



Todd Lammle's CompTIA Network+
Chapter 8: IP Subnetting,
Troubleshooting
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Chapter 8 Objectives

The Following CompTIA Network+ Exam

Objectives are Covered in this Chapter:

- 1.4 Given a scenario, evaluate the proper use of the following addressing technologies and addressing schemes
- Addressing Technologies
 - Subnetting
 - Classful vs. classless (e.g. CIDR, Supernetting)
 - NAT
 - PAT
 - SNAT
 - Public vs. private

Subnetting Basics

There are loads of reasons in favor of subnetting, including the following benefits:

- Reduced network traffic
- Optimized network performance
- Simplified management
- Facilitated spanning of large geographical distances

How to Create Subnets

To create subnetworks, you take bits from the host portion of the IP address and reserve them to define the subnet address. This means fewer bits for hosts, so the more subnets, the fewer bits left available for defining hosts.

- 1. Determine the number of required network IDs:
 - One for each subnet
 - One for each wide area network connection
- 2. Determine the number of required host IDs per subnet:
 - One for each TCP/IP host
 - One for each router interface
- 3. Based on the previous requirements, create the following:
 - One subnet mask for your entire network
 - A unique subnet ID for each physical segment
 - A range of host IDs for each subnet

Exponents

- $2^1 = 2$
- $2^2 = 4$
- $2^3 = 8$
- $2^4 = 16$
- $2^5 = 32$
- $2^6 = 64$
- $2^7 = 128$
- $2^8 = 256$
- $2^9 = 512$
- $2^{10} = 1,024$
- $2^{11} = 2,048$
- $2^{12} = 4,096$
- $2^{13} = 8,192$
- $2^{14} = 16,384$

Subnet Masks

For the subnet address scheme to work, every machine on the network must know which part of the host address will be used as the subnet address.

This is accomplished by assigning a *subnet mask* to each machine. A subnet mask is a 32-bit value that allows the recipient of IP packets to distinguish the network ID portion of the IP address from the host ID portion of the IP address.

Table 8.1: Default Subnet Mask

CLASS	FORMAT	DEFAULT SUBNET MASK
A	<i>network.host.host.host</i>	255.0.0.0
B	<i>network.network.host.host</i>	255.255.0.0
C	<i>network.network.network.host</i>	255.255.255.0

Classless Inter-Domain Routing

Table 8.2 offers a listing of every available subnet mask and its equivalent CIDR slash notation.

Table 8.2: CIDR Values

SUBNET MASK	CIDR VALUE
255.0.0.0	/8
255.128.0.0	/9
255.192.0.0	/10
255.224.0.0	/11
255.240.0.0	/12
255.248.0.0	/13
255.252.0.0	/14
255.254.0.0	/15
255.255.0.0	/16
255.255.128.0	/17
255.255.192.0	/18
255.255.224.0	/19
255.255.240.0	/20
255.255.248.0	/21
255.255.252.0	/22
255.255.254.0	/23
255.255.255.0	/24
255.255.255.128	/25
255.255.255.192	/26
255.255.255.224	/27
255.255.255.240	/28
255.255.255.248	/29
255.255.255.252	/30

Class C Subnets

- There are many different ways to subnet a network. The right way is the way that works best for you. In a Class C address, only 8 bits are available for defining the hosts.
- Remember that subnet bits start at the left and go to the right, without skipping bits.

BINARY	DECIMAL	CIDR
00000000	0	/24
10000000	128	/25
11000000	192	/26
11100000	224	/27
11110000	240	/28
11111000	248	/29
11111100	252	/30

Subnetting Class C

When you've chosen a possible subnet mask for your network and need to determine the number of subnets, valid hosts, and broadcast addresses of a subnet that the mask provides, all you need to do is answer five simple questions:

- How many subnets does the chosen subnet mask produce?
- How many valid hosts per subnet are available?
- What are the valid subnets?
- What's the broadcast address of each subnet?
- What are the valid hosts in each subnet?

Practice Example #1C: 255.255.255.128 (/25)

- Because 128 is 10000000 in binary, there is only 1 bit for subnetting, and there are 7 bits for hosts. We're going to subnet the Class C network address 192.168.10.0.
- 192.168.10.0 = Network address
- 255.255.255.128 = Subnet mask
- Now, let's answer the big five:
- *How many subnets?* Because 128 is 1 bit on (10000000), the answer is $2^1 = 2$.
- *How many hosts per subnet?* We have 7 host bits off (10000000), so the equation is $2^7 - 2 = 126$ hosts.
- (continued....)

