Chapter 4

Name of the chapter

4.1 CLI Access Option

Like any other piece of computer hardware, Cisco switches need some kind of operating system software. Cisco calls this OS the Internetwork Operating System (IOS). Cisco IOS Software for Catalyst switches implements and controls logic and functions performed by a Cisco switch. Besides controlling the switch's performance and behavior, Cisco IOS also defines an interface for humans called the command line interface (CLI). The Cisco IOS CLI allows the user to use a terminal emulation program, which accepts text entered by the user. When the user presses Enter, the terminal emulator sends that text to the switch. The switch processes the text as if it is a command, does what the command says, and sends text back to the terminal emulator. The switch CLI can be accessed through three popular methods—the console, Telnet, and Secure Shell (SSH). Two of these methods (Telnet and SSH) use the IP network in which the switch resides to reach the switch. The console is a physical port built specifically to allow access to the CLI. Fig. 4.1 depicts the options.

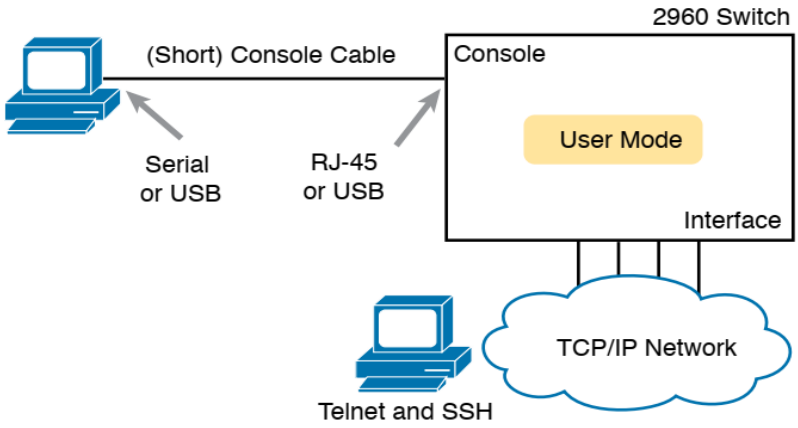

Figure 4.1 CLI access options

Console access requires both a physical connection between a PC (or other user device) and the switch's console port, as well as some software on the PC. Telnet and SSH require software on the user's device, but they rely on the existing TCP/IP network to transmit data. The next few pages detail how to connect the console and set up the software for each method to access the CLI.

Cabling the Console Connection

The physical console connection, both old and new, uses three main components: the physical console port on the switch/router, a physical serial port on the PC, and a cable that works with the console and serial ports. However, the physical cabling details have changed slowly over time, mainly because of advances and changes with serial interfaces on PC hardware. For this next topic, the text looks at three cases: newer connectors on both the PC and the switch, older connectors on both, and a third case with the newer (USB) connector on the PC but with an older connector on the switch.

Most PCs today use a familiar standard USB cable for the console connection. Cisco has been including USB ports as console ports in newer routers and switches as well. All you have to do is look at the switch to make sure you have the correct style of USB cable end to match the USB console port. In the simplest form, you can use any USB port on the PC, with a USB cable, connected to the USB console port on the switch or router, as shown on the far right side of Fig. 4.2.

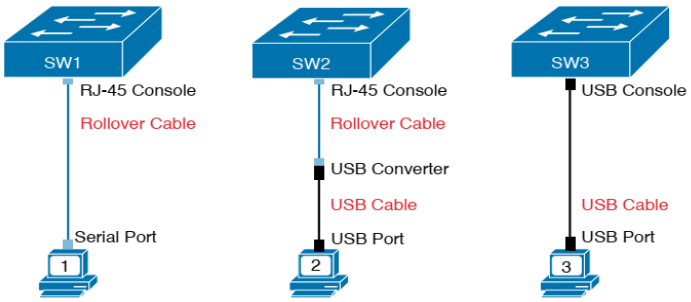

Figure 4.2 Console Connection to a Switch

Older console connections use a PC serial port that pre-dates USB, a UTP cable, and an RJ-45 console port on the switch, as shown on the left side of Figure 4-3. The PC serial port typically has a D-shell connector (roughly rectangular) with nine pins (often called a DB-9 (see Fig. 4.3)). The console port looks like any Ethernet RJ-45 port (but is typically colored in blue and with the word console beside it on the switch).

