Tutorial 2 and 3

What is an IP address?

IP address is an network layer protocol address for a host in a TCP/IP network.

What is the use of an IP address?

IP address is used to uniquely identify each host in a network. IP address is needed in order to communicate with other hosts in the network using the TCP/IP suite of protocols.

Which version of IP is covered by this document?

This document covers IP version 4.

Which RFC specifies the IP address standard?

RFC 1166 specifies the IP Version 4 address format.

How a host determines its IP address?

A host determines its IP address during the boot-up process either from a configuration file stored in the local hard disk of the system or using a network protocol like RARP, DHCP, BOOTP from the servers in the network.

Is there any relation between the MAC address and IP address of a host?

No. There is no relation between the MAC address and the IP address of a host.

Can a single network interface have more than one IP address associated with it?

Yes. It is possible to associate more than one IP address to a single network interface. This is discussed in detail in RFC 1122.

What is the difference between a host name and an IP address?

A host name is used to identify a host by human beings and higher level user applications. But IP protocol uses only IP addresses to identify a host in the network. A host-name is provided just as a convenience for users of the network and higher level applications.

How a host name is resolved to the corresponding IP address?

A host name is resolved to the corresponding IP address either from a configuration file stored in the local machine or using a network protocol like DNS or WINS from a server in the network.

What is the size of an IP address?

The size of an IP address is 32 bits (4 bytes).

How an IP address is represented?

The following notation is used to represent an IP address. This notation is called the dotted decimal format: M.N.O.P, where M, N, O and P represent the first, second, third and fourth bytes of an IP address respectively. The size of each byte is 8 bits and the value of each byte can be from 0 to 255. For example, 192.9.205.21 is an IP address.

What are the components of an IP address?

A IP address consists of the following components: Network ID and Host ID. For example, in the IP address 192.9.205.21, the network ID is 192.9.205 and the host ID is 21.

What is a network ID?

A network ID uniquely identifies a network. All the hosts in a single network will have the same network ID. For example, in the IP address 192.9.205.21, the network ID is 192.9.205. A router analyses only the network ID portion of an IP address for datagram forwarding.

What is a host ID?

A host ID uniquely identifies a host in a network. Two hosts in two different networks can have the same host ID. For example, in the IP address 192.9.205.21, the host ID is 21.

What is a unicast IP address?

A unicast IP address is an IP address uniquely identifying a host in a network. The datagram with a unicast IP address is received and processed by only a single host. For example, the IP address 192.9.205.21 is a unicast IP address.

What is a multicast IP address?

A multicast address is an IP address identifying a particular group of hosts in network. This group of hosts is called a multicast group. For example, the IP address 225.2.100.1 is a multicast IP address.

What is a broadcast IP address?

The datagram with a broadcast IP address is received and processed by all the hosts in the local network. For example, the IP addresses 255.255.255.255, 192.9.205.255, 180.10.255.255, 10.255.255.255 are broadcast IP addresses.

How IP addresses are classified?

IP addresses are classified based on the number of bytes allocated to the Network ID and the Host ID in an IP address.

What is the use of classifying IP addresses?

IP addresses are classified so that networks and hosts can be easily managed.

What are the different classes of IP addresses?

IP addresses are classified into the following classes:

1. Class A
2. Class B
3. Class C
4. Class D
5. Class E

How to determine the class of an IP address?

The class of an IP address can be determined from the first four bits of the first byte of the IP address.

How many bytes does each Class of IP address use to represent network and host IDs?

The number of bytes used by each network Class to represent the network and host are shown below:

IP Address Class	Bytes used for Network ID	Bytes used for Host ID
Class A	1	3
Class B	2	2
Class C	3	1
Class D	-	-
Class E	-	-

What is the format of the various IP address classes?

The format of the different IP address classes is shown below:

IP Address Class	IP Address format
Class A	0NNNNNNN.HHHHHHHH.HHHHHHHH.HHHHHHHH
Class B	10NNNNNN.NNNNNNNN.HHHHHHHH.HHHHHHHH
Class C	110NNNNN.NNNNNNNN.NNNNNNNN.HHHHHHHH
Class D	1110MMMM.MMMMMMMM.MMMMMMMM.MMMMMMMM
Class E	1111RRRR.RRRRRRRR.RRRRRRRR.RRRRRRRR

In the above table,
N denotes the network ID bits,
H denotes the host ID bits,
M denotes the multicast address bits and
R denotes reserved bits.

How many number of networks and hosts can be represented using the IP address classes?