/25 continued

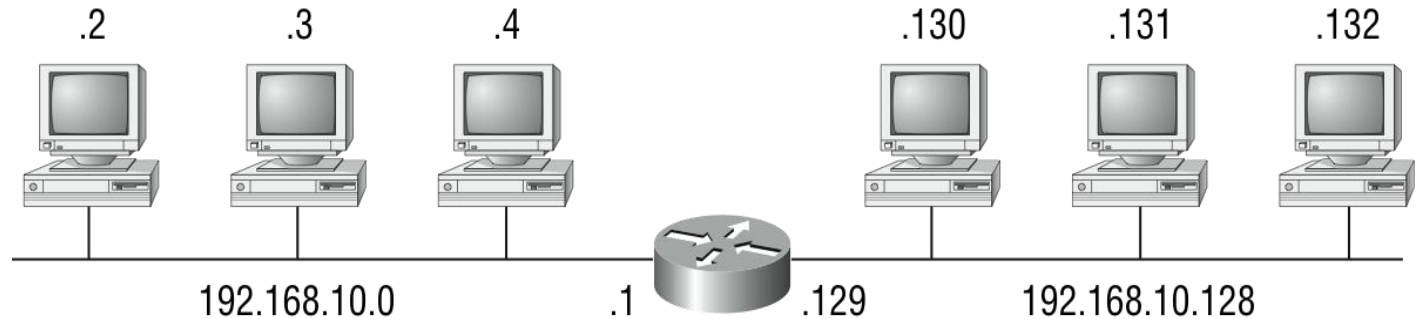
- *What are the valid subnets?* $256 - 128 = 128$. Remember, we'll start at zero and count in our block size, so our subnets are 0, 128.
- *What's the broadcast address for each subnet?* The number right before the value of the next subnet is all host bits turned on and equals the broadcast address. For the 0 subnet, the next subnet is 128, so the broadcast of the 0 subnet is 127.
- *What are the valid hosts?* These are the numbers between the subnet and broadcast address. The easiest way to find the hosts is to write out the subnet address and the broadcast address. This way, the valid hosts are obvious.

/25 continued

Subnet	0	128
First host	1	129
Last host	126	254
Broadcast	127	255

- Before moving on to the next example, take a look at the figure in the next slide.
- Okay, looking at a Class C /25, it's pretty clear there are two subnets.
- But so what—why is this significant? Well actually, it's not, but that's not the right question. What you really want to know is what you would do with this information!

Subnet Example /25



```
Router#show ip route
```

```
[output cut]
```

```
C 192.168.10.0 is directly connected to Ethernet 0.
```

```
C 192.168.10.128 is directly connected to Ethernet 1.
```

There are two physical networks, so we're going to implement a logical addressing scheme that allows for two logical networks. As always, it's a really good idea to look ahead and consider likely growth scenarios—both short and long term, but for this example, a /25 will do the trick.

Practice Example #2C: 255.255.255.192 (/26)

- In this second example, we're going to subnet the network address 192.168.10.0 using the subnet mask 255.255.255.192.
 - 192.168.10.0 = Network address
 - 255.255.255.192 = Subnet mask
- It's time to answer the big five:
- *How many subnets?* Because 192 is 2 bits on (11000000), the answer is $2^2 = 4$ subnets.
- *How many hosts per subnet?* We have 6 host bits off (11000000), so the equation is $2^6 - 2 = 62$ hosts.
- *What are the valid subnets?* $256 - 192 = 64$. Remember, we start at zero and count in our block size, so our subnets are 0, 64, 128, and 192.

Practice Example #2C: 255.255.255.192 (/26)

