

WANs and Routers

The Study Guide portion of this chapter uses a combination of multiple-choice, matching, and open-ended question exercises to test your knowledge of the theory of routers in a WAN environment.

The Lab Exercises portion of this chapter includes all the online curriculum labs as well as a challenge lab to ensure that you have mastered the practical, hands-on skills needed to use routers in a WAN environment.

Study Guide

WANs

A wide-area network (WAN) is a data communications network that connects user networks over a large geographical area. WANs have several important characteristics that distinguish them from local-area networks (LAN). In CCNA 1, you spent much of your time studying the Ethernet technology and learning how Ethernet operates at the Data Link layer. WANs use different technologies and protocols. However, much of what you learned in CCNA 1 still applies to WANs. For example, the Internet Protocol at Layer 3 is still relevant. This section of the Study Guide focuses on terms and concepts that relate to WANs.

Vocabulary Exercise: Matching

Match the definition on the left with a term on the right.

Definitions

- a. When referring to clocking, the CSU/DSU is this piece of equipment.
- b. The software used by a router.
- c. Dialup and ISDN are examples of these types of networks.
- d. Describes the timing between the router and the CSU/DSU.
- e. Lost when a device is powered down or rebooted.
- f. Wires or other media through which data is transmitted from one place to another.
- g. Connects LANs to WANs.
- h. The physical connection point on networking devices where signals enter and exit.
- i. A smaller, more compact physical interface specification.
- j. A WAN link contracted for use by the customer.
- k. Frame Relay and ATM are examples of these types of networks.
- l. When referring to clocking the customer's router, this piece of equipment is used.
- m. A communications link that is outside the normal IP network, like a console cable or a phone call between two modems and the aux port.
- n. A network that spans a large geographic area.
- o. A telecommunications path that sends 1 bit at a time.
- p. The router port that connects a WAN link.
- q. A WAN service provider.
- r. Connects a router to the CSU/DSU.
- s. The management port on a router.
- t. Equipment that is located in the customer's wiring closet and provides a clocking signal to the router.
- u. A general term that describes the measurement of a route.
- v. If a device does not know how to get to a destination, it sends data to this device.
- w. The number of bits per second that the service provider can accept and send to the customer.
- x. What the WAN service provider calls your collection of equipment, including the router and CSU/DSU.

Terms

- ___ wide-area network (WAN)
- ___ router
- ___ default gateway
- ___ leased line
- ___ telephone company (telco)
- ___ serial cable
- ___ channel service unit/data service unit (CSU/DSU)
- ___ data circuit-terminating equipment (DCE)
- ___ data terminal equipment (DTE)
- ___ clocking/clock rate
- ___ synchronous
- ___ serial link
- ___ serial interface
- ___ customer premises equipment (CPE)
- ___ metric
- ___ Cisco IOS
- ___ contents of RAM
- ___ bus
- ___ interface
- ___ smart serial interface
- ___ circuit-switching
- ___ packet-switching
- ___ console port
- ___ out-of-band management

Vocabulary Exercise: Completion

Complete the paragraphs that follow by filling in the appropriate words and phrases.

When only two devices are connected across a WAN link, it's called a _____ link or _____ line or _____ circuit, or simply a WAN link. To create a _____ WAN link, a company must use the services of a _____ or an Internet service provider (ISP) that sells WAN services. The router uses a _____ cable to attach to a _____. This device then accepts the line coming in from the provider.

The router interface that attaches to the provider is normally the _____ side of the link, whereas the _____ serves as the _____ side of the link. This distinction is important, because the _____ side of the link provides the clocking or synchronization between the two sides of the link, specifying how fast the router can send data. The router and the CSU/DSU are physically located at the customer's location. Therefore, these devices collectively are called the _____.

