CompTIA Network+® Lab Series
Network Concepts

Lab 4: IPv4 vs IPv6 – Calculating, Configuring and Testing

Objective 1.5: Identify common TCP and UDP default ports
Objective 1.6: Explain the function of common networking protocols
Objective 1.7: Summarize DNS concepts and its components
Objective 4.3: Given a scenario, use appropriate software tools to troubleshoot connectivity issues

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Contents

Introduction

This lab is part of a series of lab exercises designed to supplement coursework and provide students with a hands-on training experience based on real world applications. This series of lab exercises is intended to support courseware for CompTIA Network+® certification.

This lab will compare IPv4 and IPv6 addressing concepts such as subnetting, configuring and testing. Students will assign addresses, test connectivity and examine the results.

This lab includes the following tasks:

1. Review of Decimal, Binary and Hexadecimal Conversions
2. Subnetting IPv4 Addresses
3. Apply and Test IPv4 Subnet Addresses
4. Subnetting IPv6 Addresses
5. Apply and Test IPv6 Subnet Addresses

Objective: Subnet, Configure and Apply IPv4 and IPv6 Addresses

Subnetting a network is an essential skill that all network administrators must know. To be successful with this skill, one must understand the concepts of binary, decimal and hexadecimal numbers. One must also exercise patience and careful planning to successfully execute a networking plan.

For this lab, the following terms and concepts will be of use:

Subnetting – the process of logically dividing a large network into smaller sub-networks by modifying the subnet mask (IPv4) or prefix length (IPv6)

Binary number system – a method of representing numbers using only the digits 0 and 1; also known as the base 2 number system

Hexadecimal number system – a method of representing numbers using the digits 0 through 9 and characters A through F; also known as the base 16 number system

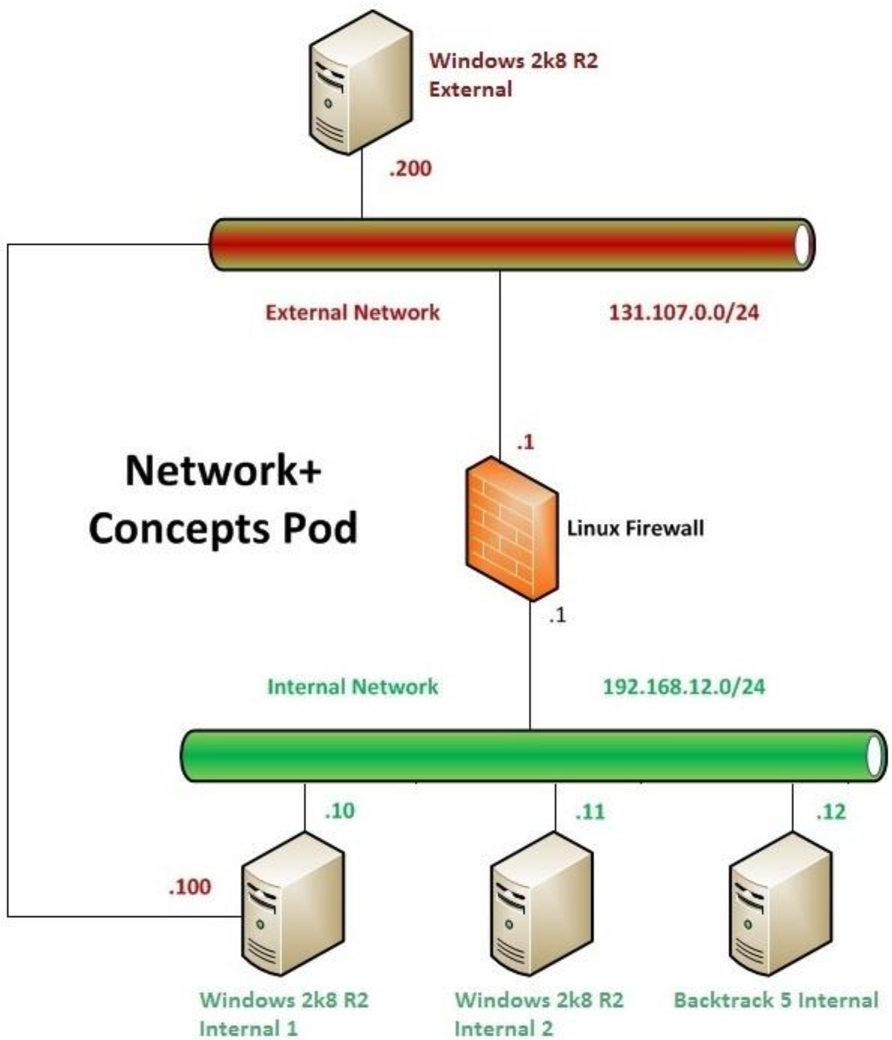
Internet Protocol version 4 (IPv4) – a 32-bit number system represented in 4 groups of 8 bits each used to address nodes on an IP network

Subnet mask – a 32-bit number that is logically "AND"ed with an IPv4 address used to determine the network an address belongs to

Internet Protocol version 6 (IPv6) – a 128-bit number system represented in 8 groups of 16 bits each used to address nodes on an IP network

Subnet prefix length – the number of bits in an IPv6 address used to determine the network an address belongs to

Lab Topology



Lab Settings

The information in the table below will be needed in order to complete the lab. The task sections below provide details on the use of this information.

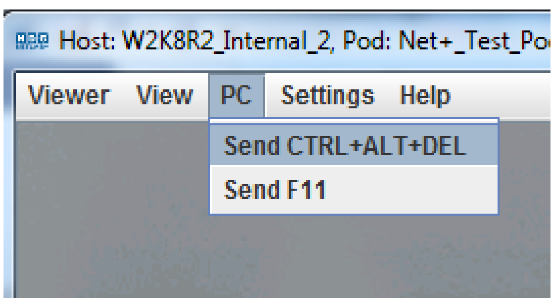
Required Virtual Machines and Applications

Log in to the following virtual machines before starting the third task section of this lab.

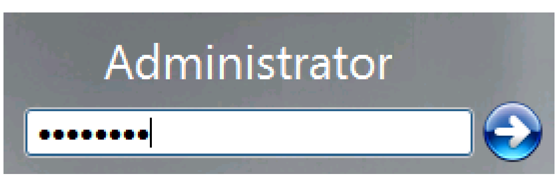
Windows 2k8 R2 Internal 1	192.168.12.10
Windows 2k8 R2 Internal 1 password	P@ssw0rd
Windows 2k8 R2 Internal 2	192.168.12.11
Windows 2k8 R2 Internal 2 password	P@ssw0rd

Windows 2k8 R2 Login (applies to all Windows machines)

1. Click on the Windows 2k8 R2 icon on the topology that corresponds to the machine you wish to log in to.
2. Use the PC menu in the NETLAB+ Remote PC Viewer to send a **Ctrl-Alt-Del** (version 2 viewer), or click the **Send Ctrl-Alt-Del** link in the bottom right corner of the viewer window (version 1 viewer).



3. In the password text box, type **P@ssw0rd** and press enter to log in.



4. If the Initial Configuration Tasks and/or Server Manager windows appear, close them by clicking on the "**X**" in the top-right corner of the window.

1 Decimal, Binary and Hexadecimal Conversions

To be successful in subnetting, one must understand the binary number system and be comfortable doing binary, decimal and hexadecimal (for IPv6) conversions.

1.1 Review of Decimal-to-Binary Conversions

The binary number system is also called the “Base 2” numbering system. This is because only two numbers are used in the system, 0 and 1. To compare, the decimal number system is called the “Base 10” system. Ten numbers are used in the system, 0 through 9.

Just like in the decimal number system, the binary number line is created by raising the base of the number system to consecutive powers.

Example:

10^0=1’s position, 10^1=10’s position, 10^2=100’s position, etc.
2^0=1’s position, 2^1=2’s position, 2^2=4’s position, etc.

Remember where the decimal goes! This means that the number line is created from right to left (the smallest number to the largest).