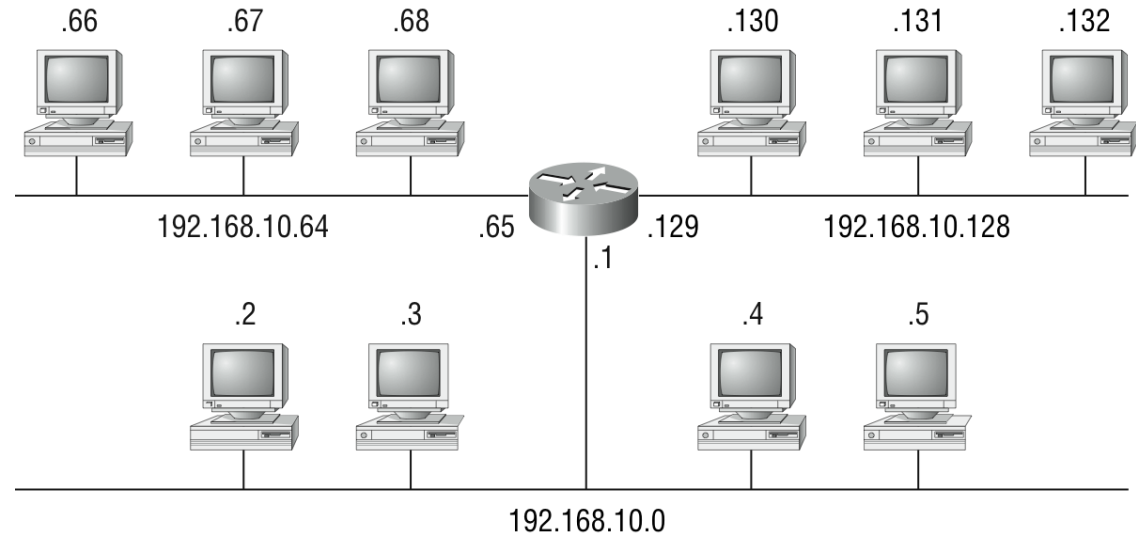
- *What's the broadcast address for each subnet?*
The number right before the value of the next subnet is all host bits turned on and equals the broadcast address. For the 0 subnet, the next subnet is 64, so the broadcast address for the 0 subnet is 63.
- *What are the valid hosts?* These are the numbers between the subnet and broadcast address. The easiest way to find the hosts is to write out the subnet address and the broadcast address.
- This way, the valid hosts are obvious. The following table shows the 0, 64, 128, and 192 subnets, the valid host ranges of each, and the broadcast address of each subnet:

Practice Example #2C: 255.255.255.192 (/26)

The subnets (do this first)	0	64	128	192
Our first host (perform host addressing last)	1	65	129	193
Our last host	62	126	190	254
The broadcast address (do this second)	63	127	191	255

Okay, again, before getting into the next example, you can see that we can now subnet a /26. And what are you going to do with this fascinating information? Implement it! We'll use the figure on the next slide to practice a /26 network implementation.

Implementing a Class C /26



```
Router#show ip route
[output cut]
C 192.168.10.0 is directly connected to Ethernet 0
C 192.168.10.64 is directly connected to Ethernet 1
C 192.168.10.128 is directly connected to Ethernet 2
```

The /26 mask provides four subnetworks, and we need a subnet for each router interface. With this mask, in this example, we actually have room to add another router interface.

Practice Example #3C: /27

This time, we'll subnet the network address
192.168.10.0 and subnet mask 255.255.255.224.

- 192.168.10.0 = Network address
- 255.255.255.224 = Subnet mask
- *How many subnets?* 224 is 11100000, so our equation is $2^3 = 8$.
- *How many hosts?* $2^5 - 2 = 30$.
- *What are the valid subnets?* $256 - 224 = 32$. We just start at zero and count to the subnet mask value in blocks (increments) of 32: 0, 32, 64, 96, 128, 160, 192, and 224.
- *What's the broadcast address for each subnet (always the number right before the next subnet)?*
- *What are the valid hosts (the numbers between the subnet number and the broadcast address)?*

/27 Continued

- To answer the last two questions, first just write out the subnets, and then write out the broadcast addresses—the number right before the next subnet.
- Last, fill in the host addresses.
- The following table gives you all the subnets for the 255.255.255.224 Class C subnet mask:

The subnet address	0	32	64	96	128	160	192	224
The first valid host	1	33	65	97	129	161	193	225
The last valid host	30	62	94	126	158	190	222	254
The broadcast address	31	63	95	127	159	191	223	255

Practice Example #4C: 255.255.255.240 (/28)

Let's practice on another one:

- 192.168.10.0 = Network address
- 255.255.255.240 = Subnet mask
- *Subnets?* 240 is 11110000 in binary. $2^4 = 16$.
- *Hosts?* 4 host bits, or $2^4 - 2 = 14$.
- *Valid subnets?* $256 - 240 = 16$. Start at 0: $0 + 16 = 16$. $16 + 16 = 32$. $32 + 16 = 48$. $48 + 16 = 64$. $64 + 16 = 80$. $80 + 16 = 96$. $96 + 16 = 112$. $112 + 16 = 128$. $128 + 16 = 144$. $144 + 16 = 160$. $160 + 16 = 176$. $176 + 16 = 192$. $192 + 16 = 208$. $208 + 16 = 224$. $224 + 16 = 240$.
- *Broadcast address for each subnet?*
- *Valid hosts?*