The cabling for this older-style console connection can be simple or require some effort, depending on what cable you use. You can use the purpose-built console cable that ships with new Cisco switches and routers and not think about the details. However, you can make your own cable with a standard serial cable (with a connector that matches the PC), a standard RJ-45 to DB-9 converter plug, and a UTP cable. However, the UTP cable does not use the same pinouts as Ethernet; instead, the cable uses rollover cable pinouts rather than any of the standard Ethernet cabling pinouts. The rollover pinout uses eight wires, rolling the wire at pin 1 to pin 8, pin 2 to pin 7, pin 3 to pin 6, and so on.

As it turns out, USB ports became common on PCs before Cisco began commonly using USB for its console ports. So, you also have to be ready to use a PC that has only a USB port and not an old serial port, but a router or switch that has the older RJ-45 console port (and no USB console port). The center of Fig. 4.2 shows that case. To connect such a PC to a router or switch console,

you need a USB converter that converts from the older console cable to a USB connector, and a rollover UTP cable, as shown in the middle of Fig. 4.2.

The 2960-XR series, for instance, supports both the older RJ-45 console port and a USB console port. Fig. 4.4 points to the two console ports; you would use only one or the other. Note that the USB console port uses a mini-B port rather than the more commonly seen rectangular standard USB Type A port.

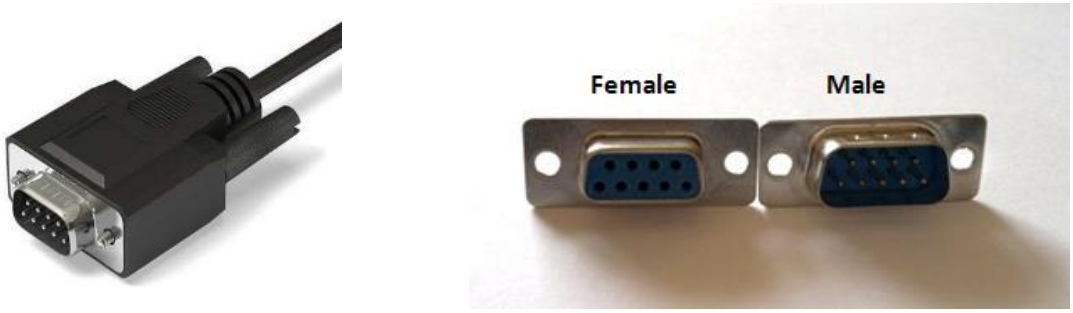

Figure 4.3 DB9 Connector (For serial port of PC)

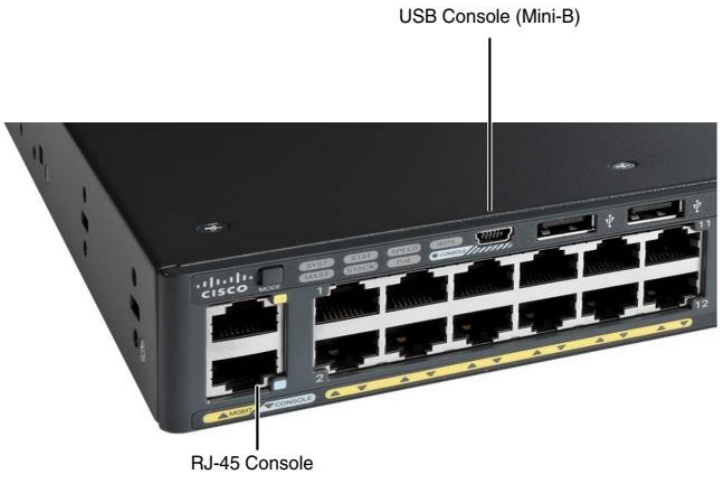

Figure 4.4 A Part of a 2960-XR Switch with Console Ports Shown

After the PC is physically connected to the console port, a terminal emulator software package must be installed and configured on the PC. The terminal emulator software treats all data as text. It accepts the text typed by the user and sends it over the console connection to the switch. Similarly, any bits coming into the PC over the console connection are displayed as text for the user to read.

