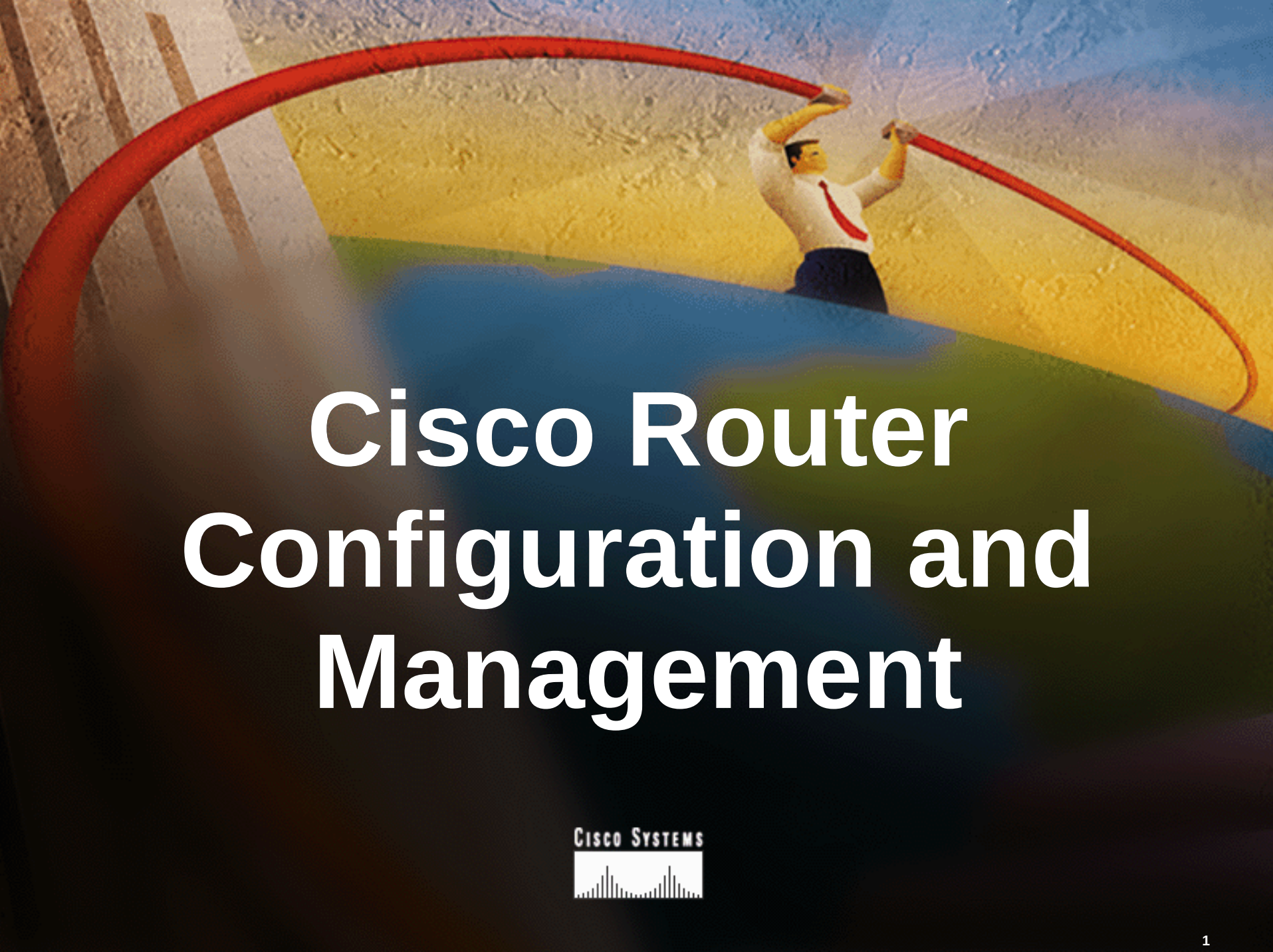


Cisco Router Configuration and Management

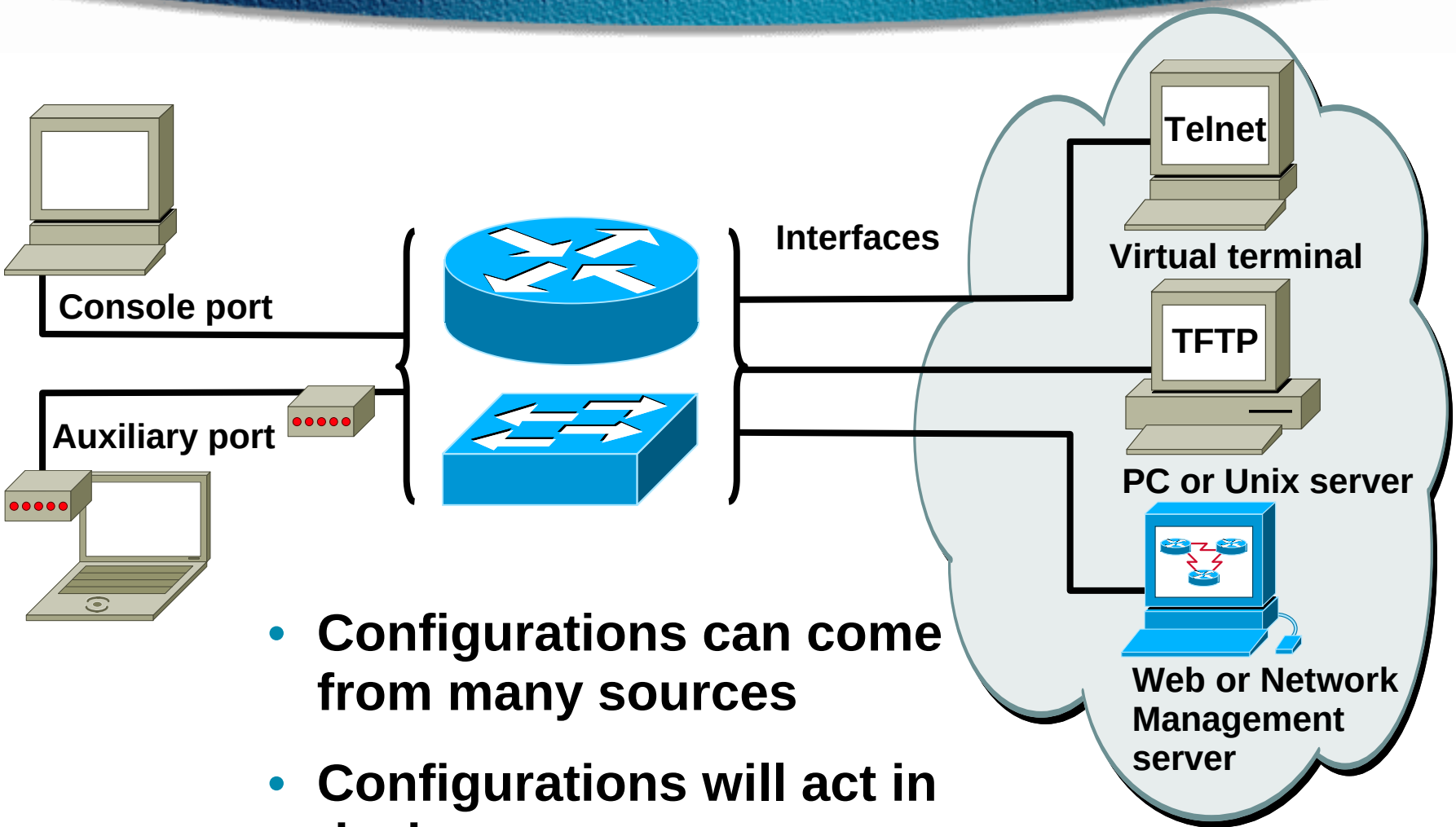
Cisco Systems

Agenda

- Router Management
- Introduction to Routing Protocols
- Access-list
- Network Address Translation
- Troubleshooting Tools

Router Management

External Configuration Sources



- Configurations can come from many sources
- Configurations will act in device memory