Each new advance in WAN speed and technology has required a new set of standards. Most WAN standards are created by one of the following organizations:

- _____, which creates a wide range of standards, not just those for networking
- _____, which develops and maintains the protocols for TCP/IP
- _____, which works closely with the Telecommunications Industry Association (TIA) to develop the electrical specifications necessary to communications
- _____, which is under the control of the United Nations and exists for the purpose of developing worldwide telecommunication standards

Concept Questions

1. What is the most important function of a router?

2. Define *default gateway*. You can use any source at your disposal.

3. In three or four sentences, explain the purpose of DCE and DTE in WAN links.

4. Explain what a router is and what it does.

-
- _____
 - _____
 - _____

Routers

Routers are specialized computers for networking services using hardware and software. The hardware includes a processor, memory, specialized chips, and a selection of interfaces or ports. The software provides an operating environment for the hardware. This section of the Study Guide focuses on the terminology and concepts relating to routers. You reinforce your understanding of the internal components of a router by working through some exercises. Other exercises ask you to identify external interfaces and choose the right cable to use to connect devices.

Vocabulary Exercise: Completion

Complete the paragraphs that follow by filling in the appropriate words and phrases.

The main purpose of a router is to _____ packets. A router, like a typical PC, has a CPU and memory components. It also has specialized software, which in Cisco routers is called the _____. The _____ provides the basic routing logic. The router also has _____, just like PCs, which holds basic diagnostic software that runs when the router is first booted. All of these basic components (CPU, RAM, ROM, and an OS) are found in PCs.

In addition, just like PCs have an interface to connect to networks (usually called a _____, or _____), routers also have interfaces. Instead of using a hard drive, routers use two types of memory to permanently store data: _____ and _____.

The main internal router components are as follows:

- _____, which stores _____ tables and the _____ file while the router is powered. It loses content when a router is powered down or restarted.
- _____, which provides storage for the startup _____ file and retains content when a router is powered down or restarted.
- _____, which is a type of EEPROM. It holds the _____ image and retains content when a router is powered down or restarted.
- _____, which maintains instructions for _____ diagnostics and stores bootstrap program and basic operating system software.
- _____, which connect routers to a network for packet entry and exit.

Flash memory is used for storage of the _____ software image. The router normally acquires the default IOS from flash. These images can be upgraded by loading a new image into flash. The IOS can be in uncompressed or compressed form. In most routers, an executable copy of the IOS is transferred to _____ during the boot process.

The three basic types of connections on a router are _____ interfaces, _____ interfaces, and _____ ports. The term *interface* specifically refers to physical connectors that forward packets. In contrast, the term *port* refers to a physical connector that manages and controls a router.

The LAN and WAN connections provide network connections through which frame packets are passed. To connect to LAN interfaces, routers use a _____ cable to connect to a switch, just like a _____ cable should be used to connect a PC NIC to a switch. If you connect a router directly to a PC NIC without an intermediate device, like a hub or a switch, you must use a _____ cable. This type of connection is common in many of the labs you will configure. To connect to WAN interfaces, the router uses a _____ or _____ cable to attach to a CSU/DSU or when directly connecting two WAN interfaces in a lab environment.

The function of management ports is different from that of the other connections. The management port provides a text-based connection for the configuration and troubleshooting of the router. The common management “interfaces” are the _____ and _____ ports. The console port and the auxiliary (AUX) port are EIA-232 _____ serial ports and are not designed as networking ports.

Internal Components of a Router

Knowing the function of the main internal components of a router is more important than knowing the locations of the physical components inside a particular model. Therefore, in the following table, provide a sufficiently detailed description of each component.