4.2 Terminal Emulation Software

The best way to manage the Cisco IOS is through a terminal emulator using the CLI. You can use a terminal emulator to connect to a router, switch, or firewall's CLI interface either over the network using Telnet or SSH protocols or over a serial line connected to the console of the device.

SecureCRT

A product of VanDyke Software, SecureCRT provides Telnet, serial, and SSH for the Windows OS. It offers a script recorder, logging, and multiple session windows. SecureCRT integrates with SecureFX for file transfer, and it only works on Windows.

PuTTY

An implementation of Telnet and SSH for Windows and UNIX platforms, PuTTY provides Telnet, serial, and SSH. It features a single executable to run and no installation. It supports logging, and source code is freely available. One downside is that the connection list isn't easily stored.

Currently PuTTY hasn't seen heavy development, but it works great. Also available are PuTTYtel, PSCP, PSFTP, Plink, Pageant, and PuTTYgen, as well as hundreds of other products based on the source code of PuTTY.

TeraTerm Pro

Available from Ayera Technologies' Web site, TeraTerm Pro provides Telnet, serial, and SSH for the Windows OS. It supports logging, and the source code is freely available. It offers a saved setup, as well as add-ons such as a macros editor. Overall, this is a very nice terminal emulator. It's similar in look and feel to SecureCRT. TeraTerm Pro is free.

Windows telnet

Supported by the Windows OS, the telnet command provides Telnet only. It's only available at the Windows command prompt, and odds are good you're already familiar with this option. Its biggest advantage is that it's free.

Windows HyperTerminal

Also included in the Windows OS, the Windows HyperTerminal program provides Telnet and serial, but no SSH. It offers logging and XMODEM file transfer to get files onto switches or routers with the correct IOS. While Windows HyperTerminal is also free, it can be frustrating to use sometimes.

4.3 Accessing CLI Through Telnet and Secure Shell

For many years, terminal emulator applications have supported far more than the ability to communicate over a serial port to a local device (like a switch’s console). Terminal emulators support a variety of TCP/IP applications as well, including Telnet and SSH. Telnet and SSH both allow the user to connect to another device’s CLI, but instead of connecting through a console cable to the console port, the traffic flows over the same IP network that the networking devices are helping to create.

Telnet uses the concept of a Telnet client (the terminal application) and a Telnet server (the switch in this case). A Telnet client, the device that sits in front of the user, accepts keyboard input and sends those commands to the Telnet server. The Telnet server accepts the text, interprets the text as a command, and replies back.

Cisco Catalyst switches enable a Telnet server by default, but switches need a few more configuration settings before you can successfully use Telnet to connect to a switch.

Using Telnet in a lab today makes sense, but Telnet poses a significant security risk in production networks. Telnet sends all data (including any username and password for login to the switch) as clear-text data. SSH gives us a much better option.

Think of SSH as the much more secure Telnet cousin. Outwardly, you still open a terminal emulator, connect to the switch's IP address, and see the switch CLI, no matter whether you use Telnet or SSH. The differences exist behind the scenes: SSH encrypts the contents of all messages, including the passwords, avoiding the possibility of someone capturing packets in the network and stealing the password to network devices.

4.4 Modes of Cisco CLI

All three CLI access methods covered so far (console, Telnet, and SSH) place the user in an area of the CLI called user EXEC mode. User EXEC mode, sometimes also called user mode, allows the user to look around but not break anything. The "EXEC mode" part of the name refers to the fact that in this mode, when you enter a command, the switch executes the command and then displays messages that describe the command's results.

