Chapter 2: Configuring Network Protocols

Objectives

After reading the chapter and completing the exercises, students should be able to:

- Understand TCP/IP addressing
- Define TCP/IP parameters
- Configure TCP/IP parameters
- Work with TCP/IP networks
- Understand the process of subnetting a TCP/IP network
- Supernet several smaller networks
- Configure other network protocols
- Use bindings to optimize network connectivity

Teaching Tips

Overview of TCP/IP

1. Before this chapter is over, make sure that students understand that TCP/IP is prevalent in almost all Internet applications.
2. Since TCP/IP is an open protocol, you can remind students that they are free to develop any application without worrying about royalty fees.
3. Cite well known examples of services that use TCP/IP. Some of these services include: HTTP, FTP, and SMTP.
4. Have students try to uninstall TCP/IP from a computer with a fully-installed edition of Windows Server 2003. Students should find that they have no choice but to keep the protocol installed.

Activity 2-1: Preparing a Network Connection

1. This is a very simple activity that involves issuing the repair command on the local area connection. Students should have no problem following the instructions provided in the text.

Defining TCP/IP Parameters

1. There are only a few parameters involved with TCP/IP communications that the students should need to understand at this time. The parameters are: IP addresses, subnet masks, default gateways, DNS servers, and WINS servers.

Teaching Tip	Pay extra attention to defining the parameters of TCP/IP. Many students will not understand the configuration or purpose of such parameters and features as they are often autoconfigured by DHCP. A competent network administrator has to know the purpose of and be able to configure all parameters.

IP Addresses

1. Make sure you utilize the analogy between a computer's IP address and the address of a house. In the same way that each house has a unique address to identify it in a neighborhood, each computer has a unique address to identify it on a network.
2. If the student is not familiar with binary numbers, the concept of a different number system might be confusing at first. Have students convert the octets of an IP address into 8-bit binary numbers to make sure they understand the conversion process. As computers only see binary numbers, it is useful for students to understand this concept. Also, the process of ANDing the subnet mask with the IP address will make much more sense if binary numbers are understood.

Subnet Masks

1. A subnet mask is just a mask. If students are familiar with the concept of a mask, then this topic should not cause any problems. If not, you must introduce the AND operation in binary logic.
2. The term subnet mask may sound complicated, but students should be shown that it is a very simple concept. Its purpose is solely to separate the network and host ID from an IP address.
3. Although most subnet masks consists of only the numbers 0 and 255, remind students that it is not impossible to have other numbers in the mask.
4. Remind students that the subnet mask is a mask and not an address.

Default Gateway

1. This is just a fancy name for a router. A router is used to send packets to computers located on different networks.
2. A router does not necessarily have to be a dedicated piece of hardware as is usually seen. It could be computer with multiple network cards.
3. Windows Server 2003 has the ability to act as a router. Linux and NetWare also have this capability.

DNS

1. Remind students that DNS is essential to computing these days.
2. If a student has not heard of DNS, then use the example of the Internet to illustrate the point. Easy to remember domain names, such as www.microsoft.com, are meaningless to computers until they are translated into IP addresses. This translation is performed by the DNS server.
3. It would probably be interesting to the students if the hierarchical structure of domain names were briefly explained. Most students know the general form of a Web address, but will not know any details on the official hierarchical naming scheme.
4. Make sure that the other uses for DNS are explained. The other uses include finding domain controllers and resources on the Internet.

WINS

1. The basic idea behind WINS is to resolve NetBIOS names into IP addresses.
2. The WINS server was developed to help alleviate the bandwidth drain on networks caused by the older broadcasting method of NetBIOS name resolution.
3. NetBIOS name resolution is included by default in TCP/IP. This is due to the fact that there still are Windows applications that require such a service for locating other computers on the network. This should make the point that, although NetBIOS is older and less frequently used, students may still run into applications that use NetBIOS names and need to be familiar with the concept.
4. The text discusses a sample lmhosts file. It might be useful to have students locate that file on their computer and discuss the different items located within.

