IST 220 Honors Project

Subnets with Variable Length Subnet Masks

Project Objectives:

In this project, you will subnet the IP address 193.170.10.0 according to needs of the organization.

Overview

a) Perform subnet calculations.

b) Configure two Cisco Routers and PCs according to your subnetting scheme.

c) Verify the configuration.

d) Write a report.

IMPORTANT NOTE: You can find number of subnetting tools (subnet calculators) on the internet that would automatically calculate for your all data you need for part a, and you are welcome to use those to check your work prior going to task B. However, you need show all calculations done in part A in your report.

Introduction

Subnetting is a process for dividing a network into smaller networks.

A subnet mask is 32-bit number that shows what part of IP address is dedicated for network use and host locations.

Benefits of subnetting:

* *Efficient utilization of IP Addressing to prevent wasted addresses*.

* *Reduction of network traffic to allow for optimal performance.*

* *Ease of administration by dividing the network into smaller, more manageable networks*

VLSM (Variable Length Subnet Mask) subnetting is about dividing subnetworks into even smaller subnetworks. In another words, VLSM is used to create subnetworks that are used according their individual needs rather then some general network rule.

Subnetting Example:

Before we start here some information you may want to recall:

Binary to decimal and opposite conversions:

To convert decimal to binary: Keep dividing number by 2 till you get 1/2, keeping track of reminder after each complete division. The pattern of produced reminders starting from **right most bit** is the binary analog of number you are converting.

Ex. Number 105

Number divisions:	105/2	52/2	26/2	13/2	6/2	3/2	1/2
Remainder :	1	0	0	1	0	1	1

Number 105 in binary is 1101001

To convert binary to decimal:

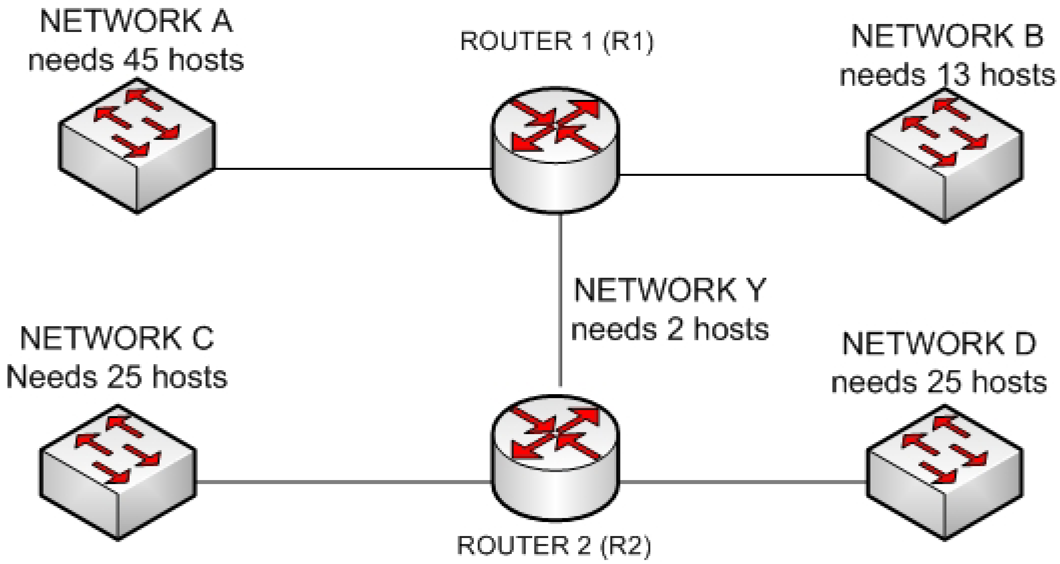
To convert 1010111 to decimal start from right most bit by multiplying it on 2^0. Now keep going from right to left, every time incrementing power of number 2 by 1.

1	0	1	0	1	1	1
*	*	*	*	*	*	*
2^6	2^5	2^4	2^3	2^2	2^1	2^0
64	0	16	0	4	2	1

Now, adding up numbers at the bottom will result in number 87 which is decimal analog of 1010111

Example Task A: Subnetting the network

Given network 210.135.83.0 /24 must be subnetted into 5 subnetworks with following requirements:



First of all, /24 or 255.255.255.0 means that 24 first bits are reserved for the network and are not available for subnetting. Therefore, we can ignore the first 24 bits that in decimal form would be **210.135.83**

STEP I: Decide how many host bits (H) will be needed for the largest network

Formula 1: 2^H – 2 = number of valid hosts per subnet.

In our case, largest subnetwork is A, which needs 45 hosts. So, 2^H -2 = 45 => smallest possible value for H would be 6. Originally, we started with 8 network bits (N) in our fourth octet of our network, so now after we have borrowed 6 for the hosts from the fourth octet of our network we are left with 2 bits for the networks.

