CHAPTER 2

Exploring the Enterprise Network Infrastructure

Objectives

Upon completion of this chapter, you should be able to answer the following questions:

- What are the main types of network documentation and how are they interpreted?
- What equipment is found in the enterprise Network Operations Center?
- What is the point of presence for service delivery and how is service delivered?
- What are network security considerations and what equipment is used at the enterprise edge?
- What are some characteristics of router and switch hardware?
- What are the most common and useful router and switch CLI configuration and verification commands?

Key Terms

This chapter uses the following key terms. You can find the definitions in the Glossary.

physical topology page 22

logical topology page 22

control plane page 22

redlined page 24

as-built page 24

business continuity plan (BCP) page 24

business security plan (BSP) page 25

network maintenance plan (NMP) page 25

service-level agreement (SLA) page 25

Network Operations Center (NOC) page 26

data center page 26

server farm page 26

load balancing page 26

network attached storage (NAS) page 27

storage-area network (SAN) page 27

rack units (RU) page 27

Structured cabling page 28

electromagnetic interference (EMI) page 28

telecommunications room page 29

intermediate distribution facility (IDF) page 29

access point (AP) page 29

main distribution facility (MDF) page 29

extended star page 29

Power over Ethernet (PoE) page 31

point of presence (POP) page 31

service provider (SP) page 32

(T1/E1) page 33

punchdown block page 33

channel service unit/data service unit (CSU/DSU) page 33

customer premise equipment (CPE) page 34

form factors page 36

out-of-band page 37

in-band page 37

Port density page 49

Enterprise networks contain hundreds of sites and support thousands of users worldwide. A well-managed network allows users to work reliably. Network documentation is crucial for maintaining the required 99.999 percent uptime. All Internet traffic flows through the enterprise edge, making security considerations necessary. Routers and switches provide connectivity, security, and redundancy while controlling broadcasts and failure domains.

Describing the Current Network

The following sections describe network documentation required to support the enterprise and equipment found in the Network Operations Center as well as telecommunications room design considerations.

Enterprise Network Documentation

One of the first tasks for a new network technician is to become familiar with the current network structure. Enterprise networks can have thousands of hosts and hundreds of networking devices, all of which are interconnected by copper, fiber-optic, and wireless technologies. End-user workstations, servers, and networking devices, such as switches and routers, must all be documented. Various types of documentation show different aspects of the network.

Network infrastructure diagrams, or topology diagrams, keep track of the location, function, and status of devices. Topology diagrams represent either the physical or logical network.

A ***physical topology*** map uses icons to document the location of hosts, networking devices, and media. It is important to maintain and update physical topology maps to aid future installation and troubleshooting efforts.

A ***logical topology*** map groups hosts by network usage, regardless of physical location. Host names, addresses, group information, and applications can be recorded on the logical topology map. Connections between multiple sites might be shown but do not represent actual physical locations.

Enterprise network diagrams can also include ***control plane*** information. Control plane information describes failure domains and defines the interfaces where different network technologies intersect. Figure 2-1 shows a physical topology and Figure 2-2 shows the corresponding logical topology.

Figure 2-1 Physical Network Topology

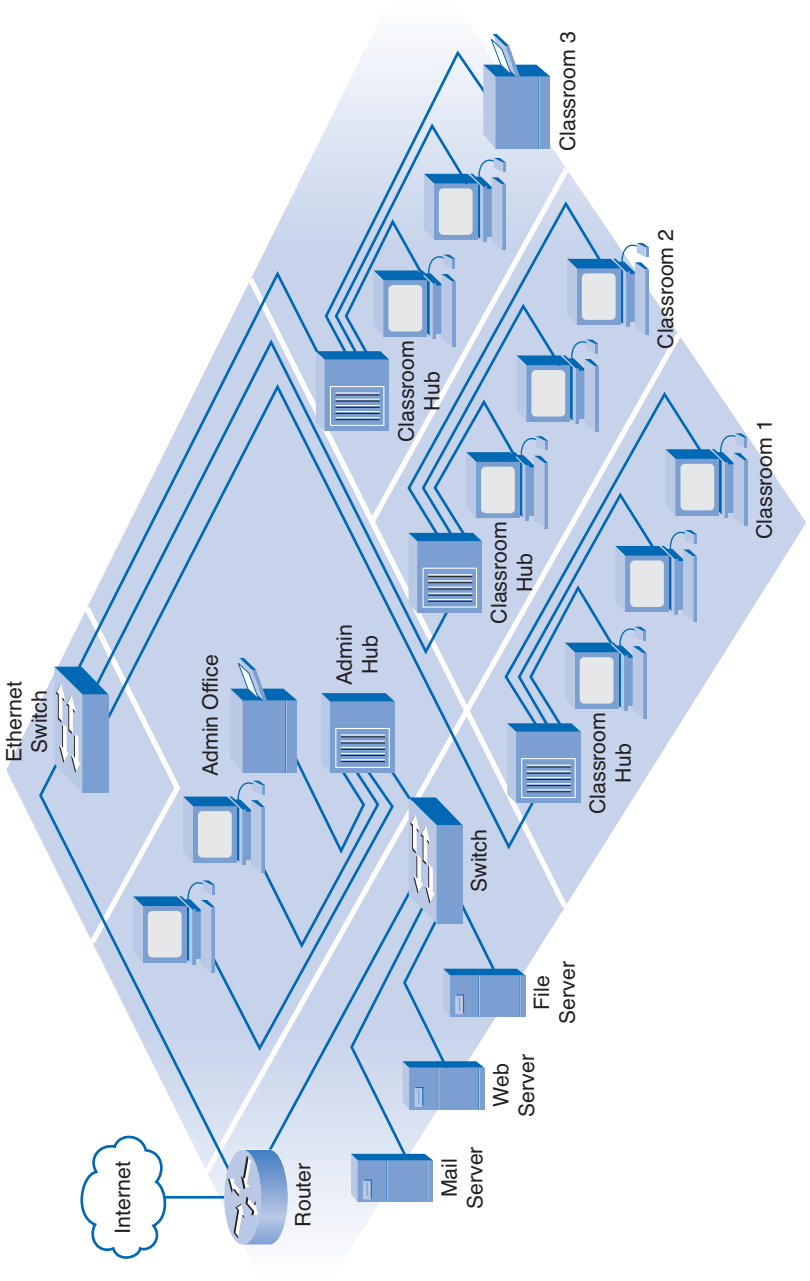
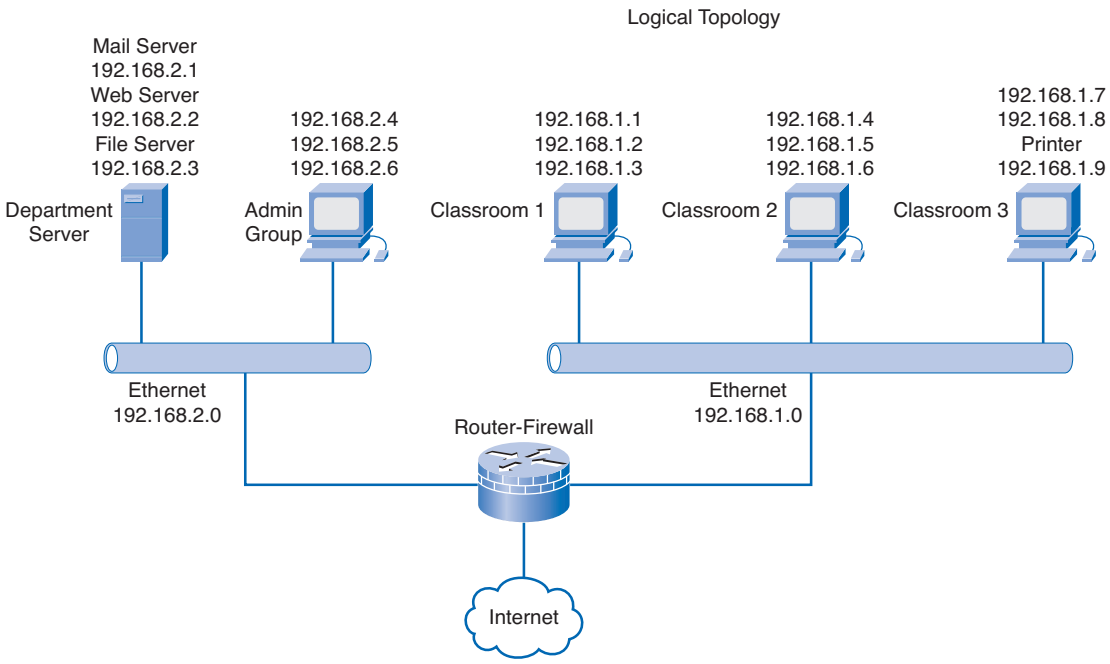


Figure 2-2 Logical Network Topology



It is crucial that network documentation remain current and accurate. Network documentation is usually accurate at the installation of a network. As the network grows or changes, however, you need to update the documentation.

Network topology maps are frequently based on original floor plans. The current floor plans might have changed since the construction of the building. Blueprints can be marked up, or ***redlined***, to show the changes. The modified diagram is known as an ***as-built***. An as-built diagram documents how a network was actually constructed, which can differ from the original plans. Always ensure that the current documentation reflects the as-built floor plan and all network topology changes.

Network diagrams are commonly created using graphical drawing software. In addition to being a drawing tool, many network diagramming tools are linked to a database. This feature allows the network support staff to develop detailed documentation by recording information about hosts and networking devices, including manufacturer, model number, purchase date, warranty period, and more. Clicking a device in the diagram opens an entry form with device data listed.

In addition to network diagrams, several other important types of documentation are used in the enterprise network, including a business continuity plan, a business security plan, a network maintenance plan, and a service-level agreement.

Business Continuity Plan

The ***business continuity plan (BCP)*** identifies the steps to be taken to continue business operation in the event of a natural or man-made disaster. The BCP helps to ensure business operations by defining procedures that must take place when a disaster strikes. IT support can include

- Off-site storage of backup data
- Alternate IT processing centers
- Redundant communication links

Business Security Plan

The ***business security plan (BSP)*** prevents unauthorized access to organizational resources and assets by defining security policies. The BSP includes physical, system, and organizational control measures. The overall security plan must include an IT portion that describes how an organization protects its network and information assets. The IT security plan can contain policies related to

- User authentication
- Permissible software
- Remote access
- Intrusion monitoring
- Incident handling

Network Maintenance Plan

The ***network maintenance plan (NMP)*** minimizes downtime by defining hardware and software maintenance procedures. The NMP ensures business continuity by keeping the network up and running efficiently. Network maintenance must be scheduled during specific time periods, usually nights and weekends, to minimize the impact on business operations. The maintenance plan can contain

- Maintenance time periods
- Scheduled downtime
- Staff on-call responsibilities
- Equipment and software to be maintained (OS, IOS, services)
- Network performance monitoring

Service-Level Agreement

A ***service-level agreement (SLA)*** ensures service parameters by defining required service provider level of performance. The SLA is a contractual agreement between the customer and a service provider or ISP, specifying items such as network availability and service response time. An SLA can include

- Connection speeds/bandwidth
- Network uptime
- Network performance monitoring
- Problem resolution response time
- On-call responsibilities

Network documentation should be kept in a centrally located area that is available by all who need access to it. Although it is common to store network documentation on network servers in digital form, hard copy versions should also be kept in filing cabinets in the event the network or server is down. Digital and hard copy versions should also be kept in a secure off-site location in the event of a disaster.

Interactive Activity 2-1: Matching Network Information to Documentation Type (2.1.1)

In this activity, you identify the network documentation where the information would most likely be found. Use file d3ia-2114 on the CD-ROM that accompanies this book to perform this interactive activity.