Cisco IOS supports a more powerful EXEC mode called enable mode (also known as privileged mode or privileged EXEC mode). Enable mode gets its name from the enable command, which moves the user from user mode to enable mode, as shown in Fig. 4.5. The other name for this mode, privileged mode, refers to the fact that powerful (or privileged) commands can be executed there. For example, you can use the reload command, which tells the switch to reinitialize or reboot Cisco IOS, only from enable mode. Please note that if the command prompt lists the hostname followed by a >, the user is in user mode; if it is the hostname followed by the #, the user is in enable mode.

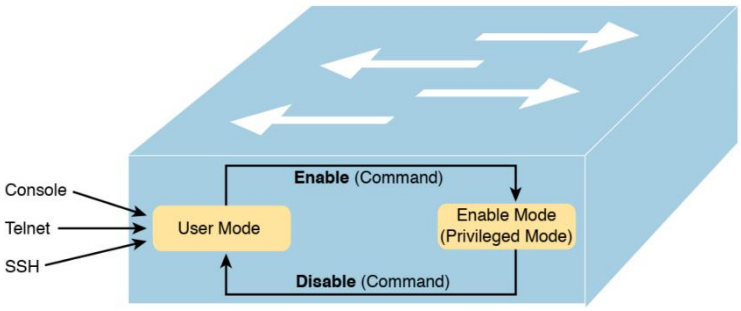

Figure 4.5 User and privileged modes

Global configuration mode is another mode for the Cisco CLI, similar to user mode and privileged mode. User mode lets you issue nondisruptive commands and displays some information. Privileged mode supports a superset of commands compared to user mode, including commands that might disrupt switch operations. However, not one of the commands in user or privileged mode changes the switch's configuration. Configuration mode accepts configuration commands—commands that tell the switch the details of what to do and how to do it. Fig. 5.6 illustrates the relationships among configuration mode, user EXEC mode, and privileged EXEC mode.

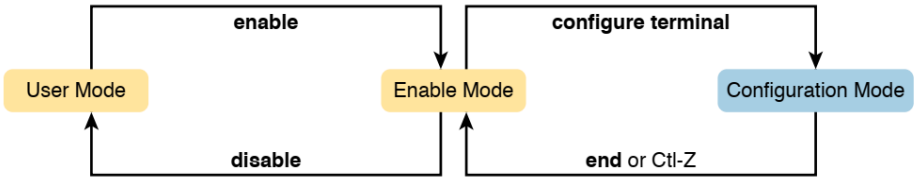

Figure 4.6 CLI Configuration Mode Versus EXEC Modes

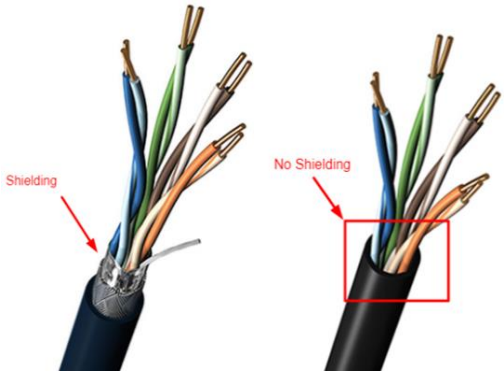

Figure 4.7 Ethernet cables (twisted pair)

4.5 Ethernet Cabling

Cable Types

Twisted pair cables are widely used in the transferring information, especially over long a distances. The twist in the cable cancels out any magnetic interference that may develop in the wiring. There are two common types of twisted pair cabling, shielded twisted pair (STP) and unshielded twisted pair (UTP). Both cables consist of four pairs of wires with color coding as shown in Fig. 4.7.

The unshielded in UTP refers to the lack of metallic shielding around the copper wires. By its very nature, the twisted-pair design helps minimize electronic interference by providing balanced signal transmission, making a physical shield unnecessary.

The Unshielded twisted pair is the most commonly used in telephone cables, computer networks, and even in video applications such as security cameras. UTP cables are generally used in short lengths such as inside a building, or within a server room.