To get the binary number line, start by raising the number “2” to the “0” power. (i.e. 2^0). According to the rules of math, any number raised to the “0” power equals “1”. This provides the first place holder in the binary number line. Then, moving to the left, continue to raise the number “2” to consecutive powers. Therefore, the next number in order would be 2^1. According to the rules of math, any number raised to the power of “1” equals itself. Therefore, the second place holder in the binary number line equals 2. The third position in the number line is equal to 2^2, or according to the rules of math it is, 2x2 which equals 4. The fourth position in the binary number line is equal to 2^3, or 2x2x2 which equals 8. As one will continue to notice, as each position of the binary number line is calculated, the number will continue to double.

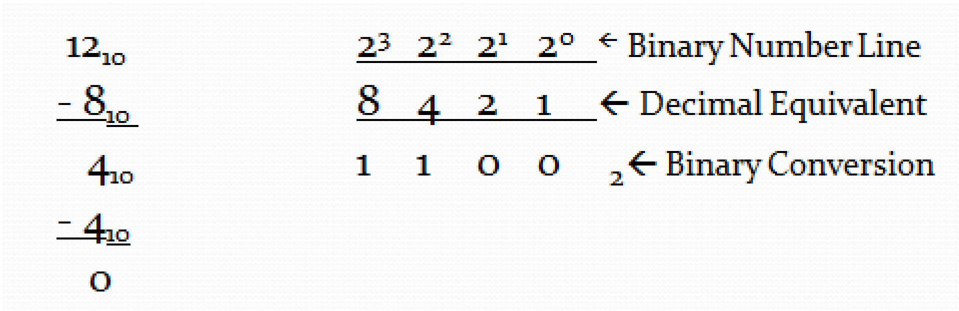
1. *What would the fifth position of the binary number line equal? _________ The sixth?_______ The seventh?_______ The eighth?________*

At this point the binary number line has been created for eight places in the line.

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	← Binary Number Line
128	64	32	16	8	4	2	1	← Decimal Equivalent

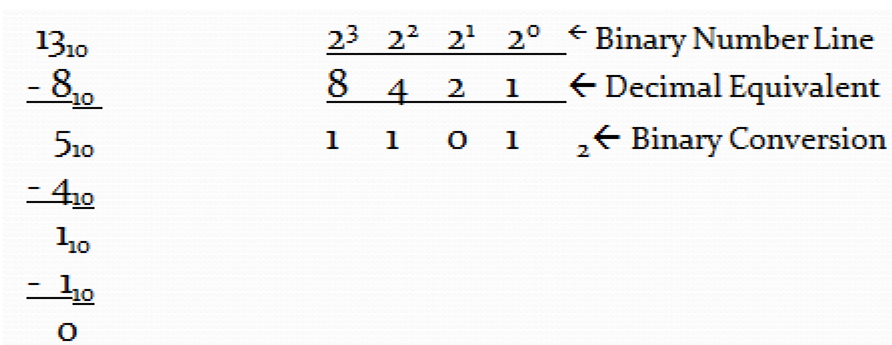
To convert numbers from binary to decimal, subtract the largest number in the binary number line from the decimal number and put a “1” in that position. If a number cannot be subtracted from the decimal number with a positive remainder (i.e. the number in the line is greater than the decimal number that is remaining), put a "0" in that position. Continue this process until zero is the final number.

Let's do an example. Convert the decimal number 12 to binary.



In this example, 2^3 or 8 can be subtracted from 12 with 4 remaining. Therefore, put a "1" in the 2^3 position of the binary number line and subtract 8 from 12. This leaves 2^2 or 4. 4 can be subtracted from 4 evenly. Therefore, put a "1" in this position of the binary number line and subtract 4. This leaves 0. Even though no other numbers will go into 0 and result in a positive number remaining, one cannot skip the other binary line positions. Since 2 and 1 will not go into 0 evenly, put a 0 in these bit positions and add the binary positional values of the places with a 1 in them. 2^3 (or 8) plus 2^2 (or 4) equals 12 in decimal. This finishes the conversion, 12_{10} equals 1100_2.

Let's do another example. In this example, convert the decimal number 13 to binary.



In this example, 8 will go into 13. Therefore, put a "1" in that position of the binary number line and subtract 8 from 13. This leaves 5. 4 will go into 5. Therefore, put a "1" in this position of the binary number line and subtract 4. This leaves 1. Since 2 will not go into 1, put a 0 in this bit position and do not subtract anything, simply move to the next number in the number line. Finally, 1 will go into 1. Therefore, put a 1 in this bit position and subtract 1. This leaves 0 and finishes the conversion, 13_{10} equals 1101_2.

Now, let's try a larger number – 191_{10}.

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	← Binary Number Line
128	64	32	16	8	4	2	1	← Decimal Equivalent
1	0	1	1	1	1	1	1	$_2$← Binary Conversion

191-128=63-32=31-16=15-8=7-4=3-2=1-1=0

Although the number is bigger, the steps stay the same. 128 in the number line will go into 191. Therefore, put a 1 in this bit position and subtract 128 from 191. This leaves 63. Since 64 will not go into 63, put a 0 in this bit position and move to the next number in the number line. 32 will go into 63, so again put a 1 in this bit position and subtract 32 from 63. This leaves 31. 16 will go into 31, so put a 1 in this bit position and subtract 16. This leaves 15. 8 will go into 15, so put a 1 in this bit position and subtract 8. This leaves 7. 4 will go into 7, so put a 1 in this bit position and subtract 4. This leaves 3. 2 will go into 3, so put a 1 in this bit position and subtract 2. This leaves 1. 1 will go into 1, so put a 1 in this bit position and subtract 1. This leaves 0. Since this is at the end of the number line, the conversion is complete, 191_{10} equals 10111111_2.

1.2 Review of Binary-to-Decimal Conversions

To convert from binary to decimal, simply put the binary number back into the binary number line and add the decimal equivalents where a "1" is present. Let's convert the number 10101010_2 back to decimal.

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	← Binary Number Line
128	64	32	16	8	4	2	1	← Decimal Equivalent
1	0	1	0	1	0	1	0	$_2$← Binary Number

$128+32+8+2=170_{10}$ ← Decimal Conversion

Once the binary number is back into the number line, simply add the decimal numbers where there is a "1" and complete the conversion, 128+32+8+2 equals 170_{10}.

Let's try another example. Convert the number 11110000_2 to decimal.

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	← Binary Number Line
128	64	32	16	8	4	2	1	← Decimal Equivalent
1	1	1	1	0	0	0	0	$_2$← Binary Number

$128+64+32+16=240_{10}$ ← Decimal Conversion

In this example, add 128+64+32+16. This equals 240_{10}.

Some of the most common conversions used with subnetting are shown in the figure below.

$11111111_2=255_{10}$	$00000001_2=1_{10}$
$11111110_2=254_{10}$	$00000011_2=3_{10}$
$11111100_2=252_{10}$	$00000111_2=7_{10}$
$11111000_2=248_{10}$	$00001111_2=15_{10}$
$11110000_2=240_{10}$	$00011111_2=31_{10}$
$11100000_2=224_{10}$	$00111111_2=63_{10}$
$11000000_2=192_{10}$	$01111111_2=127_{10}$
$10000000_2=128_{10}$	$11111111_2=255_{10}$

1.3 Review of Hexadecimal Conversions

To convert any number to hexadecimal, the easiest way is to convert the number into binary first. Then, starting at the decimal point, group the binary digits into groups of 4. Each group of 4 digits is called a “nibble”. Re-number each nibble as if they were their own binary number. Then, simply add each nibble individually to get each hexadecimal digit. Let’s do an example to explain using the same binary number just converted.

8	4	2	1 /	8	4	2	1	← Decimal Equivalent
1	1	1	1 /	0	0	0	0	$_2$← Binary Number

8+4+2+1=F ← First Hexadecimal Digit

0+0+0+0=0 ← Second Hexadecimal Digit

Notice each nibble. To get the first hexadecimal digit, add the numbers 8+4+2+1. In decimal, this equals 15. However, since only one integer can be used to represent each digit, the hexadecimal number system must also use letters to represent digits. Below is a chart displaying the 6 letters used by the hexadecimal number system and their equivalents.