Started with: NNNNNNNN
Now have: NNHHHHHH

STEP II Choose a subnet for the largest network to use with

Formula 2: 2^N = total number of usable subnets, N – network bit*
** Usually this formula looks like 2^N -2 because some routers don't allow the use of subnets where all network bits are 0s or 1's. However, Cisco routers by default allow the use of these two 'invalid subnets', so in our lab we will stick to the formula shown above.*

Now let see how many subnets we can get with 2 network bits. 2^2 = 4 subnets

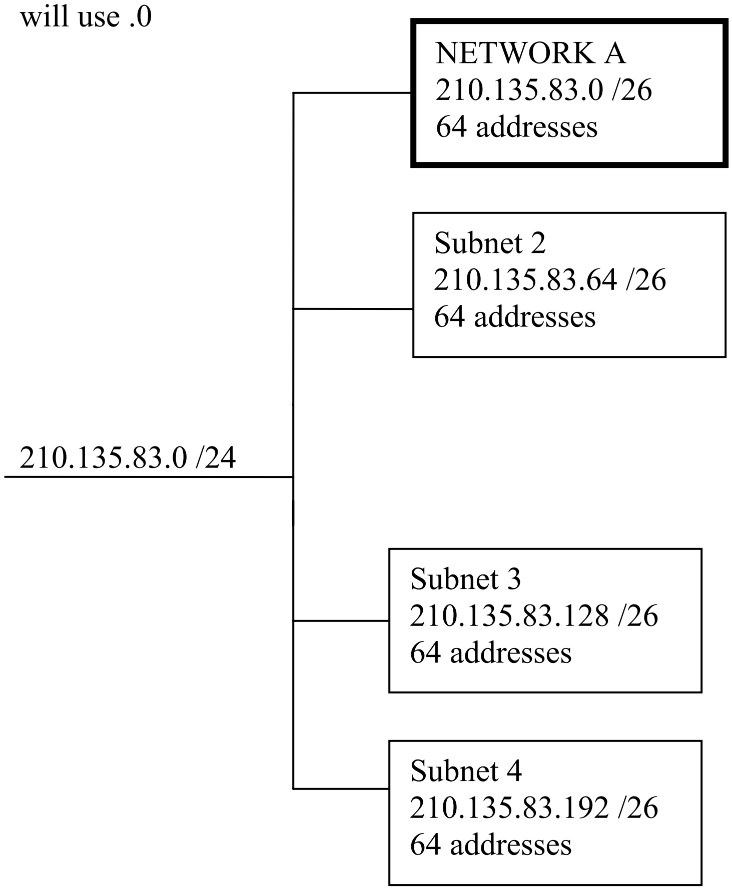
NNHHHHHH
00HHHHHH
01HHHHHH
10HHHHHH
11HHHHHH

Now if we put zeros instead of H bits we would get numbers for our four newly generated subnets.

00**000000** = .0
01**000000** = .64
10**000000** = .128
11**000000** = .192

Note that we have added 2 additional bits to our subnet mask, so all these new networks will have a subnet mask of /26 instead of the old /24

Now we can choose any of these subnets for our largest network A, in this example we will use .0



*Keep in mind that original network 210.135.83.0 /24 cannot be used anymore because it was subnetted.

STEP III Choose Subnet for the next largest network

Next, we have the two largest networks to find the subnet for: network C and D, 25 hosts each.

Let's find the number of host bits we need: 2^H – 2 = 25, H = 5.

Now we need to pick one of the 3 subnetworks left and subnet it again.