Creating a HyperTerminal Session

Step 1: Verify cabling

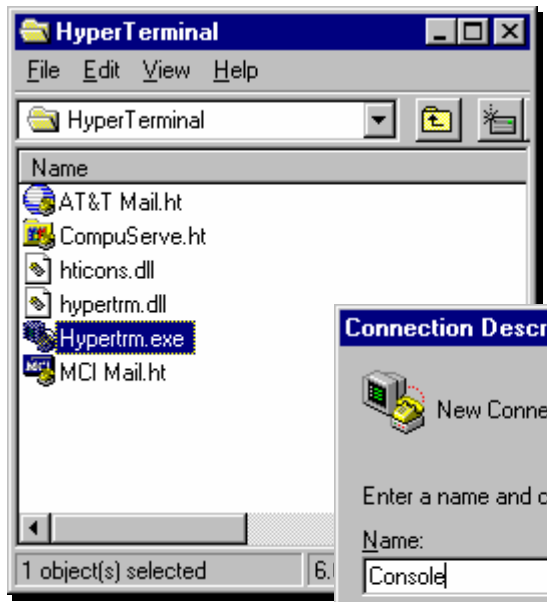
Step 2: Power on PC

Step 3: Open HyperTerminal Folder

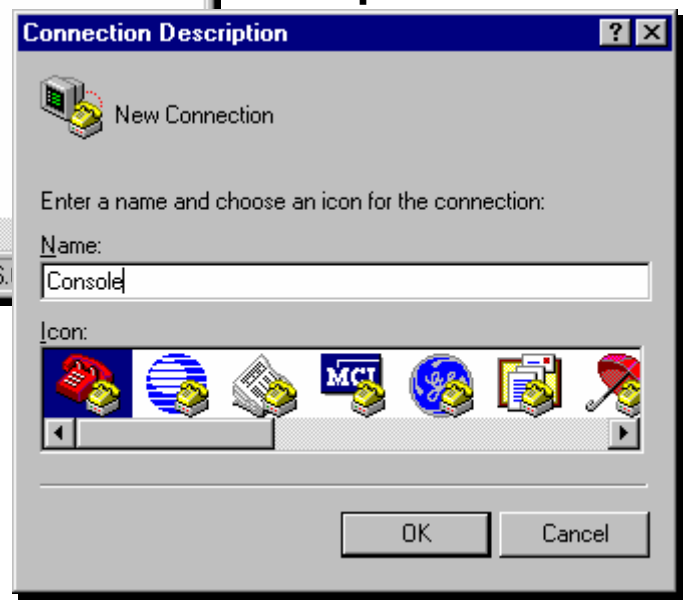
Step 4: Open HyperTerminal

Step 5: Describe Connection

Step 3 and 4



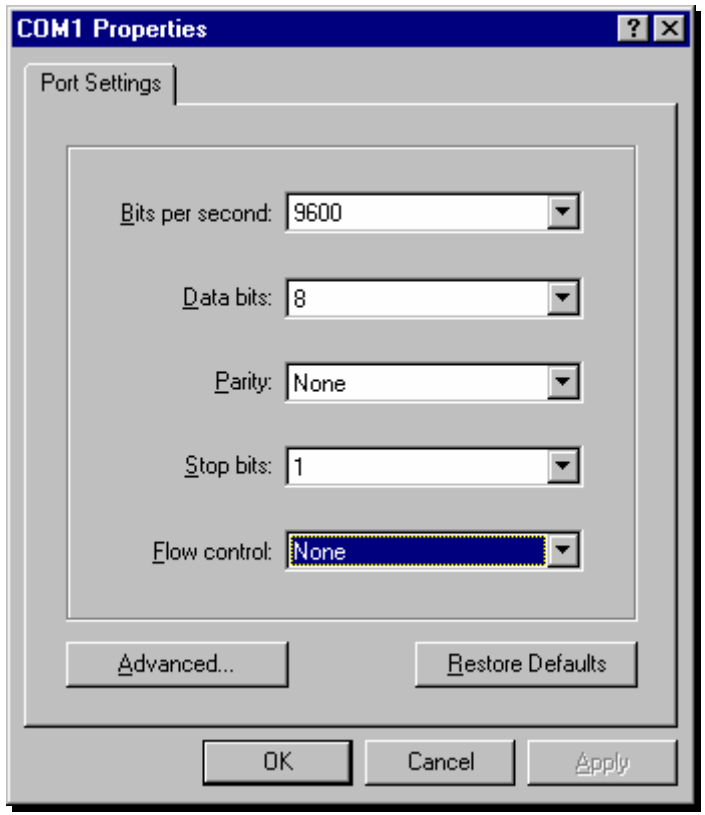
Step 5



Creating a HyperTerminal Session (cont.)

