Routers & Cisco IOS

Cisco IOS

Cisco technology is built around the Cisco Internetwork Operating System (IOS), which is the software that controls the routing and switching functions of internetworking devices.

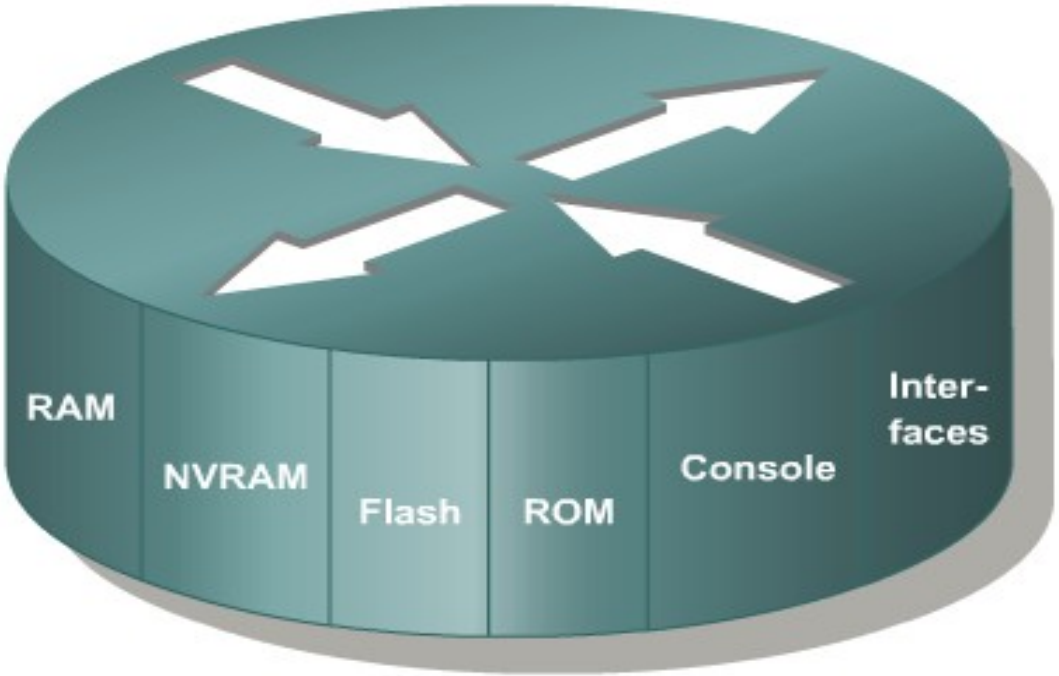
A solid understanding of the IOS is essential for a network administrator.

The Purpose of Cisco IOS

As with a computer, a router or switch cannot function without an operating system. Cisco calls its operating system the Cisco Internetwork Operating System or Cisco IOS.

Introduction to Routers

A router is a special type of computer. It has the same basic components as a standard desktop PC. However, routers are designed to perform some very specific functions. Just as computers need operating systems to run software applications, routers need the Internetwork Operating System software (IOS) to run configuration files. These configuration files contain the instructions and parameters that control the flow of traffic in and out of the routers. The many parts of a router are shown below:



Router Memory Components

ROM - Read Only Memory –
Bootstrap/POST

FLASH Memory - IOS Images are kept here
- Erasable reprogrammable ROM
- Contents are kept on Power down or reload

RAM
- Random Access memory
- Routing Tables
- Running Configuration
- Contents are lost on reboot

NVRAM
- Start up configuration
- Configuration Register
- Contents are kept on reload

ROM

Read-Only Memory

ROM has the following characteristics and functions:

- Maintains instructions for power-on self test (POST) diagnostics
- Stores bootstrap program and basic operating system software
- Mini IOS

RAM

Random Access Memory, also called dynamic RAM (DRAM)

RAM has the following characteristics and functions:

- Stores routing tables
- Holds ARP cache
- Performs packet buffering (shared RAM)
- Provides temporary memory for the configuration file of the router while the router is powered on
- Loses content when router is powered down or restarted

NVRAM

Non-Volatile RAM

NVRAM has the following characteristics and functions:

- Provides storage for the startup configuration file
- Retains content when router is powered down or restarted
- Configuration Register – 16 bit register which decides boot sequence

Flash

Flash memory has the following characteristics and functions:

- Holds the operating system image (IOS)
- Allows software to be updated without removing and replacing chips on the processor
- Retains content when router is powered down or restarted
- Can store multiple versions of IOS software
- Is a type of electronically erasable, programmable ROM (EEPROM)

Interfaces

Interfaces have the following characteristics and functions:

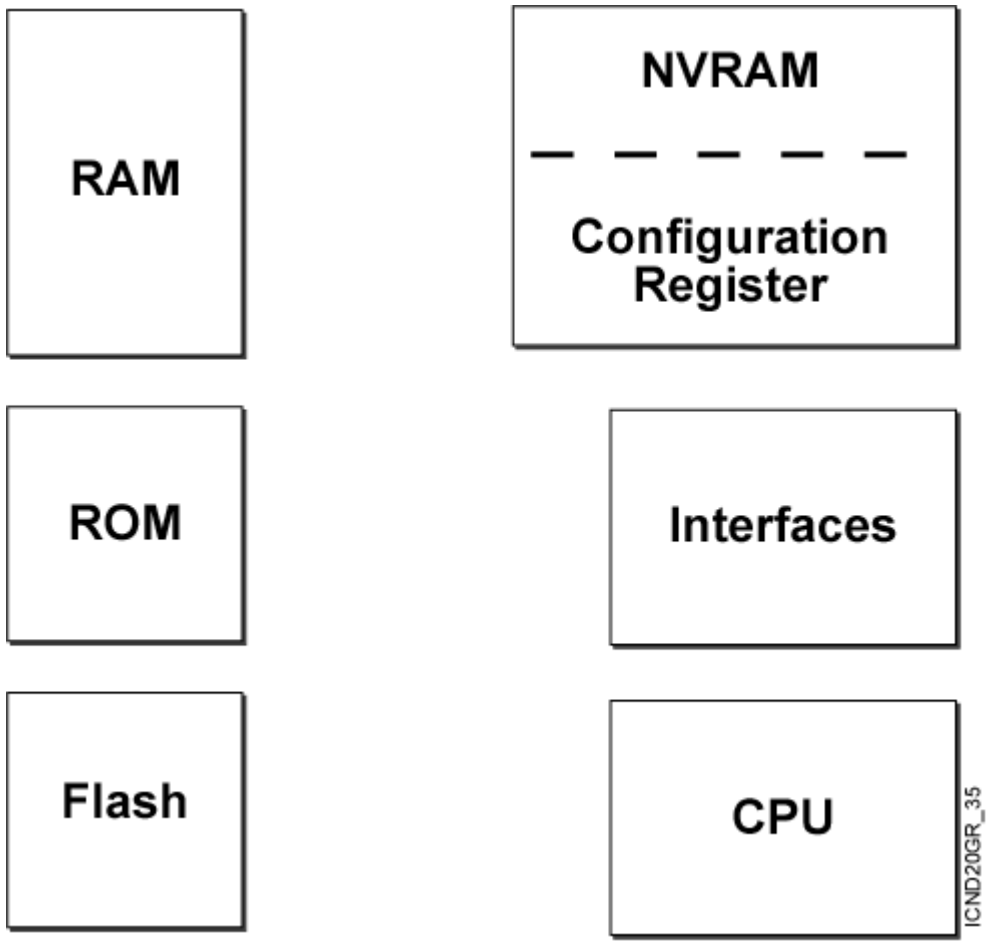
Connect router to network for frame entry and exit

Can be on the motherboard or on a separate module

Types of interfaces:

- Ethernet
- Fast Ethernet
- Serial
- ISDN BRI
- Loopback
- Console

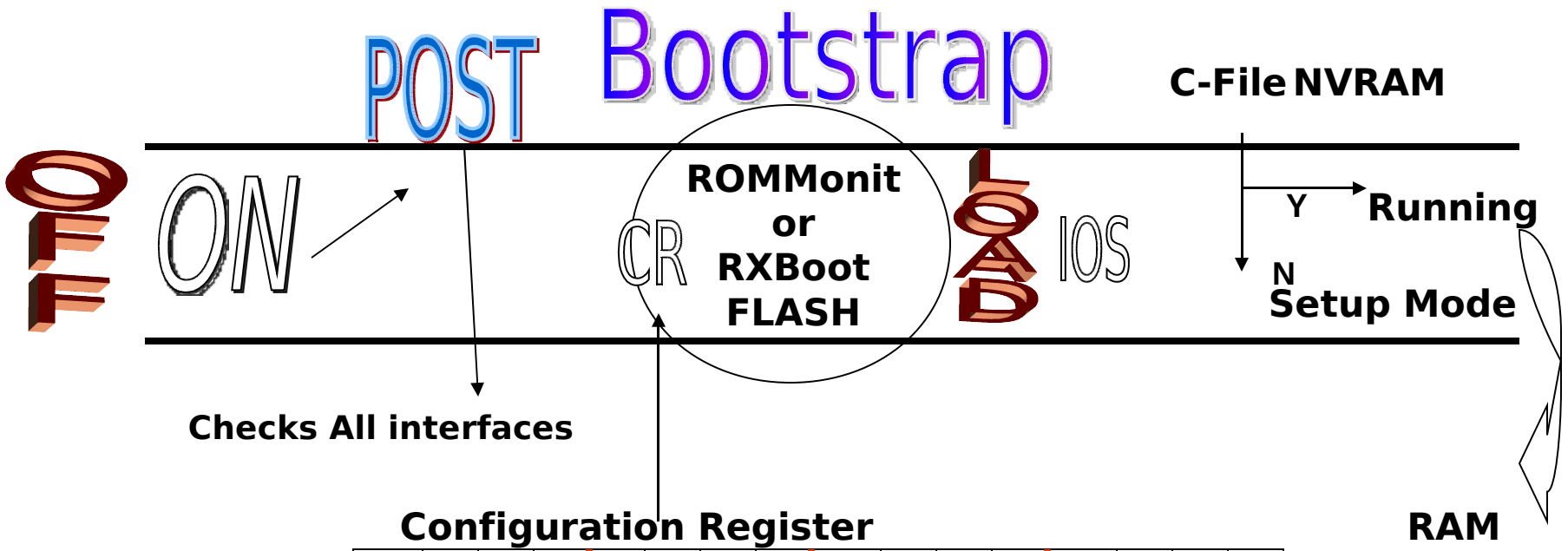
Router Internal Components



Router Power-On/Bootup Sequence

1. Perform power-on self test (POST).
2. Load and run bootstrap code.
3. Find the Cisco IOS software.
4. Load the Cisco IOS software.
5. Find the configuration.
6. Load the configuration.
7. Run the configured Cisco IOS software.

Boot Sequence



Configuration Register

8	4	2	1	8	4	2	1	8	4	2	1	8	4	2	1
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
												0	0	0	0
												0	0	0	1
												0	0	1	0
												1	1	1	1

0	ROMMonitor
1	RxBoot
2-15	Flash

After the Post…

After the POST, the following events occur as the router initializes:

Step 1
The generic bootstrap loader in ROM executes. A bootstrap is a simple set of instructions that tests hardware and initializes the IOS for operation.