Component	Description
CPU	_____ _____ _____ _____
RAM	_____ _____ _____ _____
Flash	_____ _____ _____ _____
NVRAM	_____ _____ _____ _____
Buses	_____ _____ _____ _____

Component	Description
ROM	
Power supply	

Another way to learn the internal components of a router is to list each component's function. For each of the following functions, indicate which of the following components performs the function:

- A. RAM
- B. NVRAM
- C. Flash
- D. ROM
- E. Interfaces

Answer	Function
_____	Provides temporary memory for the configuration file of the router while the router is powered on
_____	Allows software to be updated without removing and replacing chips on the processor
_____	Stores routing tables
_____	Maintains instructions for POST diagnostics
_____	Connect the router to the network for frame entry and exit
_____	Can be on the motherboard or on a separate module
_____	Is a type of EEPROM
_____	Retains content when router is powered down or restarted
_____	Stores bootstrap program and basic operating system software
_____	Holds Address Resolution Protocol (ARP) cache
_____	Loses content when router is powered down or restarted
_____	Retains content when router is powered down or restarted
_____	Holds the operating system image (IOS)
_____	Provides storage for the startup configuration file
_____	Can store multiple versions of IOS software

Label the External Components of a Router

Choose the correct label description for each number shown in Figure 1-1. Some labels can be used more than once.

Figure 1-1 Rear View of a 1721 Cisco Router

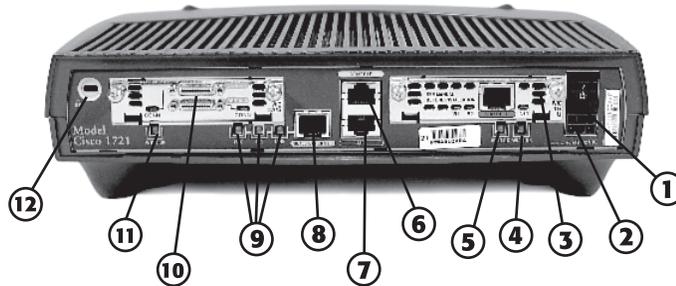


Figure 1-1 Label Description:

- ___ MOD OK LED, which is on when the Virtual Private Network (VPN) hardware encryption module is installed and recognized by the IOS.
- ___ Full duplex, 100 Mbps, and Link LEDs. The Link LED illuminates when a good physical connection exists on the Fast Ethernet port.
- ___ Illuminates when the WAN interface card (WIC) is okay and in use.
- ___ Power socket that connects to either a 120- or 220-volt AC outlet.
- ___ WAN interface card that provides access to a specific type of WAN technology.
- ___ A Kensington-compatible locking socket that allows this device to be padlocked to a secure object, like a rack mount.
- ___ Allows local configuration of the device.
- ___ Power switch.
- ___ Allows remote out-of-bandwidth configuration of the device.
- ___ LAN interface, which allows connections to hubs or switches through a patch or straight-through cable.

Choose the correct label description for each number shown in Figure 1-2. Some labels can be used more than once.

Figure 1-2 Rear View of a 2621 Cisco Router

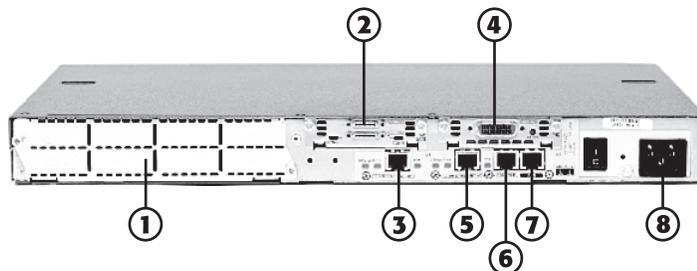
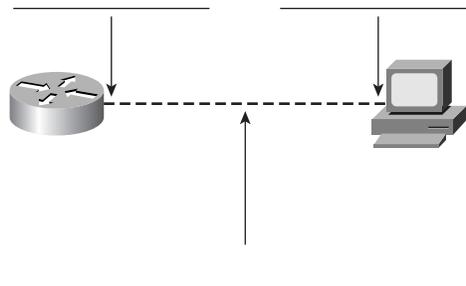


Figure 1-2 Label Description:

