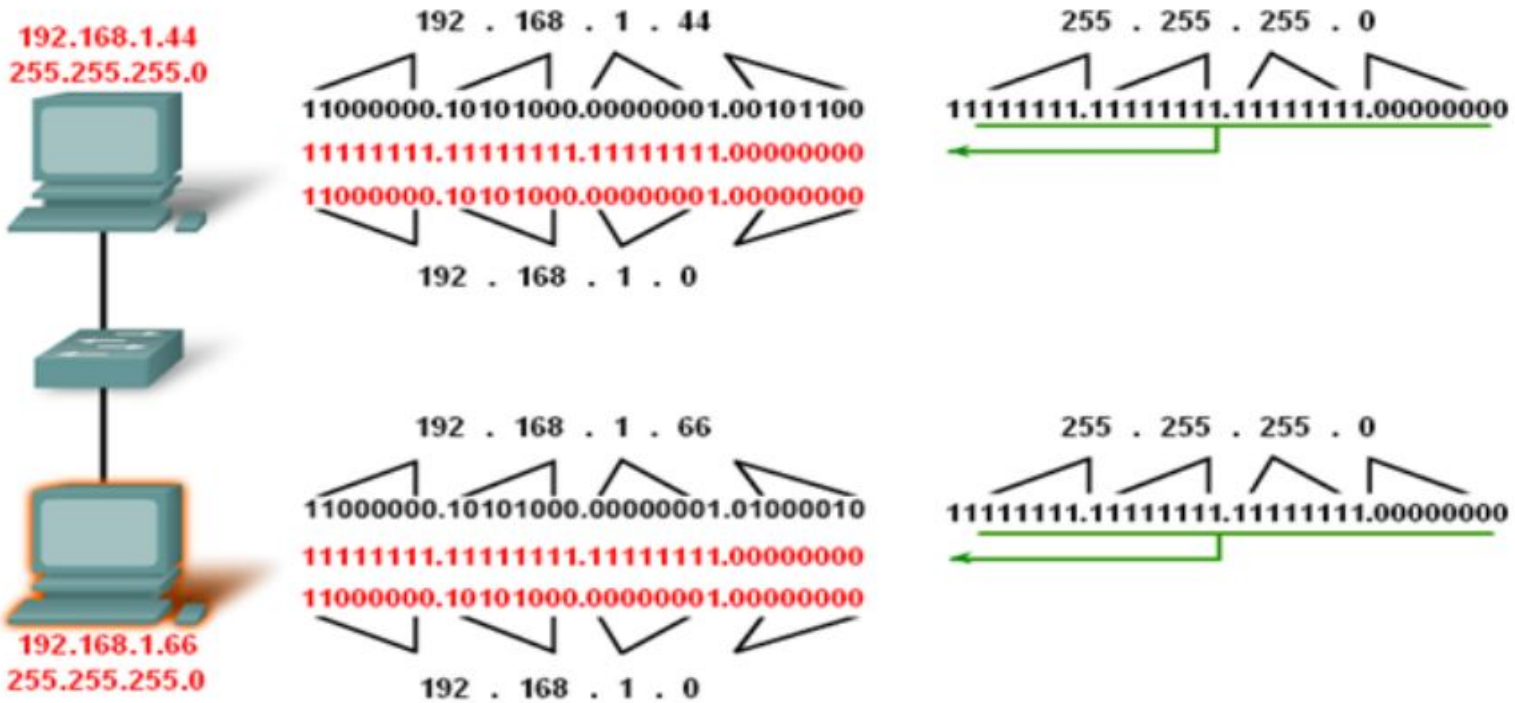
- Requires DHCP server to obtain an IP address.
- Non-static i.e. each time IP address changes, you may have to find your IP address again.

Introduction to Sub netting

- Before subnetting:
  - In any network (or subnet), one can use most of the IP addresses for host addresses.
  - Two hierarchy (Network and Host)
  - One loses two addresses for every network or subnet.
    1. Network Address - One address is reserved to that of the network.
    2. Broadcast Address – One address is reserved to address all hosts in that network or subnet.
- For example, a Class B address of 172.16.0.0/16 is used to assign $2^{16} - 2 = 65,534$ IP addresses for hosts.
- Suppose the organization needs 1000 IP addresses and if the technician uses this Network address without subnetting we will lose a number of IP addresses.