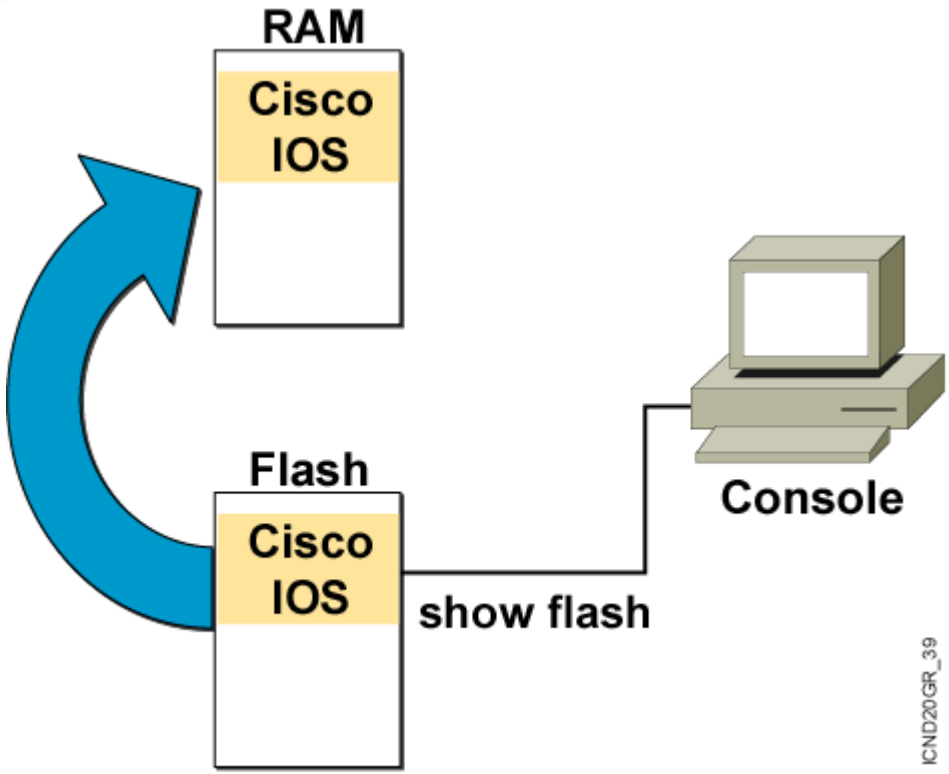
Step 2
The IOS can be found in several places. The boot field of the configuration register determines the location to be used in loading the IOS.

Step 3
The operating system image is loaded.

Step 4
The configuration file saved in NVRAM is loaded into main memory and executed one line at a time. The configuration commands start routing processes, supply addresses for interfaces, and define other operating characteristics of the router.

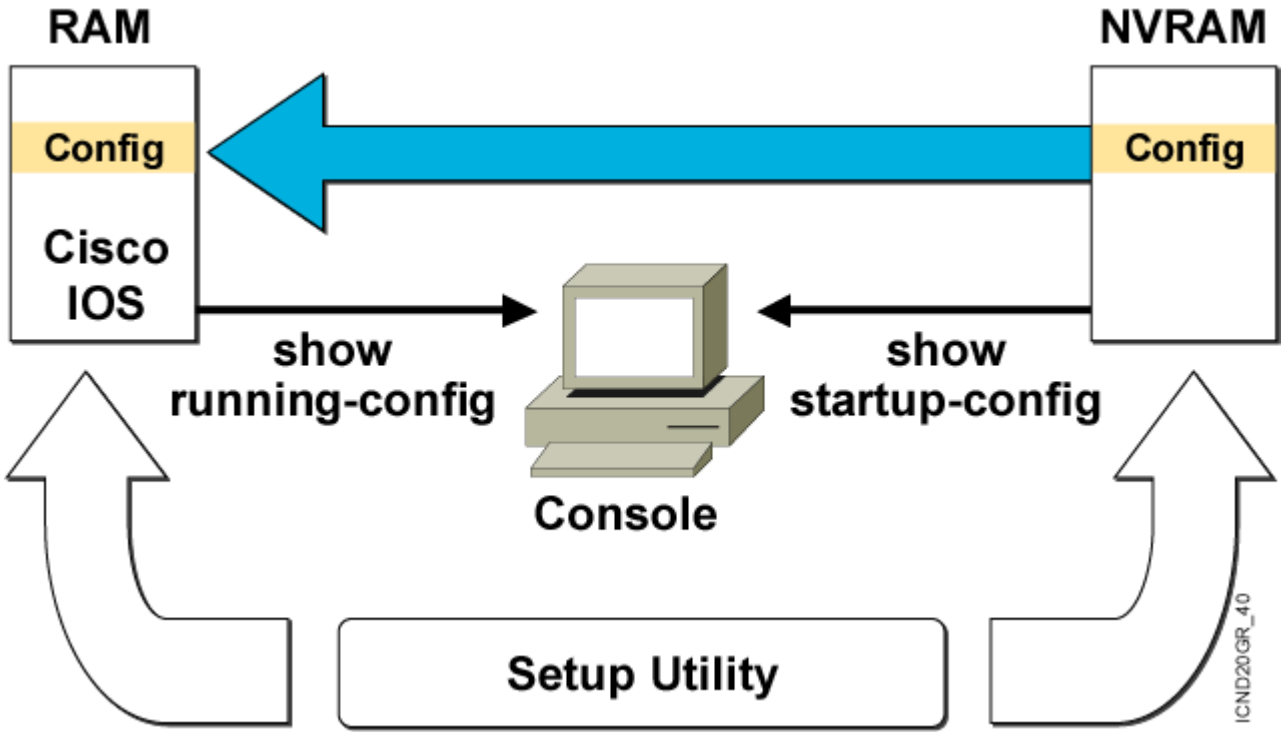
Step 5
If no valid configuration file exists in NVRAM, the operating system searches for an available TFTP server. If no TFTP server is found, the setup dialog is initiated.

Loading the Cisco IOS Software From Flash Memory



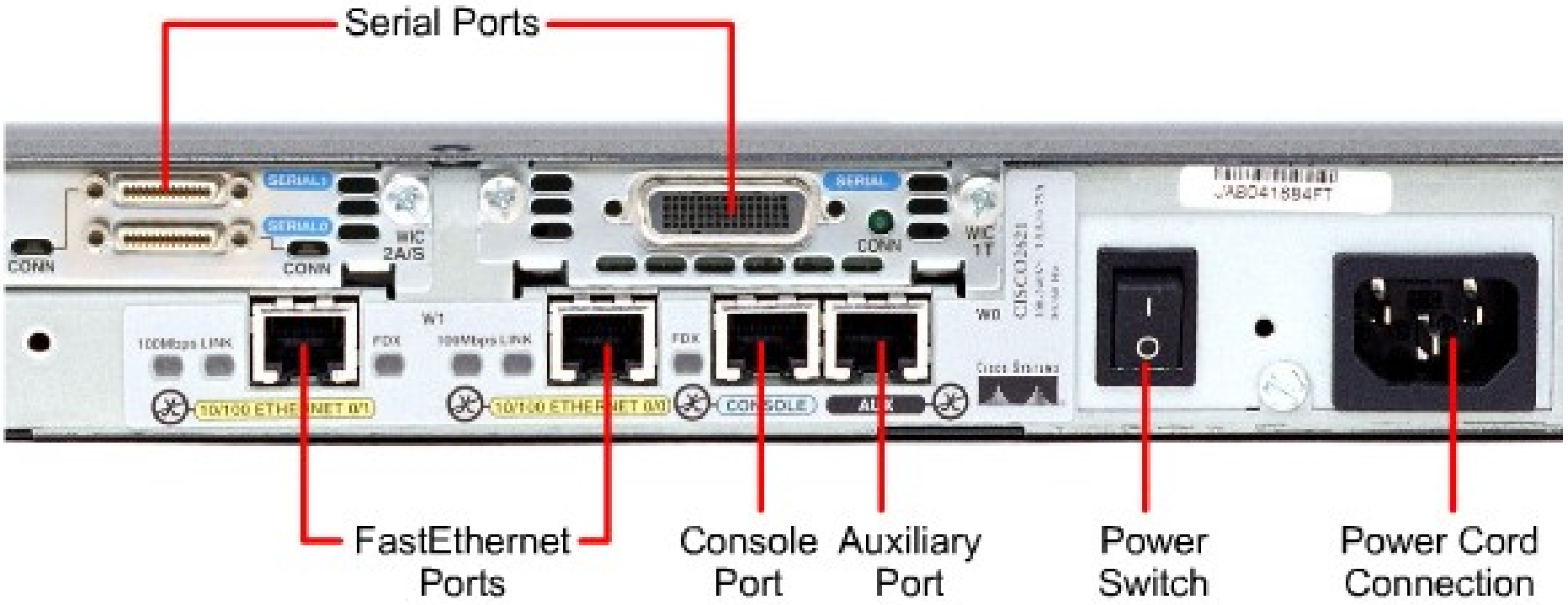
- **The flash memory file is decompressed into RAM.**

Loading the Configuration

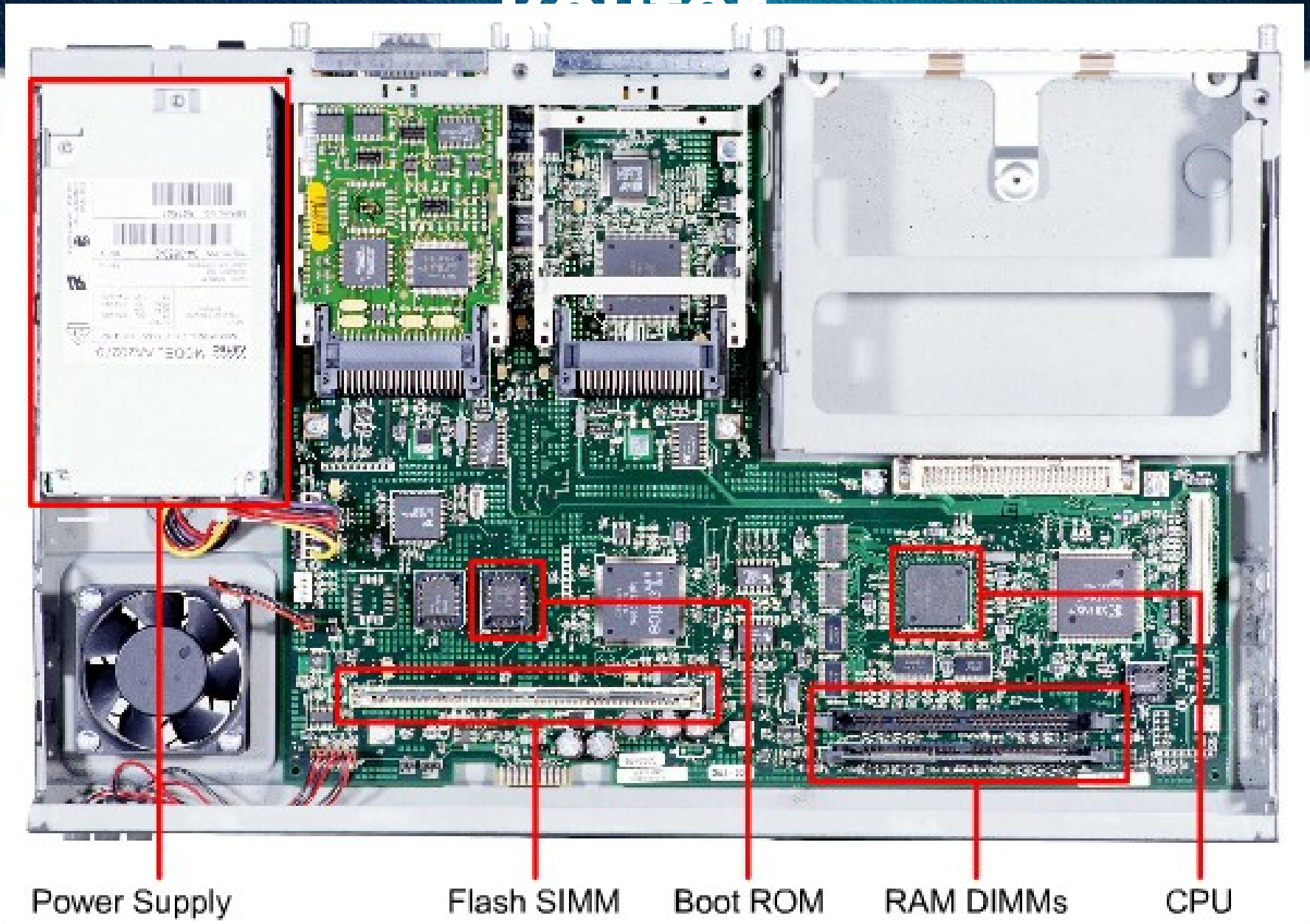


- **Load and execute the configuration from NVRAM.**
- **If no configuration is present in NVRAM, enter setup mode.**