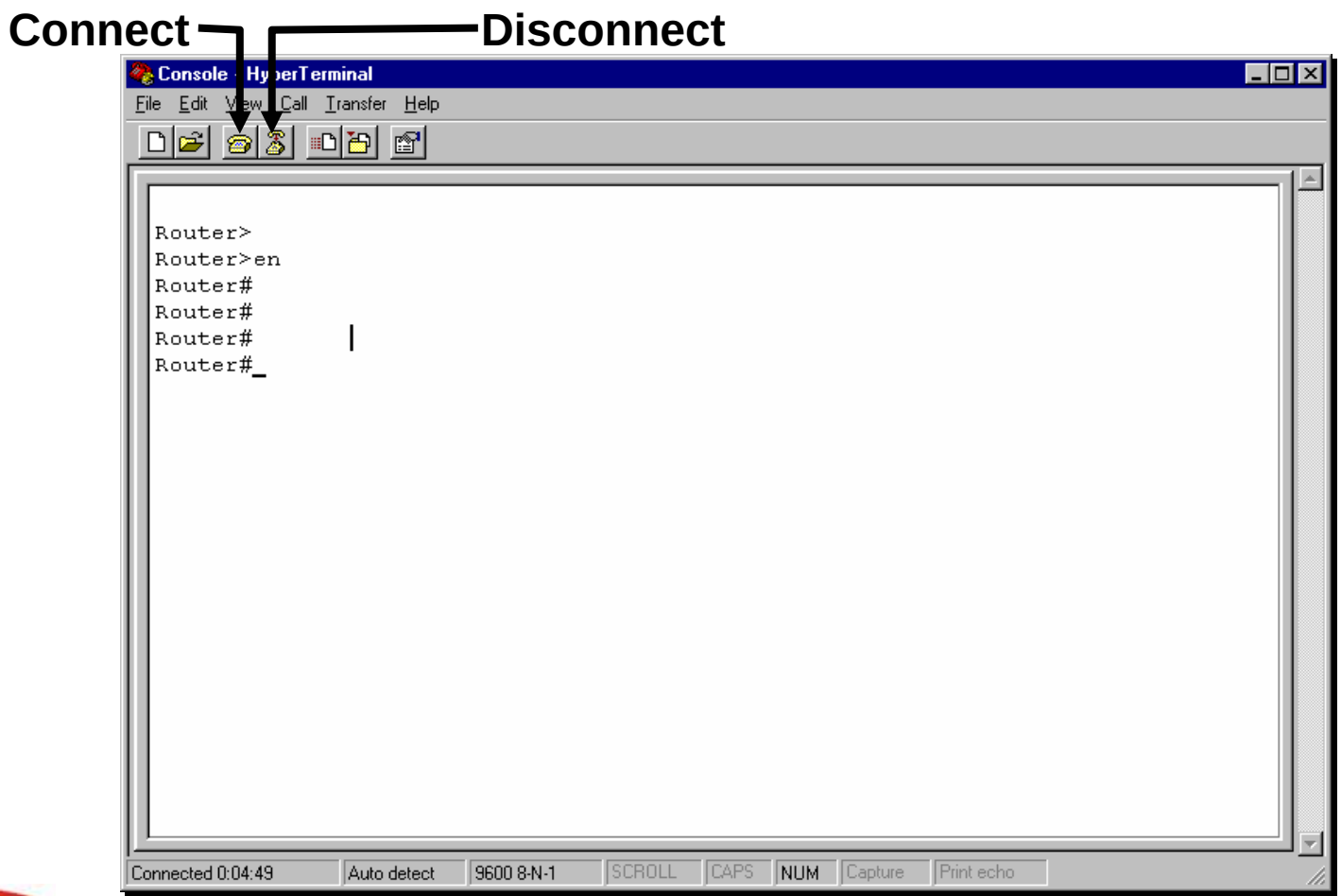
Step 6: Select COM port to be used

Step 7: Select properties



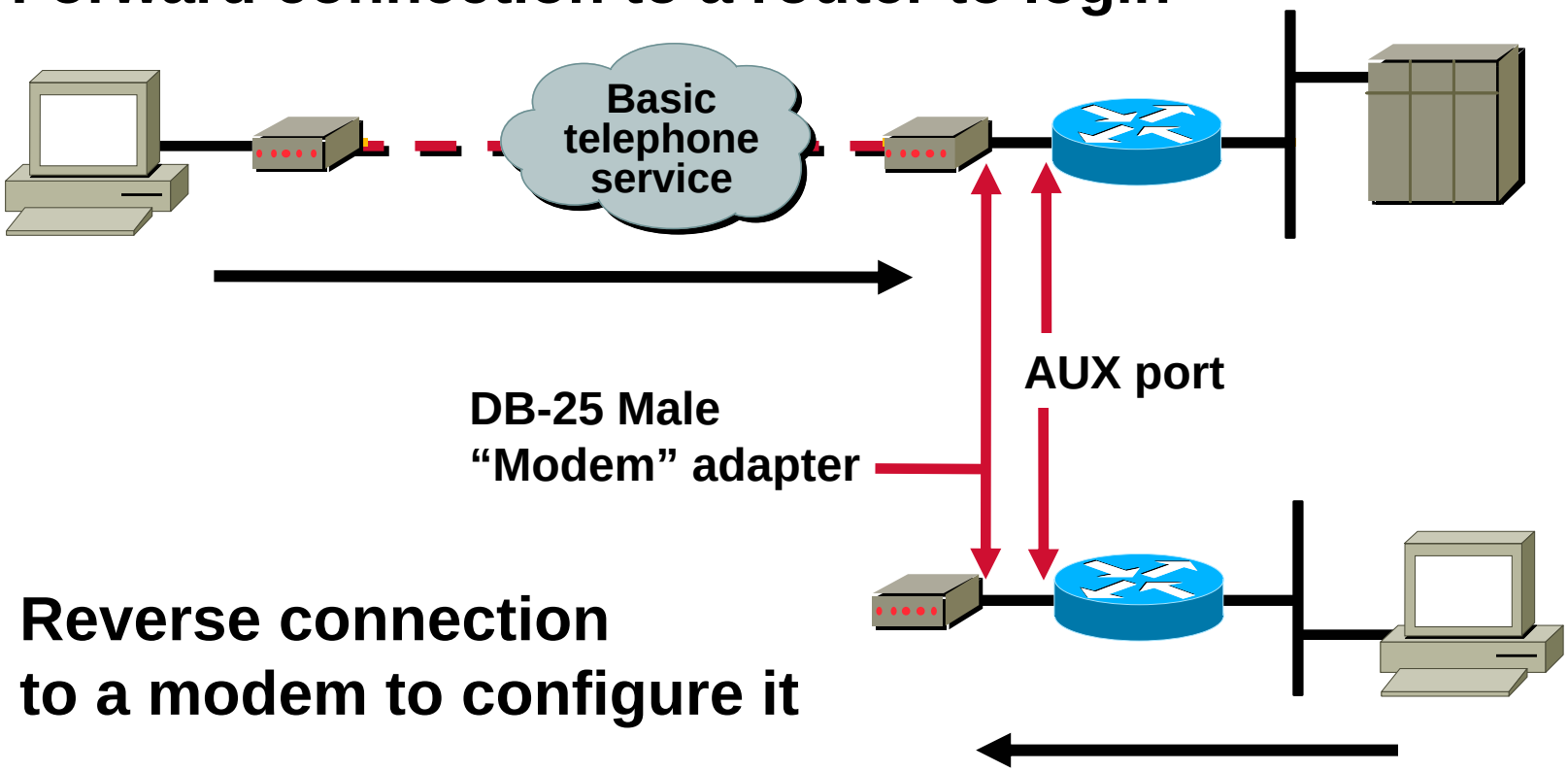
Creating a HyperTerminal Session (cont.)

Step 8: Access Device



Connecting to the Modem

Forward connection to a router to login



Reverse connection to a modem to configure it

Sample Output for *show line*

Absolute line number

Aux tty number

Line speed

This is vty2 (3rd vty) line 20

```
cherub:18> sh line
 Tty Typ     Tx/Rx      A Modem  Roty AccO AccI  Uses    Noise   Overruns
*  0 CTY                -    -      -    -    -     0        0        0/0
*  1 TTY 115200/115200 - inout      -    4    -    31       26        0/0
*  2 TTY 115200/115200 - inout      -   30    -    37       23        0/0
A  3 TTY 115200/115200 - inout      -   25    -    10       24        1/0
*  4 TTY 115200/115200 - inout      -    4    -    20       63        1/0
*  5 TTY 115200/115200 - inout      -   45    -    18      325       22/0
A  6 TTY 115200/115200 - inout      -   25    -     7        0        0/0
I  7 TTY 115200/115200 - inout      -    -    -     6       36        1/0
I  8 TTY 115200/115200 - inout      -    -    -     3       25        3/0
*  9 TTY 115200/115200 - inout      -    4    -     2        0        0/0
A 10 TTY 115200/115200 - inout      -   56    -     2      470      216/0
I 11 TTY 115200/115200 - inout      -    -    -     0        0        0/0
I 12 TTY 115200/115200 - inout      -    -    -     0        0        0/0
I 13 TTY 115200/115200 - inout      -    -    -     1        0        0/0
I 14 TTY 115200/115200 - inout      -    -    -     0        0        0/0
I 15 TTY 115200/115200 - inout      -    -    -     0        0        0/0
I 16 TTY 115200/115200 - inout      -    -    -     0        0        0/0
  17 AUX   9600/9600    -    -      -    -    -     2        1        2/104800
*  18 VTY   9600/9600    -    -      -    -    -   103        0        0/0
   19 VTY   9600/9600    -    -      -    -    -     6        0        0/0
   20 VTY   9600/9600    -    -      -    -    -     1        0        0/0
   21 VTY   9600/9600    -    -      -    -    -     0        0        0/0
   22 VTY   9600/9600    -    -      -    -    -     0        0        0/0
   23 VTY   9600/9600    -    -      -    -    -     0        0        0/0
   24 VTY   9600/9600    -    -      -    -    -     0        0        0/0
   25 VTY   9600/9600    -    -      -    -    -     0        0        0/0
   26 VTY   9600/9600    -    -      -    -    -     0        0        0/0
   27 VTY   9600/9600    -    -      -    -    -     0        0        0/0
   28 VTY   9600/9600    -    -      -    -    -     0        0        0/0
   29 VTY   9600/9600    -    -      -    -    -     0        0        0/0
   30 VTY   9600/9600    -    -      -    -    -     0        0        0/0
   31 VTY   9600/9600    -    -      -    -    -     0        0        0/0
   32 VTY   9600/9600    -    -      -    -    -     0        0        0/0
   33 VTY   9600/9600    -    -      -    -    -     0        0        0/0
```

EXEC Connection Commands

```
Router>telnet[host][2000+aux_tty#]
```

- Makes a connection with the Telnet protocol

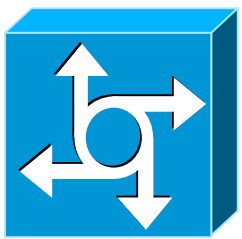
```
Router>disconnect [session-number]
```

- Disconnects the specified session or all sessions

```
Router>ctrl-shift-6 x
```

- Suspends a session

Interface AUX and Line Configuration



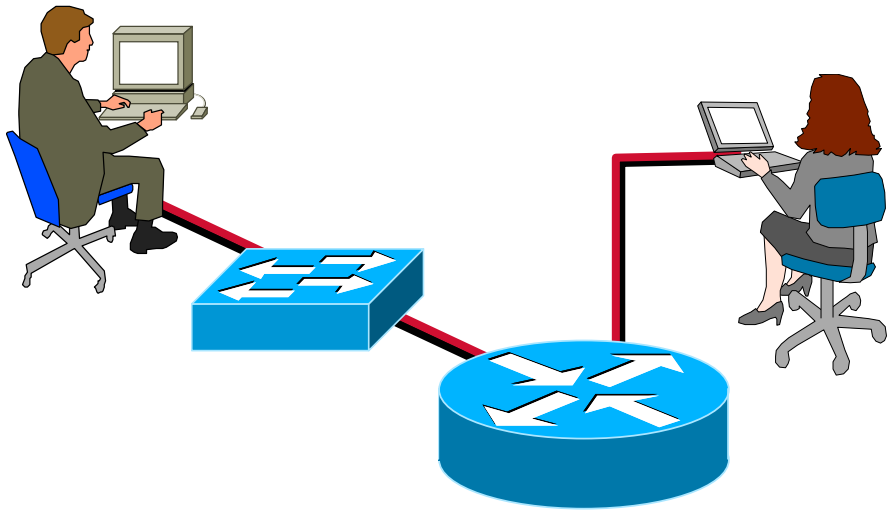
Physical configuration

```
Router(config)#line 17
Router(config-line)#modem inout
Router(config-line)#transport input all
Router(config-line)#flowcontrol hardware
```

Standard Modem Commands

Action intended	Command
Loads factory default settings	AT&F
Auto answer	ATS0=n
CD truly reflects line state	AT&C1
Hangs up at DTR low	AT&D3
Ignore “+++” (in-band signaling)	ATS2=255
Echo off	ATE0
Turn off speaker	ATM0
Save modem config	AT&W

Cisco Internetwork Operating System (IOS) Software



Cisco's IOS software delivers network services and enables networked applications.