$1010_2=10_{10}=A_{16}$	$1101_2=13_{10}=D_{16}$
$1011_2=11_{10}=B_{16}$	$1110_2=14_{10}=E_{16}$
$1100_2=12_{10}=C_{16}$	$1111_2=15_{10}=F_{16}$

Anytime a nibble adds up to be more than 10, simply substitute the appropriate letter to get the hexadecimal equivalent. Any nibble that adds up to be less than 10, simply keep the number the same. Therefore, in this example, 11110000_2 equals $F0_{16}$.

Let's do another example. Let's convert the number 10100110_2 to hexadecimal.

8	4	2	1/	8	4	2	1	← Decimal Equivalent
1	0	1	0/	0	1	1	0	$_2$← Binary Number

$8+2=A_{16}$ ← First Hexadecimal Digit

$4+2=6_{16}$ ← First Hexadecimal Digit

To get the first hexadecimal digit, add 8+2. Since this equals 10, consult the chart. 10 in hexadecimal is represented by the letter "A". To get the second hexadecimal digit, add 4+2 which equals 6. Since this number is less than 10, it stays the same. Therefore, the number 10100110_2 equals $A6_{16}$.

1.4 Conclusion

To be successful at subnetting, one must be comfortable with binary, decimal and hexadecimal conversions. The more practice one has with these conversions, the better and more comfortable they will become.

1.5 Review Questions

1. *Convert the decimal number 145 to binary.*

2. *Convert the binary number 11001100 to decimal.*

3. *Convert the binary number 01101011 to hexadecimal.*

4. *Convert the hexadecimal number C7 to binary and decimal.*

2 Subnetting IPv4 Addresses

The purpose of subnetting a network address is to provide a way to logically divide large networks into smaller, more manageable pieces to make the most efficient use of address space. This can be done with any public or private network address.

2.1 Determine the Number of Needed Subnets

To subnet an IPv4 address, the first thing to determine is the number of needed subnets. This information will typically be presented in one of two ways – by the number of networks needed or the number of hosts needed per network. Once it has been determined which method is being presented, one can determine the next step.

Example – I need 25 networks –or– I need 25 hosts per network –or– both.

This example subnets for 25 needed networks.

2.2 Write Out Host Bits

Write out the “host” portion of the subnet mask in binary. The “1”s in the subnet mask represent the network portion while the “0”s represent the host portion. This is because when the IP address is logically “AND”ed with the subnet mask, the “1”s are what determine the Network ID. Start with the default subnet mask for the class of address used. In this example, a class B address of 172.16.0.0 is used, so the default subnet mask is 255.255.0.0.

255.255.0.0 → 255.255.00000000.00000000

|Net Portion| |------------Host Portion---------------|

2.3 Determine the Number of Bits to Borrow to Get the Number of Subnets Needed

To determine how many bits to borrow from the “host” portion of the subnet mask, use the formula:

2^n = the number of available subnets

The power of “n” is determined by the binary number line.

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	← Binary Number Line
128	64	32	16	8	4	2	1	← Decimal Equivalent

For this example, the formula becomes $2^n = 25$. Since 25 is not a number directly on the line, find the next highest number. In this example, that number is 32. This number becomes the number of subnets that can be created. Looking at the binary number line, 2 was raised to the power of 5 to get this many subnets. Therefore, 5 becomes the "n" in the formula. This is also the number needed for the next step.

Notice that 2^4 cannot be used as that would only create 16 subnets instead of the required 25. 2^6 would technically work, but this would be wasteful as it would create 64 total subnets.

2.4 Set to 1's (Turn On) the Number of Bits Borrowed

Once "n" has been determined, set to "1" (or turn on) this many bits in the host portion of the subnet mask starting at the leftmost "0".

255.255.00000000.00000000 becomes

255.255.<u>11111000</u>.00000000

2.5 Determine the Subnet Variable

Using the binary number line, determine the decimal value of the last "1" turned on in the newly created subnet mask. This value becomes the subnet variable. In this example, the subnet variable is 8.

```
255.255.11111000.00000000
            ^----
```

For this problem, "8" is the subnet variable.

2.6 Determine the New Subnet Mask

Convert the new subnet mask into decimal. Refer to Section 1.2, Review of Binary to Decimal Conversion, for guidance. This becomes the new subnet mask associated with the newly created subnets.

255.255.11111000.00000000 becomes 255.255.248.0

^---- This octet converts to 248_{10}

2.7 Determine the Subnet Ranges

Starting with the original major network number, add the subnet variable from Section 2.5, Determine the Subnet Variable, to the IP address of the original major network. Be sure you are working in the correct octet when you are adding the number it must be within the same octet as the subnet variable. In this example, the variable is in the third octet. The numbers that are created are the new subnet addresses.

172.16.0.0
172.16.8.0
172.16.16.0
172.16.24.0
172.16.32.0

Keep adding the variable until all of the subnets have been created. In this example, 32 subnet addresses would be created.

To determine the number of hosts in each subnet, count the number of "0"s left in the **new subnet mask**. This number becomes the "n" in the formula $2^n - 2$. The reason for the "— 2" is that the very first and very last address in the subnet range cannot be assigned to hosts. The very first number is the subnet address; the last number is the broadcast address for that subnet. In this example, eleven "0"s were left in the subnet mask. Therefore, the formula would be $2^{11} - 2$, or 2,046 hosts per subnet.

Subnet #	Subnet Address	First Usable IP address	Last usable IP address	Broadcast Address
0	172.16.0.0	172.16.0.1	172.16.7.254	172.16.7.255
1	172.16.8.0	172.16.8.1	172.16.15.254	172.16.15.255
2	172.16.16.0	172.16.16.1	172.16.23.254	172.16.23.255
3	172.16.24.0	172.16.24.1	172.16.31.254	172.16.31.255
4	172.16.32.0	172.16.32.1	172.16.39.254	172.16.39.255
5	172.16.40.0	172.16.40.1	172.16.47.254	172.16.47.255
6	172.16.48.0	172.16.48.1	172.16.55.254	172.16.55.255
7	172.16.56.0	172.16.56.1	172.16.63.254	172.16.63.255
8	172.16.64.0	172.16.64.1	172.16.71.254	172.16.71.255
9	172.16.72.0	172.16.72.1	172.16.79.254	172.16.79.255
10	172.16.80.0	172.16.80.1	172.16.87.254	172.16.87.255
11	172.16.88.0	172.16.88.1	172.16.95.254	172.16.95.255
12	172.16.96.0	172.16.96.1	172.16.103.254	172.16.103.255
13	172.16.104.0	172.16.104.1	172.16.111.254	172.16.111.255
14	172.16.112.0	172.16.112.1	172.16.119.254	172.16.119.255
15	172.16.120.0	172.16.120.1	172.16.127.254	172.16.127.255
16	172.16.128.0	172.16.128.1	172.16.135.254	172.16.135.255
17	172.16.136.0	172.16.136.1	172.16.143.254	172.16.143.255
18	172.16.144.0	172.16.144.1	172.16.151.254	172.16.151.255
19	172.16.152.0	172.16.152.1	172.16.159.254	172.16.159.255
20	172.16.160.0	172.16.160.1	172.16.167.254	172.16.167.255
21	172.16.168.0	172.16.168.1	172.16.175.254	172.16.175.255
22	172.16.176.0	172.16.176.1	172.16.183.254	172.16.183.255
23	172.16.184.0	172.16.184.1	172.16.191.254	172.16.191.255
24	172.16.192.0	172.16.192.1	172.16.199.254	172.16.199.255
25	172.16.200.0	172.16.200.1	172.16.207.254	172.16.207.255
26	172.16.208.0	172.16.208.1	172.16.215.254	172.16.215.255
27	172.16.216.0	172.16.216.1	172.16.223.254	172.16.223.255
28	172.16.224.0	172.16.224.1	172.16.231.254	172.16.231.255
29	172.16.232.0	172.16.232.1	172.16.239.254	172.16.239.255
30	172.16.240.0	172.16.240.1	172.16.247.254	172.16.247.255
31	172.16.248.0	172.16.248.1	172.16.255.254	172.16.255.255

2.8 Conclusion

Subnetting is a skill that takes practice and patience. It is an essential skill for anyone in the networking field.