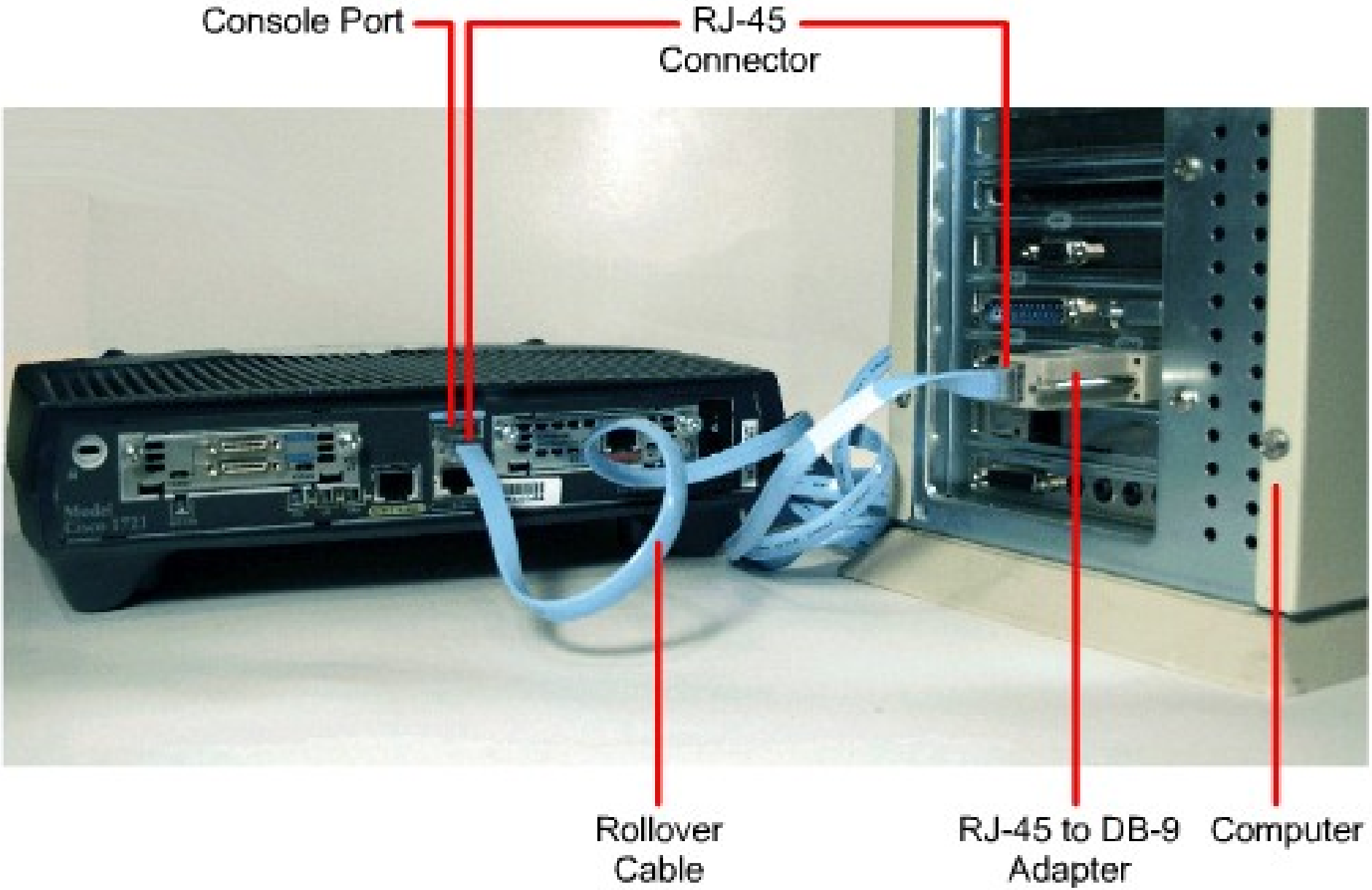
External Components of a 2600 Router



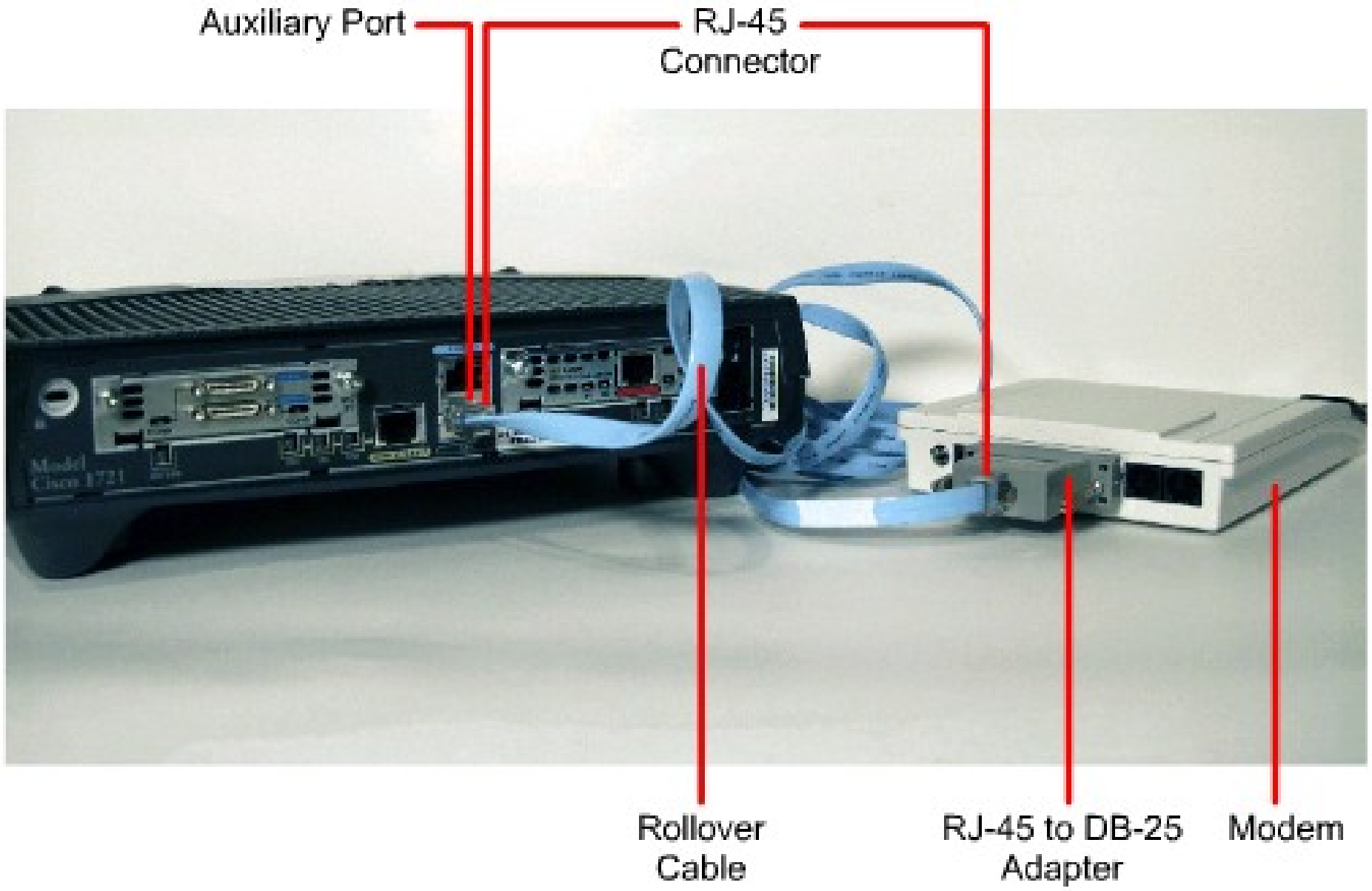
Internal Components of a 2600 Router



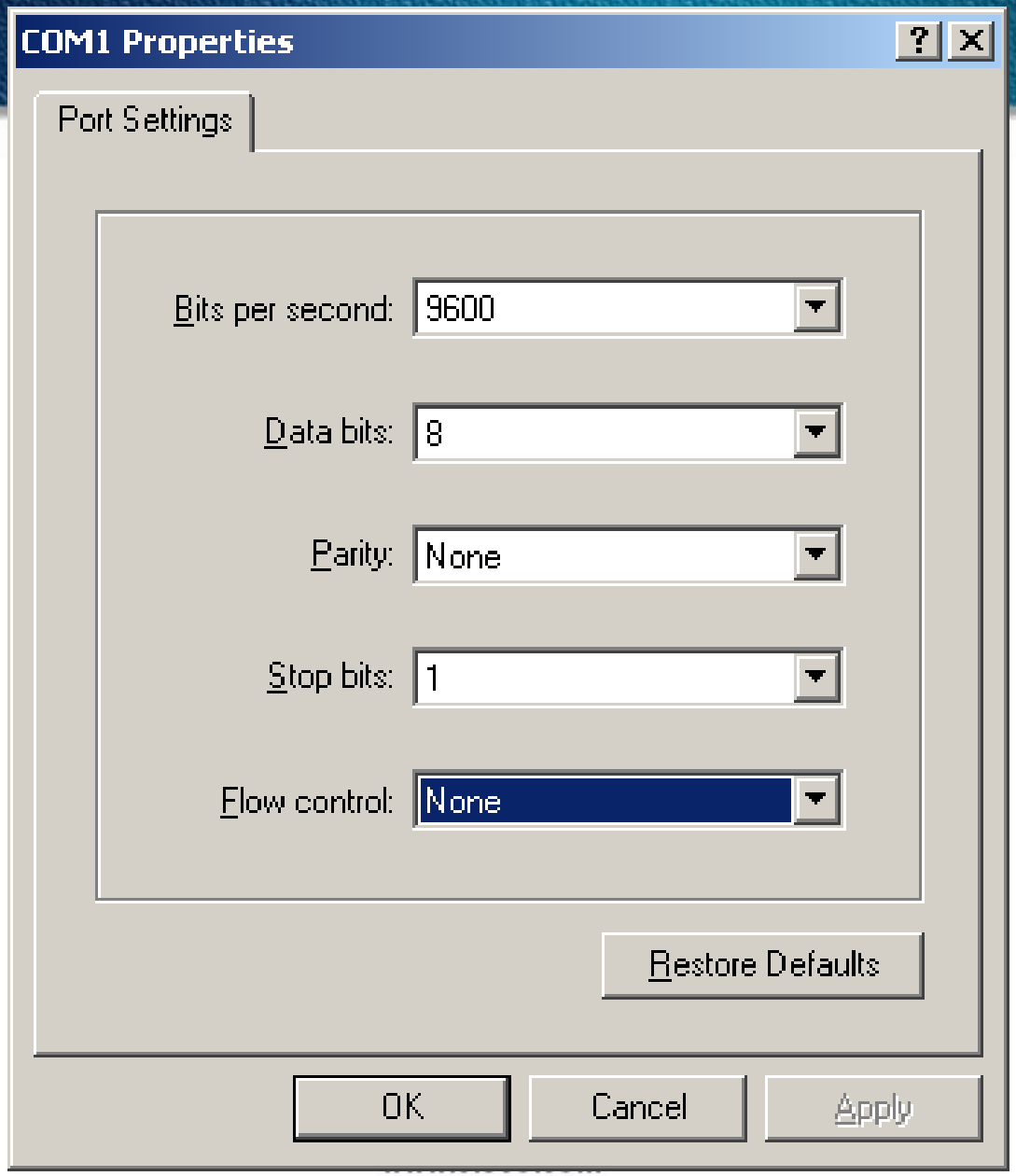
Computer/Terminal Console Connection



Modem Connection to Console/Aux Port



HyperTerminal Session Properties



Establishing a HyperTerminal Session

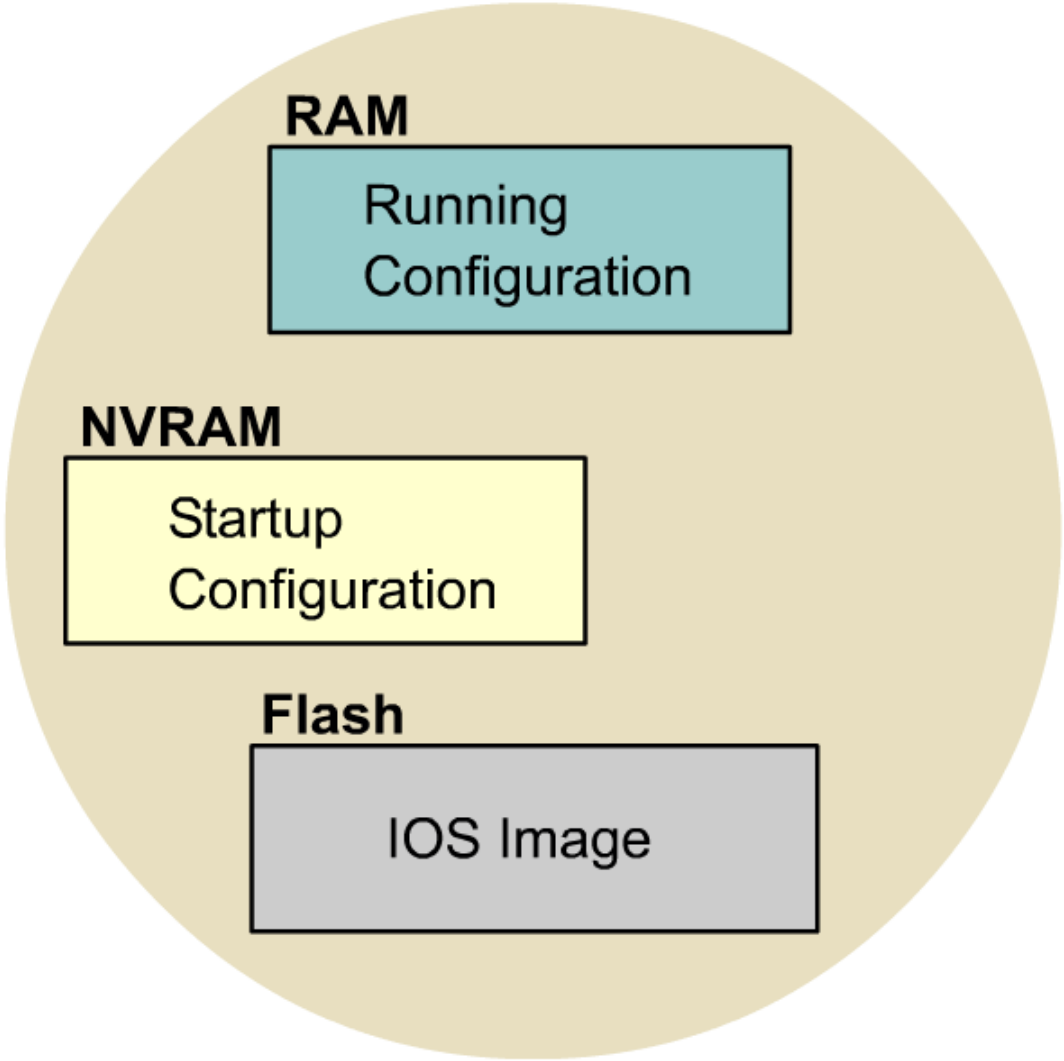
Take the following steps to connect a terminal to the console port on the router:

First, connect the terminal using the RJ-45 to RJ-45 rollover cable and an RJ-45 to DB-9 or RJ-45 to DB-25 adapter.

Then, configure the terminal or PC terminal emulation software for 9600 baud, 8 data bits, no parity, 1 stop bit, and no flow control.

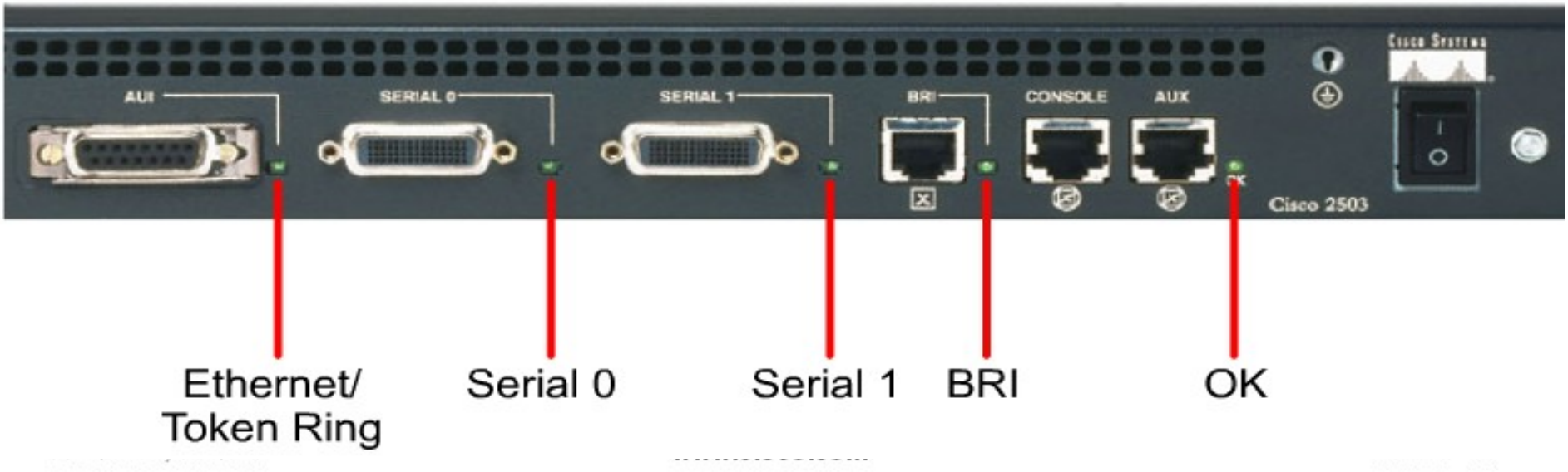
Router Command Line Interface

IOS File System Overview



Router LED Indicators

Cisco routers use LED indicators to provide status information. Depending upon the Cisco router model, the LED indicators will vary. An interface LED indicates the activity of the corresponding interface. If an LED is off when the interface is active and the interface is correctly connected, a problem may be indicated. If an interface is extremely busy, its LED will always be on. The green OK LED to the right of the AUX port will be on after the system initializes correctlv.



Router Configuration

Router User Interface Modes

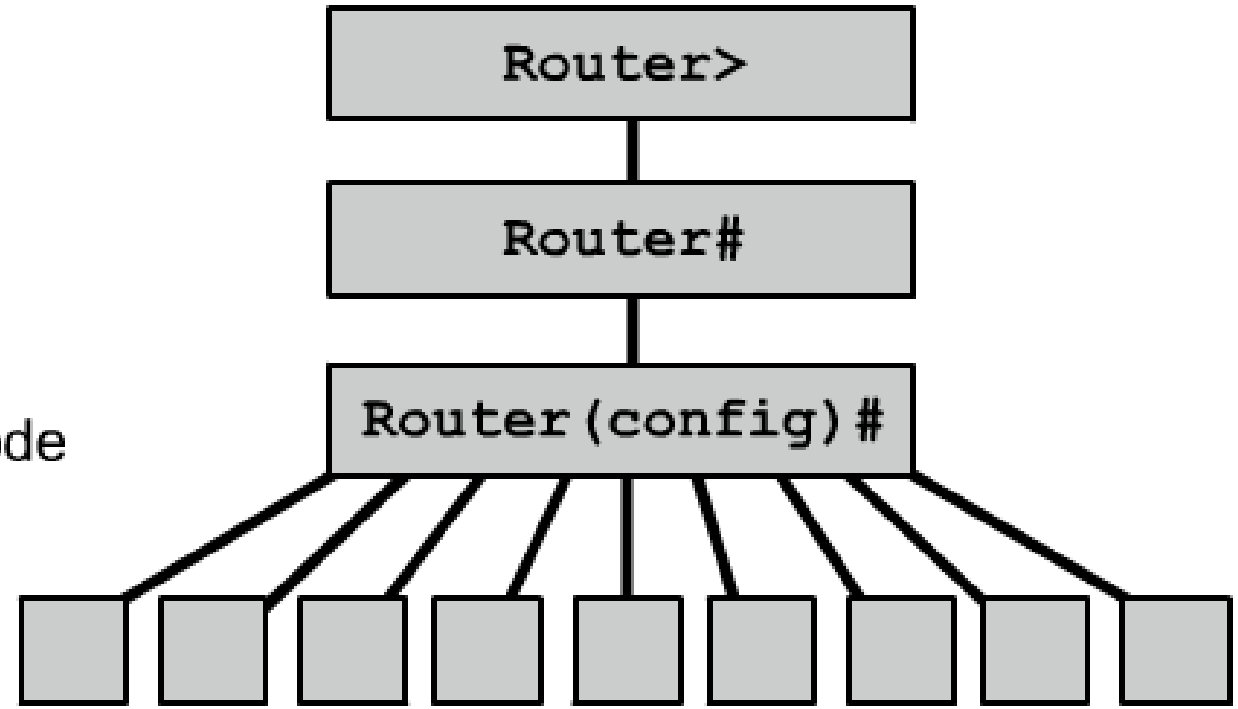
The Cisco command-line interface (CLI) uses a hierarchical structure. This structure requires entry into different modes to accomplish particular tasks.

Each configuration mode is indicated with a distinctive prompt and allows only commands that are appropriate for that mode.

As a security feature the Cisco IOS software separates sessions into two access levels, user EXEC mode and privileged EXEC mode. The privileged EXEC mode is also known as enable mode.