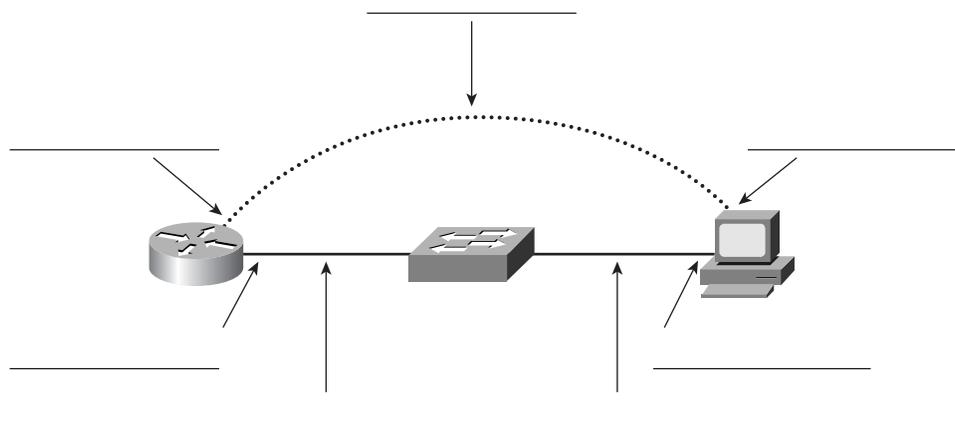
- LAN interface, which allows connections to hubs or switches through a patch or straight-through cable.
- WIC with two smart serial interfaces.
- Power cord connection.
- Allows remote configuration of the device.
- Expansion slot.
- Allows local configuration of the device.
- WIC with one DB-60 serial interface.

Label the Topology Components Exercise

In Figure 1-3, the PC is attached to the router, which is providing a packet-routing service to the PC. In other words, the PC is part of the in-band network of the router. Label the interfaces and cable type used.

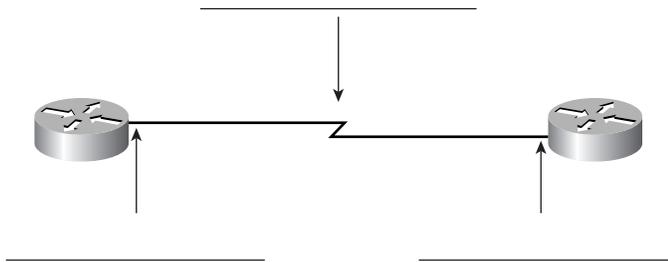
Figure 1-3 Label the Topology Components 1

In Figure 1-4, the PC is part of an in-band network and can also manage the router. Label the interfaces and cable types used.

Figure 1-4 Label the Topology Components 2

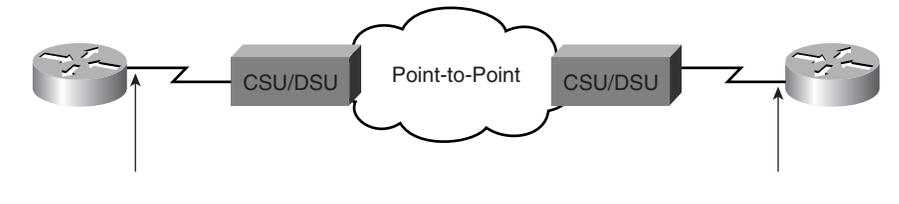
In Figure 1-5, the two routers are directly connected in a lab environment. Label the interfaces and cable types used. Also, choose a side that can provide the clocking, and label it.

Figure 1-5 Label the Topology Components 3



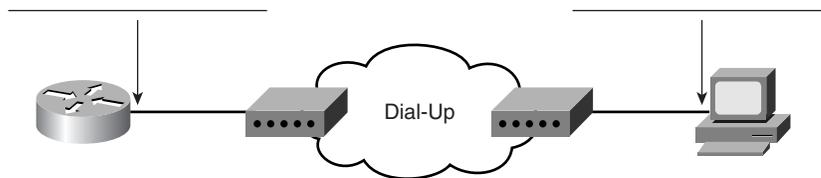
In Figure 1-6, the two routers are connected through a WAN service provider across a dedicated link. Label the interfaces.