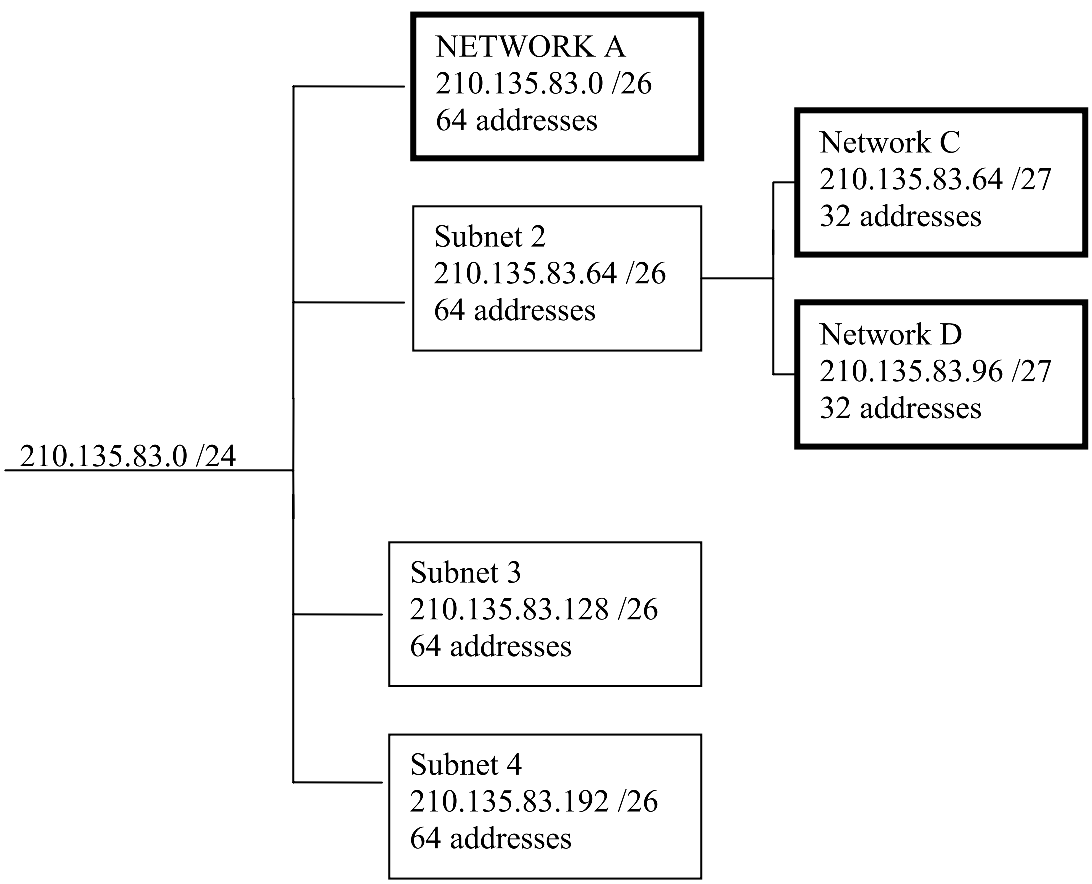
For this example we chose .64 / 26 network: 01000000
Now, after we have borrowed 5 host bits for our subnet mask we have 1 bit left for our network: | SS**N**HHHHH, S – subnet bits |
The number of maximum subnets then is 2 (refer to formula 2 for details)

Putting all zeros instead of host bits gives us two subnets:

01**000000** = .64
01**100000** = .96

*01 represents the original subnet

Now we have added 3 network bits and accordingly our new mask would be /27



STEP IV Choose Subnet for the next largest network

The next largest network we will subnet is network B: 13 hosts.

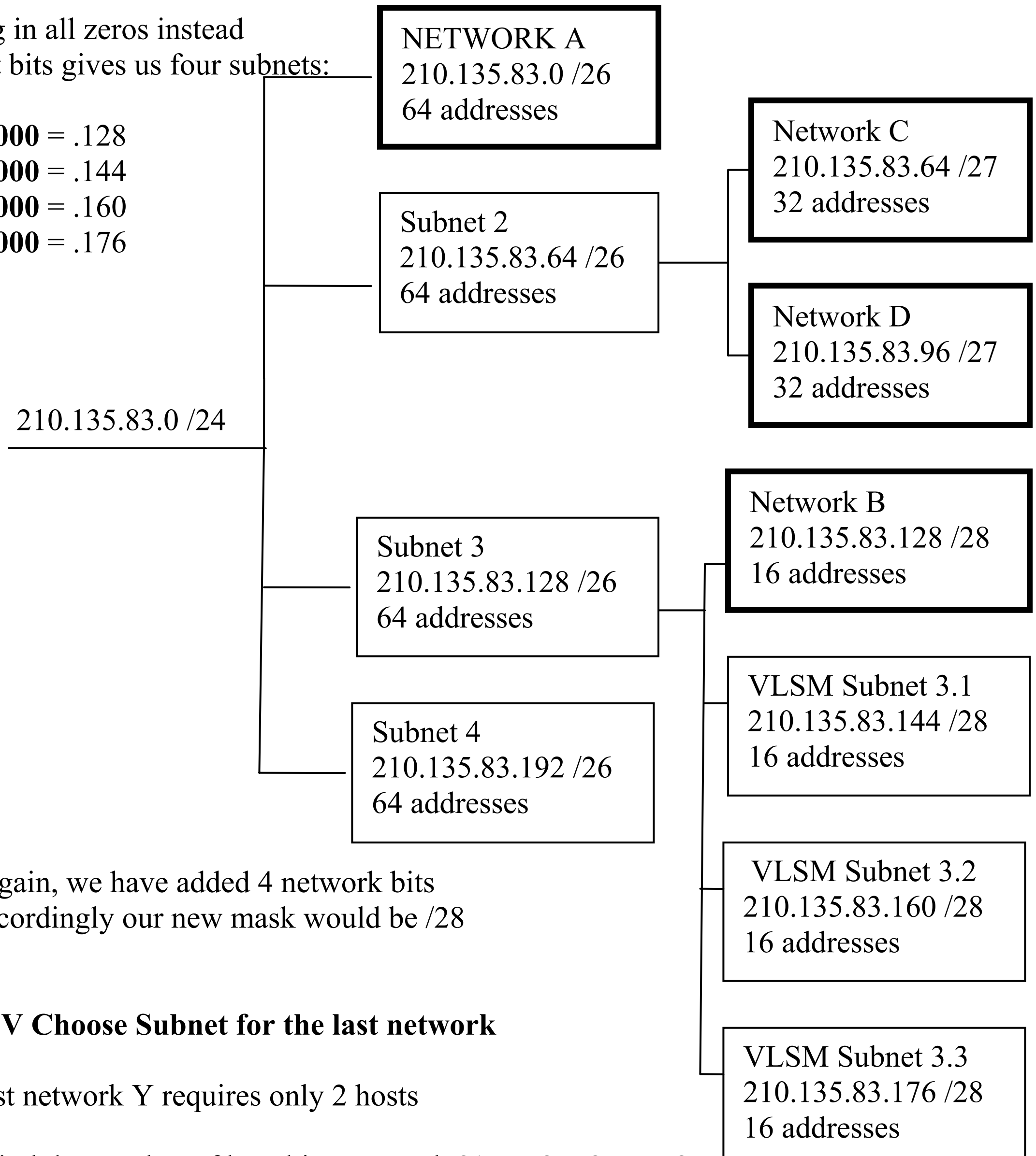
Let’s find the number of host bits we need: 2^H – 2 = 13, H = 4.