Cisco IOS Software EXEC

There are two main EXEC modes for entering commands.

First mode:

User Mode

- **Limited examination of switch or router**
- **Command Prompt is `hostname>`**

Cisco IOS Software EXEC (cont.)

Second mode (and most commonly used):

Privileged (or enabled) Mode

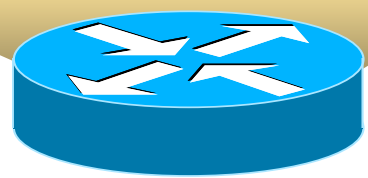
- **Detailed examination of switch or router**
- **Enables configuration and debugging**
- **Prerequisite for other configuration modes**
- **Command prompts on the device**
  `hostname#`

Initial Start Up of the Cisco Router

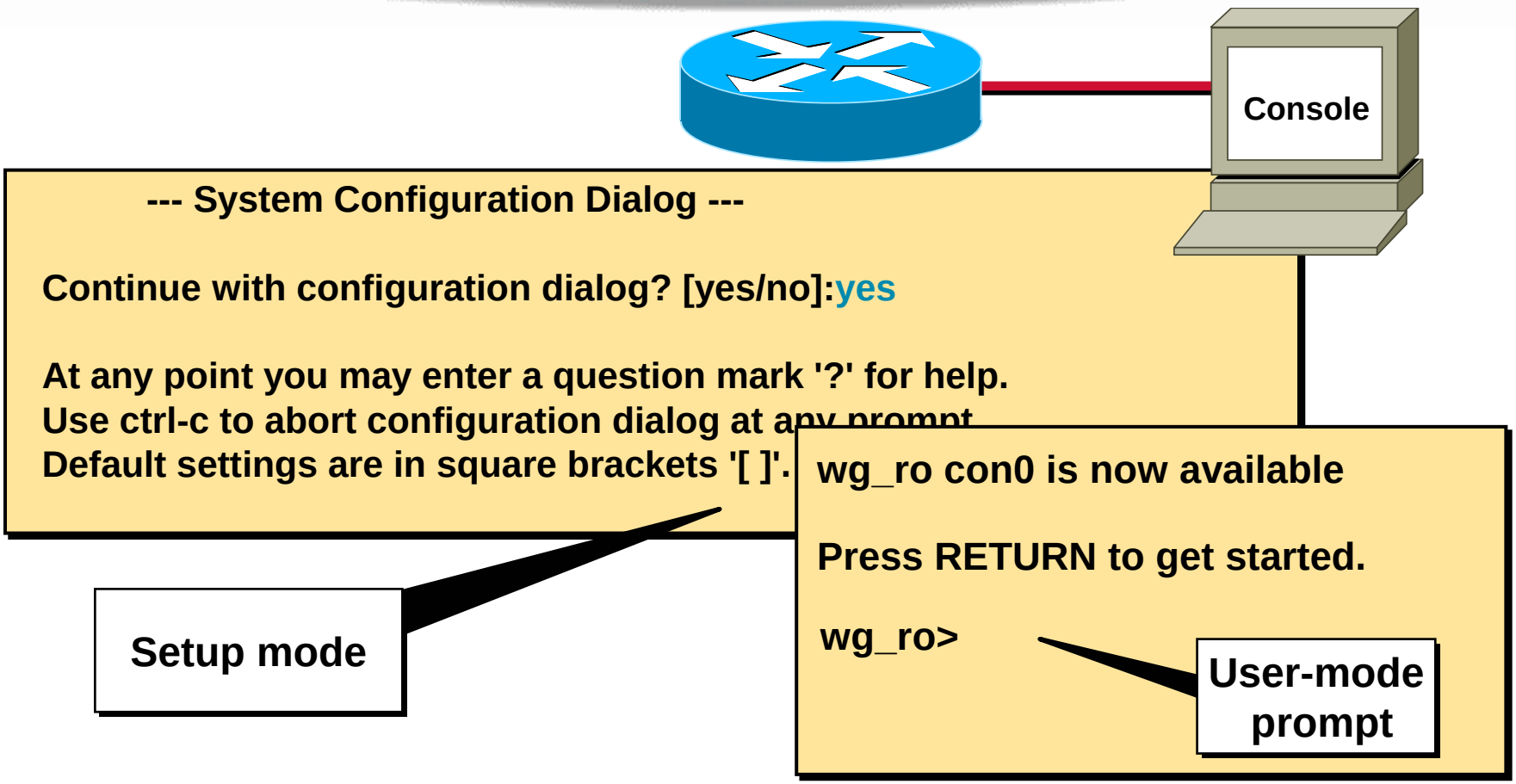
- System startup routines initiate router software
- Router falls back to startup alternatives if needed

1. Before you start the router, verify the power, cabling, and console connection
2. Push the power switch to on
3. Observe the boot sequence

   Cisco IOS software output text on the console



BootUp Output from the Router



Unconfigured versus configured router

Setup: The Initial Configuration Dialog

```
Router#setup


        --- System Configuration Dialog ---

Continue with configuration dialog? [yes/no]: y

At any point you may enter a question mark '?' for help.
Use ctrl-c to abort configuration dialog at any prompt.
Default settings are in square brackets '[]'.


Basic management setup configures only enough connectivity
for management of the system, extended setup will ask you
to configure each interface on the system

Would you like to enter basic management setup? [yes/no]: n
```

Setup Interface Summary

```
First, would you like to see the current interface summary? [yes]:

Interface              IP-Address      OK? Method Status                Protocol
BRI0                   unassigned      YES unset  administratively down down
BRI0:1                 unassigned      YES unset  administratively down down
BRI0:2                 unassigned      YES unset  administratively down down
Ethernet0              unassigned      YES unset  administratively down down
Serial0                unassigned      YES unset  administratively down down
```

Interfaces found during startup

Setup Global Parameters

Configuring global parameters:

Enter host name [Router]:wg_ro

The enable secret is a password used to protect access to privileged EXEC and configuration modes. This password, after entered, becomes encrypted in the configuration.
Enter enable secret: cisco

The enable password is used when you do not specify an enable secret password, with some older software versions, and some boot images.
Enter enable password: sanfran

The virtual terminal password is used to protect access to the router over a network interface.
Enter virtual terminal password: sanjose
Configure SNMP Network Management? [no]:

Initial global parameters

Logging into the Router


```
wg_ro con0 is now available
Press RETURN to get started.

wg_ro>
wg_ro>enable
wg_ro#
wg_ro#disable
wg_ro>
wg_ro>logout
```

User mode prompt

Privileged mode prompt

Router User Mode Command List

```
wg_ro>?
Exec commands:
  access-enable    Create a temporary Access-List entry
  atmsig           Execute Atm Signalling Commands
  cd               Change current device
  clear            Reset functions
  connect          Open a terminal connection
  dir              List files on given device
  disable          Turn off privileged commands
  disconnect       Disconnect an existing network connection
  enable           Turn on privileged commands
  exit             Exit from the EXEC
  help             Description of the interactive help system
  lat              Open a lat connection
  lock             Lock the terminal
  login            Log in as a particular user
  logout           Exit from the EXEC
-- More --
```

You can abbreviate a command to the fewest characters that make a unique character string