Overview of Router Modes

- User EXEC mode
- Privileged EXEC mode
- Global configuration mode
- Specific configuration modes



Router Modes

Router

```
Router con0 is now available.

Press RETURN to get started.

User Access Verification
Password:
Router>
Router>enable
Password:
Router#
Router#disable
Router>
Router>exit
```

User-Mode Prompt

Privileged-Mode Prompt

CLI Command Modes

All command-line interface (CLI) configuration changes to a Cisco router are made from the global configuration mode. Other more specific modes are entered depending upon the configuration change that is required.

Global configuration mode commands are used in a router to apply configuration statements that affect the system as a whole.

The following command moves the router into global configuration mode

Router#**configure terminal** **(or config t)**
Router(config)#

When specific configuration modes are entered, the router prompt changes to indicate the current configuration mode.

Typing **exit** from one of these specific configuration modes will return the router to global configuration mode. Pressing **Ctrl-Z** returns the router to all the way back privileged EXEC mode.

Show Version Command

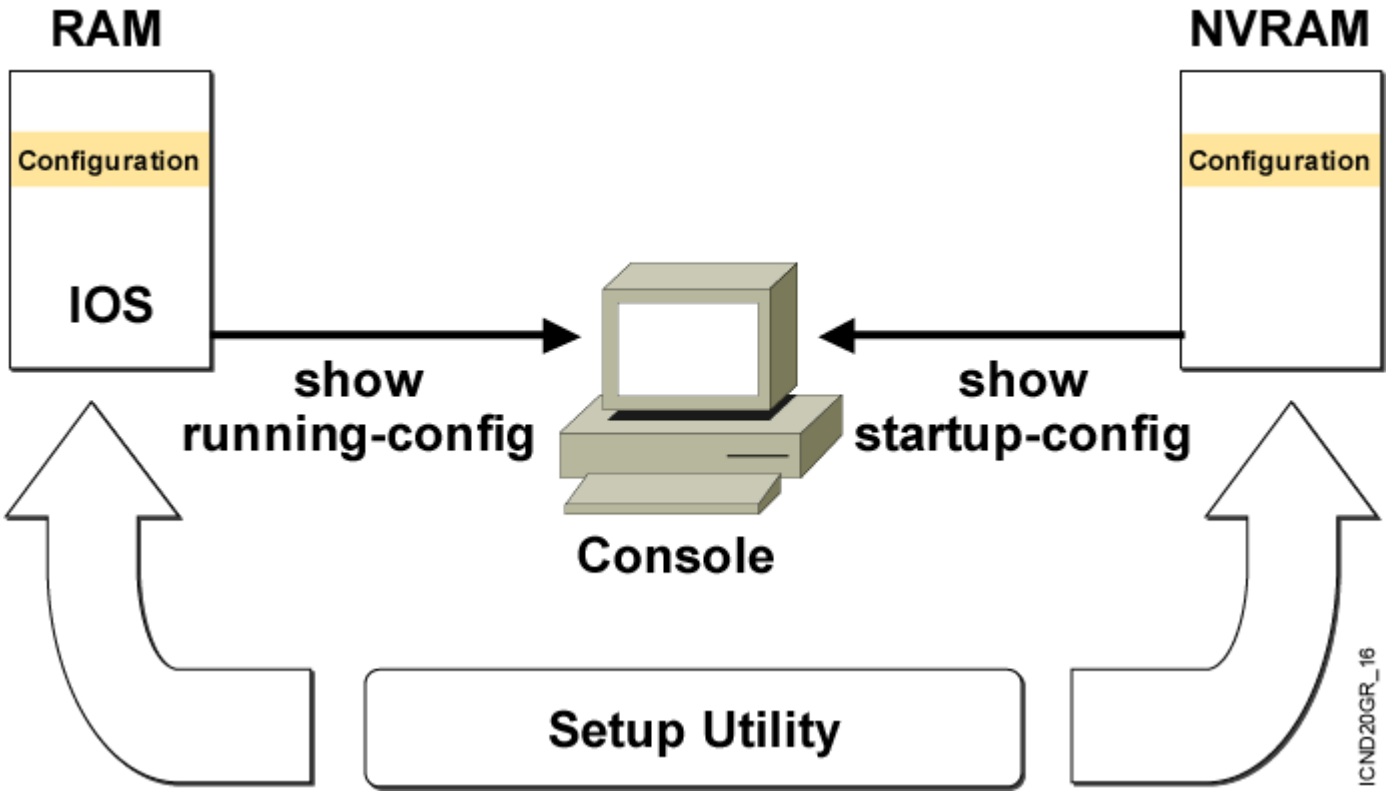
```
wg_ro_a#show version
Cisco Internetwork Operating System Software
IOS (tm) 2500 Software (C2500-JS-L), Version 12.0(3), RELEASE SOFTWARE (fc1)
Copyright (c) 1986-1999 by cisco Systems, Inc.
Compiled Mon 08-Feb-99 18:18 by phanguye
Image text-base: 0x03050C84, data-base: 0x00001000

ROM: System Bootstrap, Version 11.0(10c), SOFTWARE
BOOTFLASH: 3000 Bootstrap Software (IGS-BOOT-R), Version 11.0(10c), RELEASE SOFTWARE(fc1)

wg_ro_a uptime is 20 minutes
System restarted by reload
System image file is "flash:c2500-js-l_120-3.bin"
(output omitted)
--More--

Configuration register is 0x2102
```