Network Operations Center (NOC)

Most enterprise networks have a ***Network Operations Center (NOC)*** that allows central management and monitoring of all network resources. The NOC is sometimes referred to as a ***data center***.

Employees in a typical enterprise NOC provide support for both local and remote locations, often managing both local- and wide-area networking issues. Larger NOCs can be multiroom areas of a building where network equipment and support staff are concentrated. Figure 2-3 shows a large NOC surrounded by the types of features and equipment found there.

Figure 2-3 Network Operations Center Components and Features

The NOC usually has

- Raised floors to allow cabling and power to run under the floor to the equipment
- High-performance UPS systems and air conditioning equipment to provide a safe operating environment for equipment
- Fire suppression systems integrated into the ceiling
- Network monitoring stations, servers, backup systems, and data storage
- Access layer switches and distribution layer routers, if it serves as a main distribution facility (MDF) for the building or campus where it is located

In addition to providing network support and management, many NOCs also provide centralized resources such as servers and data storage. Servers in the NOC are usually clustered together, creating a server farm. The ***server farm*** is frequently considered as a single resource but, in fact, provides two functions: backup and ***load balancing***. If one server fails or becomes overloaded, another server takes over.

The servers in the farm can be rack-mounted and interconnected by very high-speed switches (Gigabit Ethernet or higher). They can also be blade servers mounted in a chassis and connected by a high-speed backplane within the chassis. Figure 2-4 shows a group of rack-mounted servers.

Figure 2-4 Rack-Mounted Server Farm

Server Farm

Another important aspect of the enterprise NOC is high-speed, high-capacity data storage. This data storage, or ***network attached storage (NAS)***, groups large numbers of disk drives that are directly attached to the network and can be used by any server. An NAS device is typically attached to an Ethernet network and is assigned its own IP address. Figure 2-5 shows an example of multiple rack-mounted NAS drives.

Figure 2-5 Network Attached Storage (NAS)

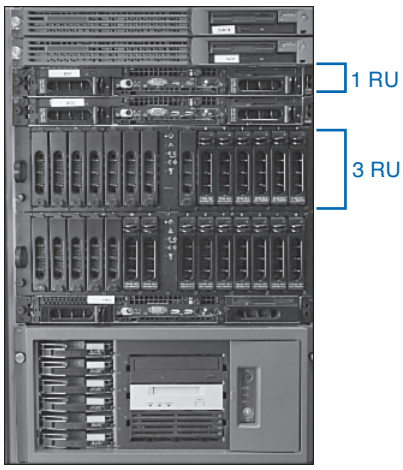
Network Attached Storage (NAS)

A more sophisticated version of NAS is a ***storage-area network (SAN)***. A SAN is a high-speed network that interconnects different types of data storage devices over a LAN or WAN.

Equipment in the enterprise NOC is usually mounted in racks. In large NOCs, racks are usually floor-to-ceiling mounted and can be attached to each other. When mounting equipment in a rack, ensure that there is adequate ventilation and access from front and back. Equipment must also be attached to a known good ground.

The most common rack width is 19 inches (48.26 cm). Most equipment is designed to fit this width. The vertical space that the equipment occupies is measured in ***rack units (RU)***. A unit equals 1.75 inches (4.4 cm). For example, a 2RU chassis is 3.5 inches (8.9 cm) high. The lower the RU number the less space a device needs; therefore, more devices can fit into the rack. Figure 2-6 shows multiple servers and disk drives in a rack configuration. Each server occupies one RU and the drives typically take two or more RUs.

Figure 2-6 Network Equipment Height Measured in RUs



Another consideration is equipment with many connections, like switches. They might need to be positioned near patch panels and close to where the cabling is gathered into cable trays.

In an enterprise NOC, thousands of cables can enter and exit the facility. ***Structured cabling*** creates an organized cabling system that is easily understood by installers, network administrators, and any other technicians who work with cables.

Cable management serves many purposes. First, it presents a neat and organized system that aids in isolating cabling problems. Second, best cabling practices protect the cables from physical damage and ***electromagnetic interference*** (***EMI***), which greatly reduces the number of problems experienced.

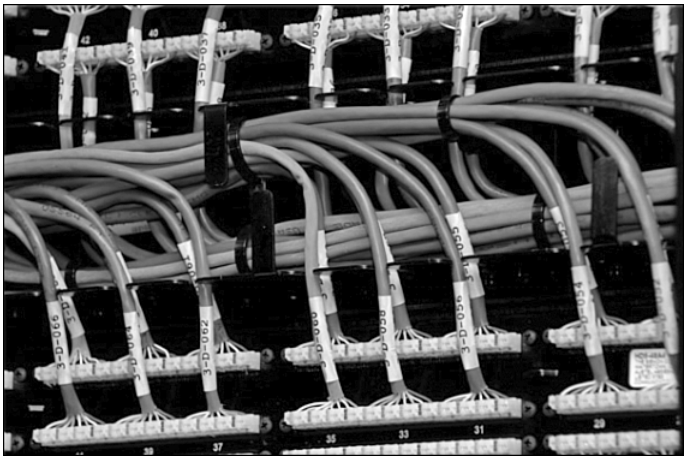
To assist in troubleshooting

- All cables should be labeled at both ends, using a standard convention that indicates source and destination.
- All cable runs should be documented on the physical network topology diagram.
- All cable runs, both copper and fiber, should be tested end to end by sending a signal down the cable and measuring loss.

Cabling standards specify a maximum distance for all cable types and network technologies. For example, the IEEE specifies that, for Fast Ethernet over unshielded twisted-pair (UTP), the cable run from switch to host cannot be greater than 100 meters (approximately 328 ft.). If the cable run is greater than the recommended length, problems could occur with data communications, especially if the terminations at the ends of the cable are poorly completed.

Documentation of the cable plan and testing are critical to network operations. Figure 2-7 shows cabling routed efficiently to the back of a patch panel. Cable bends are minimized, and each cable is clearly labeled for its destination.

Figure 2-7 Properly Routed and Labeled Cabling



Telecommunication Room Design and Considerations

The NOC is the heart of the enterprise. In practice, however, most users connect to a switch in a ***telecommunications room***, which is some distance from the NOC. The telecommunications room is also referred to as a wiring closet or ***intermediate distribution facility (IDF)***. It contains the access layer networking devices and ideally maintains environmental conditions similar to the NOC, such as air conditioning and UPS. IDFs typically contain

- Fast Ethernet switches
- Gigabit link to MDF
- Wireless access points

Users working with wired technology connect to the network through Ethernet switches or hubs. Users working with wireless technology connect through an ***access point (AP)***. Access layer devices such as switches and APs are a potential vulnerability in network security. Physical and remote access to this equipment should be limited to authorized personnel. Network personnel can also implement port security and other measures on switches, as well as various wireless security measures on APs.

Securing the telecommunications room has become even more important because of the increasing occurrence of identity theft. New privacy legislation results in severe penalties if confidential data from a network falls into the wrong hands. Modern networking devices offer capabilities to help prevent these attacks and protect data and user integrity.

Many IDFs connect to a ***main distribution facility (MDF)*** using an ***extended star*** design. The MDF is usually located in the NOC or centrally located within the building.

MDFs are typically larger than IDFs. They house high-speed switches, routers, and server farms. The central MDF switches can have enterprise servers and disk drives connected using gigabit copper links. MDFs typically contain

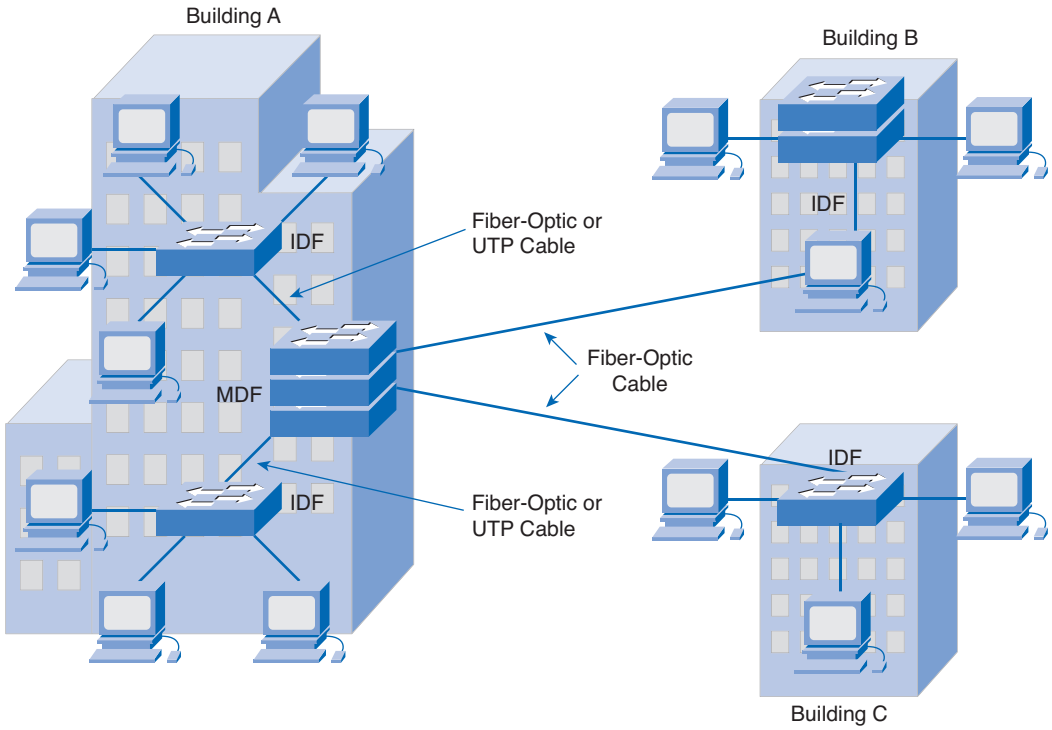
- Point of presence (POP)
- Routers
- Gigabit switches

- Gigabit links to IDFs
- Servers
- Disk storage

IDFs contain lower-speed switches, APs, and hubs. The switches in the IDFs typically have large numbers of Fast Ethernet ports for users to connect at the access layer.

The switches in the IDF usually connect to the switches in the MDF with Gigabit interfaces. This arrangement creates backbone connections, or uplinks. These backbone links, also called vertical cabling, can be copper or fiber-optic. Copper Gigabit or Fast Ethernet links are limited to a maximum of 100 meters and should use CAT5e or CAT6 UTP cable. Fiber-optic links can run much greater distances. Fiber-optic links commonly interconnect buildings, and because they do not conduct electricity, they are immune to lightning strikes, EMI, RFI, and differential grounds. Figure 2-8 illustrates a multi-building Ethernet network design with one MDF in Building A and IDFs in Buildings A, B, and C. The vertical or backbone cabling connecting the MDF and the two IDFs in Building A can be UTP or fiber depending on distance. Vertical (and horizontal) cable runs longer than 100 meters (approx. 328 ft.) should be fiber-optic.