The maximum number of networks and hosts that can be represented using the various IP address classes is shown below in the table:

IP Address Class	Maximum number of networks	Maximum number of hosts per network
Class A	126 (2^7 - 2)	16777214 (2^24 - 2)
Class B	16384 (2^14)	65534 (2^16 - 2)
Class C	2097152 (2^21)	254 (2^8 - 2)
Class D	-	-
Class E	-	-

In the above table,

1. The numbers are calculated using the number of bits used to represent the network ID and host ID.
2. The maximum number of networks for Class A IP address is reduced by 2 to account for the reserved network IP address 0.xxx.xxx.xxx and 127.xxx.xxx.xxx
3. The maximum number of hosts for all the classes is reduced by 2 to account for the reserved host IP address in which all the host ID address bits are either one or zero.

What is the possible range of IP addresses for the different classes?

IP Address Class	Possible range of IP address
Class A	0.0.0.0 through 127.255.255.255
Class B	128.0.0.0 through 191.255.255.255
Class C	192.0.0.0 through 223.255.255.255
Class D	224.0.0.0 through 239.255.255.255
Class E	240.0.0.0 through 247.255.255.255

What kind of networks use a Class A or Class B or Class C IP address typically?

Class A IP address is used for a network with large number of hosts. Class C IP address is used for a network with less number of hosts. Class B IP address is used for a network with medium number of hosts.

What is the use of Class D IP addresses?

The Class D IP addresses are used for multicasting.

What is the use of Class E IP addresses?

The Class E IP addresses are reserved for experimental purpose.

How to decide which class of IP address to use for a particular network?

The class of IP address to use for a particular network depends on the maximum number of hosts in the network. For example, if the maximum number of hosts in a network will be less than 254 hosts, then a Class C IP address can be used for the network. If the maximum number of hosts in a network will be greater than 254 hosts but less than 65534, then a Class B network can be used.

Does the maximum number of hosts in a network, restrict the class of IP address that can be used for the network?

No. Any possible class of IP address can be used to represent a network. For example, if a network has 200 hosts, it can use either a class A or class B or class C IP address.

What are the various special IP addresses?

The various special IP address are shown below in the table:

IP Address	Description
0.0.0.0	Local host.
127.xxx.xxx.xxx	Local loopback address. The value of the last 3 bytes are ignored. The datagram with this IP address is never transmitted over the network.
xxx.0.0.0 xxx.xxx.0.0 xxx.xxx.xxx.0	Local host IP address. The x represents the network ID bits.
0.xxx.xxx.xxx 0.0.xxx.xxx	IP address of a host in the local network. The x represents the host ID bits.

0.0.0.xxx	
255.255.255.255	Limited Broadcast address. Datagram with this address will be received and processed by all the hosts in the local network. This datagram is not forwarded to other networks by routers.
xxx.255.255.255 xxx.xxx.255.255 xxx.xxx.xxx.255	Directed broadcast address. The datagram with this IP address is received by all the hosts in the specified network. The x represents the network ID bits.

Questions on Subnetting:

i. What is an IP sub-network?
A subnetwork or subnet is a logical subdivision of an IP network. The practice of dividing a network into two or more networks is called Subnetting. Computers that belong to the same subnet are addressed with an identical most-significant bit-group in their IP addresses. This result in the logical division of an IP address into two fields: the network number or routing prefix and the rest field or host identifier. The rest field is an identifier for a specific host or network interface.

ii. What is the use of sub-networks?
Subnets make networks more efficient. Through subnetting, network traffic can travel a shorter distance without passing through unnecessary routers to reach its destination. This reduces network congestion.

Subnetting, the segmentation of a network address space, improves address allocation efficiency.

Subnetworks are created for manageability, performance and security of hosts and networks.

iii. Which RFC specifies IP subnetwork addressing?
RFC 950 specifies IP subnetwork addressing protocol.

iv. How sub-networks are formed?
The host ID portion of an IP address is further divided into a sub network ID part and a host ID part. The sub network ID is used to uniquely identify the different subnetwork within a network.

v. What is a subnet mask?
Subnet mask is a 4 byte (32 bit) number used to identify the sub-network ID and the host ID from an IP address. All the hosts in a subnetwork will have the same subnet mask. Eg: 255.255.255.0, 255.255.127.0, 255.255.0.0

vi. How a host determines its subnet mask?
A host determines its subnet mask during the boot up sequence either from a configuration file stored in the local hard disk or from a server in the network using a network protocol like BOOTP, ICMP.

vii. How is a subnet mask formed?
For all the bits in the IP address which are used to represent the network ID, and the subnetwork ID, the corresponding bits in the subnet mask will be zero. Eg: if the first 2 bytes of the IP address are used to represent the network (class B address) and the third byte is used to represent the sub-network, and the last byte is used to represent the host, then the subnet mask will be 255.255.255.0

viii. Why a host needs to know about its subnet mask?
When a host “A” needs to communicate with another host “B”, it must know whether host “B” is in the same network or in a different network. If the host “B” is in the same network then host “A” can send the datagram directly to host “B”. But if the host B is in a different network, then host “A” must send the datagram to a proper router. By determining the network class of the IP address of host “B”, host “A” can determine whether host “B” is in the same network or in a different network. By using the subnet mask host “A” can find out whether host “B” is in the same subnet or in a different subnet.