Figure 1-6 Label the Topology Components 4



In Figure 1-7, the router and the PC are using an out-of-band network for device management purposes. Label the interfaces.

Figure 1-7 Label the Topology Components 5



Concept Questions

1. What three components of a router retain their memory when power is not present?

2. In what three ways can you configure a router?

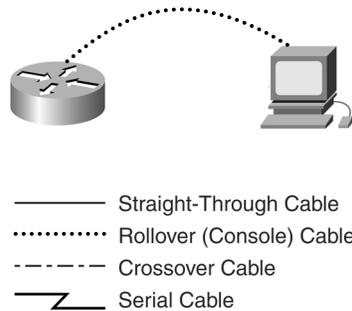
3. Of the two management ports, which one is preferred, and why?

4. Besides the PC and the router, what three components (software and hardware) are required to connect a PC to a router's management port?

Lab Exercises

Curriculum Lab 1-1: Connecting Console Interfaces (1.2.5)

Figure 1-8 Topology for Lab 1-1



Objective:

Connect a PC to a router using a console or rollover cable.

Background/preparation:

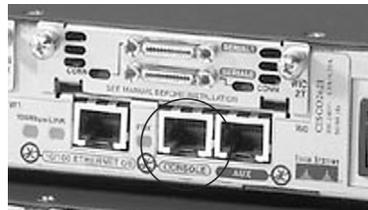
A console cable is necessary to establish a console session so that you can check or change the configuration of the router. You need the following resources:

- Workstation with a serial interface
- Cisco router
- Console rollover cable for connecting the workstation to the router

Task 1: Identify Connectors and Components

Examine the router and locate the RJ-45 connector labeled “Console,” as shown in Figure 1-9.

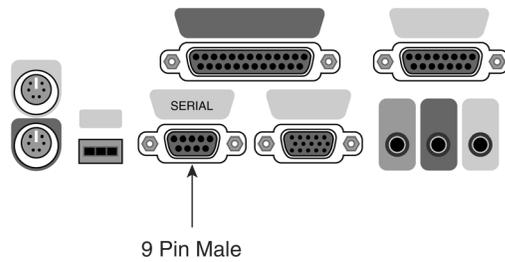
Figure 1-9 Locating the RJ-45 Console Connector on a Router



Task 2: Identify the Computer Serial Interface (COM 1 or 2)

Examine the computer and locate a 9- or 25-pin male connector labeled “Serial,” as shown in Figure 1-10. (It might not have a label.)

Figure 1-10 Locating the COM Port on a PC



Task 3: Locate the RJ-45-to-DB9 Adapter

This task calls for you to locate the RJ-45-to-DB9 adapter, which is shown in Figure 1-11.

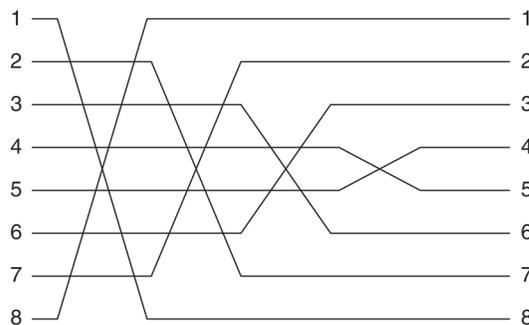
Figure 1-11 RJ-45-to-DB9 Female Adapter



Task 4: Locate or Build a Rollover Cable

Use a console or rollover cable of adequate length (see Figure 1-12), making one if necessary, to connect the router to one of the workstations.