Configuring TCP/IP Parameters

1. As long as the students understand the concepts in the previous sections, configuring the parameters of TCP/IP in Windows Server 2003 should be a simple task as each configuration parameter is clearly labeled in the configuration sections.
2. In most cases, students will probably be setting up computers for use with a DHCP server as it provides extreme utility with network administration. However, when setting up computers to be used as Web servers or to provide other publicly accessible services, a static IP configuration is often used. Therefore, ensure that students understand how to configure for both scenarios.
3. Students unfamiliar with automatic private addressing may be confused as it might appear that the machine was assigned an IP address but still cannot properly connect to the network. If the student is unfamiliar with the 169.254.0.0 network, then troubleshooting such a problem may be frustrating. Therefore, it is essential that students recognize this network and realize that, in such cases that this IP address appears, the computer is unable to contact a DHCP server and obtain an address.
4. Alternative settings may be configured in Windows Server 2003 so that, in the event that a DHCP server cannot be contacted, a static configuration is used.

Activity 2-2: Configure TCP/IP Parameters

1. This is an especially easy activity as students only need to find the local area connection on their machine to gain access to the TCP/IP parameters on that machine. Many will probably already know how to carry out this activity without reading the instructions.

Activity 2-3: Using IPCONFIG to View IP Configuration

1. In this activity, students will be using the IPCONFIG tool to view a machine's IP configuration. IPCONFIG is one of the many tools hidden from users. It requires a command prompt to execute as there is no graphical interface associated with this program.
2. Students who have never dealt with command line programs may need a little additional help and it may be useful to explain how Microsoft handles command-line options.

Activity 2-4: Test APIPA

1. This is another simple activity that involves having students see what happens when a computer is unable to access a DHCP server. The important point of this activity is for the student to understand that Windows will automatically assign itself an IP address on the network: 169.254.0.0.

Activity 2-5: Alternative IP Configuration

1. This activity demonstrates to students how to configure Windows Server 2003 to use a statically defined IP address in the case that it is unable to locate and access a DHCP server. This is known as setting an alternative IP configuration. The activity should be relatively straight forward.

Working with TCP/IP Networks

1. In order to fully understand how to work with a TCP/IP network, students should understand the next three topics outlined below.

IP Address Classes

1. Many students will know what an IP address is but few will probably know that IP addresses belong to certain classes. Although there are five IP address classes, only three are able to be assigned to machines.
2. Students should not have to memorize the properties of classes A-C if they understand what differentiates each class from each other: namely, the number of networks and hosts allowed by each class. Class A provides eight bits for the network ID and 24 bits for the host ID. Class B addresses use 16-bit network IDs and 16-bit host IDs. Finally, class C addresses use 24-bit network IDs and 8-bit host IDs.
3. Students will have to memorize the range of numbers that the first octet is allowed in order to identify what class an IP address belongs. If the default subnet mask is available, it can serve as an extremely useful hint at determining an IP address's class.
4. To test students, create random IP addresses and have students identify to which class they belong.

Classless Inter-domain Routing

1. This technique was invented to replace classful routing.
2. One of the main interests in classless routing is that it does not use the default subnet mask. Instead, the subnet mask must be specified for each network.
3. Have students practice understanding CIDR notation. Write out many IP addresses in CIDR notation and have students determine the subnet mask.
4. Remind students that the most important feature of this type of routing is the fact that it reduces the number of wasted IP addresses and substantially reduces any routing table that must be stored by a router

Reserved Addresses

1. There are a number of IP addresses that cannot be assigned to computers or used over the Internet.
2. Make sure students learn to recognize these special addresses.
3. Make sure students know the difference between a local and directed broadcast. A local broadcast is transmitted to all computers on a local network and discarded by routers. A directed broadcast is a broadcast to a specific network and is routable.
4. A local broadcast has the destination address: 255.255.255.255. A directed broadcast has a destination address consisting of the appropriate network ID and a host ID consisting of all ones.