Unshielded Twisted Pairs cable is susceptible to radio and electrical frequency interference. Though more expensive, Shielded Twisted Pair (STP) cables are a better option. Shielded Twisted pair cables can also be useful in extending maximum distance of cables. Shielded cable is available in three configurations:

- Every pair of wire is separately shielded with foil
- All wires having a braid shield inside the wire jacket
- Each individual pair having a shield, besides having another around the whole group of wires

In a shielded twisted pair (STP), the wires are enclosed in a shield that functions as a grounding mechanism. This is done so it can provide a greater protection from electromagnetic interference and radio Infrequency interference, allowing it to carry data at a faster rate of speed.

Therefore, STP cable is often used in high end applications that require high bandwidth and outdoor environments. UTP cable is often used in home, office and large scale businesses.

Speed and applications of different categories of twisted pair cable are shown in Table I. The speed mentioned in the table is applicable for cable length of 100 meter.

TABLE I Categories of Ethernet Cables

Category	Speed (Mbps)	Common use
Cat 1	< 1	Analog voice
Cat 2	4	ARCNET
Cat 3	10	10baseT Ethernet
Cat 4	16	Token Ring
Cat 5	100	100baseT Ethernet
Cat 5e	1000	1000baseT Ethernet
Cat 6	1000	1000baseT Ethernet

Transmitting Data Using Twisted Pairs

While it is true that Ethernet sends data over UTP cables, the physical means to send the data uses electricity that flows over the wires inside the UTP cable. To better understand how Ethernet sends data using electricity, break the idea down into two parts: how to create an electrical circuit and then how to make that electrical signal communicate 1s and 0s.

First, to create one electrical circuit, Ethernet defines how to use the two wires inside a single twisted pair of wires, as shown in Fig. 4.8. The figure does not show a UTP cable between two nodes, but instead shows two individual wires that are inside the UTP cable. An electrical circuit requires a complete loop, so the two nodes, using circuitry on their Ethernet ports, connect the wires in one pair to complete a loop, allowing electricity to flow.

Breaking Down a UTP Ethernet Link

The term Ethernet link refers to any physical cable between two Ethernet nodes. To learn about how a UTP Ethernet link works, it helps to break down the physical link into those basic pieces, as shown in Fig.4.9: the cable itself, the connectors on the ends of the cable, and the matching ports on the devices into which the connectors will be inserted First, think about the UTP cable itself. The cable holds some copper wires, grouped as twisted pairs. The 10BASE-T and 100BASE-T standards require two pairs of wires, while the 1000BASE-T standard requires four pairs. Each wire has a color-coded plastic coating, with the wires in a pair having a color scheme. For example, for the blue wire pair, one wire's coating is all blue, while the other wire's coating is blue-and-white striped.

Many Ethernet UTP cables use an RJ-45 connector on both ends. The RJ-45 connector has eight physical locations into which the eight wires in the cable can be inserted, called pin positions, or simply pins. These pins create a place where the ends of the copper wires can touch the electronics inside the nodes at the end of the physical link so that electricity can flow.

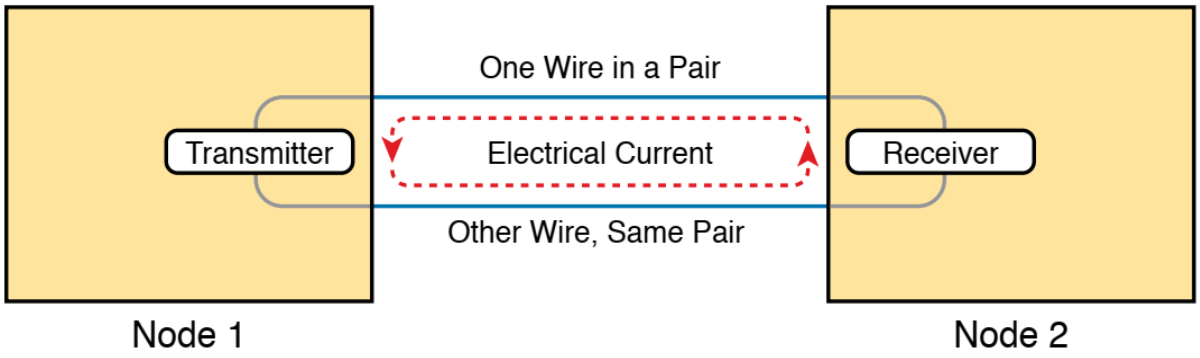

Figure 4.8 Creating One Electrical Circuit over One Pair to Send in One Direction