Router Privileged Mode Command List

```
wg_ro#?
Exec commands:
  access-enable    Create a temporary Access-List entry
  access-profile   Apply user-profile to interface
  access-template  Create a temporary Access-List entry
  bfe              For manual emergency modes setting
  cd               Change current directory
  clear            Reset functions
  clock            Manage the system clock
  configure        Enter configuration mode
  connect          Open a terminal connection
  copy             Copy from one file to another
  debug            Debugging functions (see also 'undebug')
  delete           Delete a file
  dir              List files on a filesystem
  disable          Turn off privileged commands
  disconnect       Disconnect an existing network connection
  enable           Turn on privileged commands
  erase            Erase a filesystem
  exit             Exit from the EXEC
  help             Description of the interactive help system
-- More --
```

You can complete a command string by typing the unique character string then pressing the tab key

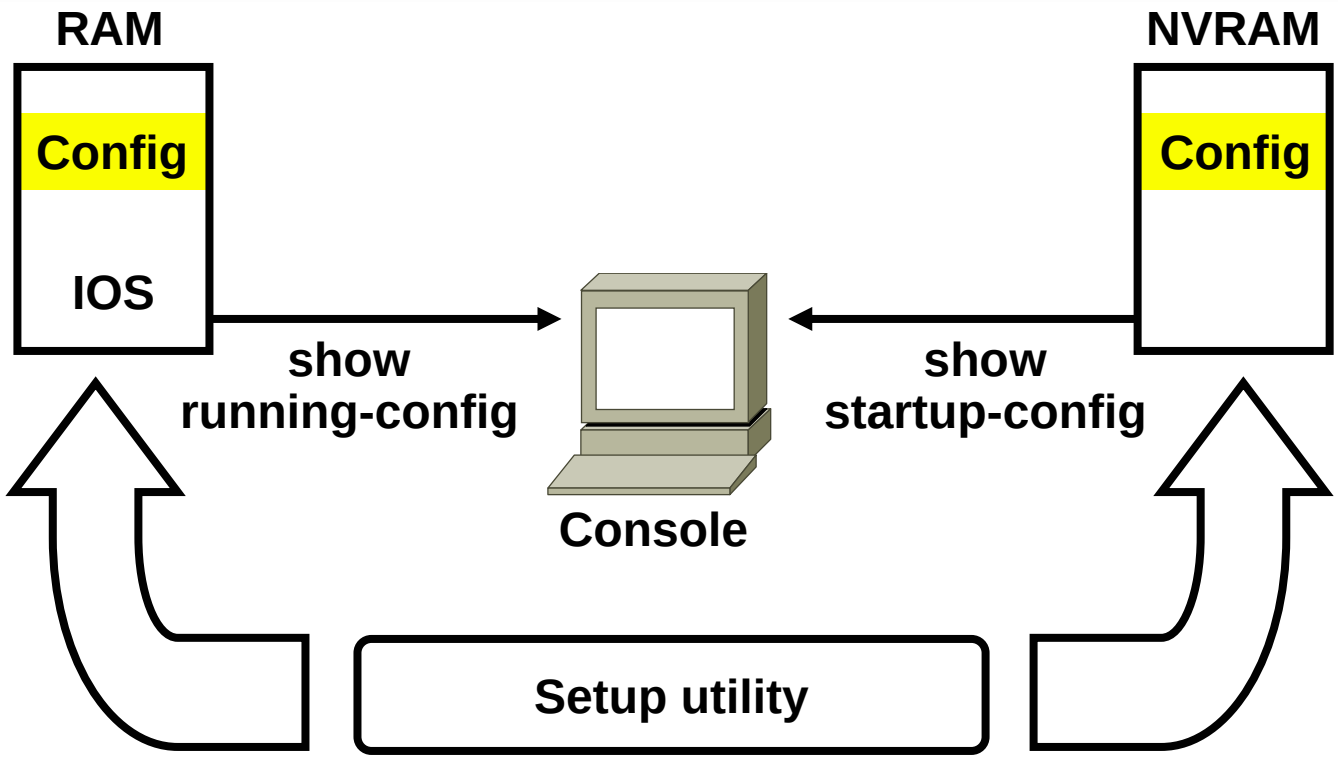
show version Command

wg_ro#*show version*
Cisco Internetwork Operating System Software
IOS (tm) 3600 Software (C3640-IK9O3S-M), Version 12.2(21), RELEASE SOFTWARE (fc3)
Copyright (c) 1986-2003 by cisco Systems, Inc
…
ROM: System Bootstrap, Version 11.1(20)AA2, EARLY DEPLOYMENT RELEASE SOFTWARE (fc1)

wg_ro uptime is 6 weeks, 2 days, 10 hours, 1 minute
System returned to ROM by reload
System restarted at 23:57:58 TPE Fri Jan 9 2004
System image file is "flash:c3640-ik9o3s-mz.122-21.bin"
…
cisco 3640 (R4700) processor (revision 0x00) with 126976K/4096K bytes of memory.
Processor board ID 16186480
R4700 CPU at 100Mhz, Implementation 33, Rev 1.0
2 Ethernet/IEEE 802.3 interface(s)
…
DRAM configuration is 64 bits wide with parity disabled.
125K bytes of non-volatile configuration memory.
16384K bytes of processor board System flash (Read/Write)

Configuration register is 0x2102

Viewing the Configuration



Setup saves the configuration to NVRAM

show running and *show startup* Commands

In RAM

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

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

In NVRAM

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

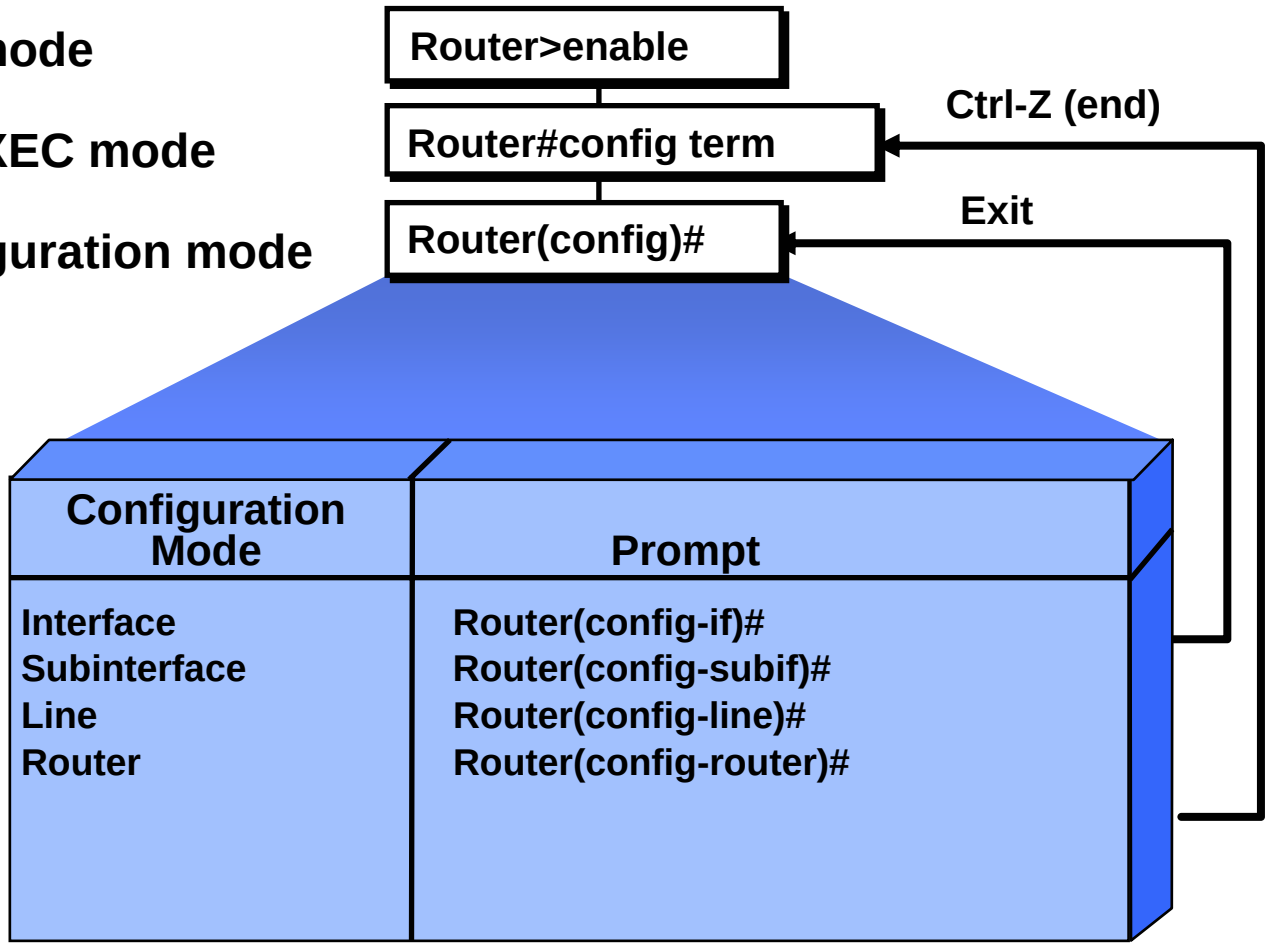
Display current and saved configuration

Overview of Router Modes

User EXEC mode

Privileged EXEC mode

Global configuration mode



Saving Configurations

```
wg_ro#
wg_ro#copy running-config startup-config
Destination filename [startup-config]?
Building configuration…

wg_ro#write memory
```