Practice Example #5C: 255.255.255.248 (/29)

Let's keep practicing:

- 192.168.10.0 = Network address
- 255.255.255.248 = Subnet mask
- *Subnets?* 248 in binary = 11111000. $2^5 = 32$.
- *Hosts?* $2^3 - 2 = 6$.
- *Valid subnets?* $256 - 248 = 0, 8, 16, 24, 32, 40, 48, 56, 64, 72, 80, 88, 96, 104, 112, 120, 128, 136, 144, 152, 160, 168, 176, 184, 192, 200, 208, 216, 224, 232, 240, \text{ and } 248$.
- *Broadcast address for each subnet?*
- *Valid hosts?*

Practice Example #6C: 255.255.255.252 (/30)

Just one more:

- 192.168.10.0 = Network address
- 255.255.255.252 = Subnet mask
- *Subnets? 64.*
- *Hosts? 2.*
- *Valid subnets? 0, 4, 8, 12, and so on, all the way to 252.*
- *Broadcast address for each subnet (always the number right before the next subnet)?*
- *Valid hosts (the numbers between the subnet number and the broadcast address)?*

Troubleshooting IP Addresses

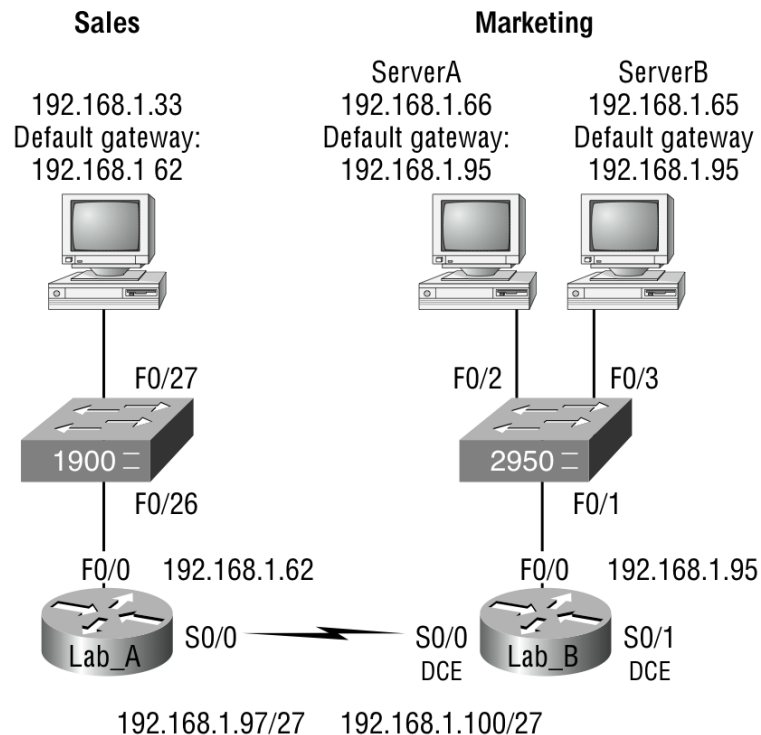
- Troubleshooting IP addressing is obviously an important skill because running into trouble somewhere along the way is pretty much a sure thing, and it's going to happen to you. Here are the steps:
 - Open a DOS window, and ping 127.0.0.1.
 - From the DOS window, ping the IP address of the local host.
 - From the DOS window, ping the default gateway (router).
 - If steps 1 through 3 were successful, try to ping the remote server.
 - If the user still can't communicate with the server after steps 1 through 4 are successful, you probably have some type of name resolution problem and need to check your Domain Name System (DNS) settings.

Command Line Tools

- **Packet InterNet Groper (ping)**
 - Uses an Internet Control Message Protocol (ICMP) echo request and replies to test if a host IP stack is initialized and alive on the network.
- **tracert**
 - Displays the list of routers on a path to a network destination by using TTL time-outs and ICMP error messages. This command will not work from a DOS prompt.
- **tracert**
 - Same command as traceroute, but it's a Microsoft Windows command and will not work on other devices, like a Cisco router or Unix box.
- **arp -a**
 - Displays IP-to-MAC-address mappings on a Windows PC.
- **ipconfig /all**
 - Used only from a DOS prompt. Shows you the PC network configuration.

Troubleshooting Example

A user in the sales department calls and tells you that she can't get to Server A in the marketing department. You ask her if she can get to Server B in the marketing department, but she doesn't know because she doesn't have rights to log on to that server. What do you do?



Summary

- Summary
- Exam Essentials Section
- Written Labs
- Review Questions