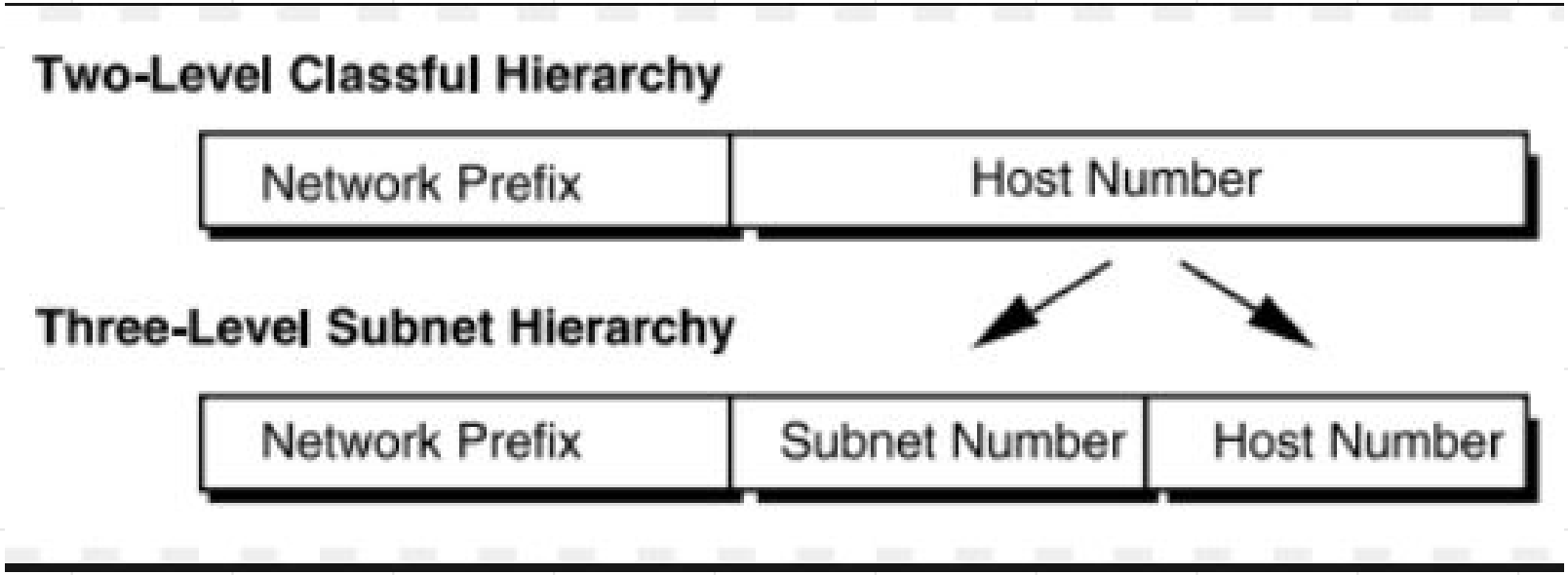
Introduction to Subnetting

- There are two parts to every IP address. How do hosts know which portion is the network and which is the host? This is the job of the subnet mask.



Introduction to Subnetting

- Example: Network address 172.16.0.0 with /16 network mask can be sub netted as follow.
- Default network mask: 255.255.0.0 or /16



Introduction to Subnetting

Creating subnets based on the network requirement

Steps:

1. Determine the number of networks required and convert it into binary.
2. Reserve bits in the mask and find the increment.
3. Find the network ranges based on the increment.

- **Example**
- Suppose the organization has a network address of 192.168.100.0 /24 and if this organization asks you to make this a Class C address in to nine valid networks, show that how you do the sub netting?

Introduction to Subnetting

- **Solution:**
  - Determine the number of networks required and convert it into binary
  - 9 networks= 0000**1001**
  - We need only **4 bits** to denote 9 in binary.
  - Reserve bits in the mask and find the increment
  - Default mask:
    - 24=255.255.255.0=11111111.11111111.11111111.00000000
  - Reserve bits in the mask:
    - 11111111.11111111.11111111.***1111***0000
  - New subnet mask: 255.255.255.240 or /28
  - Increment=lowest bit in the network portion (Italic one) i.e. **16**.