Viewing the Configuration



show running-config and show startup-config Commands

In RAM

```
wg_ro_c#show running-config
Building configuration...

Current configuration:
!
version 12.0
!
     -- More --
```

In NVRAM

```
wg_ro_c#show startup-config
Using 1359 out of 32762 bytes
!
version 12.0
!
     -- More --
```

- **Displays the current and saved configuration**

Saving Configurations

Configurations in two locations - RAM and NVRAM.

- The running configuration is stored in RAM.
- Any configuration changes to the router are made to the running-configuration and take effect immediately after the command is entered.
- The startup-configuration is saved in NVRAM and is loaded into the router's running-configuration when the router boots up.
- To save the running-configuration to the startup configuration, type the following from privileged EXEC mode (i.e. at the "Router#" prompt.)

```
Router# copy run start
```

Command Abbreviation

- Show Configuration – sh conf
- Configure Terminal – conf t
- Line auxillary – line aux
- Line console – line con

Configuring a Router's Name

A router should be given a unique name as one of the first configuration tasks.

This task is accomplished in global configuration mode using the following commands:

```
Router(config)#hostname Gates
Gates(config)#
```

As soon as the Enter key is pressed, the prompt changes from the default host name (Router) to the newly configured host name (which is Gates in the example above).

Router

```
Cisco#cl?
clear  clock
Cisco#clock
% Incomplete command.
Cisco#clock ?
  set  Set the time and date
Cisco#clock set
% Incomplete command.
Cisco#clock set ?
  hh:mm:ss  Current Time
Cisco#clock set 19:50:00
% Incomplete command.
Cisco#clock set 19:50:00 ?
  <1-31>  Day of the month
  MONTH   Month of the year
Cisco#clock set 19:50:00 14 7
                            ^
% Invalid input detected at '^' marker.
Cisco#clock set 19:50:00 14 July
% Incomplete command.
Cisco#clock set 19:50:00 14 July ?
  <1993-2035>  Year
Cisco#clock set 19:50:00 14 July 2003
Cisco#
```

Message Of The Day (MOTD)

A message-of-the-day (MOTD) banner can be displayed on all connected terminals.

Enter global configuration mode by using the command **config t**

Enter the command
banner motd # Welcome to Gates Training #.

Save changes by issuing the command **copy run start**

Privileged Mode Command

show startup-config
show running-config
show version
show flash
show interfaces
show interfaces s 0
show history
show terminal
terminal history size 25

Password

- Passwords restrict access to routers.
- Passwords should always be configured for virtual terminal lines and the console line.
- Passwords are also used to control access to privileged EXEC mode so that only authorized users may make changes to the configuration file.

Passwords

- There are five passwords for Router
  - Privileged Mode Password – 2
  - Line Console Password
  - Auxiliary Port Password
  - Telnet Password

Privileged Mode Password

Gates(config)# enable password gates

Encrypted privilege mode password

Gates(config)# enable secret gates1

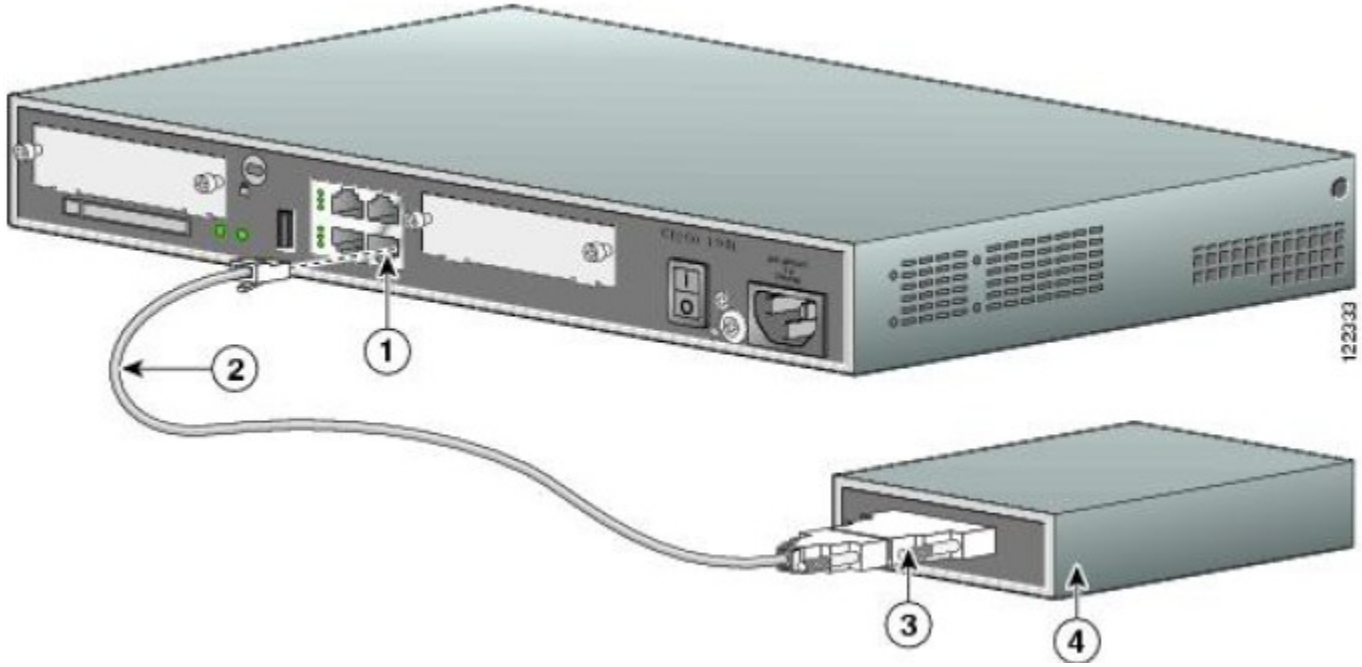
Line Password

```
Gates(config)# line console 0
Gates(config)# password cisco
Gates(config)# login
```

Aux Port Password

```
Gates(config)# line aux 0
Gates(config)# password cisco
Gates(config)# login
```

Connecting to Aux Port



1	Aux port (RJ-45)	3	DB-9-to-DB-25 modem adapter
2	Light blue console cable	4	Modem

Configuring a Telnet Password

- A password must be set on one or more of the virtual terminal (VTY) lines for users to gain remote access to the router using Telnet.
- Typically Cisco routers support five VTY lines numbered 0 through 4.

Telnet Password

```
Gates(config)# line vty 0 4
Gates(config)# password cisco
Gates(config)# login
```

Encrypting Passwords

- Only the enable secret password is encrypted by default
- Need to manually configure the user-mode and enable passwords for encryption
- To manually encrypt your passwords, use the service password-encryption command

```
Router#config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#service password-encryption
```

Disable Passwords

Gates(config)# no enable password

Gates(config)# no enable secret

For the Console

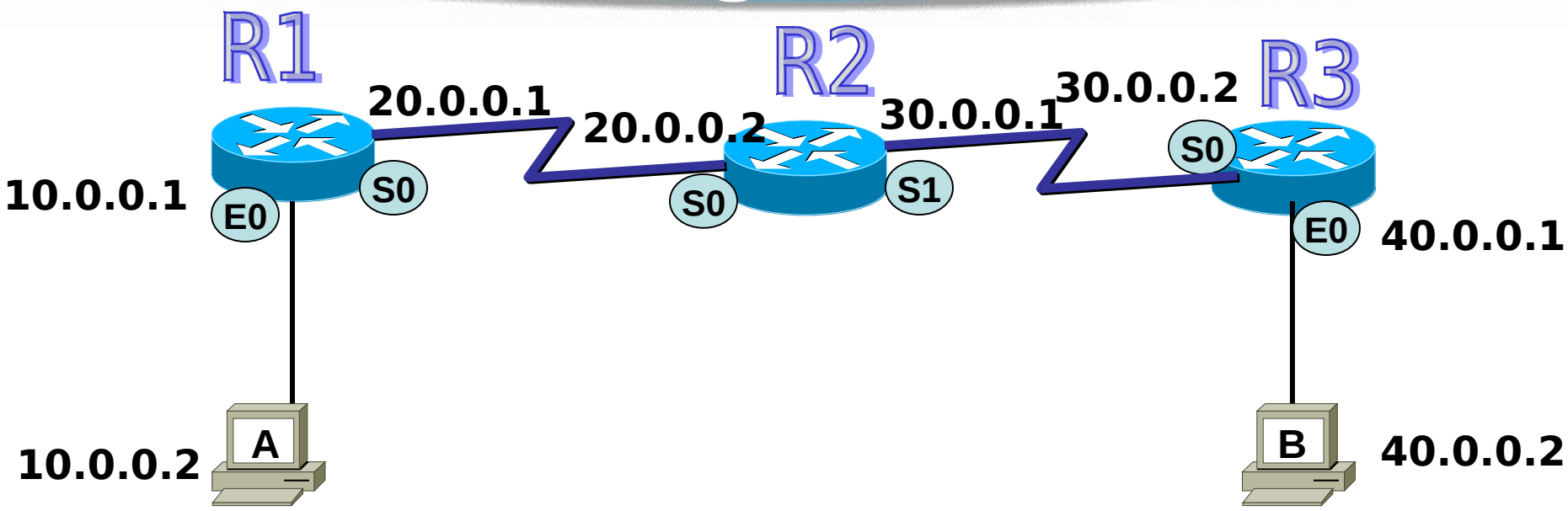
Gates(config)# line con 0

Gates(config)# no password

Gates(config)# line vty 0 4

Gates(config)# no password

LAB – Interface Configuration



Descriptions

- Setting descriptions on an interface is helpful to the administrator
- Only locally significant

R1(config)#**int e0**

R1(config-if)#**description Sales Lan**

R1(config-if)#**int s0**

R1(config-if)#**desc Wan to Mumbai**

Configuring Interfaces

- An interface needs an IP Address and a Subnet Mask to be configured.
- All interfaces are “shutdown” by default.
- The DCE end of a serial interface needs a clock rate.