Now we need to pick one of the 2 subnetworks left and subnet it again.

For this example we choose .128 / 26 network: 10000000
After we have borrowed 4 host bits for our subnet mask we have 2 bits left for our network: | SS**NN**HHHH, S – subnet bits |
The number of maximum subnets is now 4 (refer to formula 2 for details)

Putting in all zeros instead of host bits gives us four subnets:

10**000000** = .128
10**010000** = .144
10**100000** = .160
10**110000** = .176



Here again, we have added 4 network bits and accordingly our new mask would be /28

STEP V Choose Subnet for the last network

Our last network Y requires only 2 hosts

Let’s find the number of host bits we need: 2^H – 2 = 2, H = 2.

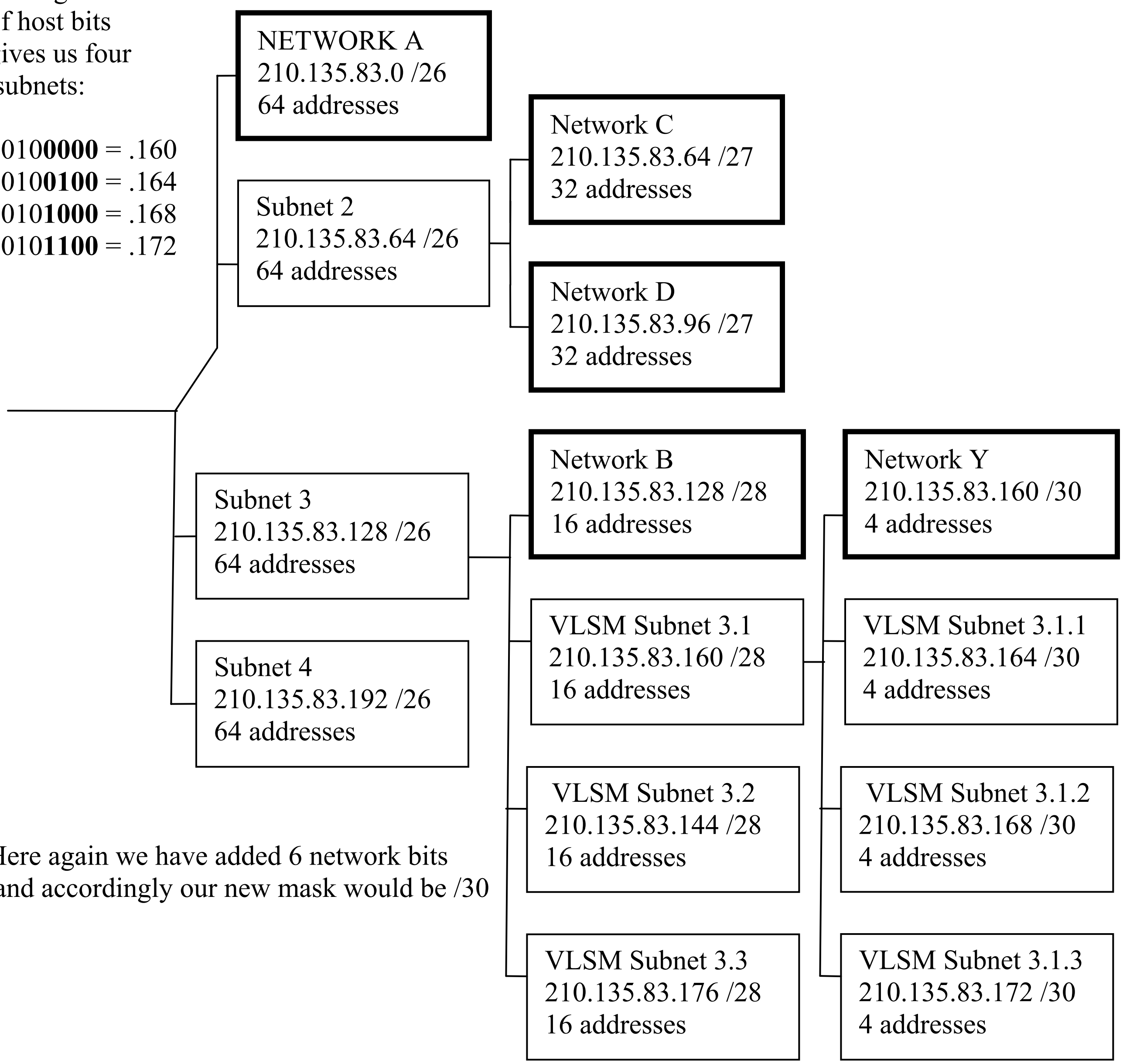
Now we need to pick one of the subnetworks left or one of the three VLSM subnetworks to subnet again.