Subnetting TCP/IP Networks

1. The most important idea in this section is learning the fact that a large network can be broken down into multiple smaller networks.
2. Subnetting results in: collision reduction, broadcast limiting, and traffic control.
3. The specifics of each of these advantages are outlined in the next few sections.

Quick Quiz

1. A computer sees an IP address in binary form. How many bits are there in an entire IP address?
   Answer: 32 bits

2. What is the purpose of a subnet mask?
   Answer: A subnet mask is required to separate the network and host IDs from an IP address.

3. What range of IP addresses would be assigned to a computer automatically in the event that an IP address could not be obtained from a DHCP server?
   Answer: 169.254.x.x

Reducing Collisions

1. Many students will probably not know the definition of a network collision. Therefore, make sure this concept is clear before describing exactly how subnetting can reduce this problem. Collisions occur when two computers try to transmit data at the same time. Collisions can greatly reduce network utilization as computers must stall a certain amount of time in order to wait for the collision to clear and transmit its data.
2. Collision frequency can be decreased simply by reducing the number of hosts on each network. Because subnetting reduces the number of hosts on a network, it is a very useful tool in reducing collisions.
3. Students may still be unclear of how subnetting can reduce the frequency of collisions. After all, the overall number of computers has not been reduced. Students must understand that, in a routed network, each network is its own collision domain. Therefore, the collisions that may occur in one network will have no effect on any other network.

Limiting Broadcasts

1. Students should not have too much trouble understanding why subnetting a network will reduce broadcast traffic.
2. As more hosts are added to a network, the number of broadcast packets will increase and decrease network efficiency. Subnetting reduces the number of hosts on a network and therefore reduces the number of broadcasts that occur on that network.
3. Routers do not forward local broadcasts. If they did, subnetting could not reduce the network traffic due to these broadcasts.

Controlling Traffic

1. The main idea of this section is that, if a network is broken down into multiple smaller networks connected through routers, a higher degree of control can be obtained over network traffic.
2. The increase in control is gained from the ability of setting rules over which packets are allowed to be forwarded by the router.
3. This section also briefly discusses the fact that computers handle IP addresses and subnet masks in binary instead of with dotted decimal notation. Make sure students know this in order to motivate their learning of binary numbers.

Conversion between Binary and Decimal

1. This section very briefly outlines how to convert between binary and decimal without providing the explanation really needed to fully understand the process or concept.
2. If a thorough understanding of binary numbers is desired of students, you will need to go into more detail concerning the conversion process and the fact that decimal is a base-ten number system while binary is a base-two number system.
3. The best way to learn the conversion process is by example. Work out multiple examples of converting between the two number systems together in class if needed.
4. Students are used to thinking in terms of decimal numbers and may not realize that they are really working with base-ten numbers. With base-ten numbers, there are ten possible digits that can be used. In binary, there are only two possible digits that can be used.
5. Some students may wonder why binary is used by computers. The answer to this question would involve the explanation of simple electronic circuits. Specifically, describe the concept that voltages on a wire can either be high or low. Therefore, computers can only recognize two different states. These two states are well represented using the binary number system.

Activity 2-6: Converting Binary Numbers to Decimal Using Windows Calculator

1. This should be a particularly easy activity as it involves students playing with the calculator software provided by Windows.
2. Make sure students know how to switch to scientific mode on the calculator. Otherwise, they might wonder where the advanced features, needed to complete this exercise, are located.

Working with Binary IP Addresses and Subnet Masks

1. The main idea behind this section is for students to understand the operation of masking through logical ANDing.
2. Have students convert various IP addresses and subnet masks into binary form and AND the two numbers. The result of this operation should be the network ID of the network.
3. If the details of ANDing are not required to be understood by students, merely explain that they can determine the network and host IDs by lining up the two 32-bit binary numbers. Any part of the IP address that lines up with a one in the subnet mask is part of the network ID. Any part of the IP address that lines up with a zero in the subnet mask corresponds to the host ID.
4. Working with the binary forms of the IP address and subnet mask is useful mostly for subnet masks that contain an octet other that 0 or 255.