Introduction to Subnetting

Subnet	Network Address (0000)	Range of Valid Hosts (0001–1110)	Broadcast Address (1111)
0 (0000)	192.168.100.**0**	192.168.100.**1**–192.168.100.**14**	192.168.100.**15**
1 (0001)	192.168.100.**16**	192.168.100.**17**–192.168.100.**30**	192.168.100.**31**
2 (0010)	192.168.100.**32**	192.168.100.**33**–192.168.100.**46**	192.168.100.**47**
3 (0011)	192.168.100.**48**	192.168.100.**49**–192.168.100.**62**	192.168.100.**63**
4 (0100)	192.168.100.**64**	192.168.100.**65**–192.168.100.**78**	192.168.100.**79**
5 (0101)	192.168.100.**80**	192.168.100.**81**–192.168.100.**94**	192.168.100.**95**
6 (0110)	192.168.100.**96**	192.168.100.**97**–192.168.100.**110**	192.168.100.**111**
7 (0111)	192.168.100.**112**	192.168.100.**113**–192.168.100.**126**	192.168.100.**127**
8 (1000)	192.168.100.**128**	192.168.100.**129**–192.168.100.**142**	192.168.100.**143**
9 (1001)	192.168.100.**144**	192.168.100.**145**–192.168.100.**158**	192.168.100.**159**
10 (1010)	192.168.100.**160**	192.168.100.**161**–192.168.100.**174**	192.168.100.**175**
11 (1011)	192.168.100.**176**	192.168.100.**177**–192.168.100.**190**	192.168.100.**191**
12 (1100)	192.168.100.**192**	192.168.100.**193**–192.168.100.**206**	192.168.100.**207**
13 (1101)	192.168.100.**208**	192.168.100.**209**–192.168.100.**222**	192.168.100.**223**
14 (1110)	192.168.100.**224**	192.168.100.**225**–192.168.100.**238**	192.168.100.**239**
15 (1111)	192.168.100.**240**	192.168.100.**241**–192.168.100.**254**	192.168.100.**255**

Introduction to Subnetting

Creating subnets based on the host requirement

Steps:

1. Determine the number of host required per networks and convert it into binary.
2. Reserve bits in the mask and find the increment.
3. Find the network ranges based on the increment

- **Example**
- Suppose the organization has a network address of 172.16.0.0/16 and this organization asks you to divide this Class B address in to subnets. The organization needs each sub network to support 400 hosts. Show that how you do the sub netting?

Introduction to Subnetting

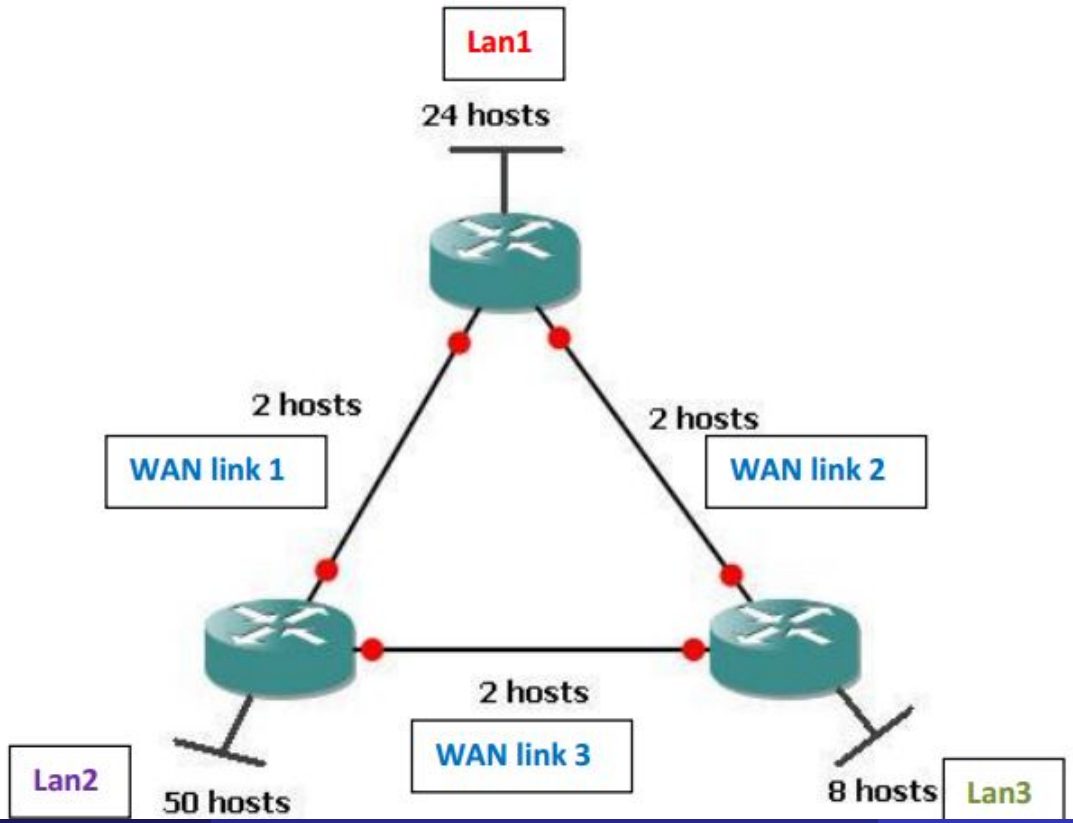
- **Solution:**
  - Determine the number of hosts required per network and convert it into binary
  - 400 hosts per networks = 110010000
  - We need only **9 bits** to denote 400 in binary.
  - Reserve bits in the mask and find the increment
  - Default mask:
    - /16=255.255.0.0=11111111.11111111.00000000.00000000
  - Reserve bits in the mask:
    - 11111111.11111111.111111***10*.00000000**
  - New subnet mask: 255.255.254.0 or /23
  - Increment=lowest bit in the network portion (Italic one) i.e.**2**.
  - Find the network ranges based on the increment.