R1#**config t**
R1(config)#**int e0**
R1(config)#**Description Connoted to Host**
R1(config-if)#**ip address 10.0.0.1 255.0.0.0**
R1(config-if)#**no shutdown**
R1(config-if)#**exit**
R1(config)#**interface serial 0**
R1(config-if)#**ip address 20.0.0.1 255.255.255.0**
R1(config-if)# bandwidth 64
R1(config-if)#**clock rate 64000 (required for serial DCE only)**
R1(config-if)#**no shutdown**
R1(config-if)#**exit**
R1(config)#**exit**
R1#

On new routers, Serial 1 would be just Serial 0/1 and e0 would be f0/0.
s = serial e = Ethernet f = fast Ethernet

DCE DTE

- To find out DCE or DTE

#Show controllers s 0

Viewing Configuration

- To Check the status of interface

#Show IP interface brief

or

#Sh IP int brief

Saving and Erasing Configurations

- To copy RAM to NVRAM

copy run startup-config

- To remove all configuration

erase startup-config

reload

Routing

Objectives

- Upon completion of this chapter, you will be able to complete the following tasks:
  - Distinguish the use and operation of static and dynamic routes
  - Configure and verify a static route
  - Identify how distance vector IP routing protocols such as RIP and IGRP operate on Cisco routers
  - Enable Routing Information Protocol (RIP)
  - Enable Interior Gateway Routing Protocol (IGRP)

Routing

- The process of transferring data from one local area network to another
- Layer 3 devices
- Routed protocol Enables to forward packet from one router to another – Ex – IP, IPX
- Routing protocol sends and receives routing information packets to and from other routers – Ex -RIP, OSPF , IGRP
- Routing protocols gather and share the routing information used to maintain and update routing tables.
- That routing information is in turn used to route a routed protocol to its final destination

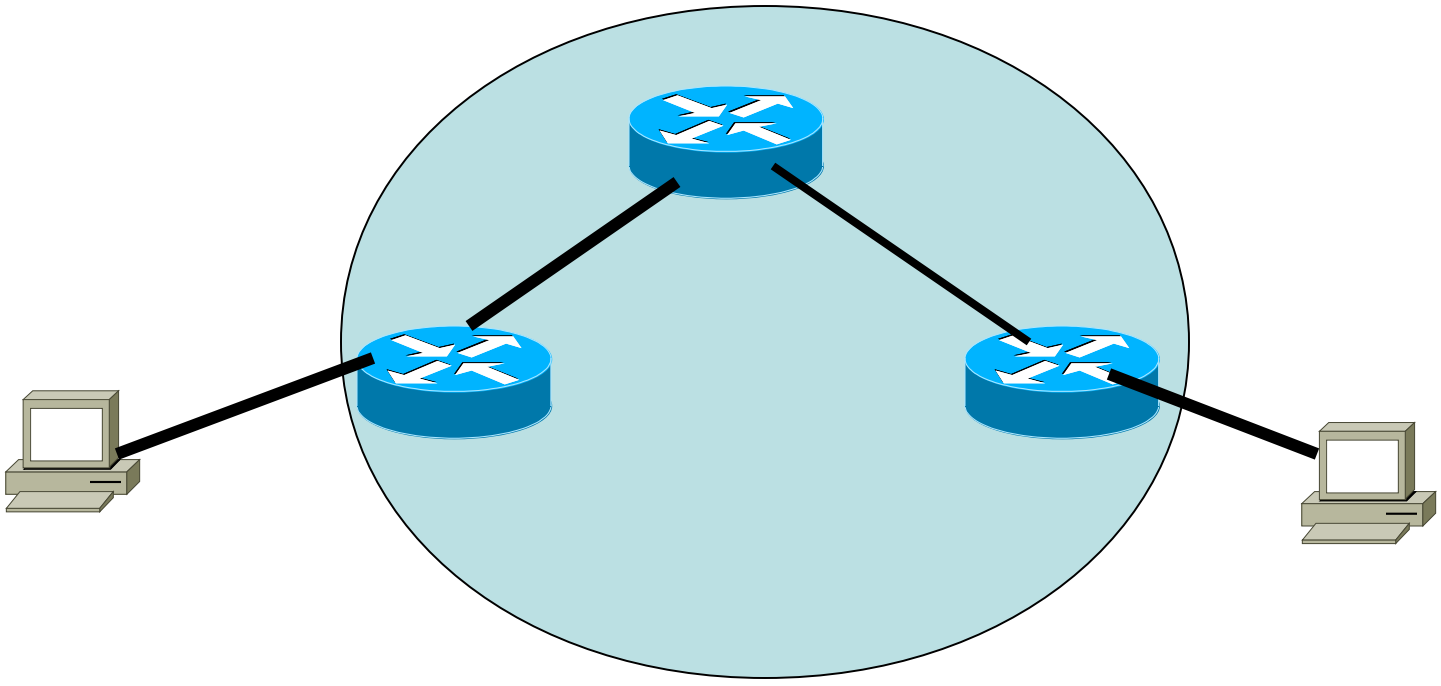
Routing

From

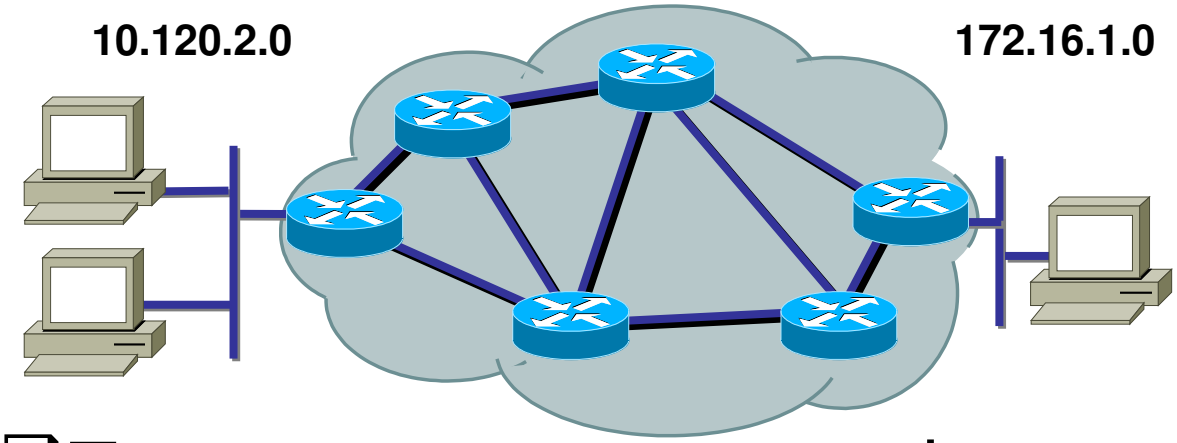
Raj
House #213, 4th Street
Jayanagar, Bangalore

To

Ram
House #452, 2nd Street
Dadar, Mumbai

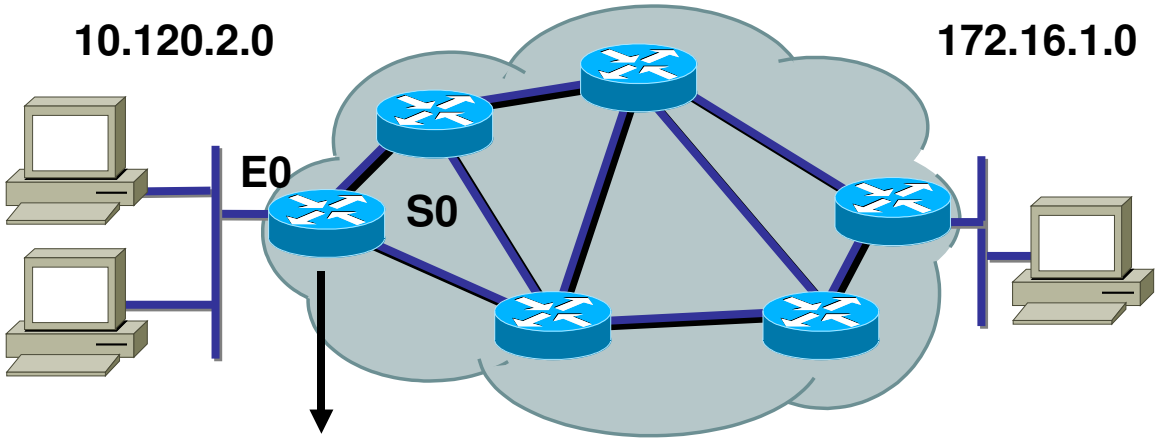


What is Routing?



- To route, a router needs to know:
  - Destination addresses
  - Sources it can learn from
  - Possible routes
  - Best route

What is Routing? (cont.)



Network Protocol	Destination Network	Exit Interface
Connected	10.120.2.0	E0
Learned	172.16.1.0	S0

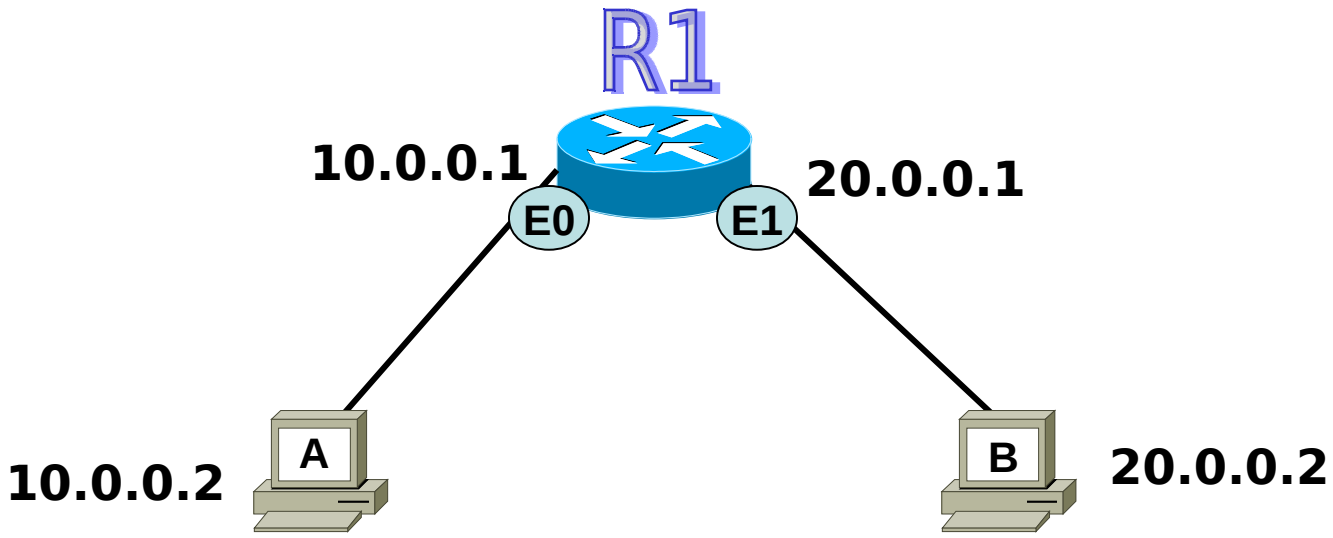
Routed Protocol: IP

Routers must learn destinations that are not directly connected

Route Types

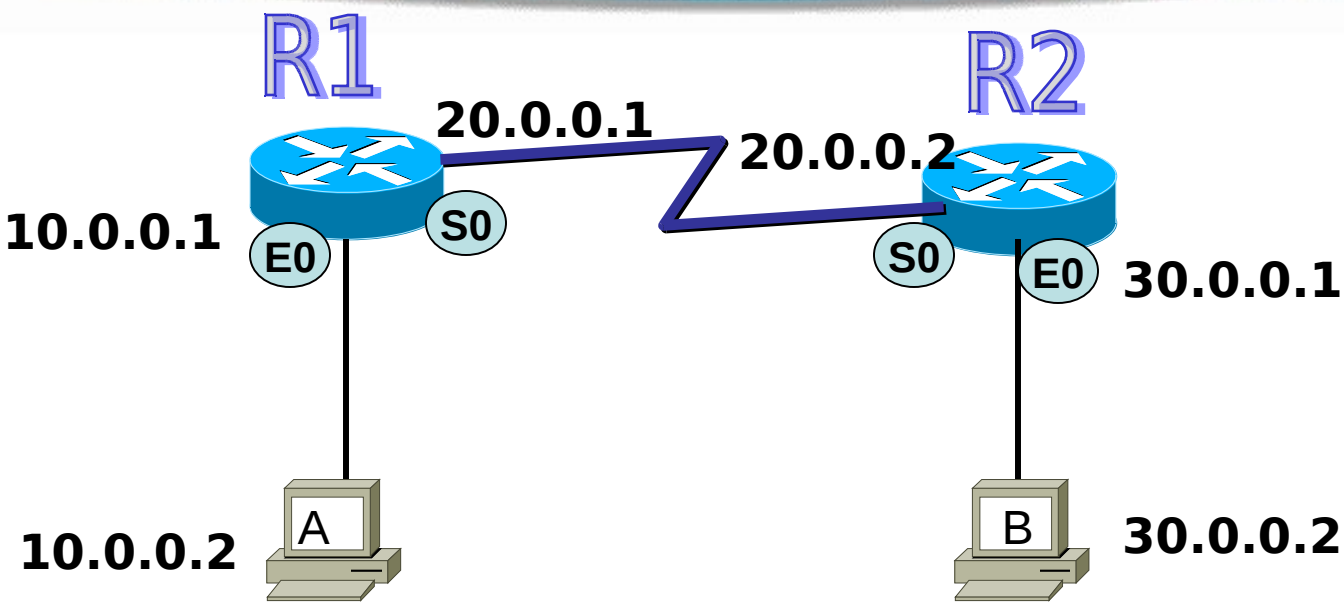
- Static routing - network administrator configures information about remote networks manually. They are used to reduce overhead and for security.
- Dynamic routing - information is learned from other routers, and routing protocols adjust routes automatically.
- Because of the extra administrative requirements, static routing does not have the scalability of dynamic routing.