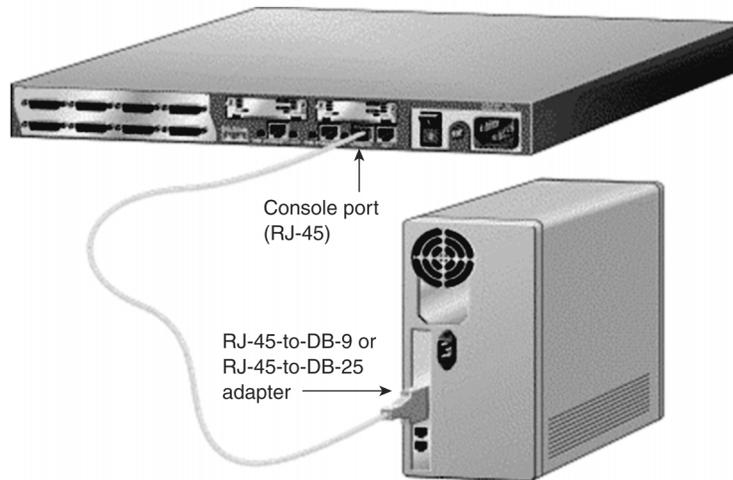
Figure 1-12 Using a Rollover Cable



Task 5: Connect Cabling Components

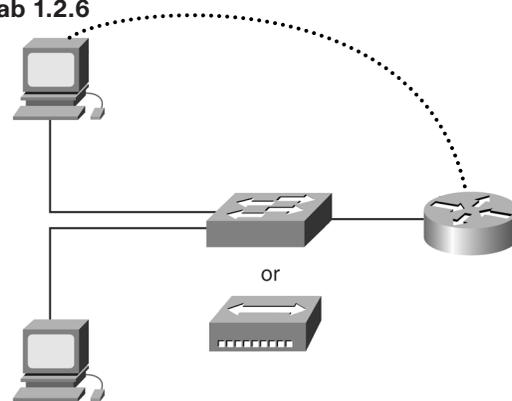
- Step 1.** Connect the console or rollover cable to the router console port using an RJ-45 connector. Next, connect the other end of the console or rollover cable to the RJ-45-to-DB9 or the RJ-45-to-DB25 adapter, depending on the available PC serial port.
- Step 2.** Attach the adapter to a PC serial port, either DB9 or DB25, depending on the computer. Figure 1-13 illustrates the necessary connections.

Figure 1-13 Connecting the Router to the PC



Curriculum Lab 1-2: Connecting Router LAN Interfaces (1.2.6)

Figure 1-14 Topology for Lab 1.2.6



- Straight-Through Cable
- Rollover (Console) Cable
- - - - Crossover Cable
- Serial Cable

Objectives:

This lab contains the following objectives:

- Identify the Ethernet or Fast Ethernet interfaces on the router.
- Identify and locate the proper cables to connect the router and PC to a hub or switch.
- Use the cables to connect the router and PC to the hub or switch.

Background/Preparation:

This lab focuses on the ability to connect the physical cabling between Ethernet LAN devices, such as hubs and switches, and the appropriate Ethernet interface on a router. The computers and router should already have the correct IP network settings. Start this lab with the computers, router, and hub or switch turned off and unplugged. You need the following resources:

- At least one workstation with an Ethernet 10/100 NIC installed
- One Ethernet switch or hub
- One router with an RJ-45 Ethernet or Fast Ethernet interface (or an attachment unit interface [AUI])
- One 10BASE-T AUI transceiver (DB15-to-RJ-45) for a router with an AUI Ethernet interface (2500 series)
- Several Ethernet cables (straight-through and crossover) for connecting the workstation and router to the hub or switch

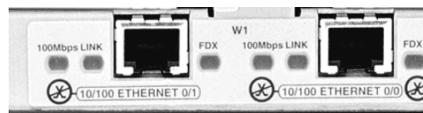
Task 1: Identify the Ethernet or Fast Ethernet Interfaces on the Router

Step 1. Examine the router.

