Assignment No: 2 Using a Network Simulator (e.g. packet tracer) Configure Sub-netting of a given network & Super-netting of a given networks.

Theory:

IP Addressing & Sub netting:

Some useful definition related to the sub-point are:

- **Address**—The unique number ID assigned to one host or interface in a network.
- **Subnet**—A portion of a network sharing a particular subnet address.
- **Subnet mask**—A 32-bit combination used to describe which portion of an address refers to the subnet and which part refers to the host.
- **Interface**—A network connection.

Understanding IP Addresses

An IP address is an address used in order to uniquely identify a device on an IP network. The address is made up of 32 binary bits, which can be divisible into a network portion and host portion with the help of a subnet mask. The 32 binary bits are broken into four octets (1 octet = 8 bits). Each octet is converted to decimal and separated by a period (dot). For this reason, an IP address is said to be expressed in dotted decimal format (for example, 172.16.81.100). The value in each octet ranges from 0 to 255 decimal, or 00000000 - 11111111 binary.

Here is how binary octets convert to decimal: The right most bit, or least significant bit, of an octet holds a value of 2^0. The bit just to the left of that holds a value of 2^1. This continues until the left-most bit, or most significant bit, which holds a value of 2^7. So if all binary bits are a one, the decimal equivalent would be 255 as shown here:

1 1 1 1 1 1 1 1

128 64 32 16 8 4 2 1 (128+64+32+16+8+4+2+1=255)

Here is a sample octet conversion when not all of the bits are set to 1.

0 1 0 0 0 0 0 1

0 64 0 0 0 0 0 1 (0+64+0+0+0+0+0+1=65)

And this is sample shows an IP address represented in both binary and decimal.

10. 1. 23. 19 (decimal)

00001010.00000001.00010111.00010011 (binary)

Given an IP address, its class can be determined from the three high-order bits. Figure 1 shows the significance in the three high order bits and the range of addresses that fall into each class. For informational purposes, Class D and Class E addresses are also shown.

In a Class A address, the first octet is the network portion, so the Class A example in Figure 13 has a major network address of 1.0.0.0 - 127.255.255.255. Octets 2, 3, and 4 (the next 24 bits) are for the network manager to divide into subnets and hosts as he/she sees fit. Class A addresses are used for networks that have more than 65,536 hosts (actually, up to 16777214 hosts!).

In a Class B address, the first two octets are the network portion, so the Class B example in Figure 13 has a major network address of 128.0.0.0 - 191.255.255.255. Octets 3 and 4 (16 bits) are for local subnets and hosts. Class B addresses are used for networks that have between 256 and 65534 hosts.