2.9 Review Questions

1. *Subnet the following IP address for 50 networks. Complete the table with the information for the first four newly created subnets.*

172.16.0.0			
New Subnet Mask		255.255.252.0	
Hosts per Subnet		1022	
Subnet Address	**First Available IP**	**Last Available IP**	**Broadcast**

2. *Subnet the following IP address for 2000 networks. Complete the table with the information for the first four newly created subnets.*

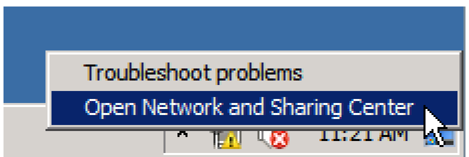
10.0.0.0			
New Subnet Mask		255.255.224.0	
Hosts per Subnet		8190	
Subnet Address	**First Available IP**	**Last Available IP**	**Broadcast**

3 IPv4 Subnet Addresses

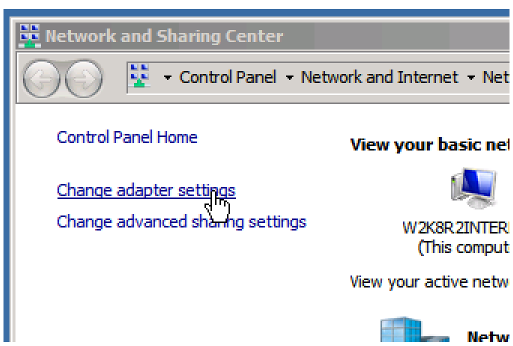
Once subnets have been created, they must be applied correctly to be meaningful. This example will show correctly and incorrectly configured machines and the results of both configurations.

3.1 Apply and Test IPv4 Subnet Addresses

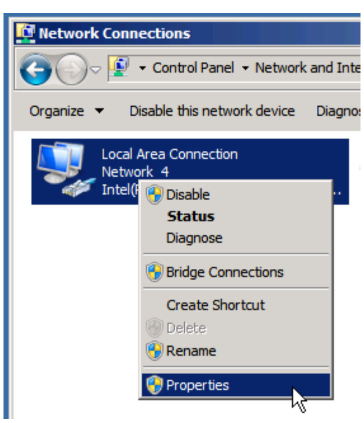
1. Use the instructions in the Lab Settings section to log into the Windows 2k8 R2 Internal 1 and Windows 2k8 R2 Internal 2 machines, if you are not logged in already.
2. On the Windows 2k8 Internal 1 machine, right-click on the network icon in the taskbar and select **Open Network and Sharing Center**.



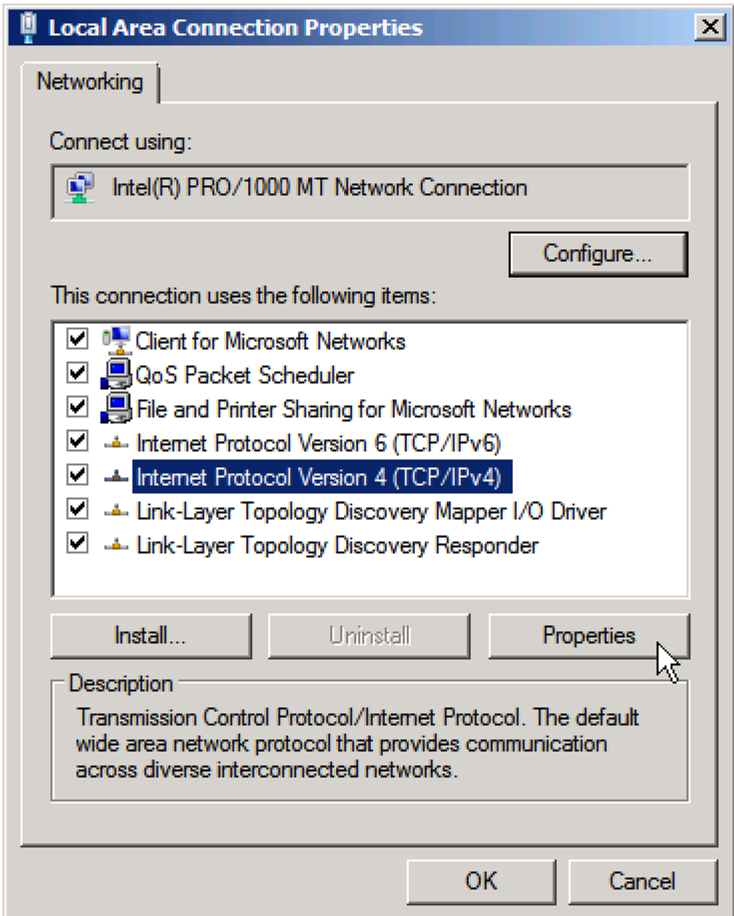
3. In the left column, click the link **Change Adapter Settings**.



4. Right-click on the **Local Area Connection** icon and select **Properties** from the context menu.



5. Select the **Internet Protocol Version 4 (TCP/IPv4)** option and click **Properties**.



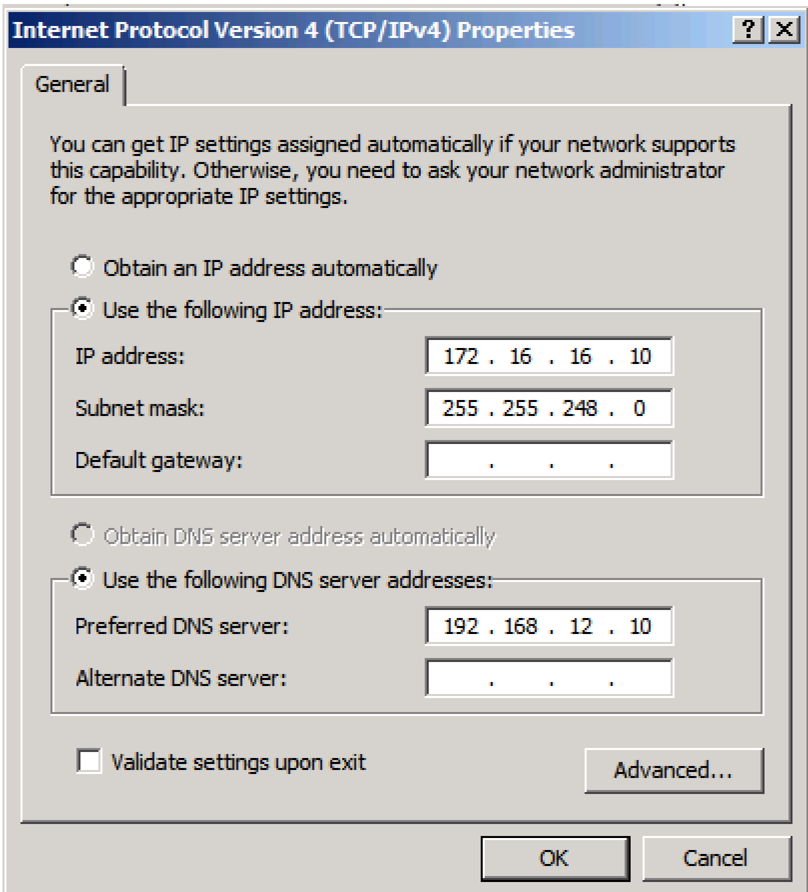
6. Complete the table below to record all the current IPv4 Properties information for this network card so you can return it to the original setting at the completion of this exercise.