Figure 2-8 MDFs and IDFs Connect Multiple Buildings and Users



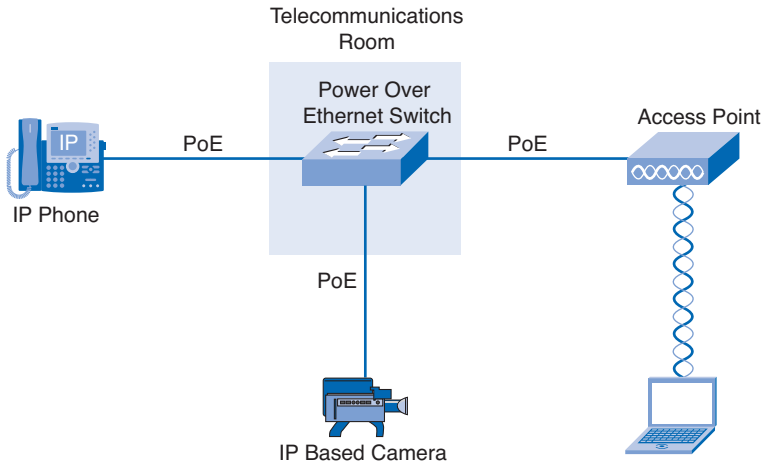
The vertical cabling between the buildings should always be fiber-optic, regardless of distance, to account for the electrical differential between buildings. Inter-building cabling can also be exposed to weather and lightning strikes, which fiber-optic can withstand more easily without damaging equipment connected to it.

In addition to providing basic network access connectivity, it is becoming more common to provide power to end-user devices directly from the Ethernet switches in the telecommunications room. These devices include IP phones, access points, and surveillance cameras.

These devices are powered using the IEEE 802.3af standard, ***Power over Ethernet (PoE)***. PoE provides power to a device over the same twisted-pair cable that carries data. This allows an IP phone, for example, to be located on a desk without the need for a separate power cord or a power outlet. To support PoE devices such as the IP phone, the connecting switch must have PoE capability.

PoE can also be provided by power injectors or PoE patch panels for those switches that do not support PoE. Panduit and other suppliers produce PoE patch panels that allow non-PoE-capable switches to participate in PoE environments. Legacy switches connect into the PoE patch panel, which then connects to the PoE-capable device. Figure 2-9 illustrate devices that can be powered by a PoE-capable switch. This allows the devices to be placed without regard to the location of power outlets.

Figure 2-9 End Devices Receive Power from a PoE Switch



Interactive Activity 2-2: Placing MDFs, IDFs, and Cabling (2.1.3)

In this activity, you place the MDFs and IDFs in an appropriate location in the campus diagram and identify appropriate cables to connect them. Use file d3ia-213 on the CD-ROM that accompanies this book to perform this interactive activity.

Supporting the Enterprise Edge

The enterprise edge is the entry and exit point to the network for external users and services. The following sections describe how external services are delivered as well as security considerations at the edge.

Service Delivery at the Point of Presence

At the outer edge of the enterprise network is the ***point of presence (POP)***, which provides an entry point for services to the enterprise network. Externally provided services coming in through the POP include Internet access, wide-area connections, and telephone services (public switched telephone network [PSTN]).

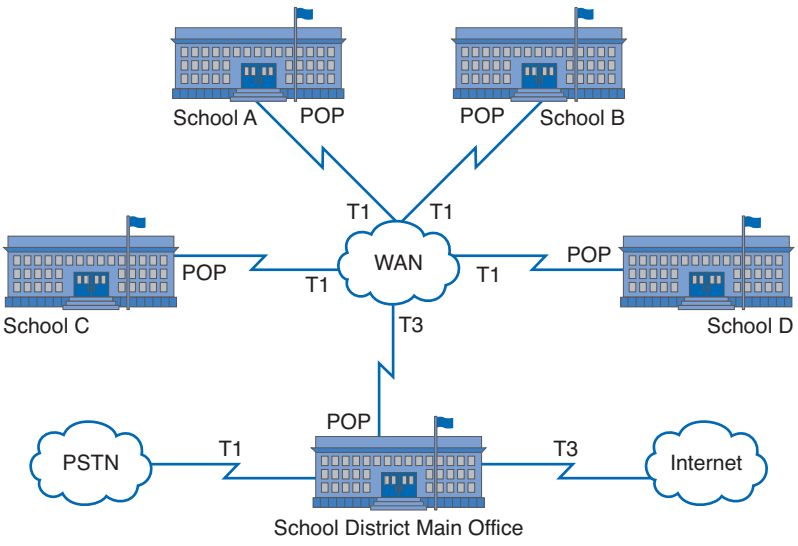
The POP contains a point of demarcation, or the demarc. The demarc provides a boundary that designates responsibility for equipment maintenance and troubleshooting between the ***service provider (SP)*** and customer. Equipment from the service provider up to the point of demarcation is the responsibility of the provider; anything past the demarc point is the responsibility of the customer.

In an enterprise, the POP provides links to outside services and sites. The POP can provide a direct link to one or more ISPs, which allows internal users the required access to the Internet. The remote sites of an enterprise are also interconnected through the POPs. The service provider establishes the wide-area links between these remote sites.

The location of the POP and the point of demarcation vary in different countries. While they are often located within the MDF of the customer, they can also be located at the SP.

Figure 2-10 shows an example of a school district with a hub-and-spoke, or star, design. The school district main office is the center of the star or hub and has the primary connections to the Internet and the PSTN. Each of the schools A, B, C, and D connect back to the district office for phone and Internet access to the outside world. The district office and each of the schools have their own POP to make the necessary WAN connections. Each school is connected to the district office with a T1 circuit with a bandwidth of 1.544 Mbps. Because all the schools share the main Internet connection at the district office, the connection to the ISP is a T3 circuit with approximately 45 Mbps bandwidth. This is a scalable design, where additional schools with T1s can connect back to the district office. This design can be applied to businesses and other organizations with multiple remote locations that connect to a central site. If additional remote sites are added to the network, the bandwidth of the Internet and PSTN connections at the central site can be upgraded to higher-speed links, if necessary.

Figure 2-10 POPs at Each Location Connect Schools to the District Office and External Services



Security Considerations at the Enterprise Edge

Large enterprises usually consist of multiple sites that interconnect. Multiple locations can have edge connections at each site connecting the enterprise to other individuals and organizations.

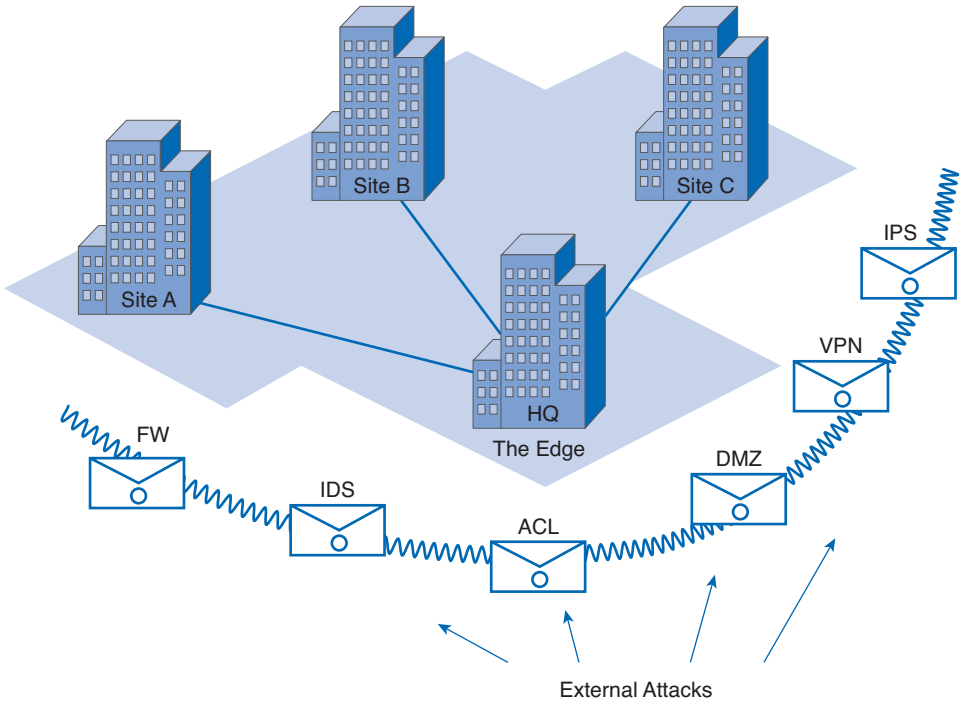
The edge is the point of entry for outside attacks and is a point of vulnerability. Attacks at the edge can affect thousands of users. For example, denial of service (DoS) attacks prevent access to resources for legitimate users inside or outside the network, affecting productivity for the entire enterprise.

All traffic into or out of the organization goes through the edge. Edge devices must be configured to defend against attacks and provide filtering based on website, IP address, traffic pattern, application, and protocol.

An organization can deploy a firewall and security appliances with an intrusion detection system (IDS) and intrusion prevention system (IPS) at the edge to protect the network. They can also set up a demilitarized zone (DMZ), an area isolated be firewalls, where web and FTP servers can be placed for external users to access.

External network administrators require access for internal maintenance and software installation. Virtual Private Networks (VPN), access control lists (ACL), user IDs, and passwords provide that access. VPNs also allow remote workers access to internal resources. Figure 2-11 depicts a network with the headquarters (HQ) as the edge, with security protection tools deployed to protect the internal network.

Figure 2-11 Security Defense Tools at the Enterprise Edge



Connecting the Enterprise Network to External Services

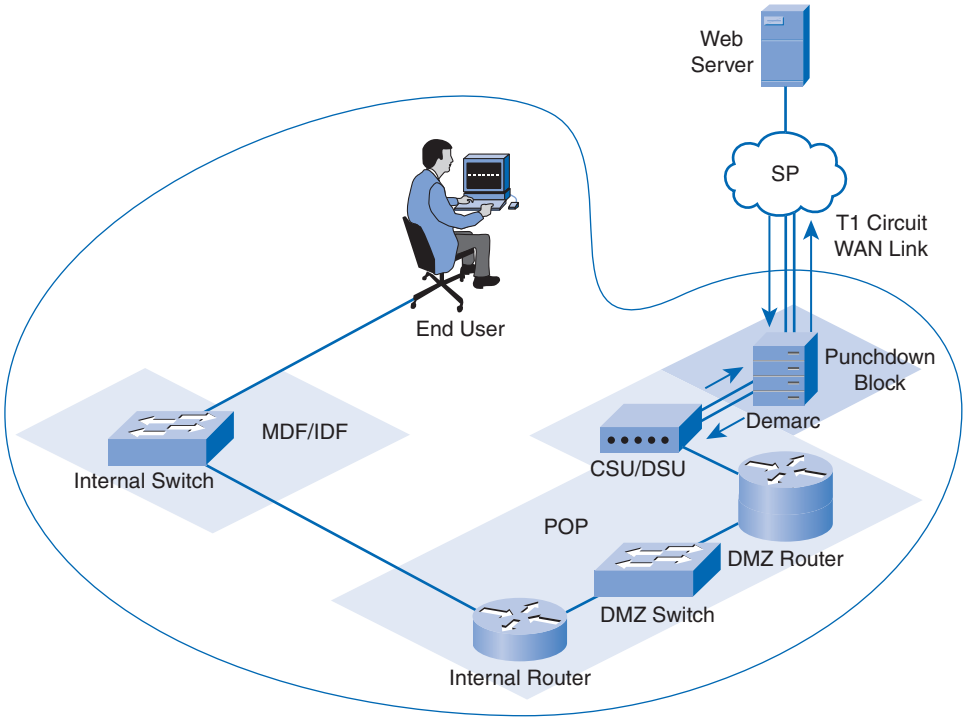
The network connection services commonly purchased by an enterprise include leased lines ***(T1/E1)***, Frame Relay, and ATM. Physical cabling brings these services to the enterprise using copper wires, as in the case of T1/E1, or fiber-optic cable for higher-speed services.