Introduction to Subnetting

Subnet	Network Address	Range of Valid Hosts	Broadcast Address
0	172.16.**0.0**	172.16.0.1-172.16.1.254	172.16.**1.255**
1	172.16.**2.0**	172.16.2.1-172.16.3.254	172.16.**3.255**
2	172.16.**4.0**	172.16.4.1-172.16.5.254	172.16.**5.255**
3	172.16.**6.0**	172.16.6.1-172.16.7.254	172.16.**7.255**
.	.	.	.
.	.	.	.
.	.	.	.
127	172.16.**254.0**	172.16.254.1-172.16.255.254	172.16.**255.255**

VLSM (Variable Length Subnet Masks)

- VLSMs allow you to use different masks for each subnet, and thereby use address space efficiently.
- **Example:**
- Given the 192.168.2.0/24 network and requirements below, develop a sub netting scheme with the use of VLSM:



VLSM (Variable Length Subnet Masks)

- **Solution:**
- In this network we have 6 networks (LAN1 – LAN2 – LAN3 – WAN link1-WAN link2 – WAN link3)
  1. Determine the class of this network 192.168.2.0/24
     (Class: C , N = 24bits , H = 8bits, Default Mask = 24)
  2. Order the networks from the largest size to the smallest:
     1. LAN 2 (50 hosts)
     2. LAN1 (24 hosts)
     3. LAN3 (8 hosts)
     4. WAN link 1 - WAN link 2 - WAN link 3 (2 hosts)
  3. Start from the biggest network:

VLSM (Variable Length Subnet Masks)

- **LAN 2 (50 hosts):**
  - H = 6 bits -> $2^6 - 2 = 62$ hosts
  - S = 2 bits -> $2^2 = 4$ subnets
  - /mask = N + S = 24+2 = /26 =(255.255.255.192)
  - LAN2 will take the subnet ID: 192.168.2.0 /26
  - Where H is host bit, N is network bit, and S is borrow bit.