IPV4 Property	Value
IP Address	
Subnet Mask	
Default Gateway	
Preferred DNS server	

7. For this example, the address range for **Subnet 2** from Section 4.7 Determining the Subnet Range will be used.

2	172.16.16.0	172.16.16.1	172.16.23.254	172.16.23.255

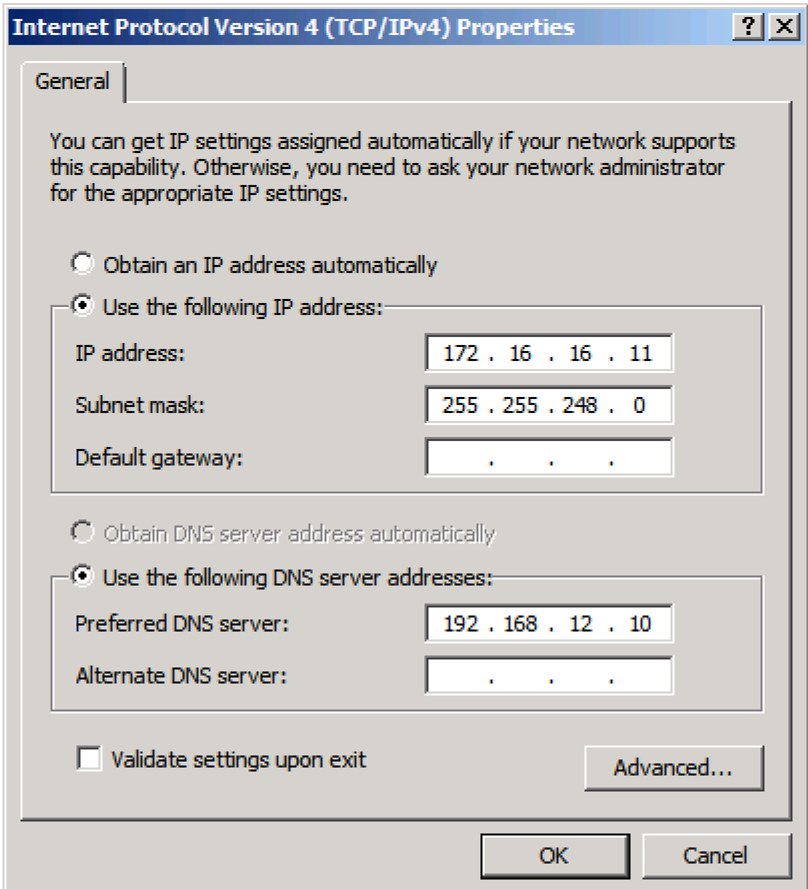
8. Change the IP Address and Subnet Mask of the Windows 2K8 R2 Internal 1 machine to IP address 172.16.16.10 with a subnet mask of 255.255.248. Note that a default gateway is not necessary as all traffic will remain on the local LAN so delete it. You can leave the DNS server address configured.



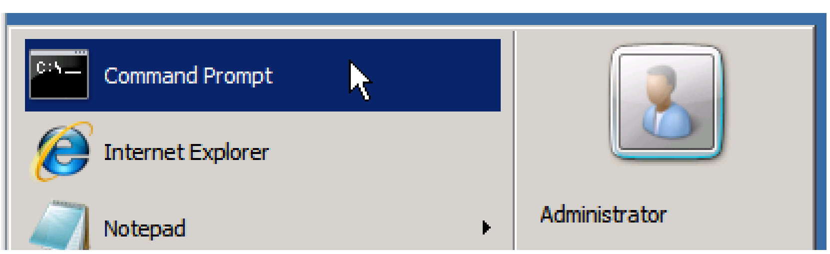
9. Click **OK** then **Close** to save the changes.
10. Complete the table below to record all the current IPv4 Properties information for the Windows 2K8 R2 Internal 2 machine network card so you can return it to the original setting at the completion of this exercise.

IPV4 Property	Value
IP Address	
Subnet Mask	
Default Gateway	
Preferred DNS server	

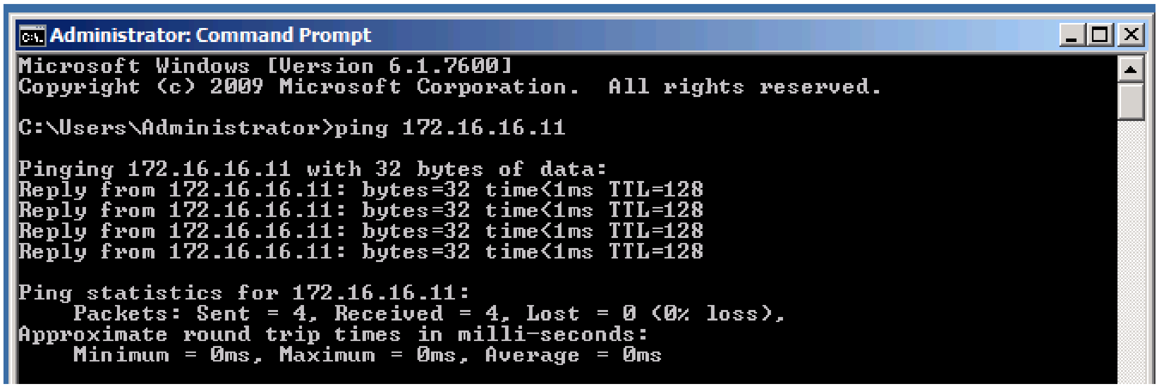
11. Use steps 3-9 to change the IPv4 address on the Windows 2K8 R2 Internal 2 machine using the IP address 172.168.16.11 with a subnet mask of 255.255.248.0. The Preferred DNS server can remain the same. Once completed, click **OK** twice to save the changes.



12. On the Windows 2K8 R2 Internal 1 machine, open a command prompt window by clicking **Start** and selecting **Command Prompt**.

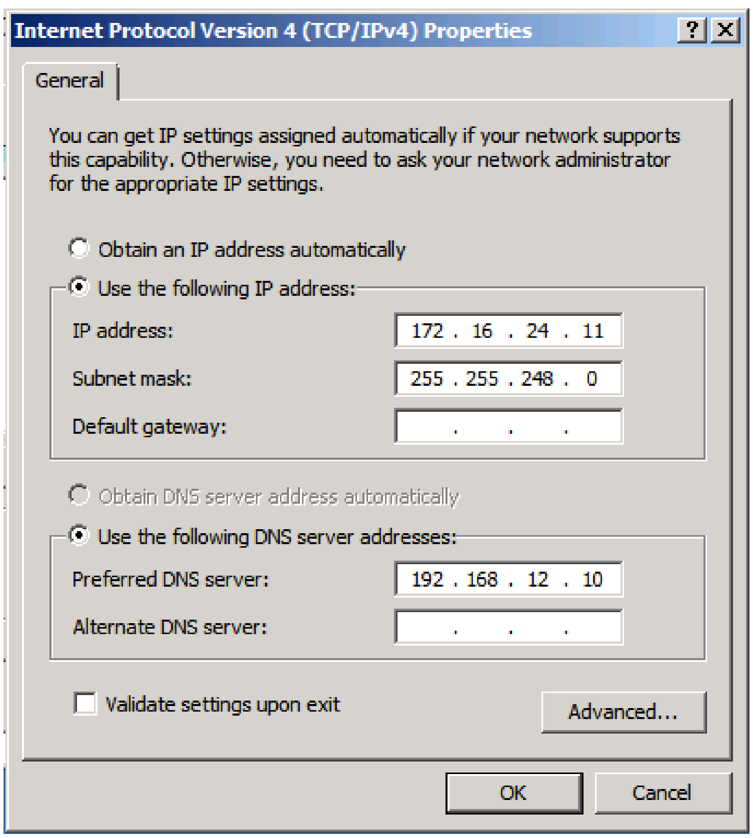


13. In the command prompt window, type the command **ping 172.16.16.11** and press **Enter.**



Notice that the ping is successful even though no default gateway was set. This is because all traffic is on the local LAN. Therefore, no gateway is needed. If you were attempting to ping a machine on a different subnet, a default gateway would be required.

14. Using the same process as above, change the IP address of the Windows 2K8 R2 Internal 2 machine to 172.16.24.11 leaving the subnet mask unchanged. Notice this address is **<u>NOT</u>** on the same subnet. At this time, do not set a default gateway. Once completed, click **OK** twice to save the changes.



15. Attempt to ping the Windows 2K8 R2 Internal 2 machine once again by typing the command **ping 172.16.24.11** into the command prompt window on the Windows 2K8 R2 Internal 1 machine and pressing **Enter**.