The POP must contain certain pieces of equipment to obtain whichever WAN service is required. For example, to obtain T1/E1 service, the customer might require a ***punchdown block*** to terminate the T1/E1 circuit, as well as a ***channel service unit/data service unit (CSU/DSU)*** to provide the proper

electrical interface and signaling for the service provider. This equipment can be owned and maintained by the service provider or can be owned and maintained by the customer. Regardless of ownership, all equipment located within the POP at the customer site is referred to as ***customer premise equipment (CPE)***. The CSU/DSU can be an external standalone device connected to the edge router with a cable or it can be integrated into the router.

Figure 2-12 shows an example of the equipment in the proper sequence required to bring a T1 circuit from a service provider to a customer and finally to the end user. The T1 can be provided by an SP or an ISP and can provide access to the Internet directly or to another site to form a WAN.

Figure 2-12 Connections and Devices from Service Provider to End User



Interactive Activity 2-3: Specifying Components to Bring Service to the Internal Network (2.2.3)

In this activity, you specify the components, in order, needed to connect a service from the edge to the internal network. Use file d3ia-223 on the CD-ROM that accompanies this book to perform this interactive activity.

Reviewing Routing and Switching

The following sections provide a review of router and switch hardware characteristics. They also serve as a review of router and switch commands most commonly used to display information about and configure these devices.

Router Hardware

One important device in the distribution layer of an enterprise network is a router. Without the routing process, packets could not leave the local network.

The router provides access to other private networks as well as to the Internet. All hosts on a local network specify the IP address of the local router interface in their IP configuration. This router interface is the default gateway.

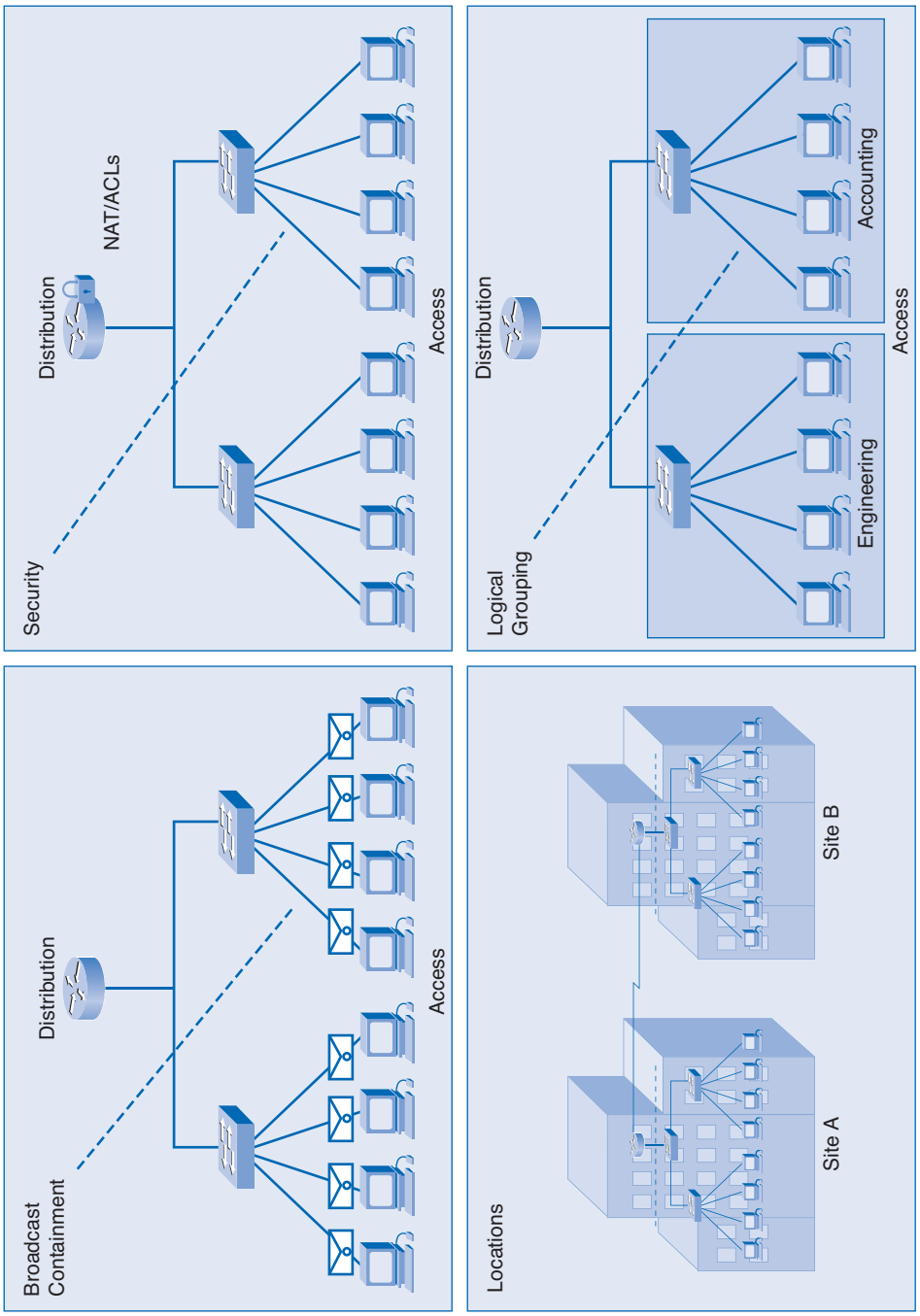
Routers play a critical role in networking by interconnecting multiple sites within an enterprise network, providing redundant paths, and connecting ISPs on the Internet. Routers can also act as a translator between different media types and protocols. For example, a router can re-encapsulate packets from an Ethernet to a serial encapsulation.

Routers use the network portion of the destination IP address to route packets to the proper destination. They select an alternate path if a link goes down or traffic is congested. Routers also serve the following other beneficial functions:

- **Provide broadcast containment:** Routers in the distribution layer limit broadcasts to the local network where they need to be heard. Although broadcasts are necessary, too many hosts connected on the same local network generate excessive broadcast traffic and slow the network.
- **Connect remote locations:** Routers in the distribution layer interconnect local networks at various locations of an organization that are geographically separated.
- **Group users logically by application or department:** Routers in the distribution layer logically group users, such as departments within a company, who have common needs or for access to resources.
- **Provide enhanced security (using Network Address Translation [NAT] and ACLs):** Routers in the distribution layer separate and protect certain groups of computers where confidential information resides. Routers also hide the addresses of internal computers from the outside world to help prevent attacks and control who gets into or out of the local network.

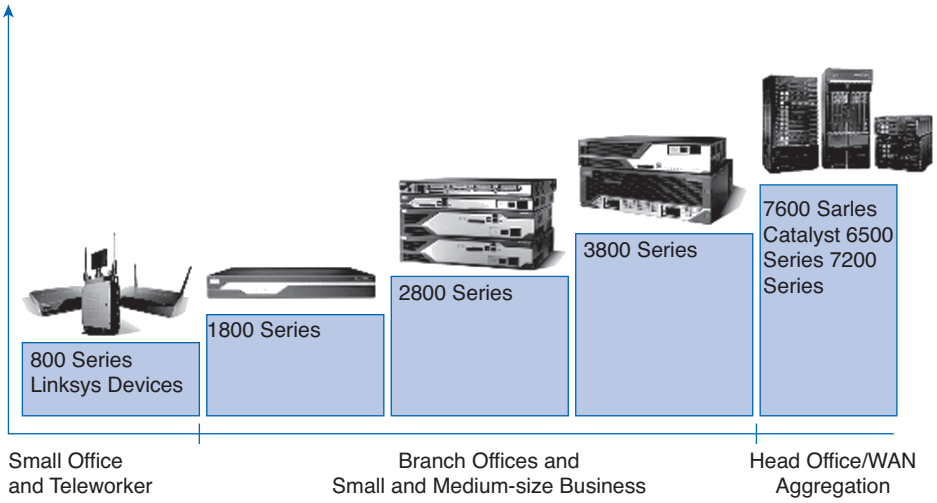
With the enterprise and the ISP, the ability to route efficiently and recover from network link failures is critical to delivering packets to their destination. Figure 2-13 depicts each of the main functions the routers can perform.

Figure 2-13 Functions of Routers



Routers come in many shapes and sizes called ***form factors***, as shown in Figure 2-14, and can support a few users or thousands of users, depending on the size and needs of the organization. Network administrators in an enterprise environment should be able to support a variety of routers and switches, from a small desktop to a rack-mounted or blade model.

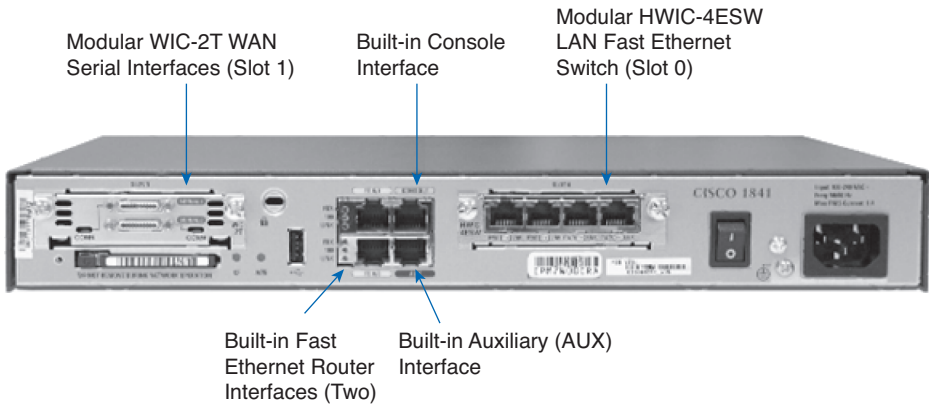
Figure 2-14 Router Classes and Form Factors



Routers can also be categorized as fixed configuration or modular. With the fixed configuration, the desired router interfaces are built in. Modular routers come with multiple slots that allow a network administrator to change the interfaces on the router. As an example, a Cisco 1841 router comes with two Fast Ethernet RJ-45 interfaces built in and two slots that can accommodate many different network interface modules.

Routers come with a variety of different interfaces, such as Fast and Gigabit Ethernet, serial, and fiber-optic. Router interfaces use the controller/interface or controller/slot/interface conventions. For example, using the controller/interface convention, the first Fast Ethernet interface on a router is numbered as Fa0/0 (controller 0 and interface 0). The second is Fa0/1. The first serial interface on a router using controller/slot/interface is S0/0/0. Figure 2-15 shows the back of an 1841 ISR router with a serial interface card and an integrated 4-port Fast Ethernet switch.

Figure 2-15 Router Interfaces



Two methods exist for connecting a PC to a network device for configuration and monitoring tasks: ***out-of-band*** and ***in-band*** management.