To complete the physical link, the nodes each need an RJ-45 Ethernet port that matches the RJ-45 connectors on the cable so that the connectors on the ends of the cable can connect to each node. PCs often include this RJ-45 Ethernet port as part of a network interface card (NIC), which can be an expansion card on the PC or can be built in to the system itself. Switches typically have many RJ-45 ports because switches give user devices a place to connect to the Ethernet LAN. Fig. 4.9 shows photos of the cables, connectors, and ports.

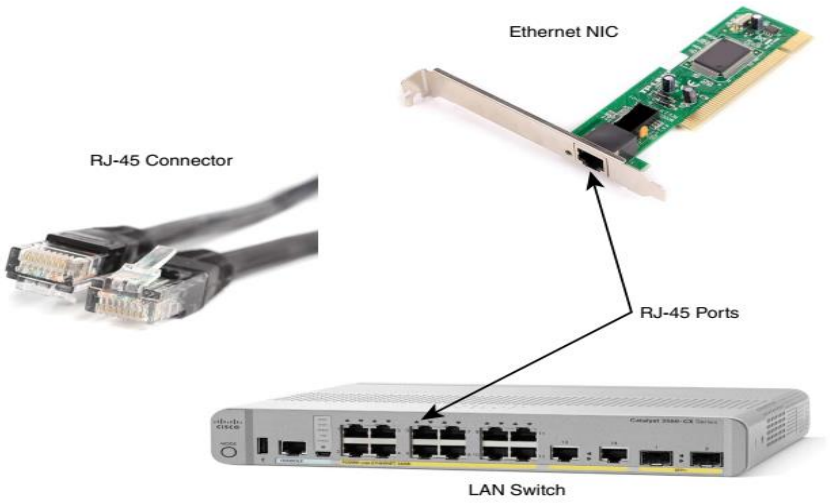

Figure 4.9 RJ-45 Connectors and Ports

The figure shows a connector on the left and ports on the right. The left shows the eight pin positions in the end of the RJ-45 connector. The upper right shows an Ethernet NIC that is not yet installed in a computer. The lower-right part of the figure shows the side of a Cisco switch, with multiple RJ-45 ports, allowing multiple devices to easily connect to the Ethernet network.

Finally, while RJ-45 connectors with UTP cabling can be common, Cisco LAN switches often support other types of connectors as well. When you buy one of the many models of Cisco switches, you need to think about the mix and numbers of each type of physical ports you want on the switch.

UTP Cabling Pinouts for 10BASE-T and 100BASE-T

Straight-Through Cable Pinout

10BASE-T and 100BASE-T use two pairs of wires in a UTP cable, one for each direction, as shown in Figure 4.10. The figure shows four wires, all of which sit inside a single UTP cable that connects a PC and a LAN switch. In this example, the PC on the left transmits using the top pair, and the switch on the right transmits using the bottom pair.

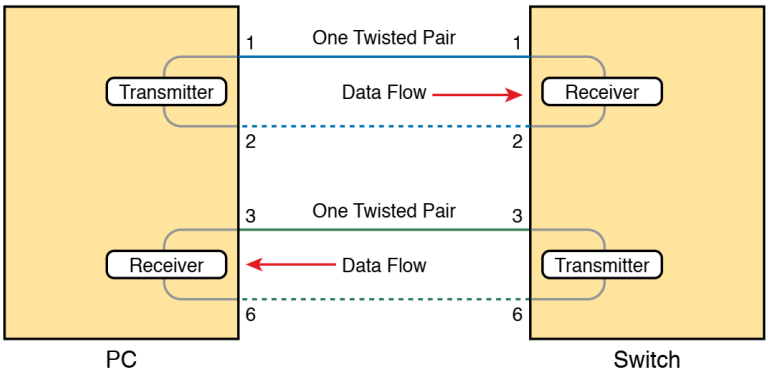

Figure 4.10 Using One Pair for Each Transmission Direction with 10- and 100-Mbps Ethernet