We should use one of our VLSM addresses to prevent wasted IP space.

For this example we choose .160 / 28 network: 10100000
After we have borrowed 2 host bits for our subnet mask, we have 2 bits left for our network: | SSSS**NN**HH, S – subnet bits |
The number of maximum subnets is 4 (refer to formula 2 for details)

Putting all zeros instead of host bits gives us four subnets:

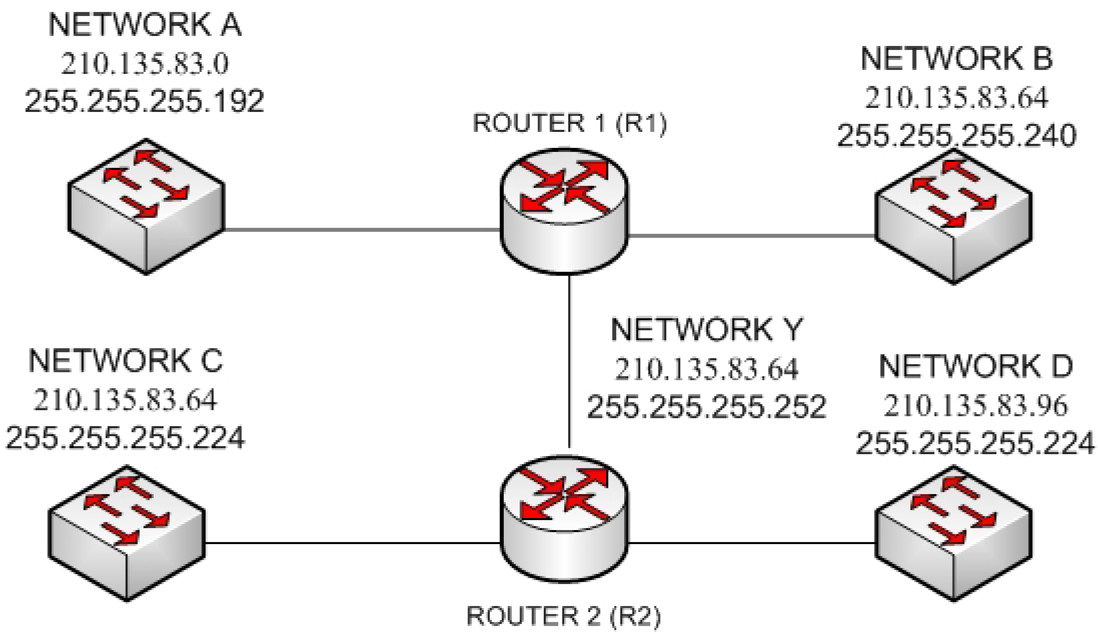
1010**0000** = .160
1010**0100** = .164
1010**1000** = .168
1010**1100** = .172



Here again we have added 6 network bits and accordingly our new mask would be /30

STEP VI Determine first and last usable IP addresses for the networks

The process of determining this information is relatively simple, so we will discuss only one IP address/subnet mask case. Here is the overview of our networks/masks



For our example we will pick network C.

As stated earlier, 210.135.83 cannot be changed, so we should ignore that part.

Now, let's start with converting to the binary fourth octet of the Network C (.64 and the fourth octet of network C, with a subnet mask of .224). Now, every address in the subnetwork are net bits and all zeros are host bits; so to find out the first and last IP addresses we need to fill in the host bits of the network.

.64	.010**00000**
.224	.111**00000**

That would bring us to:

Subnet ID Address	.010**00000**	.64
First usable IP address	.010**00001**	.65
Last usable IP address	.010**11110**	.95
Broadcast Address	.010**11111**	.96

Please note that every network ID address (the first IP address range for the network) and broadcast address (the last IP address in range for the network) cannot act as a host address, and therefore cannot be assigned to PCs.

The ID address is used in conjunction with the subnet mask by routers to route between networks. The broadcast address is only used when all computers in the network must receive the data.