Out-of-Band Management

Out-of-band management is used for initial configuration or when a network connection is not unavailable. If there is a problem with access to a network device through the network, it might be

necessary to use out-of-band management. For example, a WAN serial interface on a remote router might have been misconfigured so that normal network access is not possible. If the AUX port is properly configured for remote access and a dialup modem is connected, it might be possible to dial in to the modem using out-of-band management and reconfigure the router to correct the problem. Configuration using out-of-band management requires

- Direct connection to the device console port or a direct or remote connection (through dialup) to the AUX port
- Terminal emulation client

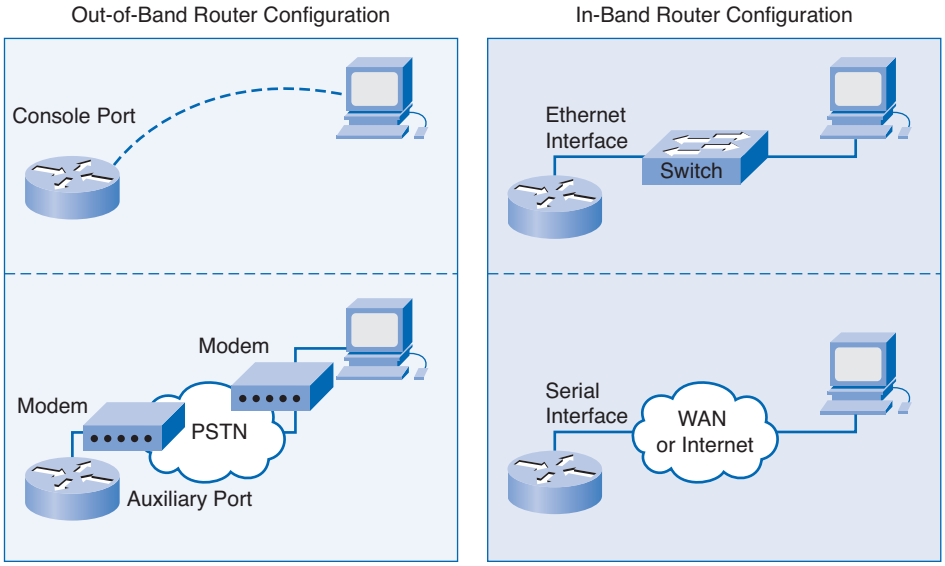
In-Band Management

In-band management is used to monitor and make configuration changes to a network device over a network connection. With in-band, the connection shares network bandwidth with other hosts on the network. Configuration using in-band management requires

- At least one network interface on the device to be connected and operational
- Valid IP configuration on interfaces involved (for an IP-based network)
- Telnet, Secure Shell (SSH), or HTTP to access a Cisco device (these protocols are primarily IP based)

Figure 2-16 shows two forms of out-of-band and two forms of in-band management.

Figure 2-16 Out-of-Band and In-Band Management Methods



Basic Router CLI show Commands

This section includes some of the most commonly used Cisco IOS commands to display and verify the operational status of the router and related network functionality. These commands are divided into several categories, as shown in Table 2-1.

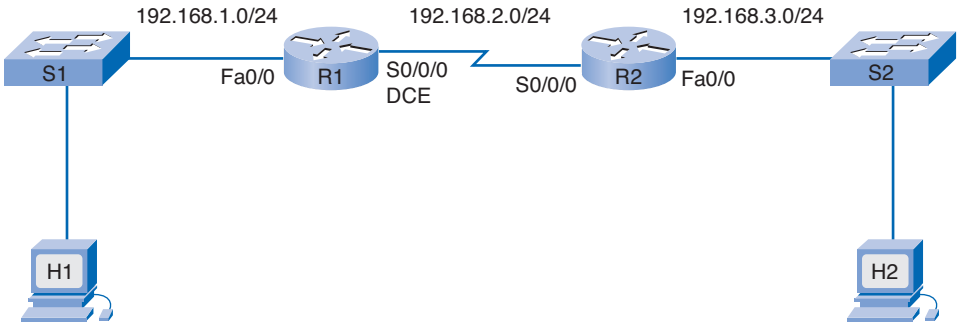
Table 2-1 lists these commands with common options used and the minimum abbreviation allowable, along with a description of their function and key information displayed.

Table 2-1 Common Router show Commands

Full Command	Abbreviation	Purpose / Information Displayed
		General Use
show running-config	**sh run**	Displays current config running in RAM. Includes host name, passwords, interface IP addresses, routing protocol activated, DHCP, and NAT configuration. Must be issued in EXEC mode.
show startup-config	**sh star**	Displays backup config in NVRAM. Can be different if running config has not been copied to backup. Must be issued in EXEC mode.
show version	**sh ve**	Displays IOS version, ROM version, router uptime system image file name, boot method, number and type of interfaces installed, and amount of RAM, NVRAM, and flash. Also shows the Configuration register.
		Routing Related
show ip protocols	**sh ip pro**	Displays information for routing protocols configured including timer settings, version numbers, update intervals, active interfaces, and networks advertised.
show ip route	**sh ip ro**	Displays routing table information including routing code, networks known, admin distance and metric, how they were learned, last update next hop, interface learned through, and any static routes (including default) configured.
		Interface Related
show interfaces (type #)	**sh int f0/0**	Displays one or all interfaces with line (protocol) status, bandwidth, delay, reliability, encapsulation, duplex, and I/O statistics.
show ip interface brief	**sh ip int br**	Displays all interfaces with IP address with interface status (up/down/admin down) and line protocol status (up/down).
show protocols	**sh prot**	Displays all interfaces with IP address and subnet mask (slash notation) with interface status (up/down/admin down) and line protocol status (up/down) .
		Connectivity Related
show cdp neighbors (detail)	**sh cdp ne**	Displays information on directly connected devices including device ID (host name), local interface where device is connected, capability (R=router, S=switch), platform (e.g., 2620XM), and port ID of remote device. The detail option provides the IP address of the other device as well as the IOS version.
show sessions	**sh ses**	Displays Telnet sessions (VTY) with remote hosts. Displays session number, host name, and address.
show ssh	**sh ssh**	Displays SSH server connections with remote hosts.
ping (ip / hostname)	**p**	Sends five ICMP echo requests to an IP address or host name (if DNS is available) and displays the min/max and avg time to respond.
traceroute (ip / hostname)	**tr**	Sends echo request with varying TTL. Lists routers (hops) in path and time to respond.

Figure 2-17 shows two networks (192.168.1.0/24 and 192.168.3.0/24) interconnected with a WAN link (network 192.168.2.0/24).

Figure 2-17 Multi-router and Multi-switch Network



The following examples display the **show** command output for the R1 model 1841 router in the Figure 2-17 network topology. Example 2-1 shows the **show running-config** output for R1.

Example 2-1 R1 show running-config Command Output

```
R1# show running-config

<output omitted>
Building configuration...
Current configuration : 1063 bytes
!
version 12.4
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
hostname R1
enable secret 5 $1$i6w9$dvdpVM6zV10E6tSyLdkR5/
no ip domain lookup
!
interface FastEthernet0/0
 description LAN 192.168.1.0 default gateway
 ip address 192.168.1.1 255.255.255.0
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Serial0/0/0
 description WAN link to R2
 ip address 192.168.2.1 255.255.255.0
 encapsulation ppp
 clock rate 64000
 no fair-queue
```

```
!
interface Serial0/0/1
 no ip address
 shutdown
!
interface Vlan1
 no ip address
!
router rip
 version 2
 network 192.168.1.0
 network 192.168.2.0
!
banner motd ^CUnauthorized Access Prohibited^C
!
ip http server
!
line con 0
 password cisco
 login
line aux 0
line vty 0 4
 password cisco
 login
```

Example 2-2 presents the **show version** output for R1.

Example 2-2 R1 show version Command Output

```
R1# show version

<output omitted>
Cisco IOS Software, 1841 Software (C1841-ADVIPSERVICESK9-M), Version 12.4(10b),
RELEASE SOFTWARE (fc3)
Technical Support: http://www.cisco.com/techsupport
Copyright (c) 1986-2007 by Cisco Systems, Inc.
Compiled Fri 19-Jan-07 15:15 by prod_rel_team

ROM: System Bootstrap, Version 12.4(13r)T, RELEASE SOFTWARE (fc1)
R1 uptime is 43 minutes
System returned to ROM by reload at 22:05:12 UTC Sat Jan 5 2008
System image file is "flash:c1841-advipservicesk9-mz.124-10b.bin"

Cisco 1841 (revision 6.0) with 174080K/22528K bytes of memory.
Processor board ID FTX1111W0QF
6 FastEthernet interfaces
2 Serial(sync/async) interfaces
1 Virtual Private Network (VPN) Module
DRAM configuration is 64 bits wide with parity disabled.
191K bytes of NVRAM.
62720K bytes of ATA CompactFlash (Read/Write)

Configuration register is 0x2102
```

Example 2-3 presents the **show ip protocols** output for R1.

Example 2-3 R1 show ip protocols Command Output

```
R1# show ip protocols

Routing Protocol is "rip"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Sending updates every 30 seconds, next due in 20 seconds
  Invalid after 180 seconds, hold down 180, flushed after 240
  Redistributing: rip
  Default version control: send version 2, receive version 2
    Interface             Send  Recv  Triggered RIP  Key-chain
    FastEthernet0/0       2     2
    Serial0/0/0           2     2
  Automatic network summarization is in effect
  Maximum path: 4
  Routing for Networks:
    192.168.1.0
    192.168.2.0
  Routing Information Sources:
    Gateway         Distance      Last Update
    192.168.2.2          120      00:00:20
  Distance: (default is 120)
```

Example 2-4 presents the **show ip route** output for R1.

Example 2-4 R1 show ip route Command Output

```
R1# show ip route

Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set
C    192.168.1.0/24 is directly connected, FastEthernet0/0
C    192.168.2.0/24 is directly connected, Serial0/0/0
R    192.168.3.0/24 [120/1] via 192.168.2.2, 00:00:24, Serial0/0/0
```

Example 2-5 presents the **show interfaces** output for R1.

Example 2-5 R1 show interfaces Command Output

```
R1# show interfaces

< Some output omitted >
FastEthernet0/0 is up, line protocol is up
  Hardware is Gt96k FE, address is 001b.5325.256e (bia 001b.5325.256e)
  Internet address is 192.168.1.1/24
  MTU 1500 bytes, BW 100000 Kbit, DLY 100 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  Full-duplex, 100Mb/s, 100BaseTX/FX
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input 00:00:17, output 00:00:01, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     196 packets input, 31850 bytes
     Received 181 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 watchdog
     0 input packets with dribble condition detected
     392 packets output, 35239 bytes, 0 underruns
     0 output errors, 0 collisions, 3 interface resets
     0 babbles, 0 late collision, 0 deferred
     0 lost carrier, 0 no carrier
     0 output buffer failures, 0 output buffers swapped out

FastEthernet0/1 is administratively down, line protocol is down

Serial0/0/0 is up, line protocol is up
  Hardware is GT96K Serial
  Internet address is 192.168.2.1/24
  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation PPP, LCP Listen, loopback not set
  Keepalive set (10 sec)
  Last input 00:00:02, output 00:00:03, output hang never
  Last clearing of "show interface" counters 00:51:52
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     401 packets input, 27437 bytes, 0 no buffer
     Received 293 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     389 packets output, 26940 bytes, 0 underruns
```

```
     0 output errors, 0 collisions, 2 interface resets
     0 output buffer failures, 0 output buffers swapped out
     6 carrier transitions
     DCD=up  DSR=up  DTR=up  RTS=up  CTS=up

Serial0/0/1 is administratively down, line protocol is down
```

Example 2-6 presents the **show ip interfaces brief** output for R1.

Example 2-6 R1 show ip interfaces brief Command Output

```
R1# show ip interface brief

Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            192.168.1.1     YES manual up                    up
FastEthernet0/1            unassigned      YES unset  administratively down down
Serial0/0/0                192.168.2.1     YES manual up                    up
Serial0/0/1                unassigned      YES unset  administratively down down
Vlan1                      unassigned      YES unset  up                    down
```

Example 2-7 presents the **show protocols** output for R1.

Example 2-7 R1 show protocols Command Output

```
R1# show protocols

Global values:
  Internet Protocol routing is enabled
FastEthernet0/0 is up, line protocol is up
  Internet address is 192.168.1.1/24
FastEthernet0/1 is administratively down, line protocol is down
FastEthernet0/1/0 is up, line protocol is down
FastEthernet0/1/1 is up, line protocol is down
FastEthernet0/1/2 is up, line protocol is down
FastEthernet0/1/3 is up, line protocol is down
Serial0/0/0 is up, line protocol is up
  Internet address is 192.168.2.1/24
Serial0/0/1 is administratively down, line protocol is down
Vlan1 is up, line protocol is down
```

Example 2-8 presents the **show cdp neighbors** output for R1.