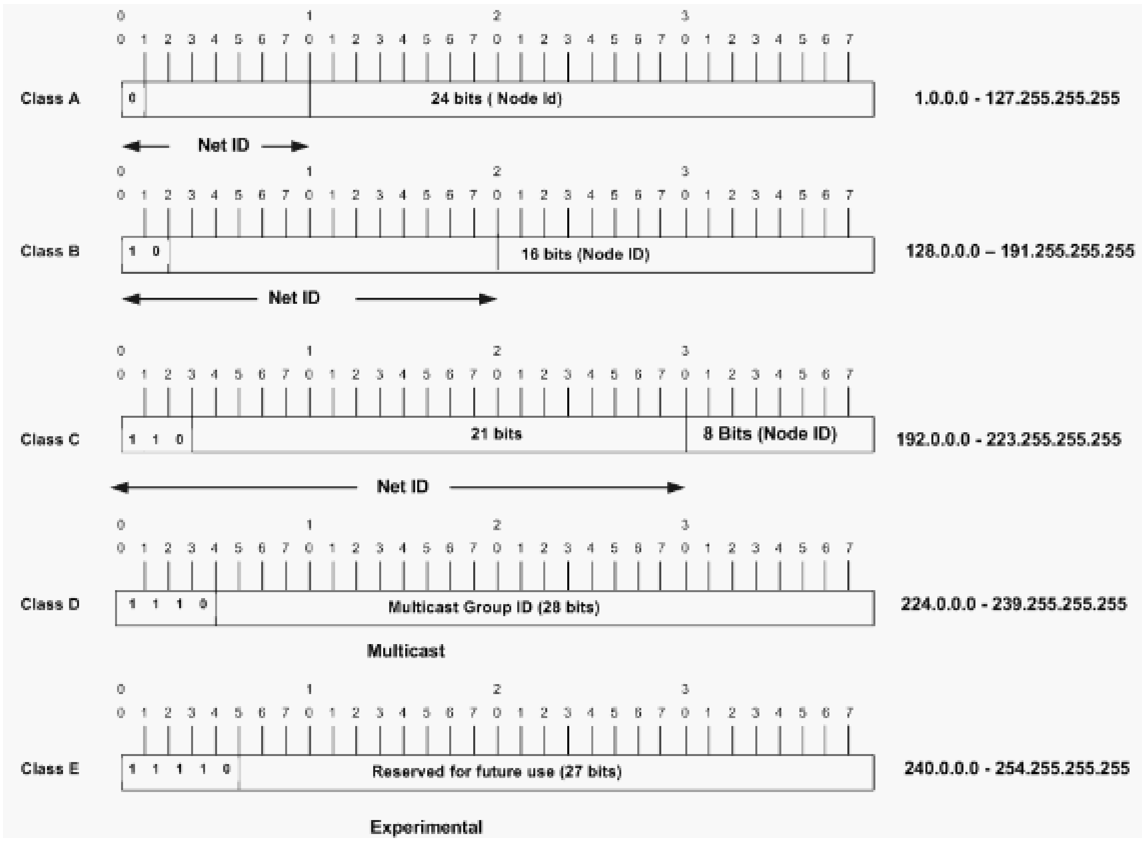


Figure. 13: Addressing Schemes

In a Class C address, the first three octets are the network portion. The Class C example in Figure 13 has a major network address of 192.0.0.0 - 223.255.255.255. Octet 4 (8 bits) is for local subnets and hosts - perfect for networks with less than 254 hosts.

Network Masks

A network mask helps you know which portion of the address identifies the network and which portion of the address identifies the node. Class A, B, and C networks have default masks, also known as natural masks, as shown here:

Class A: 255.0.0.0

Class B: 255.255.0.0

Class C: 255.255.255.0

An IP address on a Class A network that has not been subnetted would have an address/mask pair similar to: 8.20.15.1 255.0.0.0. To see how the mask helps you identify the network and node parts of the address, convert the address and mask to binary numbers.

8.20.15.1 = 00001000.00010100.00001111.00000001

255.0.0.0 = 11111111.00000000.00000000.00000000

Once you have the address and the mask represented in binary, then identifying the network and host ID is easier. Any address bits which have corresponding mask bits set to 1 represent the network ID. Any address bits that have corresponding mask bits set to 0 represent the node ID.

8.20.15.1 = 00001000.00010100.00001111.00000001

255.0.0.0 = 11111111.00000000.00000000.00000000

----

net id | host id

netid = 00001000 = 8

hostid = 00010100.00001111.00000001 = 20.15.1

Subnetting

Subnetting allows you to create multiple logical networks that exist within a single Class A, B, or C network. If you do not subnet, you are only able to use one network from your Class A, B, or C network, which is unrealistic.

Each data link on a network must have a unique network ID, with every node on that link being a member of the same network. If you break a major network (Class A, B, or C) into smaller subnetworks, it allows you to create a network of interconnecting subnetworks. Each data link on this network would then have a unique network/subnetwork ID. Any device, or gateway, connecting *n* networks/subnetworks has *n* distinct IP addresses, one for each network / subnetwork that it interconnects.

In order to subnet a network, extend the natural mask using some of the bits from the host ID portion of the address to create a subnetwork ID. For example, given a Class C network of 204.17.5.0 which has a natural mask of 255.255.255.0, you can create subnets in this manner:

204.17.5.0 - 11001100.00010001.00000101.00000000

255.255.255.224 - 11111111.11111111.11111111.11100000

--------------------------|sub|----

By extending the mask to be 255.255.255.224, you have taken three bits (indicated by "sub") from the original host portion of the address and used them to make subnets. With these three bits, it is possible to create eight subnets. With the remaining five host ID bits, each subnet can have up to 32 host addresses, 30 of which can actually be assigned to a device since host ids of all zeros or all ones are not allowed (it is very important to remember this). So, with this in mind, these subnets have been created.

204.17.5.0 255.255.255.224 host address range 1 to 30

204.17.5.32 255.255.255.224 host address range 33 to 62

204.17.5.64 255.255.255.224   host address range 65 to 94

204.17.5.96 255.255.255.224   host address range 97 to 126

204.17.5.128 255.255.255.224   host address range 129 to 158

204.17.5.160 255.255.255.224   host address range 161 to 190

204.17.5.192 255.255.255.224   host address range 193 to 222

204.17.5.224 255.255.255.224   host address range 225 to 254

The network subnetting scheme in this section allows for eight subnets, and the network might appear as:

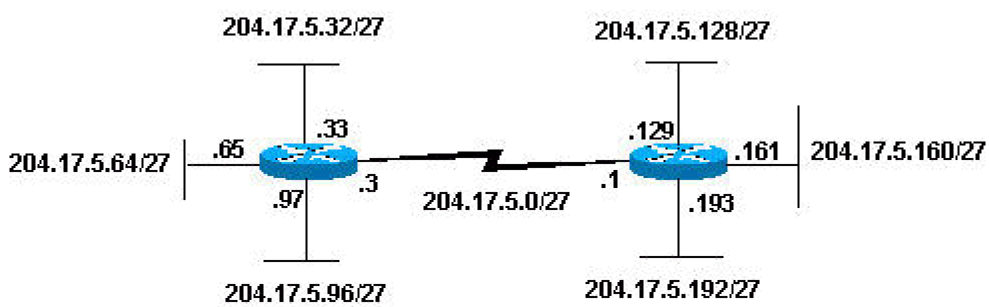


Figure. Sample Network

Notice that each of the routers in Figure 2 is attached to four subnetworks, one subnetwork is common to both routers. Also, each router has an IP address for each subnetwork to which it is attached. Each subnetwork could potentially support up to 30 host addresses.