EXAMPLE TASK B: ROUTER CONFIGURATION

% - comments

NETWORK A

R1(config)##interface fastethernet 0/0 *% enter configuration mode for router Ethernet interface 0*
R1(config-if)#ip address 210.135.83.65 255.255.255.192 % *assign IP address and mask to the interface 0*
R1(config-if)#no shutdown % *physically turning on interface 0*
*Mar 23 20:30:43.559: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state t
o up

NETWORK B

R1(config)##interface fastethernet 0/1 *% enter configuration mode for router Ethernet interface 1*
R1(config-if)#ip address 210.135.83.129 255.255.255.240 % *assign IP address and mask to the interface 1*
R1(config-if)#no shutdown % *physically turning on interface*

NETWORK Y

R1(config)##interface fastethernet 0/2 *% % enter configuration mode for router Ethernet interface 2*
R1(config-if)#ip address 210.135.83.161 255.255.255.252 % *assign IP address and mask to the interface 2*
R1(config-if)#no shutdown % *physically turning on interface*

ENABLING ROUTING BETWEEN NETWORK A, B and Y

R1(config-if)#router rip % *enables RIP protocol for the routing purposes*
R1(config-router)#version 2 *% turns on support for the VLSM subneting*
R1(config-router)#network 210.135.83.128 *% includes network 210.135.83.0 into routing process*
R1(config-router)#network 210.135.83.160

R1(config-router)#end *% return to privileged mode*
Router R2 configuration is done in similar way; in other words if you understand how to configure router R1, you should not have any problem configuring Router 2

EXAMPLE TASK C: Verifying Configuration

To test our configuration we would run ping command from network A PC to the network C PC

C:\>ping 210.135.83.98 % *ip address that being targeted with ICMP packets*

Pinging 210.135.83.98 with 32 bytes of data:

Reply from 210.135.83.98: bytes=32 time<10ms TTL=126
Reply from 210.135.83.98: bytes=32 time<10ms TTL=126
Reply from 210.135.83.98: bytes=32 time<10ms TTL=126
Reply from 210.135.83.98: bytes=32 time<10ms TTL=126

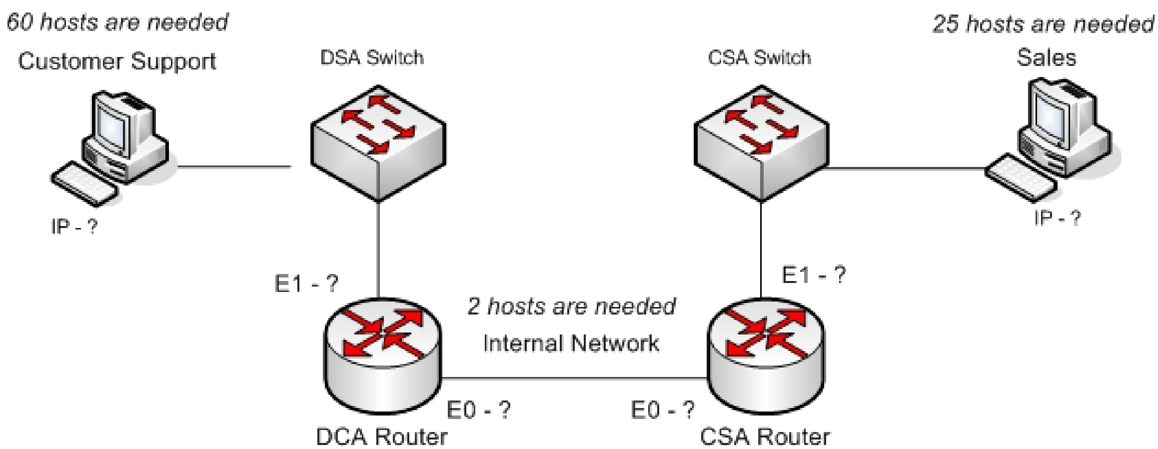
Ping statistics for 210.135.83.98:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms

Project Tasks:

Task A:

You need to subnet the network 193.170.10.0 /24 to create 3 subnetoworks with following host requirements:

Customer Support network requires 60 hosts
Sales network requires 25 hosts
Internal Network requires 2 hosts



Task B:

Now you need to configure two routers and 2 PCs according to the subnet information you have acquired from Task A.

You will need to configure the Cisco routers through the Hyperterminal application using the command line, which looks similar to the command prompt in Windows.

Here is guideline for doing so:

The Cisco Routers have three levels of authorization: user, privileged, and globalconfig.

User level allows views to the most general information and the execution of certain test commands, such as traceroute and ping. *Privileged* level allows for the management of the file system and the use of debug mode on the router. *Globalconfig* level allows the user to perform the main setup configuration for the router including, but not limited to, IP address assignments, routing protocols, and firewall configuration.

You will start in *global configuration* mode, but you may need change back to *privileged*; please refer to the command reference for doing so.