Example 2-8 R1 show cdp neighbors Command Output

```
R1# show cdp neighbors

Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater

Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
R2               Ser 0/0/0          137        R S I      1841      Ser 0/0/0
S1               Fas 0/0            175         S I       WS-C2960- Fas 0/1
```

Example 2-9 presents the **show cdp neighbors detail** output for R1.

Example 2-9 R1 show cdp neighbors detail Command Output

```
R1# show cdp neighbors detail

-------------------------
Device ID: R2
Entry address(es):
  IP address: 192.168.2.2
Platform: Cisco 1841,  Capabilities: Router Switch IGMP
Interface: Serial0/0/0,  Port ID (outgoing port): Serial0/0/0
Holdtime : 164 sec
Version :
Cisco IOS Software, 1841 Software (C1841-ADVIPSERVICESK9-M), Version 12.4(10b),
RELEASE SOFTWARE (fc3)
Technical Support: http://www.cisco.com/techsupport
Copyright (c) 1986-2007 by Cisco Systems, Inc.
Compiled Fri 19-Jan-07 15:15 by prod_rel_team
advertisement version: 2
VTP Management Domain: ''

-------------------------
Device ID: S1
Entry address(es):
  IP address: 192.168.1.5
Platform: cisco WS-C2960-24TT-L,  Capabilities: Switch IGMP
Interface: FastEthernet0/0,  Port ID (outgoing port): FastEthernet0/1
Holdtime : 139 sec
Version :
Cisco IOS Software, C2960 Software (C2960-LANBASE-M), Version 12.2(25)SEE3, RELE
ASE SOFTWARE (fc2)
Copyright (c) 1986-2007 by Cisco Systems, Inc.
Compiled Thu 22-Feb-07 13:57 by myl
advertisement version: 2
Protocol Hello:  OUI=0x00000C, Protocol ID=0x0112; payload len=27, value=0000000
0FFFFFFFF010221FF000000000000001D46350C80FF0000
VTP Management Domain: ''
Native VLAN: 1
Duplex: full
```

Interactive Activity 2-4: Matching the Command to the Information Needed (2.3.2)

In this activity, you identify the command that can provide the information indicated. Use file d3ia-232 on the CD-ROM that accompanies this book to perform this interactive activity.

Basic Router Configuration Using CLI

A basic router configuration includes the host name for identification, passwords for security, and assignment of IP addresses to interfaces for connectivity. Verify and save configuration changes using the **copy running-config startup-config** command. To clear the router configuration, use the **erase startup-config** command and then the **reload** command. Table 2-2 shows common IOS commands used to configure routers. Also listed are the abbreviation, the purpose of the command, and the required mode to execute the command.

Table 2-2 Common Router Configuration Commands

Full Command / Example	Abbreviation	Purpose / Mode
	Configuration Management	
enable	**en**	Changes from user EXEC mode (>) to privileged EXEC mode (#)
configure terminal	**conf t**	Changes from privileged EXEC mode to global configuration mode
copy running-config startup-config	**cop r s**	Copies the running configuration from RAM to the startup configuration file in NVRAM
erase startup-config	**era sta**	Deletes the startup configuration file (startup-config)
reload	**rel**	Performs a software reboot
	Global Settings	
hostname R1	**ho**	Sets the device host name to R1
banner motd #XYZ#	**ban m**	Sets the banner message of the day, which is displayed at login, to XYZ
enable secret itsasecret	**ena s**	Sets the privileged mode encrypted password to itsasecret
	Line Settings	
line con 0	**lin c**	Enters line config mode for console port 0
line aux 0	**lin a**	Enters line config mode for auxiliary port 0
line vty 0 4	**lin v**	Enters line config mode for VTY lines 0 through 4
login	**login**	Allows login to a line in line config mode
password	**pas**	Sets line login password in line config mode

Full Command / Example	Abbreviation	Purpose / Mode
	Interface Settings	
interface S0/0/0	**int**	Enters interface config mode for interface Serial 0/0/0 (specifies the interface as type/number)
description XYZ	**des**	Specifies a description for the interface as XYZ (in interface config mode)
ip address 192.168.1.1 255.255.255.0	**ip add**	Specifies an IP address and subnet mask for the interface (in interface config mode)
no shutdown	**no sh**	Brings up the interface (in interface config mode). Use **shutdown** to disable the interface.
clock rate 64000	**clo r**	Sets the clock rate for a serial interface, with a DCE cable connected, to 64000 (in interface config mode)
encapsulation ppp	**enc**	Specifies the encapsulation for the interface as ppp (in interface config mode)
	Routing Settings	
router rip	**router**	Enters router config mode for the RIP routing protocol
network 172.16.0.0	**net**	Specifies network 172.16.0.0 to be advertised by RIP (in RIP router config mode)
ip route 172.16.0.0 255.255.0.0 S0/0/0	**ip route**	Specifies a static route to network 172.16.0.0 through exit interface Serial 0/0/0
ip route 0.0.0.0 0.0.0.0 192.168.2.2	**ip route**	Specifies a static default route through next-hop IP address 192.168.2.2

Example 2-10 shows the configuration commands used to configure the R1 router in Figure 2-18. Refer to Example 2-1 to see the results of the commands as displayed with the **show running-config** command. The resulting running configuration frequently has a number of commands inserted automatically by the IOS that were not entered during the configuration process.

Example 2-10 Router R1 Basic Configuration Commands

```
Router> enable
Router# configure terminal

Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)# hostname R1
R1(config)# banner motd %Unauthorized Access Prohibited%
R1(config)# enable secret class
R1(config)# line con 0
R1(config-line)# password cisco
R1(config-line)# login
R1(config-line)# line aux 0
R1(config-line)# line vty 0 4
R1(config-line)# password cisco
R1(config-line)# login
```

```
R1(config-line)# exit
R1(config)# no ip domain-lookup

R1(config)#
R1(config)# interface FastEthernet0/0
R1(config-if)# description LAN 192.168.1.0 default gateway
R1(config-if)# ip address 192.168.1.1 255.255.255.0
R1(config-if)# no shutdown
R1(config-if)#
R1(config-if)# interface Serial0/0/0
R1(config-if)# description WAN link to R2
R1(config-if)# ip address 192.168.2.1 255.255.255.0
R1(config-if)# encapsulation ppp
R1(config-if)# clock rate 64000
R1(config-if)# no shutdown
R1(config-if)#
R1(config-if)# router rip
R1(config-router)# version 2
R1(config-router)# network 192.168.1.0
R1(config-router)# network 192.168.2.0
```

It is common to copy the running configuration of a device, such as the R1 router, and paste it into a text editor file for backup or use it as a starting point for modification. The text file can then be edited as necessary so that it can be used to reconfigure the router or configure another router.

Note

After a device has been configured, it is critical to copy the running configuration to the startup configuration using the **copy run start** command. Otherwise, changes will be lost if the router is restarted using the **reload** command or if it loses power.

Packet Tracer Activity

Basic Router Configuration Using CLI (2.3.3)

In this activity, you practice basic router configuration and verification commands. Use file d3-233.pka on the CD-ROM that accompanies this book to perform this activity using Packet Tracer.

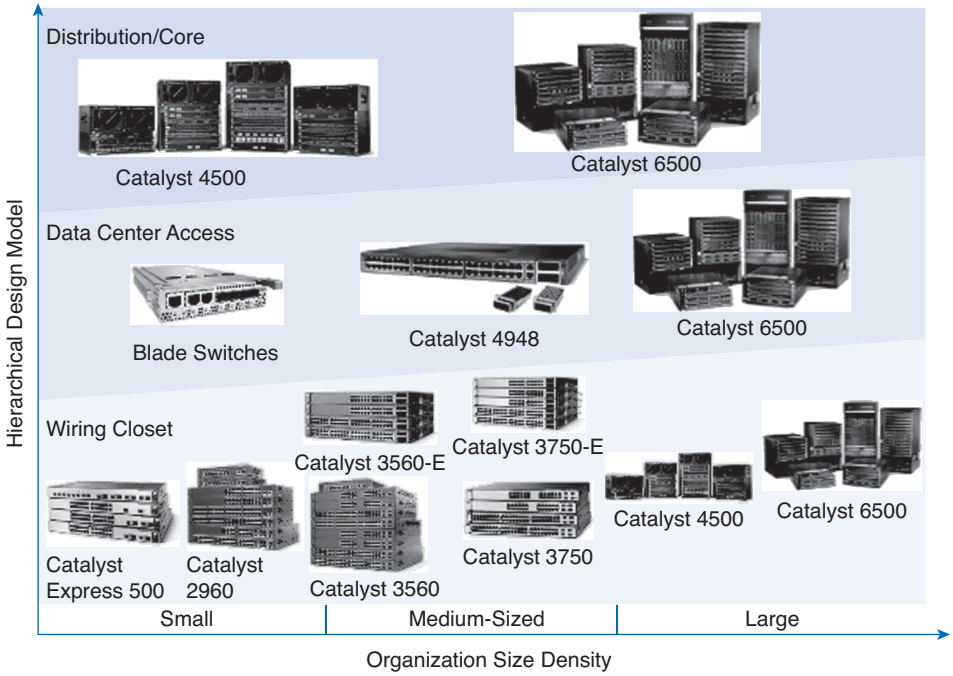
Switch Hardware

Although all three layers of the hierarchical design model contain switches and routers, the access layer generally has more switches. The main function of switches is to connect hosts such as end-user workstations, servers, IP phones, web cameras, access points, and routers. This means that there are many more switches in an organization than routers.

As shown in Figure 2-18, switches come in many form factors:

- Small standalone models sit on a desk or mount on a wall.
- Integrated routers include a switch built into the chassis that is rack mounted.
- High-end switches mount into a rack and are often a chassis-and-blade design to allow more blades to be added as the number of users increases.

Figure 2-18 Switch Classes and Form Factors



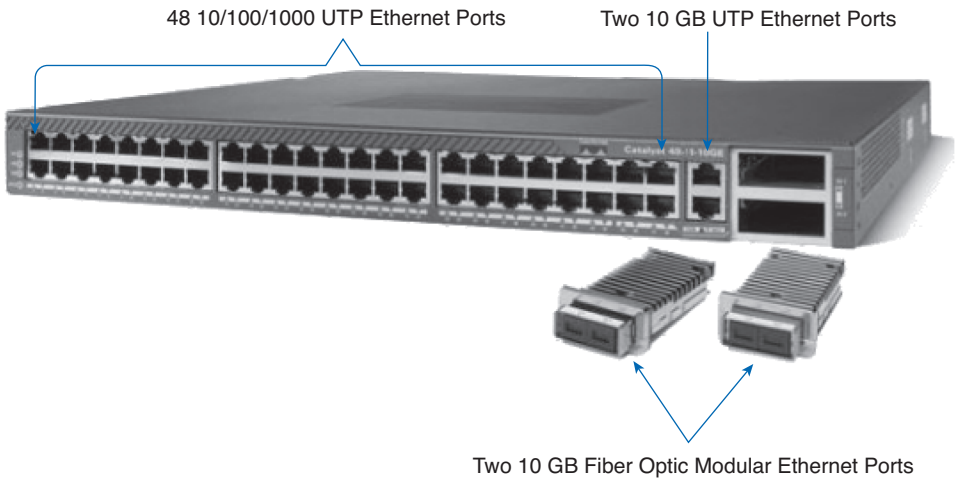
High-end enterprise and service provider switches support ports of varying speeds, from 100 MB to 10 GB.