Copy the current configuration to NVRAM

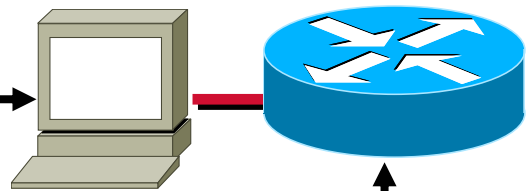
Configuring Router Identification

Router Name

```
Router(config)#hostname wg_ro
wg_ro(config)#
```

Message of the Day Banner

```
wg_ro(config)#banner motd  #
        Accounting Department
    You have entered a secured
    system. Authorized access
    only! #
```



Interface Description

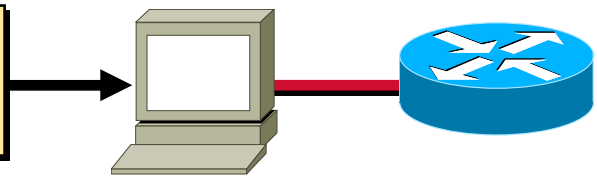
```
wg_ro(config)#interface ethernet 0
wg_ro(config-if)#description Engineering LAN, Bldg. 18
```

- **Sets local identity or message for the accessed router or interface**

Router Password Configuration

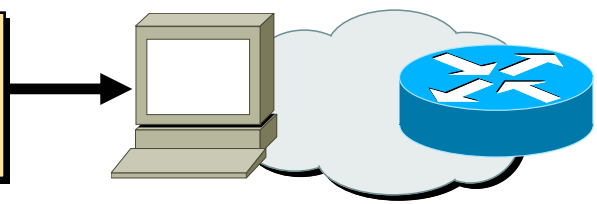
Console Password

```
Router(config)#line console 0
Router(config-line)#login
Router(config-line)#password cisco
```



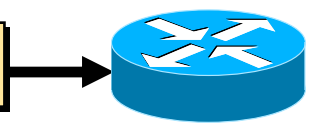
Virtual Terminal Password

```
Router(config)#line vty 0 4
Router(config-line)#login
Router(config-line)#password sanjose
```



Enable Password

```
Router(config)#enable password cisco
```



Secret Password

```
Router(config)#enable secret sanfran
```

Configuring an Interface

```
Router(config)#interface type number
Router(config-if)#
```

- *type* includes serial, ethernet, token ring, fddi, hssi, loopback, dialer, null, async, atm, bri, and tunnel
- *number* is used to identify individual interfaces

```
Router(config)#interface type slot/port
Router(config-if)#
```

- For modular routers

```
Router(config-if)#exit
```

- Quit from current interface configuration mode

Disabling or Enabling an Interface

```
Router#configure term
Router(config)#interface serial 0
Router(config-if)#shutdown
%LINK-5-CHANGED: Interface Serial0, changed state to administratively down
%LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0, changed state to down
```

Administratively turns off an interface

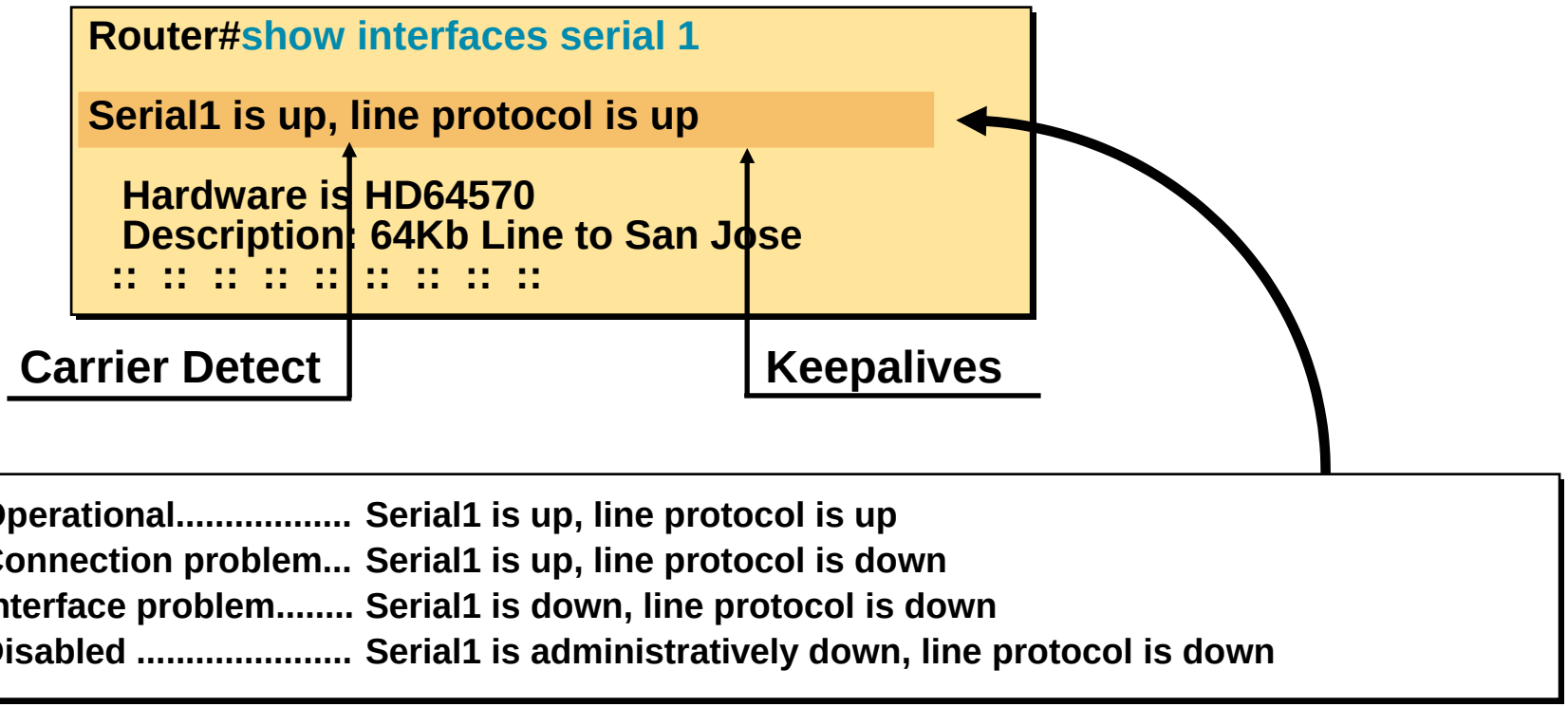
```
Router#configure term
Router(config)#interface serial 0
Router(config-if)#no shutdown
%LINK-3-UPDOWN:  Interface Seria0, changed state to up
%LINEPROTO-5-UPDOWN:  Line Protocol on Interface Serial0, changed state to up
```

Enables an interface that is administratively shutdown

Router *show interfaces* Command

```
Router#show interfaces
Ethernet0 is up, line protocol is up
  Hardware is Lance, address is 00e0.1e5d.ae2f (bia 00e0.1e5d.ae2f)
  Internet address is 10.1.1.11/24
  MTU 1500 bytes, BW 10000 Kbit, DLY 1000 usec, rely 255/255, load 1/255
  Encapsulation ARPA, loopback not set, keepalive set (10 sec)
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input 00:00:07, output 00:00:08, output hang never
  Last clearing of "show interface" counters never
  Queueing strategy: fifo
  Output queue 0/40, 0 drops; input queue 0/75, 0 drops
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     81833 packets input, 27556491 bytes, 0 no buffer
     Received 42308 broadcasts, 0 runts, 0 giants, 0 throttles
     1 input errors, 0 CRC, 0 frame, 0 overrun, 1 ignored, 0 abort
     0 input packets with dribble condition detected
     55794 packets output, 3929696 bytes, 0 underruns
     0 output errors, 0 collisions, 1 interface resets
     0 babbles, 0 late collision, 4 deferred
     0 lost carrier, 0 no carrier
     0 output buffer failures, 0 output buffers swapped out
```