ix. How to determine to the network ID, sub-network ID and the host ID, given the IP address and the subnet mask?
The network class (A or B or C) of a given IP address can be easily determined by looking at the value of the first 4 bits of the first byte. From the network class, the number of byte used to represent the network can be determined and hence the network ID can be determined. By performing a “AND” logical operation of the IP address and the subnet mask, the subnetwork ID can be determined. In the value resulting from the “AND” operation, by removing the bytes used for the network ID, the remaining bits for which the corresponding bit in the subnet mask is one, represents the sub-network ID.

x. Is it possible to form a subnet mask by using bits in non-contiguous positions in the IP address?
Yes. It is possible to use non-contiguous bits in the host portion of an IP address to form the subnet field according to the standard. Only contiguous fields are usually used to from a subnet field.

xi. Is it possible to determine whether the network is subnetted by using the IP address of a host alone?
No. It is not possible to determine whether a network is subnetted just by using the IP address alone. The subnet mask is used to determine this.

xii. Is it necessary for hosts in a network "M" to know about the subnetworks in another network "N" to communicate with hosts in that network?

No. Subnetworks in one network are transparent to hosts in another network.

Example 1:
For example, let us say the IP address is 100.24.124.27 and the subnet mask is 255.255.0.0. As the most significant bit in the first byte of the IP address is zero, this is a Class A IP address. Therefore, the first byte represents the network ID. In this case, the network ID is 100. The result of a logical AND operation between the IP address and the subnet mask is 100.24.0.0. In this value, the first byte represents the network ID. For all the remaining one bit in the subnet mask, the corresponding bit in the IP address represents the sub-network ID. In this case it is 24. The remaining bits in the IP address represent the host ID. In this case it is 124.27.

Example 2:
IP Address: 187.199.127.5
Sub-net mask: 255.255.255.0

Network Class: B
Network ID: 187.199
Result of logical AND operation: 187.199.127
Sub-network ID: 127
Host ID: 5

Example 3:
IP Address: 187.199.127.5
Sub-net mask: 255.255.240.0

Network Class: B
Network ID: 187.199
Result of logical AND operation: 187.199.112.0
Sub-network ID: 112
Host ID: 15.5

Example 4:
IP Address: 187.199.127.5
Sub-net mask: 255.255.128.0

Network Class: B
Network ID: 187.199
Result of logical AND operation: 187.199.0.0
Sub-network ID: 0
Host ID: 127.5

xiii. What are the possible values for a sub-net mask?
All the possible values for a sub-net mask are shown below:
255.128.0.0
255.192.0.0
255.224.0.0
255.240.0.0

255.248.0.0
255.252.0.0
255.254.0.0
255.255.0.0
255.255.128.0
255.255.192.0
255.255.224.0
255.255.240.0
255.255.248.0
255.255.252.0
255.255.254.0
255.255.255.0
255.255.255.128
255.255.255.192
255.255.255.224
255.255.255.240
255.255.255.248
255.255.255.252

xiv. What are the two types of subnetting?
The two types of subnetting are:
Static length
Variable length

xv. What is 'Static Length' subnetting?
If all the subnetworks in a single network use the same subnet mask, it is called as 'Static Length' subnetting.

xvi. What is 'Variable Length' subnetting?
If the different subnetworks in a single network use different subnet masks, it is called as 'Variable Length' subnetting.

xvii. What is the disadvantage in using 'Static Length' subnetting?
In the case of a 'Static Length' subnetwork, irrespective of the number of hosts in the subnetwork, a single subnet mask is used for all the subnetworks. Because of this, a large number of IP addresses will be wasted. For example, let us say, we have a class C IP network address 192.9.205.0 subnetted using a subnet mask 255.255.255.192. The total number of possible subnetworks is 4 and the total number of possible hosts per subnetwork is 32. Even if a subnetwork has just 4 hosts, it will be allocated the above subnetwork IP address; in this case 28 host IP addresses will be wasted.

xviii. What is the advantage in using 'Static Length' subnetting?
It is easy to configure a network using 'Static Length' subnetting. In addition, native IP routing understands only static subnetting.

xix. What is the advantage is using 'Variable Length' subnetting?
In the case of 'Variable Length' subnetwork, IP addresses are allocated depending on the number of hosts present in the subnetwork. So available host IP addresses are efficiently used and are not wasted.

xx. What is the disadvantage in using 'Variable Length' subnetting?
All the routers in a 'Variable Length' subnetted network must understand this type of subnetting.

xxi. What are the special subnetwork IP addresses?
The subnet addresses in which all the bits are zero or one are special subnet IP addresses. The subnet address, in which all the bits are zero, represents the local subnetwork in which the datagram originated. The subnet address in which all the bits are one represents a subnet broadcast address. In the broadcast address, all the other bits including the network and host ID must be one.

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