For correct transmission over the link, the wires in the UTP cable must be connected to the correct pin positions in the RJ-45 connectors. For example, in Fig. 4.10, the transmitter on the PC on the left must know the pin positions of the two wires it should use to transmit. Those two wires must be connected to the correct pins in the RJ-45 connector on the switch so that the switch's receiver logic can use the correct wires.

To understand the wiring of the cable—which wires need to be in which pin positions on both ends of the cable—you need to first understand how the NICs and switches work. As a rule, Ethernet NIC transmitters use the pair connected to pins 1 and 2; the NIC receivers use a pair of wires at pin positions 3 and 6. LAN switches, knowing those facts about what Ethernet NICs do, do the opposite: Their receivers use the wire pair at pins 1 and 2, and their transmitters use the wire pair at pins 3 and 6.

To allow a PC NIC to communicate with a switch, the UTP cable must also use a straight-through cable pinout. The term pinout refers to the wiring of which color wire is placed in each of the eight numbered pin positions in the RJ-45 connector. An Ethernet straight-through cable connects the wire at pin 1 on one end of the cable to pin 1 at the other end of the cable; the wire at pin 2 needs to connect to pin 2 on the other end of the cable; pin 3 on one end connects to pin 3 on the other, and so on, as seen in Fig. 11. Also, it uses the wires in one wire pair at pins 1 and 2, and another pair at pins 3 and 6.

A straight-through cable works correctly when the nodes use opposite pairs for transmitting data. However, when two like devices connect to an Ethernet link, they both transmit on the same pins. In that case, you then need another type of cabling pinout called a crossover cable. The crossover cable pinout crosses the pair at the transmit pins on each device to the receive pins on the opposite device.

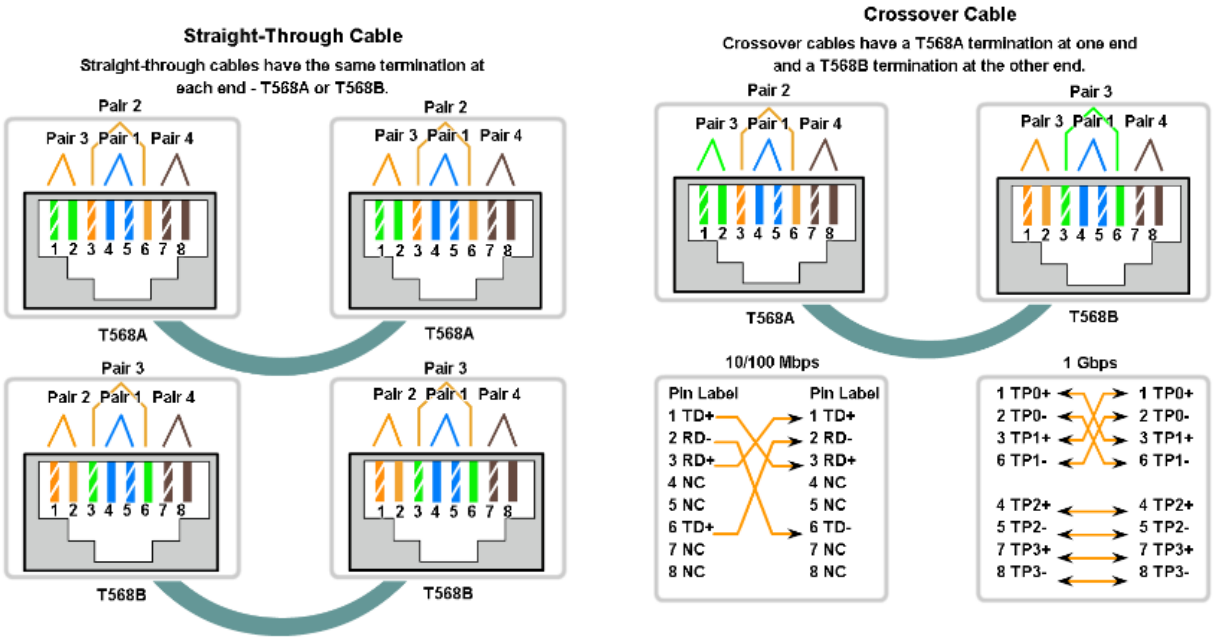

Figure 4.11 Color coding for straight-through cable and crossover cable.