Interpreting Interface Status



Configuring SNMP

```
Router#configure term
Router(config)# snmp-server community string [view view-name] [ro | rw] [acl_number]
```

Defines the community access string

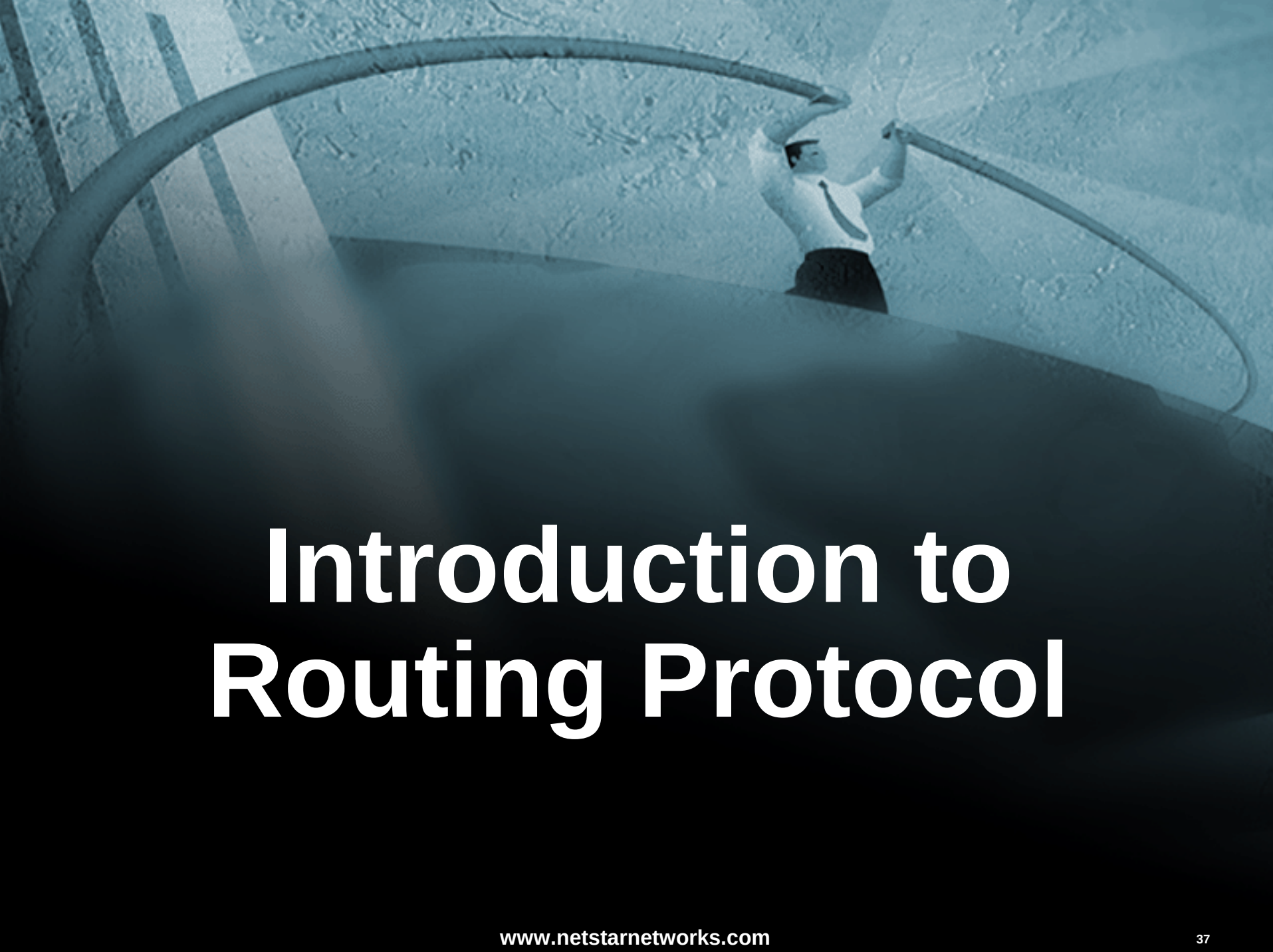
```
Router#configure term
Router(config)# snmp-server host host-id [traps | informs][version {1 | 2c | 3 [auth | noauth | priv]} ]
community-string [udp-port port-number] [notification-type]
```

Specifies the recipient (host) of the notifications

show snmp Command

```
Router#sh snmp
337739 SNMP packets input
    0 Bad SNMP version errors
    10 Unknown community name
    0 Illegal operation for community name supplied
    0 Encoding errors
    1283846 Number of requested variables
    0 Number of altered variables
    332559 Get-request PDUs
    5170 Get-next PDUs
    0 Set-request PDUs
341921 SNMP packets output
    0 Too big errors (Maximum packet size 1500)
    1685 No such name errors
    0 Bad values errors
    0 General errors
    337729 Response PDUs
    4192 Trap PDUs

SNMP logging: enabled
    Logging to 10.10.19.241.162, 0/10, 3995 sent, 197 dropped.
```



Introduction to Routing Protocol

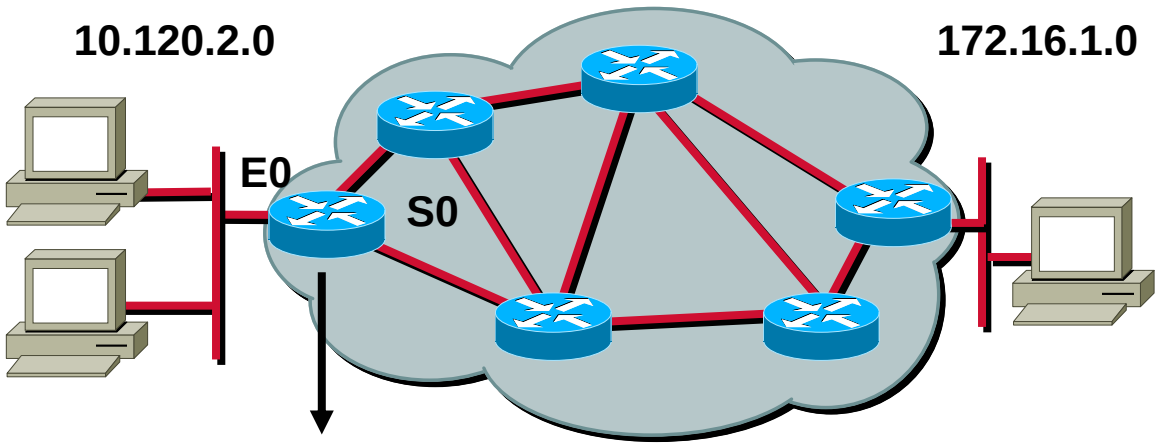
Introduction to Routing Protocol

- Type of Routing Protocol
- Routing Information Protocol
- Enhanced IGRP
- OSPF

What Is Routing?

- Routing is the process of forwarding an item from one location to another
- Routers forward traffic to a logical destination in a computer network
- Routers perform two major functions:
  - Routing
    - Learning the logical topology of the network
  - Switching
    - Forwarding packets from an inbound interface to an outbound interface

What is Routing? (cont.)