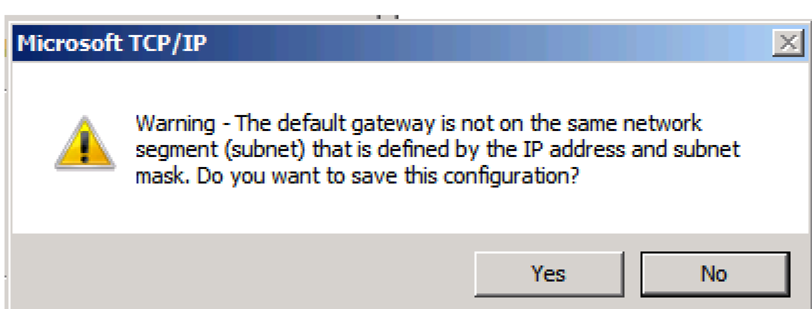
```
C:\Users\Administrator>ping 172.16.24.11

Pinging 172.16.24.11 with 32 bytes of data:
PING: transmit failed. General failure.
PING: transmit failed. General failure.
PING: transmit failed. General failure.
PING: transmit failed. General failure.

Ping statistics for 172.16.24.11:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
```

Notice the error message received. This is the result of the machine attempting to ping an IP address on a different subnet and not having a default gateway set. Since the machine does not have a path to get off of its local network, it simply returns a failure.

16. Had a valid default gateway been available and assigned to the Windows 2K8 R2 Internal 1 machine, the ping would have reached the default gateway and been forwarded to the 172.16.24.0/20 network. This would have been an undesirable result as the machine that was attempting to be reached was incorrectly configured as if it were a machine on the local network. Therefore, no machines would be able to communicate to the incorrectly configured machine.

```
C:\Users\Administrator>ping 172.16.24.11

Pinging 172.16.24.11 with 32 bytes of data:
Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping statistics for 172.16.24.11:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
```

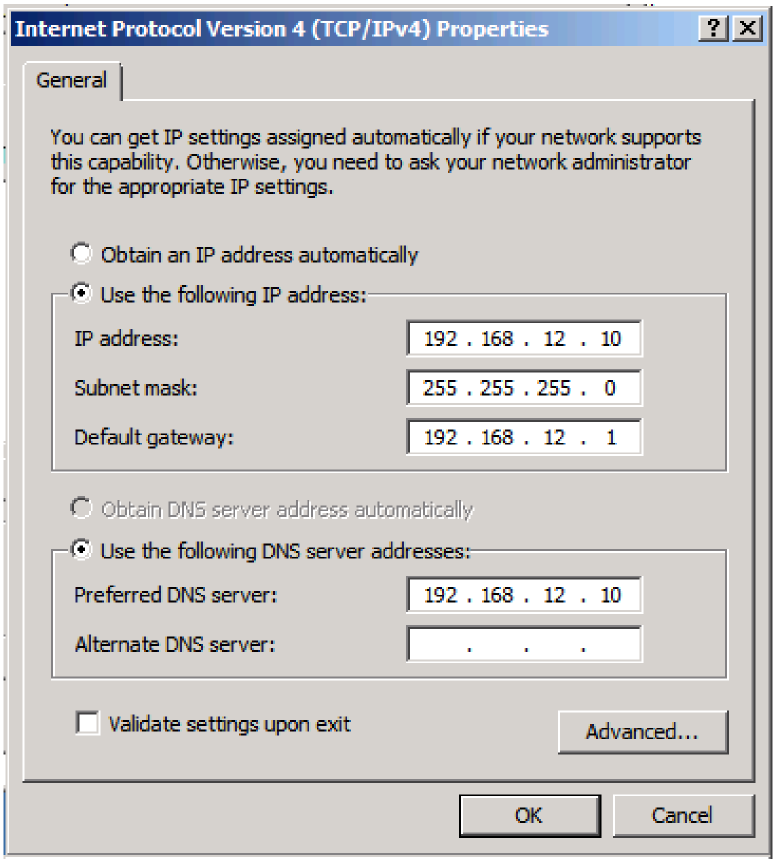
17. Had a valid default gateway been available and assigned to the Windows 2K8 R2 Internal 2 machine, an administrator would have received two errors. The first would have been given if the administrator attempted to assign a default gateway that did not reside in the same subnet (for example, if the administrator attempted to assign the default gateway of 172.16.16.1 to the Windows 2K8 R2 Internal 2 machine).

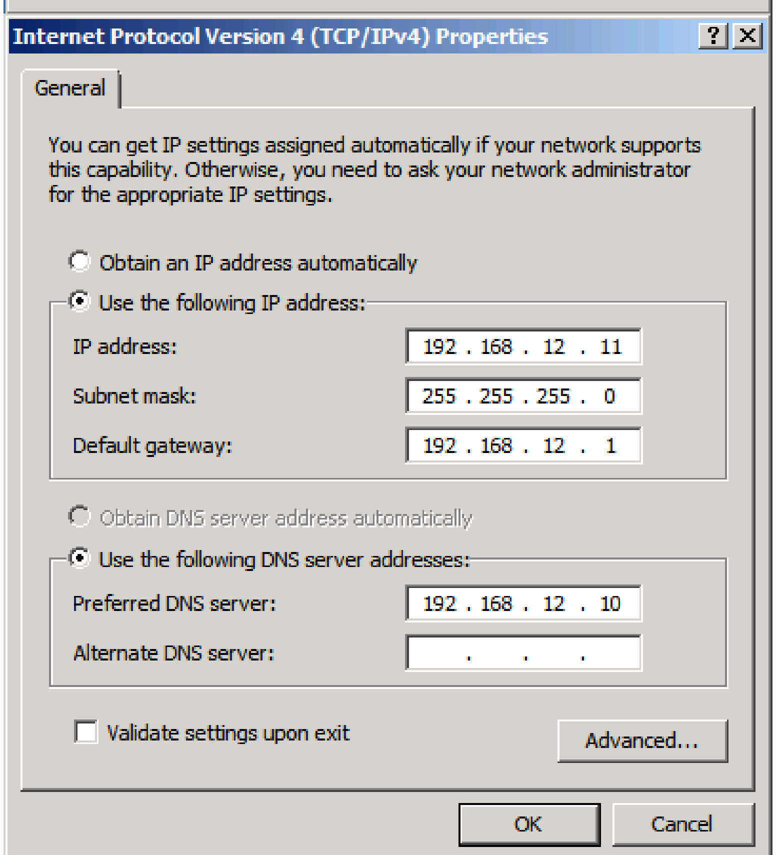


Secondly, had the administrator ignored this warning and proceeded to assign the default gateway, a ping would have revealed the error **Destination host unreachable**. This is a way for a machine to tell other machines that no path exists to a particular network. In this case, no path exists from the source machine to the default gateway (again, it is on another network).

```
C:\Users\Administrator>ping 172.16.16.10

Pinging 172.16.16.10 with 32 bytes of data:
Reply from 172.16.24.11: Destination host unreachable.
Reply from 172.16.24.11: Destination host unreachable.
Reply from 172.16.24.11: Destination host unreachable.
Reply from 172.16.24.11: Destination host unreachable.

Ping statistics for 172.16.16.10:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

C:\Users\Administrator>_
```

18. Set the IPv4 settings back to their original state using the information you recorded in the tables (see steps 7 and 11). Close all open windows on both machines.


Internet Protocol Version 4 (TCP/IPv4) Properties
General
You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.
Obtain an IP address automatically
Use the following IP address:
IP address: 192 . 168 . 12 . 10
Subnet mask: 255 . 255 . 255 . 0
Default gateway: 192 . 168 . 12 . 1
Obtain DNS server address automatically
Use the following DNS server addresses:
Preferred DNS server: 192 . 168 . 12 . 10
Alternate DNS server:
Validate settings upon exit
Advanced...
OK
Cancel


Internet Protocol Version 4 (TCP/IPv4) Properties
General
You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.
Obtain an IP address automatically
Use the following IP address:
IP address: 192 . 168 . 12 . 11
Subnet mask: 255 . 255 . 255 . 0
Default gateway: 192 . 168 . 12 . 1
Obtain DNS server address automatically
Use the following DNS server addresses:
Preferred DNS server: 192 . 168 . 12 . 10
Alternate DNS server:
Validate settings upon exit
Advanced...
OK
Cancel

3.2 Conclusion

Incorrectly configuring subnet addresses can have disastrous results on a network. Careful planning and execution is the key to a successful implementation.