Activity 2-7: ANDing

1. In this activity, students will be demonstrating their ability to convert between binary and decimal formats and their ability to perform the AND operation on binary numbers.
2. Students should convert both the subnet mask and IP address into binary, AND the two numbers together to form the network ID, and convert the binary network ID back into dotted decimal format.
3. When converting back to dotted decimal format, students should remember to convert from binary eight bits at a time.

Creating Subnets

1. Make sure students understand that the concept of subnetting is very simple. To subnet a network, take bits away from the host ID and give them to the network ID. This effectively reduces the number of hosts allowed on a network but increases the number of networks. The result is that, instead of a single network with a large number of hosts, there are multiple networks with a smaller number of hosts.
2. The other main concept students should remember from this section is the difference between simple and complex subnetting. Simple subnetting involves taking an entire octet from the host ID and giving it to the network ID. Complex subnetting involves taking less than an entire octet from the host ID.

Activity 2-8: Complex Subnetting

1. This is an important activity as it involves a task that may be encountered by administrators in a real industrial scenario.
2. There are two main ideas to be learned from this activity. The first idea is how to subnet a network. The second idea is to make sure that the network is subnetted using the fewest bits necessary.

Activity 2-9: Finding Valid Hosts

1. This activity is meant to demonstrate knowledge of which and how many host addresses are allowed on a subnetted network.
2. The formula required is 2n-2.
3. The two host addresses that are not allowed is the subnet address itself and its broadcast address.

Supernetting TCP/IP Networks

1. If students understand the concept of subnetting, the idea behind supernetting will not be difficult to understand.
2. In the process of supernetting, multiple smaller networks are combined into one larger network.
3. A very important point for students is the fact that the networks being combined must be contiguous. Students need to understand that you cannot just take any group of networks and combine them into one.

Reasons for Supernetting

1. The idea of supernetting itself is not complicated. Students should learn why it is important so that they can apply the concept, if needed, in any administration setting.
2. The main reason for supernetting occurs whenever one has the need for a range of IP addresses larger than that required of a class C network but much smaller than that provided by a class B network.
3. Students should understand the situations in which supernetting can decrease routing complexity. If multiple networks are combined, routers can be replaced with switches. This would result in a simpler network structure.

Configuring Other Protocols

1. There are a number of other protocols with which students should be familiar as they might encounter them in an administration task.
2. Two relatively popular protocols that are still used and may potentially be required in a network setting include IPX/SPX and AppleTalk.

IPX/SPX

1. There is a lot of information contained in this section of the text and the details may be relatively confusing to many students. Explain each concept of IPX/SPX carefully.
2. Make sure you explain both why IPX/SPX was popular and why its popularity has diminished.
3. IPX/SPX used to be the most popular protocol used on local area networks. However, the Internet required the TCP/IP protocol. Therefore, instead of using two different protocols in their networks, companies would use TCP/IP over IPX. Thus, TCP/IP effectively replaced IPX/SPX.
4. If students look around at the network protocols installed on the operating system, they will notice that NWLink is used often in conjunction with IPX/SPX. NWLink is the name Microsoft uses for their IPX/SPX compatible protocol.
5. The older NetWare operating system was once very popular and required IPX/SPX. This operating system helped increase the popularity of IPX/SPX.
6. Students should understand that the IPX/SPX protocol is not suited for wide area networks as computers providing services must broadcast an announcement of these services every sixty seconds. This broadcasting is very wasteful over a WAN network.
7. Each IPX/SPX address consists of an eight character hexadecimal network ID and a 12 character hexadecimal host ID. Students should know that, because the sizes of the IDs are fixed, a subnet mask is not necessary for this protocol.
8. Make sure students understand what a MAC address is. The host ID of an IPX/SPX address consists of the networks card's MAC address.
9. IPX/SPX supports multiple frame types. Any student administrating a network utilizing IPX/SPX has to understand that two computers configured with different frame types will not be able to communicate.