N = 24 S=2 H=6

11000000.10101000.00000010.00000000

192 . 168 . 2 . 0

Subnet no.	Subnet ID in binary	Subnet ID in decimal	Subnet mask	No of hosts per subnet	Network
0	11000000.10101000.00000010.00000000	192.168.2.0	/26	62 hosts	LAN2
1	11000000.10101000.00000010.01000000	192.168.2.64	/26	62 hosts	unused
2	11000000.10101000.00000010.10000000	192.168.2.128	/26	62 hosts	unused
3	11000000.10101000.00000010.11000000	192.168.2.192	/26	62 hosts	unused

VLSM (Variable Length Subnet Masks)

- **LAN 1 (24 hosts):**
  - H = 5 bits -> $2^5 - 2 = 30$ hosts
  - S = 3 bits -> $2^3 = 8$ subnets
  - /mask = N + S = 24+3 = /27 =(255.255.255.224)
  - LAN1 size is smaller than the available networks sizes so we will choose any “unused” subnet and subnet it to smaller size as follows: // Choose 192.168.2.64 and subdivide it into smaller subnets

N = 24 S=3 H=5

11000000.10101000.00000010.01000000

Subnet no.	Subnet ID in binary	Subnet ID in decimal	Subnet mask	No of hosts per subnet	Network
0	11000000.10101000.00000010.00000000	192.168.2.0	/26	62 hosts	LAN2
1	11000000.10101000.00000010.01000000	192.168.2.64	/27	30 hosts	LAN1
2	11000000.10101000.00000010.01100000	192.168.2.96	/27	30 hosts	unused
3	11000000.10101000.00000010.10000000	192.168.2.128	/26	62 hosts	unused
4	11000000.10101000.00000010.11000000	192.168.2.192	/26	62 hosts	unused

VLSM (Variable Length Subnet Masks)

- **LAN 3 (8 hosts):**
  - H = 4 bits -> $2^4 - 2 = 14$ hosts
  - S = 4 bits -> $2^4 = 16$ subnets
  - /mask = N + S = 24+4 = /28 =(255.255.255.240)
  - LAN3 size is smaller than the available networks sizes so we will choose any “unused” subnet and subnet it to smaller size as follows:// Choose 192.168.2.96 and subdivide it into smaller subnets

N = 24 S=4 H=4

11000000.10101000.00000010.01000000

Subnet no.	Subnet ID in binary	Subnet ID in decimal	Subnet mask	No of hosts per subnet	Network
0	11000000.10101000.00000010.00000000	192.168.2.0	/26	62 hosts	LAN2
1	11000000.10101000.00000010.01000000	192.168.2.64	/27	30 hosts	LAN1
2	11000000.10101000.00000010.01100000	192.168.2.96	/28	14 hosts	LAN3
3	11000000.10101000.00000010.01110000	192.168.2.112	/28	14 hosts	unused
4	11000000.10101000.00000010.10000000	192.168.2.128	/26	62 hosts	unused
5	11000000.10101000.00000010.11000000	192.168.2.192	/26	62 hosts	unused

VLSM (Variable Length Subnet Masks)

- **WAN Links 1,2,3 (2 hosts):**
  - H = 2 bits -> $2^2 - 2 = 2$ hosts
  - S = 6 bits -> $2^6 = 64$ subnets
  - /mask = N + S = 24+6 = /30 =(255.255.255.252)
  - WAN links 1,2 and 3 sizes are smaller than the available networks sizes so we will choose any “unused” subnet and subnet it to smaller size as follows: // Choose 192.168.2.112 and subdivide it into smaller subnets

N = 24 S=6 H=2

11000000.10101000.00000010.01000000

Subnet no.	Subnet ID in binary	Subnet ID in decimal	Subnet mask	No of hosts per subnet	Network
0	11000000.10101000.00000010.00000000	192.168.2.0	/26	62 hosts	LAN2
1	11000000.10101000.00000010.01000000	192.168.2.64	/27	30 hosts	LAN1
2	11000000.10101000.00000010.01100000	192.168.2.96	/28	14 hosts	LAN3
3	11000000.10101000.00000010.01110000	192.168.2.112	/30	2 hosts	WAN link1
4	11000000.10101000.00000010.01110100	192.168.2.116	/30	2 hosts	WAN link2
5	11000000.10101000.00000010.01111000	192.168.2.120	/30	2 hosts	WAN link3
6	11000000.10101000.00000010.01111100	192.168.2.124	/30	2 hosts	unused
7	11000000.10101000.00000010.10000000	192.168.2.128	/26	62 hosts	unused
8	11000000.10101000.00000010.11000000	192.168.2.192	/26	62 hosts	unused

Reading Assignment

- IPv6
- Unicast, multicast and broadcast addresses in IPv4 and IPv6 (if any)
- OSI model layer
- Intranet,Extranet,internet


Thank You!