While that previous sentence is true, this concept is much clearer with a figure such as Fig. 4.11. The figure shows what happens on a link between two switches. The two switches both transmit on the pair at pins 3 and 6, and they both receive on the pair at pins 1 and 2. So, the cable must connect a pair at pins 3 and 6 on each side to pins 1 and 2 on the other side, connecting to the other node's receiver logic. The top of the figure shows the literal pinouts, and the bottom half shows a conceptual diagram.

Choosing the Right Cable Pinouts

For the exam, you should be well prepared to choose which type of cable (straight-through or crossover) is needed in each part of the network. The key is to know whether a device acts like a PC NIC, transmitting at pins 1 and 2, or like a switch, transmitting at pins 3 and 6.

Then, just apply the following logic:

- Crossover cable: If the endpoints transmit on the same pin pair
- Straight-through cable: If the endpoints transmit on different pin pairs

TABLE II 10BASE-T and 100BASE-T Pin Pairs Used

Transmits on Pins 1,2	Transmits on Pins 3,6
PC NICs	Hubs
Router	Switches
Wireless Access Points (Ethernet interfaces)	-

Table II lists the devices and the pin pairs they use, assuming that they use 10BASE-T and 100BASE-T.

For example, Fig. 4.12 shows a campus LAN in a single building. In this case, several straight-through cables are used to connect PCs to switches. In addition, the cables connecting the switches require crossover cables.

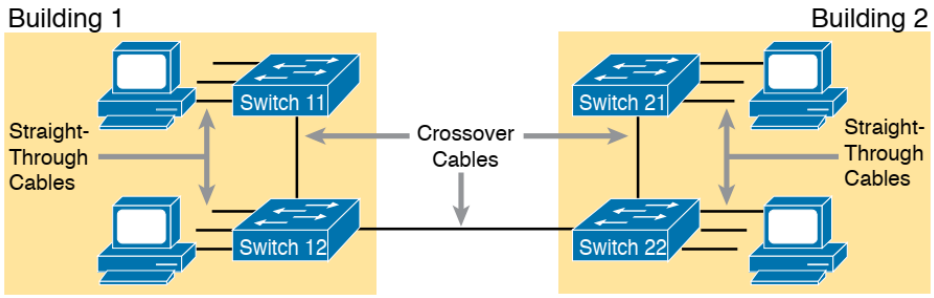

Figure 4.12 Typical Uses for Straight-Through and Crossover Ethernet Cables

UTP Cabling Pinouts for 1000BASE-T

1000BASE-T (Gigabit Ethernet) differs from 10BASE-T and 100BASE-T as far as the cabling and pinouts. First, 1000BASE-T requires four wire pairs. Second, it uses more advanced electronics that allow both ends to transmit and receive simultaneously on each wire pair. However, the wiring pinouts for 1000BASE-T work almost identically to the earlier standards, adding details for the additional two pairs. The straight-through cable for 1000BASE-T uses the four wire pairs to create four circuits, but the pins need to match. It uses the same pinouts for two pairs as do the 10BASE-T and 100BASE-T standards, and it adds a pair at pins 4 and 5 and the final pair at pins 7 and 8, as shown in Fig. 4.11.

The Gigabit Ethernet crossover cable crosses the same two-wire pairs as the crossover cable for the other types of Ethernet (the pairs at pins 1,2 and 3,6). It also crosses the two new pairs as well (the pair at pins 4,5 with the pair at pins 7,8).