What is the model number of the router?

Step 2. Locate one or more RJ-45 connectors on the router labeled “10/100 Ethernet” (see Figure 1-15). This identifier can vary depending on the type of router. A 2500 Series router has an AUI DB15 Ethernet port labeled AUI 0. This port requires a 10BASE-T transceiver to connect to the RJ-45 cable.

Figure 1-15 RJ-45 Ethernet Connectors on the Router



Step 3. Identify the Ethernet ports that you could use for connecting the routers. Record the information in the following table. Record the AUI port numbers if you are working with a Cisco 2500 Series router.

Router	Port	Port

Task 2: Identify the Proper Cables and Connect the Router to a Hub or Switch

Step 1. You can make the connection between the router and the hub using a Category 5 (CAT 5) or better straight-through patch cable. Locate a patch cable that is long enough to reach from the router to the hub. Be sure to examine the cable ends carefully and select only straight-through cables.

- Step 2.** Use a cable to connect the Ethernet interface that uses the 0 (zero) designation on the router to a port on the hub or switch. Also use the 10BASE-T AUI transceiver for the 2500 Series.

Task 3: Connect the Workstation Ethernet Cabling

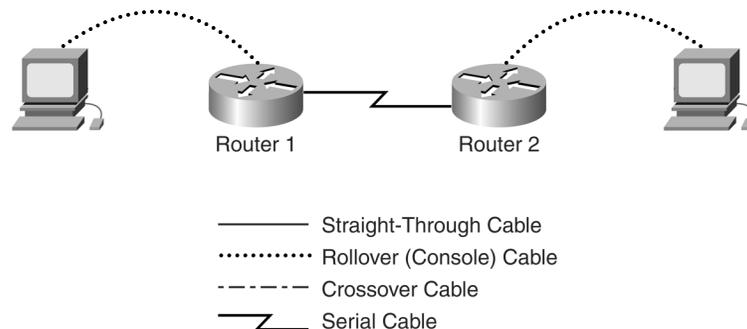
The computers can also connect to the hub using a straight-through patch cable. Run CAT 5 patch cables from each PC to where the switch or hub is located. Connect one end of these cables to the RJ-45 connector on the computer NIC, and connect the other end to a port on the hub or switch. Be sure to examine the cable ends carefully and select only straight-through cables.

Task 4: Verify the Connection

- Step 1.** Plug in and turn on the routers, computers, and hub or switch.
- Step 2.** To verify the router connections, ensure that the link lights on the router interface and the hub or switch interface are both illuminated.
- Step 3.** To verify the computer connections, ensure that the link lights on the NIC and the hub interface are both illuminated.

Curriculum Lab 1-3: Connecting WAN Interfaces (1.2.7)

Figure 1-16 Topology for Lab 1.2.7



Objectives:

This lab contains the following objectives:

- Identify the serial interfaces on the router.
- Identify and locate the proper cables to connect the routers.
- Use the cables to connect the routers.

Background/Preparation:

This lab connects two routers using directly attached cables to simulate a WAN link. This setup lets you configure and test the routers as though they were geographically separated. You can consider this simulated WAN link, which takes the place of the service provider's network, a CSU/DSU eliminator. The first steps involve finding out the kinds of connections on the router and the kinds of cables you need.

Task 1: Identify the Serial Interfaces on the Router

Step 1. Examine the routers.

What is the model number of the first router?

What is the model number of the second router?

How many serial ports on each router could be used for connecting the routers? Record the information in the table that follows.

Router Name	Serial Port	Serial Port
Router 1		
Router 2		

Task 2: Identify and Locate the Proper Cables

Step 1. Inspect the serial cables available in the lab. Depending on the type of router and serial card, the router might have different connectors. The two most common types are the DB60 and the smart serial connectors, as shown in Figure 1-17.