An enterprise switch in an MDF connects other switches from IDFs using Gigabit fiber or copper cable. An IDF switch typically needs both RJ-45 Fast Ethernet ports for device connectivity and at least one Gigabit Ethernet port (copper or fiber) to uplink to the MDF switch. Some high-end switches have modular ports that can be changed if needed. For example, it might be necessary to switch from multimode fiber to single-mode fiber, which would require a different port.

Like routers, switch ports are also designated using the controller/port or controller/slot/port convention. For example, using the controller/port convention, the first Fast Ethernet port on a switch is numbered as Fa0/1 (controller 0 and port 1). The second is Fa0/2. The first port on a switch that uses controller/slot/port is Fa0/0/1. Gigabit ports are designated as Gi0/1, Gi0/2, and so on.

Port density on a switch is an important factor. In an enterprise environment where hundreds or thousands of users need switch connections, a switch with a 1RU height and 48 ports has a higher port density than a 1RU 24-port switch. Figure 2-19 shows a Cisco Catalyst 4948 switch with 48 access ports capable of operating at 10 Mbps (regular Ethernet), 100 Mbps (Fast Ethernet), or 1000 Mbps (Gigabit Ethernet). In addition, it has two built-in 10-Gbps UTP ports and two modular ports that can accept various fiber-optic Ethernet interfaces, including 10-Gbps multimode or single-mode.

Figure 2-19 Ethernet Switch Ports: Built-in and Modular



Basic Switch CLI Commands

Switches make use of common IOS commands for configuration, to check for connectivity and to display current switch status. These commands can be divided into several categories, as shown in Table 2-2.

Table 2-3 lists these commands with common options used and the minimum abbreviation allowable, along with a description of their function and key information displayed.

Table 2-3 Common Switch show Commands

Full Command	Abbreviation	Purpose / Information Displayed
	General Use	
show running-config	**sh run**	Displays current config running in RAM. Includes host name, passwords, interface IP addresses (if present), port numbers, and characteristics (duplex/speed).
show startup-config	**sh star**	Displays backup config in NVRAM. Can be different if running config has not been copied to backup.
show version	**sh ve**	Displays IOS version, ROM version, switch uptime, system image file name, boot method, number and type of interfaces installed, and amount of RAM, NVRAM, and flash. Also shows the Configuration register.
	Interface / Port Related	
show interfaces (type and number)	**sh int f0/1**	Displays one or all interfaces with line (protocol) status, bandwidth, delay, reliability, encapsulation, duplex, and I/O statistics.
show ip interface brief	**sh ip int br**	Displays all interfaces with IP address with interface status (up/down/admin down) and line protocol status (up/down).

Full Command	Abbreviation	Purpose / Information Displayed
	Interface / Port Related	
show port-security	**sh por**	Displays any ports where security has been activated, along with max address allowed, current count, security violation count, and action to take (normally shut-down).
show mac-address-table	**sh mac-a**	Displays all MAC addresses the switch has learned, how learned (dynamic/static), the port number, and VLAN the port is in.
	Connectivity Related	
show cdp neighbors (detail)	**sh cdp ne**	Displays information on directly connected devices, including device ID (host name), local interface where device is connected, capability (R=router, S=switch), platform (e.g., WS-2950-2), and port ID of remote device. The detail option provides the IP address of the other device as well as the IOS version.
show sessions	**sh ses**	Displays Telnet sessions (VTY) with remote hosts. Displays session number, host name, and address.
show ssh	**sh ssh**	Displays SSH server connections with remote hosts.
ping (ip / hostname)	**p**	Sends five ICMP echo requests to an IP address or host name (if DNS is available) and displays the min/max and avg time to respond.
traceroute (ip / hostname)	**tr**	Sends echo request with varying TTL. Lists routers (hops) in path and time to respond.

The same in-band and out-of-band management techniques that apply to routers also apply to switch configuration.

The following examples display **show** command output for the S1 model 2960 switch in the Figure 2-18 network topology. This switch has 24 10/100 Ethernet UTP ports and two Gigabit ports. Port Fa0/3 has a host attached and port security has been set. If the **mac-address sticky** option is used with the **switchport port-security** command, the running configuration is automatically updated when the MAC address of the host attached to that port is learned.

Example 2-11 presents the **show running-config** output for S1.

Example 2-11 S1 show running-config Command Output

```
S1# show running-config

< output omitted >
Building configuration...
Current configuration : 1373 bytes
!
version 12.2
```

```
no service pad
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname S1
enable secret 5 $1$9y6K$CE6oM7XmLRg6ISQPAJOk10
no ip domain-lookup
spanning-tree mode pvst
!
interface FastEthernet0/1
interface FastEthernet0/2
interface FastEthernet0/3
 switchport mode access
 switchport port-security
 switchport port-security mac-address sticky
 switchport port-security mac-address sticky 000b.db04.a5cd
!
< Output for ports Fa0/4 through Fa0/21 omitted >
!
interface FastEthernet0/22
interface FastEthernet0/23
interface FastEthernet0/24
!
interface GigabitEthernet0/1
interface GigabitEthernet0/2
!
interface Vlan1
 ip address 192.168.1.5 255.255.255.0
 no ip route-cache
!
ip default-gateway 192.168.1.1
ip http server
!
banner motd ^CUnauthorized Access Prohibited^C
!
line con 0
 password cisco
 login
line vty 0 4
 password cisco
 login
line vty 5 15
 password cisco
 login
!
end
```

Example 2-12 presents the **show version** command output for S1.

Example 2-12 S1 show version Command Output

```
S1#  show version

< output omitted >
Cisco IOS Software, C2960 Software (C2960-LANBASE-M), Version 12.2(25)SEE3, RELEASE SOFTWARE
  (fc2)
Copyright (c) 1986-2007 by Cisco Systems, Inc.
Compiled Thu 22-Feb-07 13:57 by myl
Image text-base: 0x00003000, data-base: 0x00AA3380

ROM: Bootstrap program is C2960 boot loader
BOOTLDR: C2960 Boot Loader (C2960-HBOOT-M) Version 12.2(25r)SEE1, RELEASE SOFTWARE (fc1)

S1 uptime is 55 minutes
System returned to ROM by power-on
System image file is "flash:c2960-lanbase-mz.122-25.SEE3/c2960-lanbase-mz.122-25.SEE3.bin"

cisco WS-C2960-24TT-L (PowerPC405) processor (revision D0) with 61440K/4088K bytes of memory.
Processor board ID FOC1129X56L
Last reset from power-on
1 Virtual Ethernet interface
24 FastEthernet interfaces
2 Gigabit Ethernet interfaces
The password-recovery mechanism is enabled.

64K bytes of flash-simulated non-volatile configuration memory.
Base ethernet MAC Address       : 00:1D:46:35:0C:80
Motherboard assembly number     : 73-10390-04
Power supply part number        : 341-0097-02
Motherboard serial number       : FOC11285HJ7
Power supply serial number      : AZS11280656
Model revision number           : D0
Motherboard revision number     : A0
Model number                    : WS-C2960-24TT-L
System serial number            : FOC1129X56L
Top Assembly Part Number        : 800-27221-03
Top Assembly Revision Number    : A0
Version ID                      : V03
CLEI Code Number                : COM3L00BRB
Hardware Board Revision Number  : 0x01

Switch   Ports  Model              SW Version              SW Image
------   -----  -----              ----------              ----------
*    1   26     WS-C2960-24TT-L    12.2(25)SEE3            C2960-LANBASE-M

Configuration register is 0xF
```

Example 2-13 presents the **show interfaces** command output for S1.

Example 2-13 S1 show interfaces Command Output

```
S1# show interfaces

< output omitted >
Vlan1 is up, line protocol is up
  Hardware is EtherSVI, address is 001d.4635.0cc0 (bia 001d.4635.0cc0)
  Internet address is 192.168.1.5/24
  MTU 1500 bytes, BW 1000000 Kbit, DLY 10 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input 00:00:09, output 00:47:51, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     216 packets input, 23957 bytes, 0 no buffer
     Received 0 broadcasts (0 IP multicast)
     0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     25 packets output, 5161 bytes, 0 underruns
     0 output errors, 1 interface resets
     0 output buffer failures, 0 output buffers swapped out
FastEthernet0/1 is up, line protocol is up (connected)
  Hardware is Fast Ethernet, address is 001d.4635.0c81 (bia 001d.4635.0c81)
  MTU 1500 bytes, BW 100000 Kbit, DLY 100 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  Full-duplex, 100Mb/s, media type is 10/100BaseTX
  input flow-control is off, output flow-control is unsupported
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input 00:00:28, output 00:00:00, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     564 packets input, 57713 bytes, 0 no buffer
     Received 197 broadcasts (0 multicast)
     0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 watchdog, 195 multicast, 0 pause input
     0 input packets with dribble condition detected
     2515 packets output, 195411 bytes, 0 underruns
     0 output errors, 0 collisions, 1 interface resets
     0 babbles, 0 late collision, 0 deferred
     0 lost carrier, 0 no carrier, 0 PAUSE output
     0 output buffer failures, 0 output buffers swapped out
< output omitted >
```

Example 2-14 presents the **show ip interface brief** command output for S1.

Example 2-14 S1 show ip interface brief Command Output

```
S1# show ip interface brief

< output omitted >
Interface              IP-Address      OK? Method Status                Protocol
Vlan1                  192.168.1.5     YES manual up                    up
FastEthernet0/1        unassigned      YES unset  up                    up
FastEthernet0/2        unassigned      YES unset  down                  down
FastEthernet0/3        unassigned      YES unset  up                    up
< Output for ports Fa0/4 through Fa0/21 omitted >
FastEthernet0/22       unassigned      YES unset  down                  down
FastEthernet0/23       unassigned      YES unset  down                  down
FastEthernet0/24       unassigned      YES unset  down                  down
GigabitEthernet0/1     unassigned      YES unset  down                  down
GigabitEthernet0/2     unassigned      YES unset  down                  down
```

Example 2-15 presents the **show mac-address-table** output for S1.

Example 2-15 S1 show mac-address-table Command Output

```
S1# show mac-address-table

          Mac Address Table
-------------------------------------------

Vlan    Mac Address       Type        Ports
----    -----------       --------    -----
 All    0100.0ccc.cccc    STATIC      CPU
< Output for some CPU ports omitted >
 All    0180.c200.0010    STATIC      CPU
 All    ffff.ffff.ffff    STATIC      CPU
   1    000b.db04.a5cd    DYNAMIC     Fa0/3
   1    001b.5325.256e    DYNAMIC     Fa0/1
Total Mac Addresses for this criterion: 22
```

Example 2-16 presents the **show port-security** output for S1.

Example 2-16 S1 show port-security Command Output

```
S1# show port-security

Secure Port  MaxSecureAddr  CurrentAddr  SecurityViolation  Security Action
                (Count)       (Count)          (Count)
---------------------------------------------------------------------------
      Fa0/9          1            1               0         Shutdown
---------------------------------------------------------------------------
Total Addresses in System (excluding one mac per port)     : 0
Max Addresses limit in System (excluding one mac per port) : 8320
```

Example 2-17 presents the **show cdp neighbors** output for S1.

Example 2-17 S1 show cdp neighbors Command Output

```
S1# show cdp neighbors

Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater, P - Phone

Device ID         Local Intrfce        Holdtme    Capability    Platform   Port ID
R1                  Fas 0/1             122           R S I     1841       Fas0/0
```

A basic switch configuration includes the host name for identification, passwords for security, and assignment of IP addresses for connectivity. In-band access requires the switch to have an IP address.