The router is a gateway for any network of computers directly connected to it; so first you need to assign an IP address for the routers' gateway Ethernet ports.

NETWORK "SALES"

```
CSA(config)##interface fastethernet 0/0
CSA(config-if)#ip address (Network "sales" gateway) (subnetmask)
CSA(config-if)#no shutdown
```

NETWORK "Customer Support"

```
DCA(config-if)#interface fastethernet 0/0
DCA(config-if)# ip address (Network "customer support" gateway) (subnetmask)
DCA(config-if)#no shutdown
```

Now assign IP addresses for point-to-point links between routers.

INTERNAL NETWORK

```
CSA(config)##interface fastethernet 0/1
CSA(config-if)#ip address (internal gateway) (subnetmask)
CSA(config-if)#no shutdown
```

```
DCA(config-if)#interface fastethernet 0/1
DCAconfig-if)# ip address (internal gateway) (subnetmask)
DCA(config-if)#no shutdown
```

Finally, enable routing on both routers and add the networks.

ENABLING ROUTING BETWEEN NETWORKS

```
CSA(config-if)#router rip
CSA(config-router)#version 2
CSA(config-router)#network (sales)
CSA(config-router)#network (internal network)
CSA(config-router)#end
```

```
DCA(config-if)#router rip
DCA(config-router)#version 2
DCA(config-router)#network (customer support)
DCA(config-router)#network (internal network)
DCA(config-router)#end
```

CISCO ROUTER COMMANDS REFERENCE

Inviked from	***command type***	***command***	***comments***	***example***
user mode	Changing between authorization modes	**enable**	Switch to privileged mode	router>enable → router#
privileged mode	-----------------------	**configure terminal**	Switch to global configuration mode	router# configure terminal → router(config)##
any mode	------------	**end**	go back to lower hierarchy mode	router(config)## end → router #
global configuration mode	Ethernet interface configuration	**interface fastethernet (interface number)**	enters interface configuration mode	router(config)##interface fastethernet 0/0 → router (config-if)#
interface configuration mode	---------------------	**ip address (address) (mask)**	Assigns IP address and subnetmask to the chosen interface	router(config-if)#ip address 193.140.15.1 255.255.255.0
interface configuration mode	---------------------	**no shutdown**	Turns on chosen Ethernet interface	router(config-if)# no shutdown
global configuration mode and any submode of global config	Routing protocols configuration	**router (name of protocol)**	Enables chosen routing protocol and enters routing configure mode	router(config-if)#router rip → router(config-router)#
router configuration mode	---------------------	**network (subnet ID)**	Adds network to routing table	router(config-router)#network 198.16.7.3
privileged mode	Troubleshooting	**show run**	shows current configuration file	router#show run
any submode of global configure mode	---------------------	**no**	Erases specified configuration entry	Router(config-if)#no ip address 193.170.10.98 255.255.255.252

Task C: Verification

Now, when we have configured everything it is time to test our configuration.

To do so, run the *ping* command from the command prompt of the Customer Support PC

C:\ping (ip address of sales PC)

You have now completed the lab.

If you have received a timeout message when running the ping command, there is an error somewhere in your configuration. Please refer to the troubleshooting part of the lab.

TROUBLESHOOTING

If the ping fails at the end of the lab, there could be several reasons why. It may be that your subnetting calculations were wrong, which is why we strongly suggest that you double check your calculations on one of the many subnetting calculators that are available on the internet prior to configuring the routers. Also, check that the IP address or mask is not mistyped.

If the above solutions do not solve the issue, follow the guideline below to determine the problem.