IP Routing Process

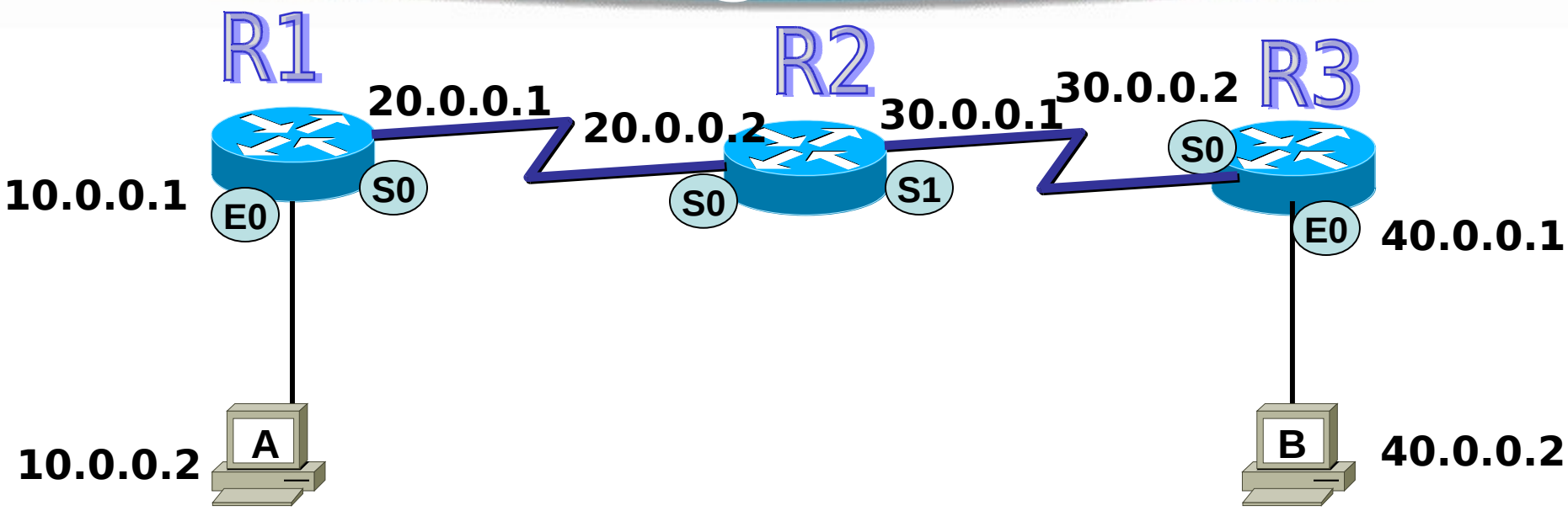


- Step-by-step what happens when Host A wants to communicate with Host B on a different network
- A user on Host A pings Host B's IP address.

LAB Configuration



LAB – Interface Configuration



Test The Connection

- Host A can ping router R1 and R2
- To enable Host A to Ping Host B we need to configure Routes

IP Routing

- The different types of routing are:
  - Static routing
  - Default routing
  - Dynamic routing

Static Routes

- **Benefits**
  - No overhead on the router CPU
  - No bandwidth usage between routers
  - Adds security
- **Disadvantage**
  - Administrator must really understand the internetwork
  - If a network is added to the internetwork, the administrator has to add a route to it on all routers
  - Not feasible in large networks

Static Route Configuration

```
R1(config)#ip route network  [mask]
{address | interface}[distance] [permanent]
```

- R1(config)# iproute DestAddress SNM Nexthop address

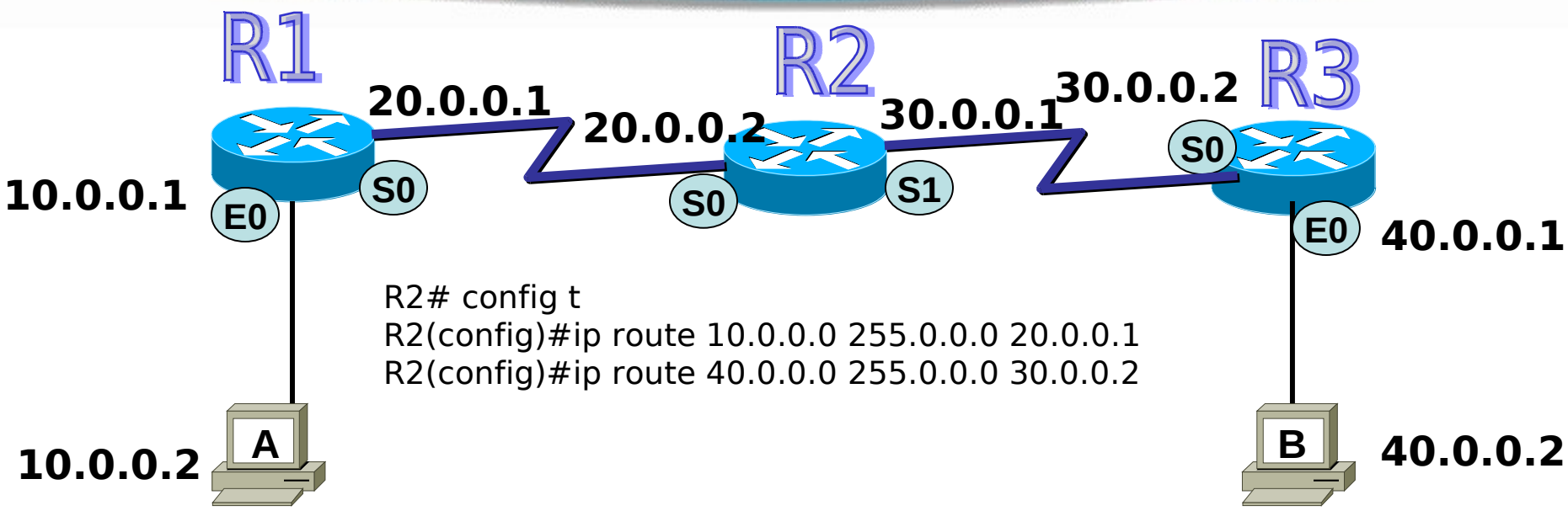
Static Route Configuration

ip route [*destination_network*] [*mask*] [*next-hop_address or exitinterface*] [*administrative_distance*] [permanent

- **ip route** The command used to create the static route.
- **destination_network** The network you're placing in the routing table.
- **mask** The subnet mask being used on the network.
- **next-hop_address** The address of the next-hop router that will receive the packet and forward it to the remote network. This is a router interface that's on a directly connected network.
- **exitinterface** You can use it in place of the next-hop address if you want, but it's got to be on a point-to-point link, such as a WAN
- **administrative_distance** By default, static routes have an administrative distance of 1 (or even 0 if you use an exit interface instead of a next-hop address)
- **permanent** If the interface is shut down, or the router can't communicate to the next-hop router, the route will automatically be discarded from the routing table. Choosing the permanent option keeps the entry in the routing table no matter what happens.

```
R1(config)#ip route 30.0.0.0 255.0.0.0 20.0.0.2
```

LAB – Static Route Configuration



R2# config t
R2(config)#ip route 10.0.0.0 255.0.0.0 20.0.0.1
R2(config)#ip route 40.0.0.0 255.0.0.0 30.0.0.2

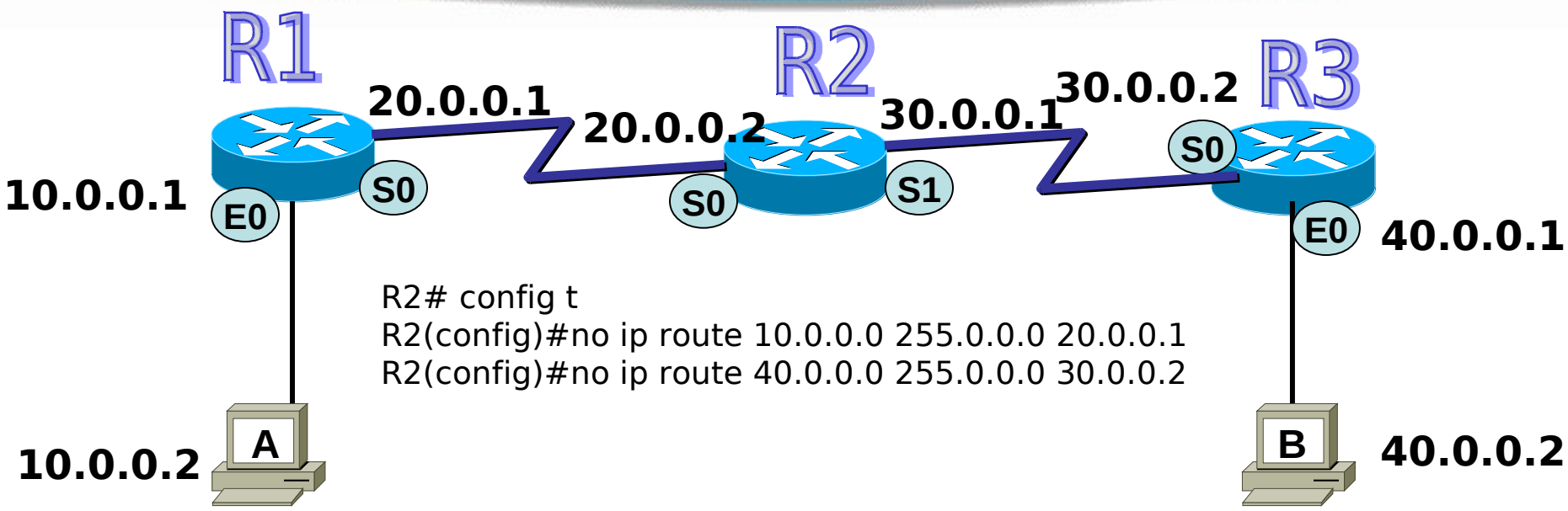
R1# config t
R1(config)#ip route 30.0.0.0 255.0.0.0 20.0.0.2
R1(config)#ip route 40.0.0.0 255.0.0.0 20.0.0.2

R3# config t
R3(config)#ip route 10.0.0.0 255.0.0.0 30.0.0.1
R3(config)#ip route 20.0.0.0 255.0.0.0 30.0.0.1

Verifying Static Route Configuration

- After static routes are configured it is important to verify that they are present in the routing table and that routing is working as expected.
- The command **show running-config** is used to view the active configuration in RAM to verify that the static route was entered correctly.
- The **show ip route** command is used to make sure that the static route is present in the routing table.