This brings up an interesting point. The more host bits you use for a subnet mask, the more subnets you have available. However, the more subnets available, the less host addresses available per subnet. For example, a Class C network of 204.17.5.0 and a mask of 255.255.255.224 (/27) allows you to have eight subnets, each with 32 host addresses (30 of which could be assigned to devices). If you use a mask of 255.255.255.240 (/28), the break down is:

```
204.17.5.0 -      11001100.00010001.00000101.00000000
255.255.255.240 - 11111111.11111111.11111111.11110000
                  --------------------------|sub |---
```

Since you now have four bits to make subnets with, you only have four bits left for host addresses. So in this case you can have up to 16 subnets, each of which can have up to 16 host addresses (14 of which can be assigned to devices).

Take a look at how a Class B network might be subnetted. If you have network 172.16.0.0,then you know that its natural mask is 255.255.0.0 or 172.16.0.0/16. Extending the mask to anything beyond 255.255.0.0 means you are subnetting. You can quickly see that you have the ability to create a lot more subnets than with the Class C network. If you use a mask of 255.255.248.0 (/21), how many subnets and hosts per subnet does this allow for?

```
172.16.0.0  -   10101100.00010000.00000000.00000000
255.255.248.0 - 11111111.11111111.11111000.00000000
```

-----------------| sub |-----------

You are using five bits from the original host bits for subnets. This allows you to have 32 subnets (2^5). After using the five bits for subnetting, you are left with 11 bits for host addresses. This allows each subnet so have 2048 host addresses (2^{11}), 2046 of which could be assigned to devices.

Supernetting

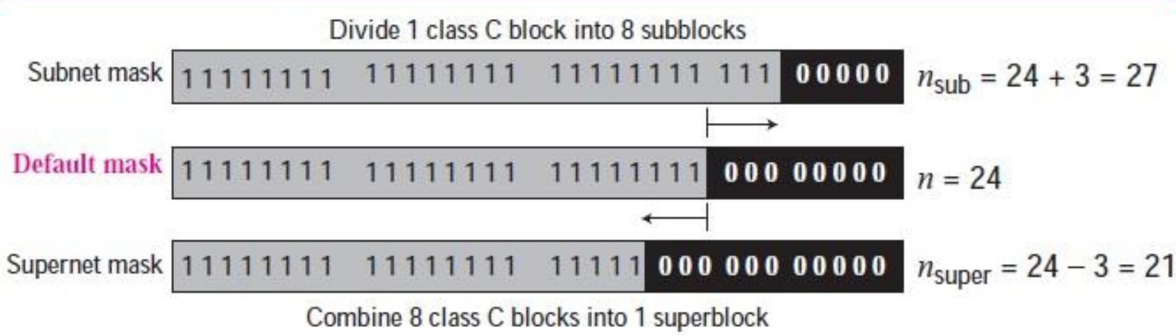
Subnetting could not completely solve address depletion problems in classful addressing because most organizations did not want to share their granted blocks with others. Since class C blocks were still available but the size of the block did not meet the requirement of new organizations that wanted to join the Internet, one solution was supernetting. In supernetting, an organization can combine several class C blocks to create a larger range of addresses. In other words, several networks are combined to create a supernetwork. By doing this, an organization can apply for several class C blocks instead of just one. For example, an organization that needs 1000 addresses can be granted four class C blocks.

Supernet Mask

A supernet mask is the reverse of a subnet mask. A subnet mask for class C has more 1s than the default mask for this class. A supernet mask for class C has less 1s than the default mask for this class.

Figure 5.26 shows the difference between a subnet mask and a supernet mask. A subnet mask that divides a block into eight subblocks has three more 1s (23 = 8) than the default mask; a supernet mask that combines eight blocks into one superblock has three less 1s than the default mask.

Figure 5.26 *Comparison of subnet, default, and supernet masks*



In supernetting, the number of class C addresses that can be combined to make a supernet needs to be a power of 2. The length of the supernetid can be found using the formula in which nsuper defines the length of the supernetid in bits and c defines the number of class C blocks that are combined. Unfortunately, supernetting provided two new problems: First, the number of blocks to combine needs to be a power of 2, which means an organization that needed seven blocks should be granted at least eight blocks (address wasting). Second, supernetting and subnetting really complicated the routing of packets in the Internet.

Conclusion: We have configured Subnetting & Supernetting using Network Simulator packet tracer.