3.3 Review Questions

1. *True or false? If all network traffic resides on the local LAN, configuring a default gateway is not necessary?*

2. *True or false? If a computer attempts to ping a machine that does not reside on the local LAN and it does <u>not</u> have a default gateway set, the error message returned by the local computer reads **Destination host unreachable**.*

3. *True or false? If a computer attempts to ping a machine that does not reside on the local LAN and it <u>does</u> have a default gateway set, the error message returned by the local computer reads **Request timed out**.*

4 Subnetting IPv6 Addresses

IPv6 addresses are 128-bit addresses represented in eight 16-bit segments informally known as “hextets”. Each hextet is separated by a colon and written in hexadecimal format. IPv6 network prefixes are always identified by bitcount (i.e. slash notation). Two rules can be used to reduce the length of an IPv6 address. First, leading zeros in any hextet can be omitted. Second, any single, continuous string of one or more hextets consisting of all zeros can be represented with a double colon.

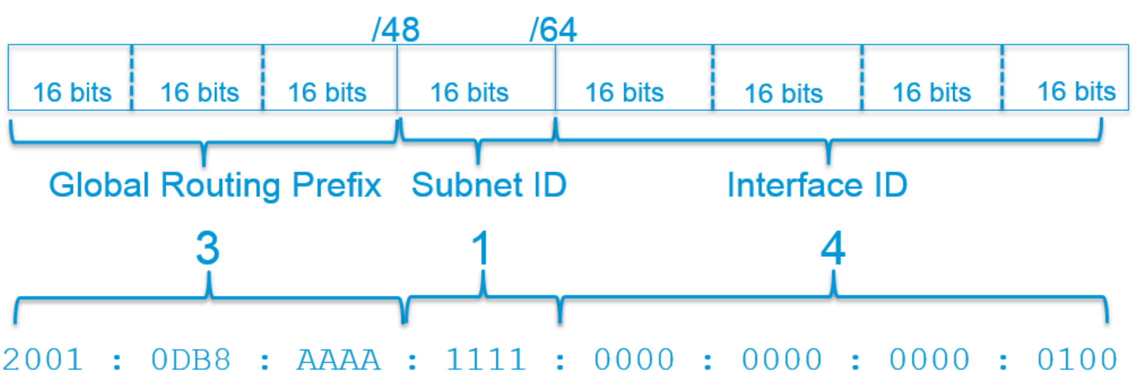
3ffe:0510:0100:0000:0000:0000:0f2e:bc00

3ffe:510:100:0:0:0:f2e:bc00 (1st rule)

3ffe:510:100::f2e:bc00 (2nd rule)

4.1 The 3-1-4 Rule

Generally, IPv6 addresses are organized by the “3-1-4” rule. This rule states, the first three hextets (48-bits) are reserved for the global routing prefix; the fourth hextet (16-bits) is reserved for the subnet ID; and the last four hextets (64-bits) are reserved for the interface ID. A 16-bit interface ID gives the possibility of 65,536 subnets, while a 64-bit interface ID gives the possibility of 18 quintillion (18,446,744,073,709,551,616) devices per subnet.



Note that the four hextets associated with the interface ID can be used for subnets as well if more than 65,636 are needed or if IT administrators want to limit the size of a network.

4.2 Subnetting IPv6

Subnetting an IPv6 address is just like subnetting an IPv4 address except for working with a hexadecimal IP address. One can still write out the subnet ID in binary form and add the subnet variable to the nibble.

```
2001:0DB8:AAAA:0000::/54 (6-bits borrowed)
2001:0DB8:AAAA:0000 0000 0000 0000::
                          ^-----The subnet variable in this example is "4".
2001:0DB8:AAAA:0000 0100 0000 0000:: = 2001:0DB8:AAAA:0400::/54
2001:0DB8:AAAA:0000 1000 0000 0000:: = 2001:0DB8:AAAA:0800::/54
2001:0DB8:AAAA:0000 1100 0000 0000:: = 2001:0DB8:AAAA:0C00::/54
2001:0DB8:AAAA:0001 0000 0000 0000:: = 2001:0DB8:AAAA:1000::/54
```

Notice that when subnetting an IPv6 address within a nibble, keeping up with the subnet addresses becomes a tedious process. For this reason (and given that so many subnets are available), the preferred method is to subnet an IPv6 address on the nibble boundary. This simplifies the subnetting process to simply learning to count by one in hexadecimal.

```
2001:0DB8:AAAA:0000::/52 (4-bits borrowed)
2001:0DB8:AAAA:0001 0000 0000 0000::
                    ^-----The subnet variable in this example is "1".
2001:0DB8:AAAA:0001 0000 0000 0000:: = 2001:0DB8:AAAA:1000::/52
2001:0DB8:AAAA:0010 0000 0000 0000:: = 2001:0DB8:AAAA:2000::/52
2001:0DB8:AAAA:0011 0000 0000 0000:: = 2001:0DB8:AAAA:3000::/52
2001:0DB8:AAAA:0100 0000 0000 0000:: = 2001:0DB8:AAAA:4000::/52
.....
2001:0DB8:AAAA:1111 0000 0000 0000:: = 2001:0DB8:AAAA:F000::/52
```

4.3 Conclusion

If executed correctly, subnetting IPv6 address can be easier than subnetting IPv4 address. A unique fact about IPv6 is that so many addresses exist that every square micrometer (.001 millimeter) of the Earth's surface could have 5,000 unique addresses!

4.4 Review Questions

1. *What is the term used to describe a group of 4 binary bits?*

2. *Reduce the following IPv6 address to its shortest form.*
   2001:01A0:0033:0000:0000:0000:0001:00D4

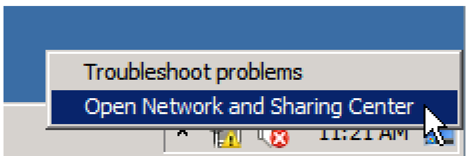
3. *How many possible host addresses are available with a 64-bit interface ID?*

5 IPv6 Subnet Addresses

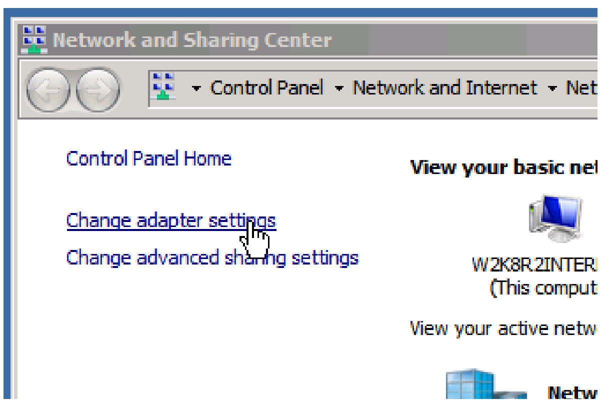
Applying IPv6 addresses is done in much the same way as IPv4 addresses. One key difference is that the subnet mask is only displayed as a prefix length.

5.1 Apply and Test IPv6 Subnet Addresses

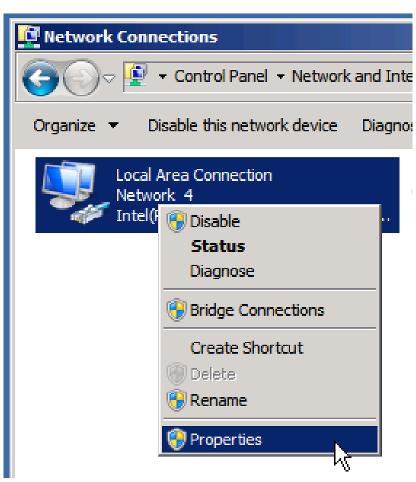
1. On the Windows 2k8 Internal 1 machine, right-click on the network icon in the taskbar and select **Open Network and Sharing Center**.