Activity 2-10: Installing NWLink

1. If students have performed the other activities in this text, this activity should pose no significant problem.
2. This activity merely involves the installation of another protocol.

Activity 2-11: Configuring NWLink

1. In this activity, students will be configuring NWLink so that it uses a specific frame type, IPX/SPX network address, and internal network number.
2. This activity is important as most students will probably not know how to configure this protocol.
3. Remind students that NWLink is just Microsoft's version of IPX/SPX.
4. Students can use the command **ipxroute config** in order to check whether or not their settings have taken effect.

Appletalk

1. Students should never have to install this protocol unless there is a Macintosh computer connected to the network.
2. Windows Server 2003 has the ability to emulate a Macintosh file or print server.
3. Something students may not realize is that the Macintosh print server is not available on the 64-bit versions of Windows Server 2003. This demonstrates that one should always check to make sure that the version of the software being purchased includes all of the features desired.

Activity 2-12: Installing AppleTalk

1. This activity should not be difficult for students. This activity involves the installation of a protocol.

Teaching Tip	If possible, connect a Macintosh computer to the network and allow students to configure Windows Server 2003 to communicate with this computer. Have students practice configuring a print or file server. This activity will help students learn to find networking information on their own and learn important troubleshooting skills.

Obsolete Protocols

1. There are a couple of protocols that students should realize are no longer provided with Windows Server 2003. The protocols are rare and will probably never be encountered in any practical situation.
2. Data Link Control (DLC) is a nonroutable protocol used for mainframe computing.
3. NetBEUI was at one time a very popular protocol. This protocol was phased out with the introduction of the Internet.

Configuring Protocol Bindings

1. Binding may be a new topic for many students. Therefore, this concept should not be skipped.
2. Binding simply involves the configuration of a network protocol for a certain network adapter.
3. An important concept for potential network administrators is for them to learn that protocols, bound to a certain connection, may be ordered. This allows for the prioritization of network services.
4. Other bindings include clients and services to adapters and network protocols to services or clients.

Activity 2-13: Optimizing Binding Order

1. This is an important activity as it involves the student learning how to order the bindings of a network connection in order to optimize it.
2. NWLink will be set to the highest priority for **File and Printer Sharing for Microsoft Networks**.
3. TCP/IP will be set to the highest priority for **Microsoft Client for Microsoft Networks**.

Activity 2-14: Removing Unnecessary Protocols

1. This is a simple activity that involves the removal of the AppleTalk protocol.

Quick Quiz

1. What condition must be satisfied in order for supernetting to be possible?
   Answer: The networks to be supernetted must be contiguous.

2. Name an obsolete protocol.
   Answer: DLC or NetBEUI

3. Which protocol is used to allow communication with Macintosh computer systems?
   Answer: AppleTalk

Class Discussion Topics

1. What are some techniques that can be used to reduce the frequency of network collisions?
2. What are the advantages and disadvantages between manually setting computer IP addresses and having the addressing automatically assigned through DHCP?
3. Suppose you needed to install a protocol that you have never configured before. Where might you look to find more information about that protocol?
4. Go through and discuss the different parameters and commands available with the ipconfig utility provided with Windows Server 2003.

Additional Projects

1. Research how a computer communicates with a DHCP server in order to receive an automated IP address and various configuration settings for TCP/IP communication.

2. Research how MAC addresses are assigned to network cards. These MAC addresses are very important in network communications.

Solution to Additional Projects

1. Whenever a computer needs to start TCP/IP services, it sends a broadcast request for the appropriate configuration information. The system running the DHCP server receives the request and replies to the client machine with the appropriate information. The server will issue an IP address with an associated lease. The server is guaranteed not to reallocate the IP address before the lease has expired. Client machines may request to extend the lease or receive a new address.

2. A company must first register with IEEE as an official products vendor. Upon approval, the assignment of an organizationally unique identifier (OUI) and company ID number is issued. These IDs can then be used to form the MAC addresses used by the company. Students may go into more detail as desired.