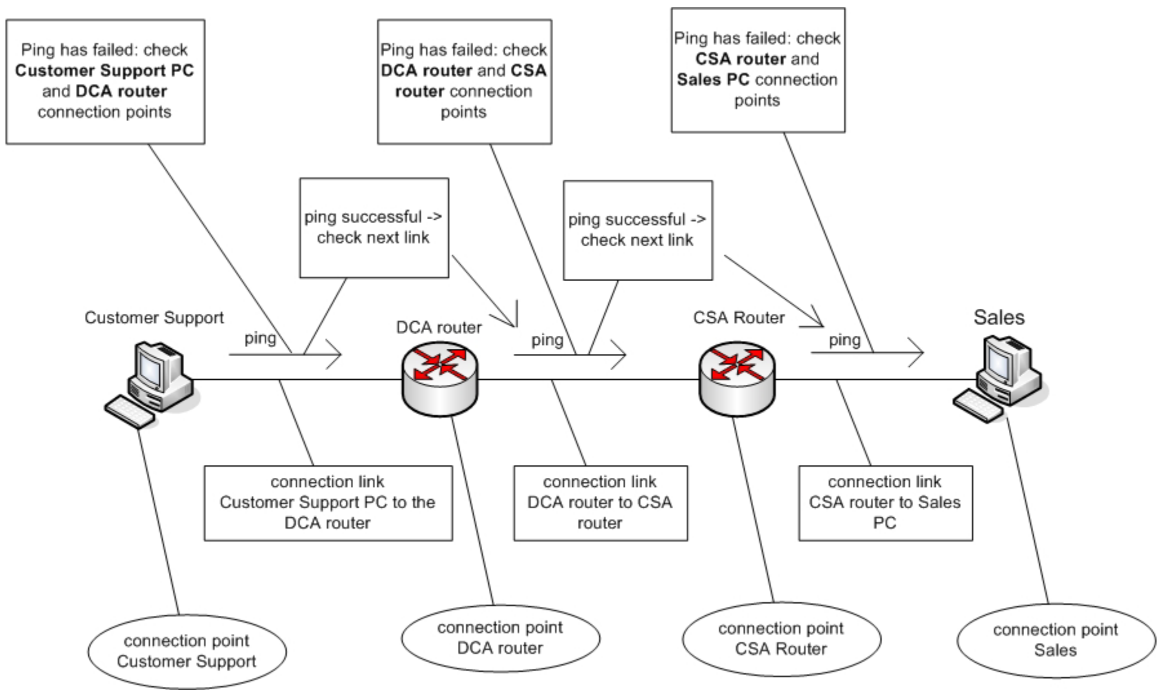
Step 1

Determine how many connection links your network has. Connection links are located between any devices with IP addresses, which in our network could be 3 connection links: two between PCs and their correlating routers and one between the routers themselves.

Step 2

After confirming how many connection links are available, we can find which link has failed by running the ping command for every link.
It is best to start from one of the ends of the network. Start by pinging from the **Customer Support PC** to the gateway port on the correlating router, which is the **DCA router**. If the ping is successful, it means that the connection link is good and we can proceed to next link. The next link is the **DCA router** and the **CSA router** (router to router) and then finally the **CSA router** to the **Sales PC**

Use the diagram drawn below as a guideline for the troubleshooting.



If the ping has still failed, it means that one of the connection points probably has mistakes in the network setup. By now, you should be familiar with how to access the network configuration from your PC, so we will not cover it in this part of the lab.

To see what you have in your network configuration for the router, go to *privileged* mode and type **show run**; that would display your current configuration along with IP addresses/Masks of the interfaces and routing information.

Example:

```
small#show run
Building configuration...

Current configuration : 743 bytes
!
-------------------------output omitted----------------
!
interface FastEthernet0/0
 ip address 193.170.10.65 255.255.255.224
 duplex auto
 speed auto
!
interface FastEthernet0/1
 ip address 193.170.10.98 255.255.255.252
 duplex auto
 speed auto
!
router rip
 version 2
 network 193.170.10.0
!
-----------------------output omitted---------------
!
end
```

If you found a mistake in one of your configurations, correct it by going back to the appropriate configuration mode (either interface or routing).
After entering the mode, you need to remove the incorrect entry by using the "no" command.

For example, if you want to change the IP address of Ethernet port 1, go to interface 1's configuration mode and type:

no ip address 193.170.10.98 255.255.255.252 and press enter. Next, just enter the new IP address with default command and the IP will be changed.

Task D: REPORT

The report consists of three parts. First, you need to show all subnet calculations using the steps showed in example above (including binary representations of addresses). Second, you need to attach to your report screenshots of ipconfig, ping and tracert outputs from both PCs.

Here is example of such screenshot:

```
C:\>ipconfig

Windows 2000 IP Configuration

Ethernet adapter Local Area Connection:

        Connection-specific DNS Suffix  . :
        IP Address. . . . . . . . . . . . : 193.170.10.2
        Subnet Mask . . . . . . . . . . . : 255.255.255.192
        Default Gateway . . . . . . . . . : 193.170.10.1

C:\>ping 193.170.10.66

Pinging 193.170.10.66 with 32 bytes of data:

Reply from 193.170.10.66: bytes=32 time<10ms TTL=126
Reply from 193.170.10.66: bytes=32 time<10ms TTL=126
Reply from 193.170.10.66: bytes=32 time<10ms TTL=126
Reply from 193.170.10.66: bytes=32 time<10ms TTL=126

Ping statistics for 193.170.10.66:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum =  0ms, Average =  0ms

C:\>tracert 193.170.10.66

Tracing route to D6HDN561 [193.170.10.66]
over a maximum of 30 hops:

  1   <10 ms   <10 ms    10 ms  193.170.10.1
  2   <10 ms   <10 ms   <10 ms  193.170.10.98
  3   <10 ms   <10 ms   <10 ms  D6HDN561 [193.170.10.66]

Trace complete.
```

Finally, you need to draw a network diagram where you clearly show IP addresses and subnet masks of all systems.

Please note that you only need one report per group. Also, at the end of the report you need to specify the distribution of work between group members.

REPORT GRADING POLICY

1. Subnetting Calculations – 50 %
2. Screenshots of test commands – 40 %
3. Network Diagram – 10 %