Verify and save the switch configuration using the **copy running-config startup-config** command. To clear the switch configuration, use the **erase startup-config** command and then the **reload** command. You might also need to erase any VLAN information using the **delete flash:vlan.dat** command. Table 2-4 shows common IOS commands used to configure switches. Also listed is a short abbreviation, the purpose of the command, and the required mode to execute the command.

Table 2-4 Common Switch Configuration Commands

Full Command / Example	Abbreviation	Purpose / Mode
	Configuration Management	
enable	**en**	Changes from user EXEC mode (>) to privileged EXEC mode (#)
configure terminal	**conf t**	Changes from privileged EXEC mode to global configuration mode
copy running-config startup-config	**cop r s**	Copies the running configuration from RAM to the startup configuration file in NVRAM
erase startup-config	**era sta**	Deletes the startup configuration file (startup-config)
delete vlan.dat	**del**	Removes the VLAN configuration from the switch
reload	**rel**	Performs a software reboot
	Global Settings	
hostname S1	**ho**	Sets the device host name to S1
banner motd #XYZ#	**Ban m**	Sets the banner message of the day, which is displayed at login, to XYZ
enable secret itsasecret	**Ena s**	Sets the privileged mode encrypted password to itsasecret
ip default gateway	**ip def ga**	Specifies the router gateway the switch will use (in global config mode)

Full Command / Example	Abbreviation	Purpose / Mode
	Line Settings	
line con 0	**Lin c**	Enters line config mode for console port 0
line vty 0 4	**Lin v**	Enters line config mode for VTY lines 0 through 4
login	**login**	Allows login to a line in line config mode
password	**Pas**	Sets line login password in line config mode
	Interface Settings	
interface vlan 1	**Int**	Enters interface config mode for logical interface management VLAN 1 (default native VLAN)
ip address 192.168.1.1 255.255.255.0	**ip add**	Specifies an IP address and subnet mask for the interface (in VLAN interface config mode)
interface f0/1	**Int**	Enters interface config mode for physical port Fast Ethernet 0/1
speed 100	**Spe**	Sets the speed of the interface at 100 Mbps (in interface config mode)
duplex full	**Du**	Sets the duplex mode of the interface to full (in interface config mode)
switchport mode access	**switch m a**	Sets the switch port to access mode unconditionally (in interface config mode)
switchport port-security	**switch po**	Sets basic default port security on a port (in interface config mode)

Example 2-18 shows the configuration commands used to configure the S1 switch in Figure 2-18. Refer to Example 2-11 to see the results of the commands as displayed with the **show running-config** command. As with the router configuration, the resulting running configuration frequently has a number of commands inserted automatically by the IOS that were not entered during the configuration process.

Example 2-18 Switch S1 Basic Configuration Commands

```
Switch> enable
Switch# configure terminal

Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)# hostname S1
S1(config)# banner motd %Unauthorized Access Prohibited%
S1(config)# enable secret class
S1(config)# line con 0
S1(config-line)# password cisco
S1(config-line)# login
S1(config-line)# line vty 0 4
S1(config-line)# password cisco
```

```
S1(config-line)# login
S1(config-line)# line vty 5 15
S1(config-line)# password cisco
S1(config-line)# login
S1(config-line)# exit
1(config)# no ip domain-lookup
S1(config)# interface FastEthernet0/3
S1(config-if)# switchport mode access
S1(config-if)# switchport port-security
S1(config-if)# switchport port-security mac-address sticky
S1(config-if)# interface Vlan1
S1(config-if)# ip address 192.168.1.5 255.255.255.0
S1(config-line)# exit
S1(config)# ip default-gateway 192.168.1.1
```

Basic Switch Configuration Using CLI (2.3.5)

In this activity, you configure a switch in a switching environment. Use file d3-235.pka on the CD-ROM that accompanies this book to perform this interactive activity using Packet Tracer.

Lab 2-1: Configuring Basic Routing and Switching (2.3.5)

In this lab, you will connect and configure a multirouter network. Refer to the hands-on lab in Part II of this *Learning Guide*. You can perform this lab now or wait until the end of the chapter.

Summary

Network infrastructure diagrams document devices in a network. Network documentation includes the business continuity plan, business security plan, network maintenance plan, and service-level agreements.

The enterprise NOC manages and monitors all network resources. End users connect to the network through access layer switches and wireless APs in the IDF, and PoE provides power to devices over the same UTP cable that carries data.

The enterprise edge provides Internet access and service for users inside the organization. Edge devices provide security against attacks.

The POP at the edge provides a direct link to an SP or ISP and connects remote sites. The POP contains a demarc line of responsibility between the service provider and customer. Services are brought to the enterprise POP by copper wires or fiber-optic cable.

Distribution layer routers move packets between locations and the Internet and can control broadcasts. Routers and switches use in-band and out-of-band management.

Activities and Labs

This summary outlines the activities and labs you can perform to help reinforce important concepts described in this chapter. You can find the activity and Packet Tracer files on the CD-ROM accompanying this book. The complete hands-on labs appear in Part II.

Interactive Activities on the CD-ROM:

Interactive Activity 2-1: Matching Network Information to Documentation Type (2.1.1)

Interactive Activity 2-2: Placing MDFs, IDFs, and Cabling (2.1.3)

Interactive Activity 2-3: Specifying Components to Bring Service to the Internal Network (2.2.3)

Interactive Activity 2-4: Matching the Command to the Information Needed (2.3.2)

Packet Tracer Activities on the CD-ROM:

Basic Router Configuration Using CLI (2.3.3)

Basic Switch Configuration Using CLI (2.3.5)

Hands-on Labs in Part II of this book:

Lab 2-1: Configuring Basic Routing and Switching (2.3.5)

Check Your Understanding

Complete all the review questions listed here to check your understanding of the topics and concepts in this chapter. Appendix A, "Check Your Understanding and Challenge Questions Answer Key," lists the answers.

1. Draw a line from each term on the left to its correct description on the right. (Not all terms are used.)

Term	Description
POP	Maliciously prevents access to network resources by legitimate users
VPN	Boundary that designates responsibility for equipment maintenance and troubleshooting
DoS	Physical link to outside networks at the enterprise edge
CPE	An area of the network accessible to external users and protected by firewalls
DM	A telecommunications room to which IDFs connect
Demarc	A method of providing electrical power to Ethernet end devices
	Allows remote workers to access the internal network securely
	Equipment located at the customer facility

2. What information can you find by using the **show mac-address-table** command on a Cisco Catalyst switch?

   A. The MAC address of the console interface on the Catalyst switch
   B. The MAC addresses of the hosts connected to the switch ports
   C. The IP addresses of directly connected network devices
   D. The mapping between MAC address and IP address for network hosts

3. While troubleshooting a network problem, the network administrator issues the **show version** command on a router. What information can be found using this command?

   A. The amount of NVRAM, DRAM, and flash memory installed on the router
   B. The bandwidth, encapsulation, and I/O statistics on the interfaces
   C. Differences between the backup configuration and the current running configuration
   D. The version of the routing protocols running on the router

4. After gathering a thorough list of network applications, the traffic generated by these applications, and the priority of this traffic, a network engineer wants to integrate this information into a single document for analysis. How can this be accomplished?

   A. Create a physical topology map of the network and annotate it with the network application data.
   B. Create a logical topology map of the network and annotate it with the network application data.
   C. Create a blueprint of the facility, including network cabling and telecommunications rooms, and annotate it with the network applications data.
   D. Take a photograph of the facility, and annotate it with the network application data.

5. One evening a network administrator attempted to access a recently deployed website and received a "Page not found" error. The next day the administrator checked the web server logs and noticed that during the same hour that the site failed to load, there were hundreds of requests for the website home page. All the requests originated from the same IP address. Given this information, what might the network administrator conclude?

   A. It is normal web-surfing activity.
   B. It is likely that someone attempted a DoS attack.
   C. The link to the website does not have enough capacity and needs to be increased.
   D. The web server was turned off and was not able to service requests.

6. What type of media typically connects an MDF switch to an IDF switch in another building with an Ethernet network?

   A. Fiber-optic
   B. Coaxial cable
   C. Unshielded twisted-pair
   D. Shielded twisted-pair

7. Which of the following devices can receive power over the same twisted-pair Ethernet cable that carries data? (Choose three.)

   A. Wireless access points
   B. Monitors
   C. Web cameras
   D. IP phones
   E. Network switches
   F. Laptops

8. Indicate which type of hardware each characteristic describes by marking with an R (router) or S (switch).

   A. Defines broadcast domains
   B. Connects IP phones and access points to the network
   C. Enhances security with ACLs
   D. Interconnects networks
   E. Appears more commonly at the access layer
   F. Connects hosts to the network
   G. First Fast Ethernet interface designation is Fa0/0
   H. First Fast Ethernet interface designation is Fa0/1

9. Which of the following protocols are normally used to access a Cisco router for in-band management? (Choose two.)

   A. ARP
   B. SSH
   C. FTP
   D. SMTP
   E. Telnet

10. A network analyst is documenting the existing network at ABC-XYZ Corporation. The analyst decides to start at the core router to identify and document the Cisco network devices attached to the core. Which command executed on the core router provides the required information?

A. **show version**
B. **show ip route**
C. **show tech-support**
D. **show running-config**
E. **show cdp neighbors detail**

11. A network administrator suspects that there is a problem with the configuration of the RIP routing protocol. She investigates the interfaces and finds that all interfaces are up/up. Which of the following commands could help to identify the problem? (Choose two.)

A. **show cdp neighbors**
B. **show ip route**
C. **show sessions**
D. **show ip protocols**
E. **show version**

12. As a network technician, you are troubleshooting a router configuration. You want to get a concise display of the status of the router interfaces. You also want to verify the IP address of each interface and the subnet mask in slash format (/XX). Which command would you use?

A. **show protocols**
B. **show ip route**
C. **show running-config**
D. **show ip protocols**
E. **show ip interfaces brief**

13. What is the correct sequence of devices and connections for providing a T1 service to an organization's end user? Number each term in the proper sequence.

A. DMZ router
B. T1 circuit line
C. Internal switch
D. CSU/DSU
E. DMZ switch
F. Punchdown block
G. Internal router
H. Service provider
I. End-user PC

14. Which of the following is not a type of network protection device or technique to help security?

A. DoS
B. Firewall
C. ACL
D. IDS
E. IPS
F. DMZ
G. VPN

Challenge Questions and Activities

These questions require a deeper application of the concepts covered in this chapter. You can find the answers in Appendix A.

1. Routers R1 and R2 are connected by a serial link. As a network administrator, you entered the following commands to configure the Serial 0/0/0 interface on Router R1. From Router R1 you are unable to ping the R2 S0/0/0 interface. What interface-related issues could be causing the problem, and what commands would you use on which routers to help isolate the problem?

```
R1(config-if)# interface Serial0/0/0
R1(config-if)# description WAN link to R2
R1(config-if)# ip address 192.168.2.1 255.255.255.0
R1(config-if)# encapsulation ppp
R1(config-if)# clock rate 64000
R1(config-if)# no shutdown
```

2. ISP or WAN Link Investigation Interview Activity (optional)

   In this activity, you will talk with your instructor or a network administrator at the institution where you work or other organization. Use the following form to ask a few questions to learn more about the organization's ISP service or service provider being used for a WAN connection.

   Organization: _____

   Person's name: _____

   Position/title: _____

   ISP or service provider name: _____

   Internet or WAN: _____

   Connection type/speed (DSL, cable, T1/E1, fractional T1, Frame Relay, and so on):
   _____

   CPE device (CSU/DSU, cable modem, DSL modem, and so on): _____

   If CSU/DSU, location of device (standalone or integrated into router):
   _____

   Location of POP: _____

   Is there a DMZ? _____

   Is there an SLA? _____