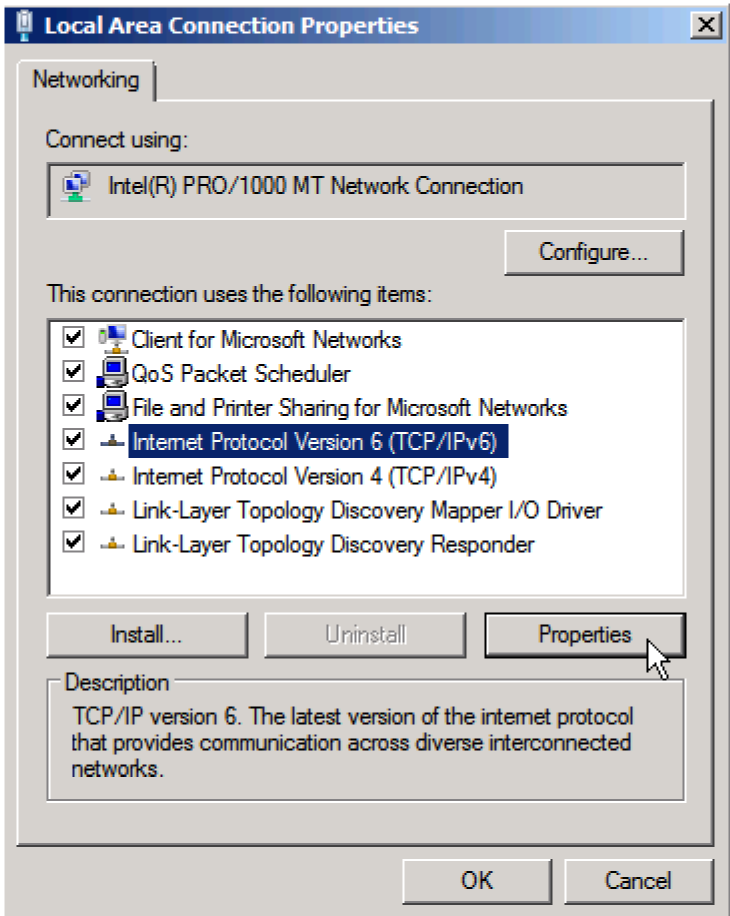
2. In the left column, click the link **Change Adapter Settings**.



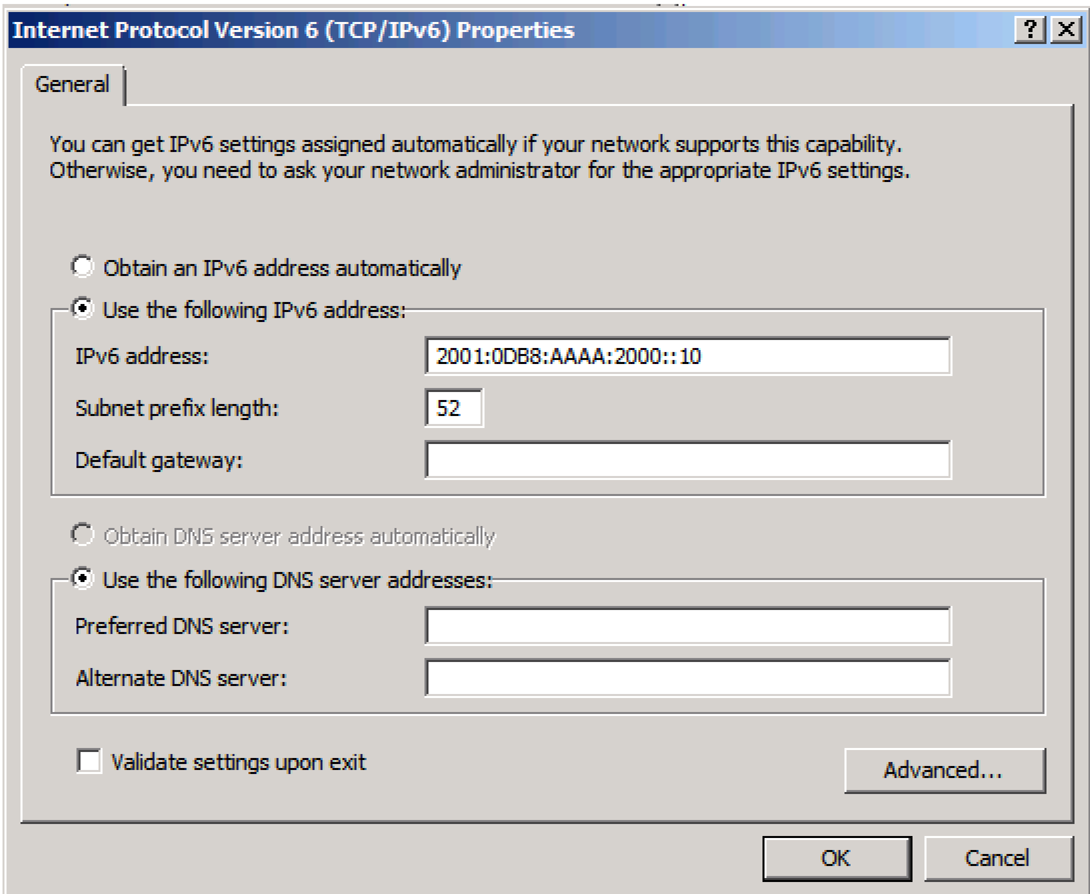
3. Right-click on the **Local Area Connection** icon and select **Properties** from the context menu.



4. Select the Internet Protocol Version 6 (TCP/IPv6) option and click Properties.

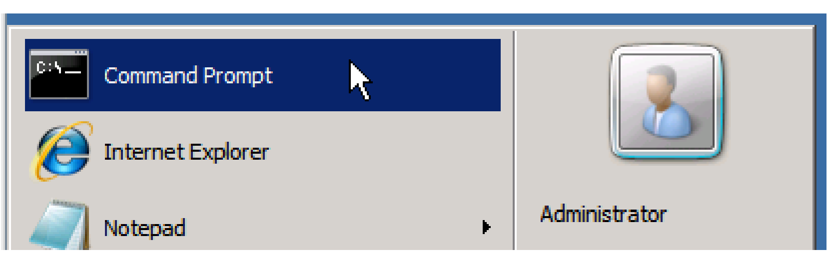


5. Select the radio button next to **Use the following IPv6 address**. Change the IP Address and Subnet prefix length of the Windows 2K8 R2 Internal 1 machine to IP address 2001:0DB8:AAAA:2000::10 and the Subnet prefix length to 52.. Notice that there is no subnet mask with IPv6 – only the prefix length is present. Note that a default gateway is not necessary as all traffic will remain on the local LAN.



Click **OK** twice to save the changes. If you get a message about the DNS server list being empty, just click **OK** to ignore the message.

6. Use steps 1-5 to assign the IPv6 address of 2001:0DB8:AAAA:2000::20 on the Windows 2K8 R2 Internal 2 machine. Once completed, click **OK** twice to save the changes.
7. On the Windows 2K8 R2 Internal 1 machine, open a Command Prompt window by clicking **Start** and selecting **Command Prompt**.



8. In the command prompt window, type the command **ping 2001:0DB8:AAAA:2000::20** and press **Enter.**

```
C:\Users\Administrator>ping 2001:0DB8:AAAA:2000::20

Pinging 2001:db8:aaaa:2000::20 with 32 bytes of data:
Reply from 2001:db8:aaaa:2000::20: time<1ms
Reply from 2001:db8:aaaa:2000::20: time<1ms
Reply from 2001:db8:aaaa:2000::20: time<1ms
Reply from 2001:db8:aaaa:2000::20: time<1ms

Ping statistics for 2001:db8:aaaa:2000::20:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

Notice that the ping is successful even though no default gateway was set. This is because all traffic is on the local LAN. Therefore, no gateway is needed. If you were attempting to ping a machine on a different subnet, a default gateway would be required.

9. Now issue the command **ping ::1**. The address ::1 represents the IPv6 loopback address. This address allows one to test the IPv6 configuration of a machine.

```
C:\Users\Administrator>ping ::1

Pinging ::1 with 32 bytes of data:
Reply from ::1: time<1ms
Reply from ::1: time<1ms
Reply from ::1: time<1ms
Reply from ::1: time<1ms

Ping statistics for ::1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

10. On the command line, type echo "your first and last names". Then press the Enter key. Take a screenshot that contains your full name and the output produced at Step 9 above.

5.2 Conclusion

With the IPv4 address space being completely exhausted, the mainstream move to IPv6 is coming quickly. Understanding IPv6 is crucial to the success of a great network administrator!

5.3 Review Questions

1. *Is the IPv6 address 2001:1D5::30A::1 a valid address? Why or why not?*
2. *Is the IPv6 address 10:10::10:10 a valid address? Why or why not?*
3. *What is the IPv6 loopback address?*