Removing IP Route



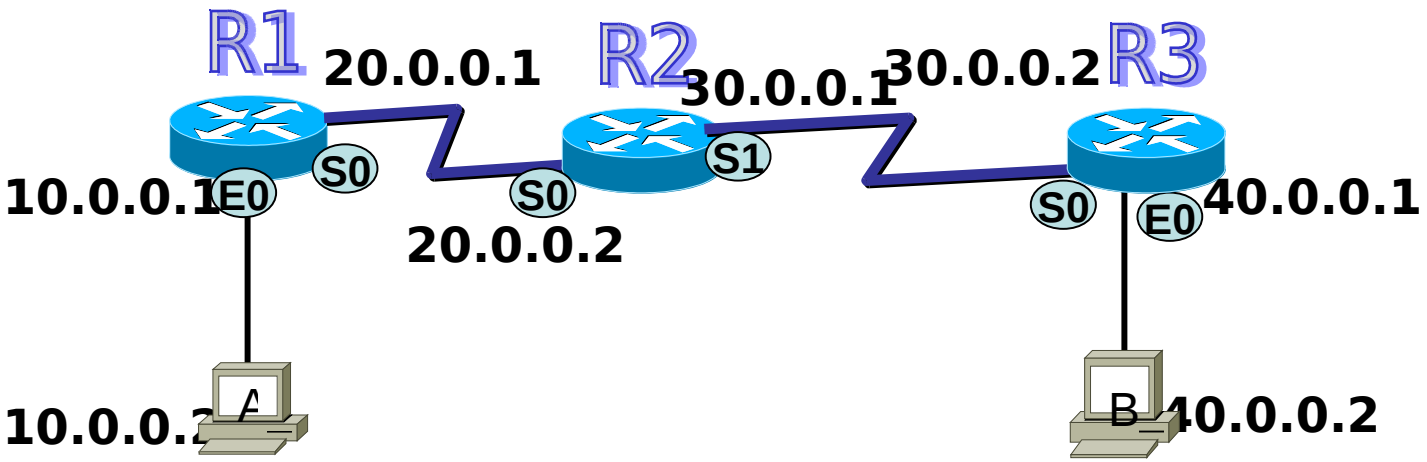
R2# config t
R2(config)#no ip route 10.0.0.0 255.0.0.0 20.0.0.1
R2(config)#no ip route 40.0.0.0 255.0.0.0 30.0.0.2

R1# config t
R1(config)#no ip route 30.0.0.0 255.0.0.0 20.0.0.2
R1(config)#no ip route 40.0.0.0 255.0.0.0 20.0.0.2

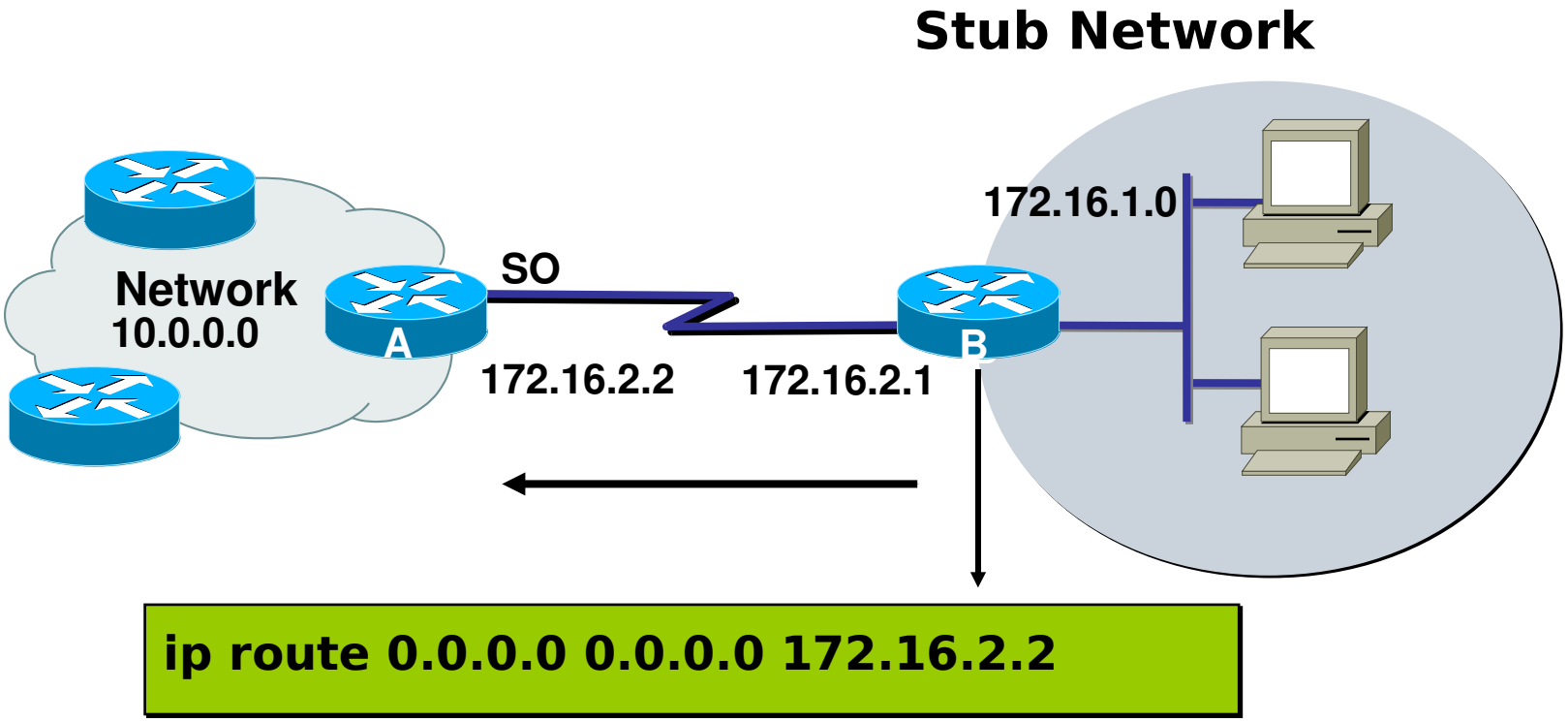
R3# config t
R3(config)#no ip route 10.0.0.0 255.0.0.0 30.0.0.
R3(config)#no ip route 20.0.0.0 255.0.0.0 30.0.0.

Default Routes

- Can only use default routing on stub networks
- Stub networks are those with only one exit path out of the network
- The only routers that are considered to be in a stub network are R1 and R3



Default Routes



- This route allows the stub network to reach all known networks beyond router A.

Configuring Default Routes

Default routes are used to route packets with destinations that do not match any of the other routes in the routing table.

A default route is actually a special static route that uses this format:

ip route 0.0.0.0 0.0.0.0 [*next-hop-address* | *outgoing interface*]

This is sometimes referred to as a “Quad-Zero” route.

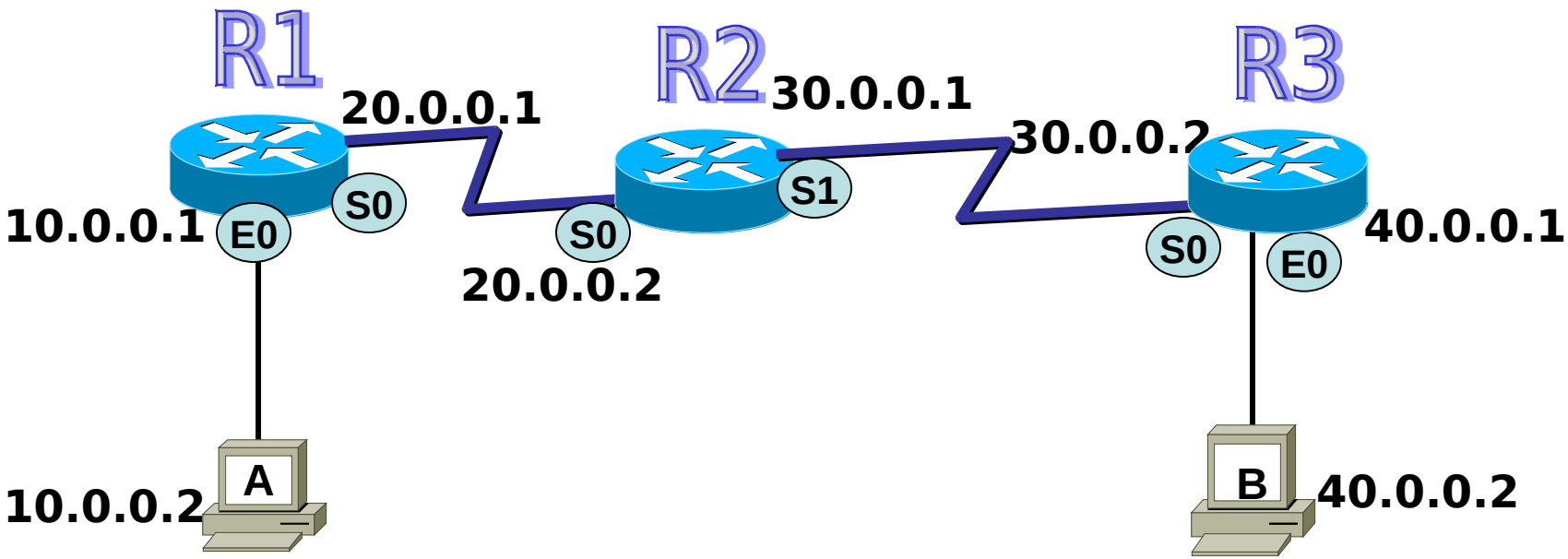
Example using next hop address:

Router(config)#**ip route 0.0.0.0 0.0.0.0 172.16.4.1**

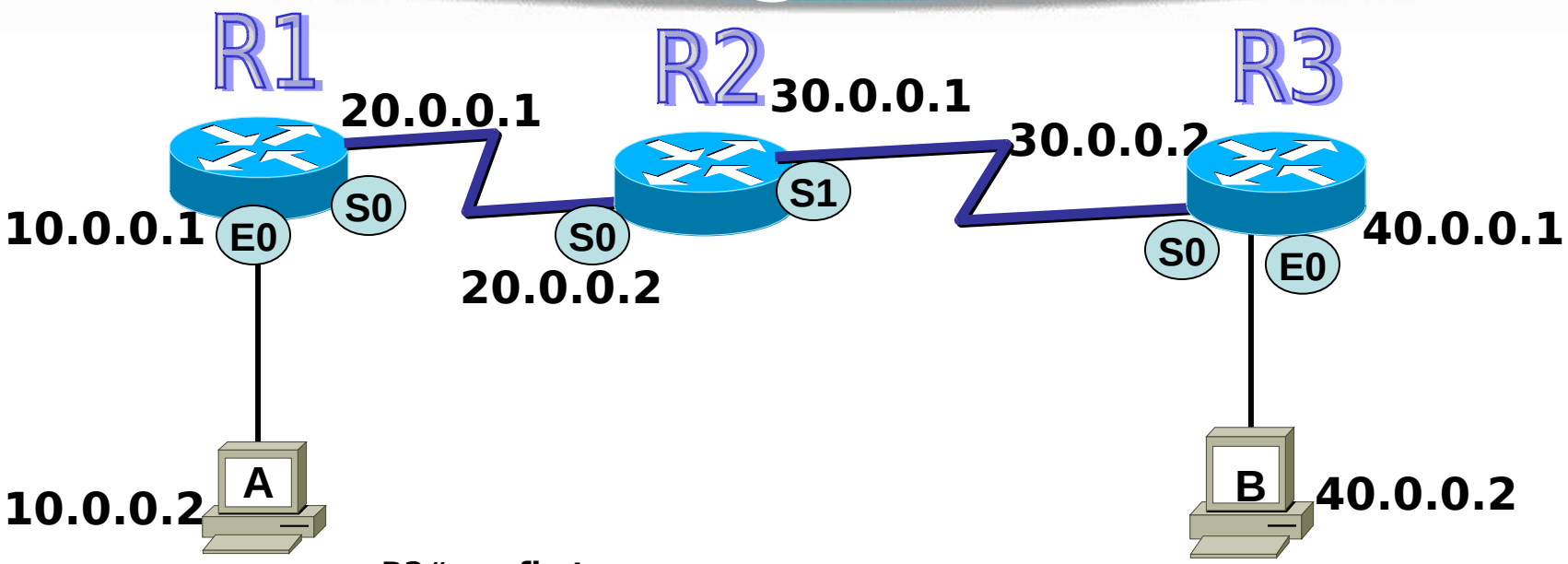
Example using the exit interface:

Router(config)#**ip route 0.0.0.0 0.0.0.0 s0/0**

LAB Configuration



Default Route LAB Configuration



R2# config t
R2(config)#ip route 10.0.0.0 255.0.0.0 20.0.0.1
R2(config)#ip route 40.0.0.0 255.0.0.0 30.0.0.2

R1# config t
R1(config)#ip route 0.0.0.0 0.0.0.0 20.0.0.2

R3# config t
R3(config)#ip route 0.0.0.0 0.0.0.0 30.0.0.1