Figure 1-17 Smart Serial and DB60 Connectors



Indicate which type of interfaces the routers have in the table that follows.

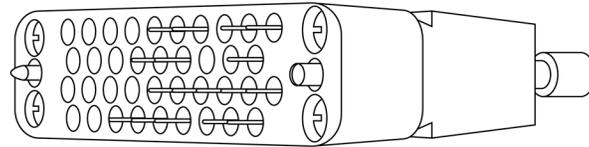
Router	Smart Serial	DB60
1		
2		

Step 2. Because this lab is not connected to a live leased line, one of the routers must provide the clocking for the circuit. The service provider normally provides the clocking signal to each of the routers. To provide this clocking signal in the lab, one of the routers needs a DCE cable instead of the DTE cable used on the other router.

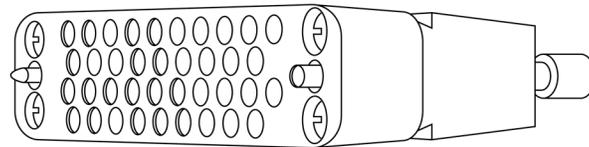
In this lab, the connection between routers uses one DCE cable and one DTE cable. The DCE-DTE connection between routers is a *null serial cable*. This lab uses one V.35 DCE cable and one V.35 DTE cable to simulate the WAN connection.

The V.35 DCE connector is usually a female V.35 (34-pin) connector. The DTE cable has a male V.35 connector. Figure 1-18 shows the male and female V.35 connectors. The cables are also labeled as DCE or DTE on the router end.

Figure 1-18 V.35 Male and Female Connectors



V.35 Male



V.35 Female

Using the chart in the table that follows, identify the V.35 cable that you can use on each router by placing a check mark in the appropriate column.

Router	DTE (V.35 Male)	DCE (V.35 Female)
Router 1		
Router 2		

Step 3. After indicating the cables required to interconnect the router, locate them in the equipment inventory.

Task 3: Cable the Routers

Step 1. You must now join the DTE and DCE V.35 cables. Holding the V.35 ends in each hand, examine the pins and sockets as well as the threaded connectors. Note that the cables can fit together only one proper way. Align the pins on the male cable with the sockets on the female cable and gently couple them; this should require little effort. Turn the thumbscrews (clockwise) and secure the connectors.

Step 2. Before making the connection to one of the routers, examine the connector on the router and the cable. Note that the connectors are tapered to help prevent improper connection. Holding the connector in one hand, orient the cable and router connectors so that the tapers match. Now, push the cable connector partially into the router connector. It probably will not go on all the way because you must tighten the threaded connectors to completely insert the cable. While holding the cable in one hand and gently pushing the cable toward the router, turn one of the thumbscrews clockwise three or four rounds to start the screws. Now, turn the other thumbscrew clockwise three or four rounds to get it started. At this point, the cable should be attached enough that you can use both hands to advance each thumbscrew at the same rate until the cable is fully inserted. Do not overtighten these connectors.

Task 2: Choose the Cables

Now choose the cables that you need to correctly connect the device. Notice that one router is connected to a switch, while the other router is directly attached to a PC. List the cable types that you need.

Connection	Cable Type
Router to router	
Router to PC (in-band)	
Router to switch	
Switch to PC	
Router to PC (out-of-band)	

What other software or hardware would you need to connect and configure this network?

Task 3: Connect the Devices

Using what you have learned so far, connect the devices with the cables according to the topology.

Task 4: Verify Connectivity

The devices should all have link lights on the interfaces you have used for your connections. Check and make sure that they are illuminated. This is a good way to verify that, at least physically, you have correctly connected the devices. Also, have someone more experienced check your work. In future labs, your connectivity problems can many times be found at the physical layer. Correctly connecting devices is the first step in successfully completing all labs.

You can check your console connectivity by opening a terminal session with the routers. If the router responds to the **Enter** key, your console connection is ready for management configuration.