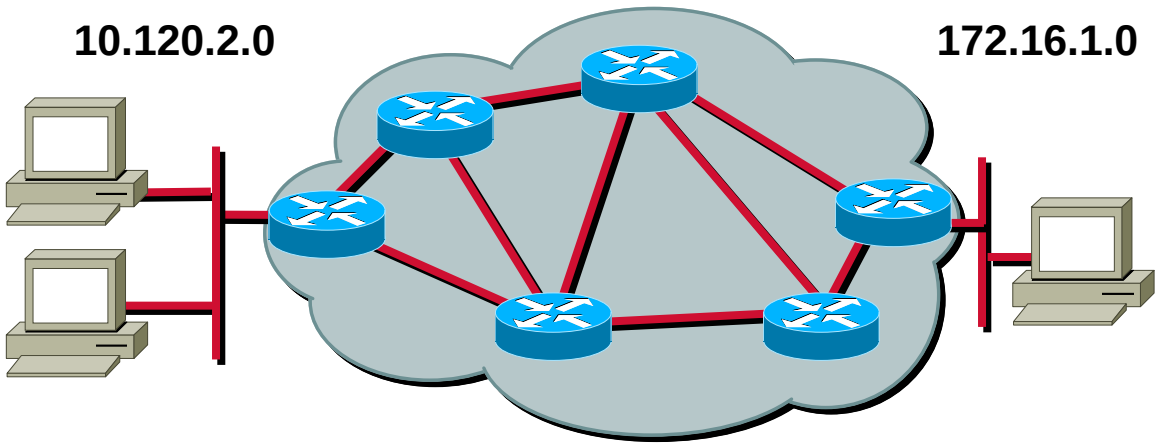


Network Protocol	Destination Network	Exit Interface
Connected	10.120.2.0	E0
Learned	172.16.1.0	S0

Routed Protocol: IP

- Routers must learn destinations that are not directly connected

Routing Requirements



To route a router need to know:

- Destination addresses
- Sources it can learn from
- Possible routes
- Best route
- Maintain and verify routing information

Identifying Static and Dynamic Routes

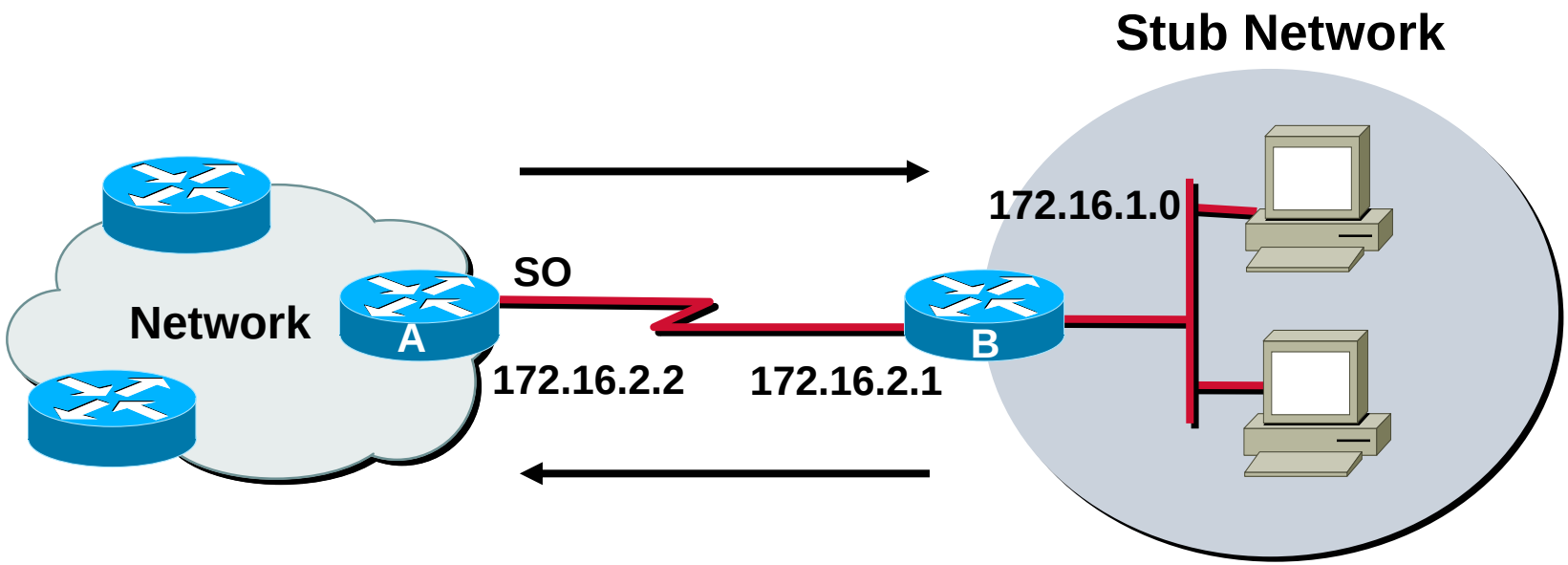
Static Route

Uses a route that a network administrator enters into the router *manually*

Dynamic Route

Uses a route that a network *routing protocol* adjusts *automatically* for topology or traffic changes

Static Routes



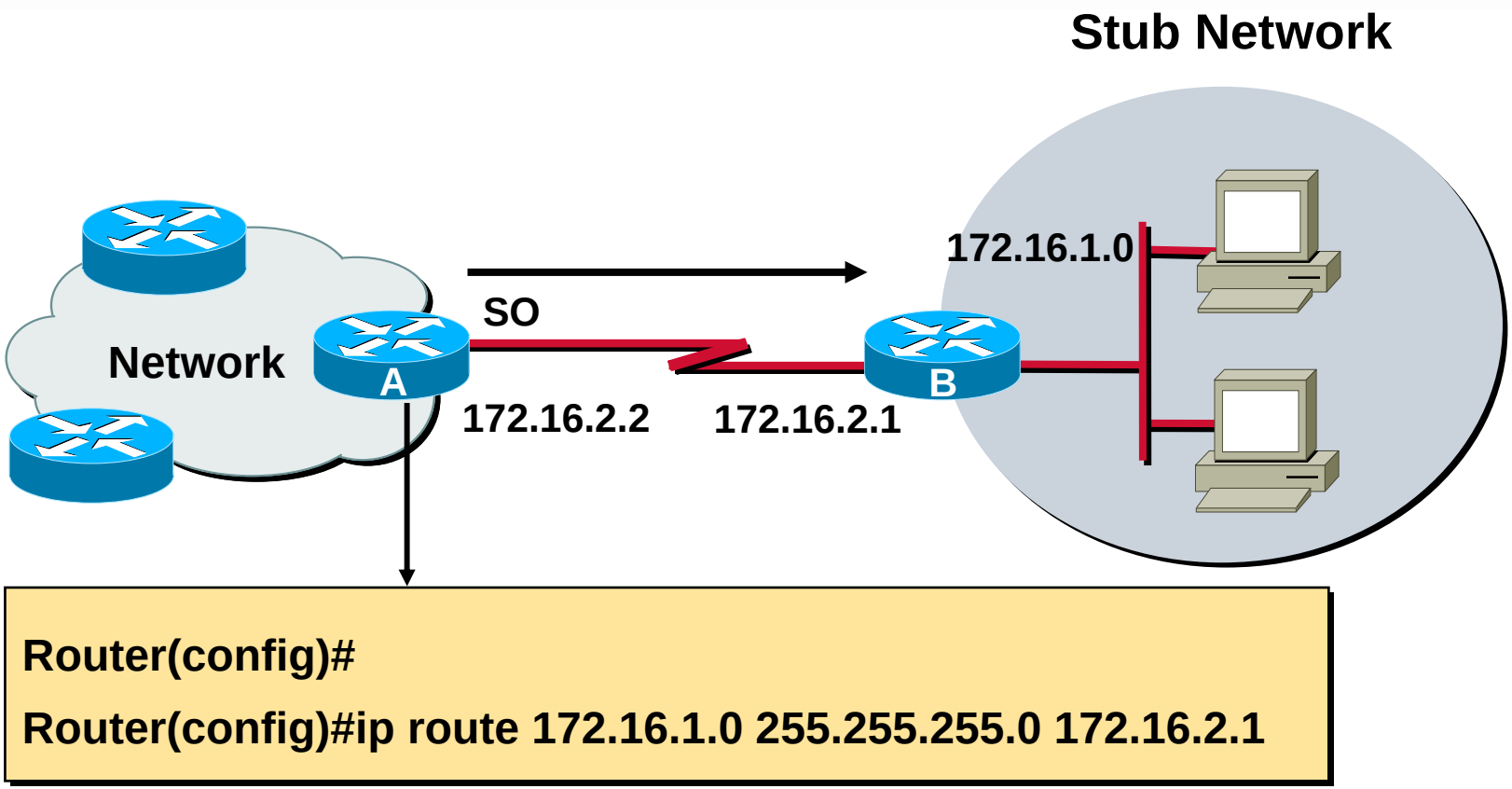
Configure unidirectional static routes to and from a stub network to allow communications to occur.

Static Route Configuration

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

Defines a path to an IP destination network or subnet

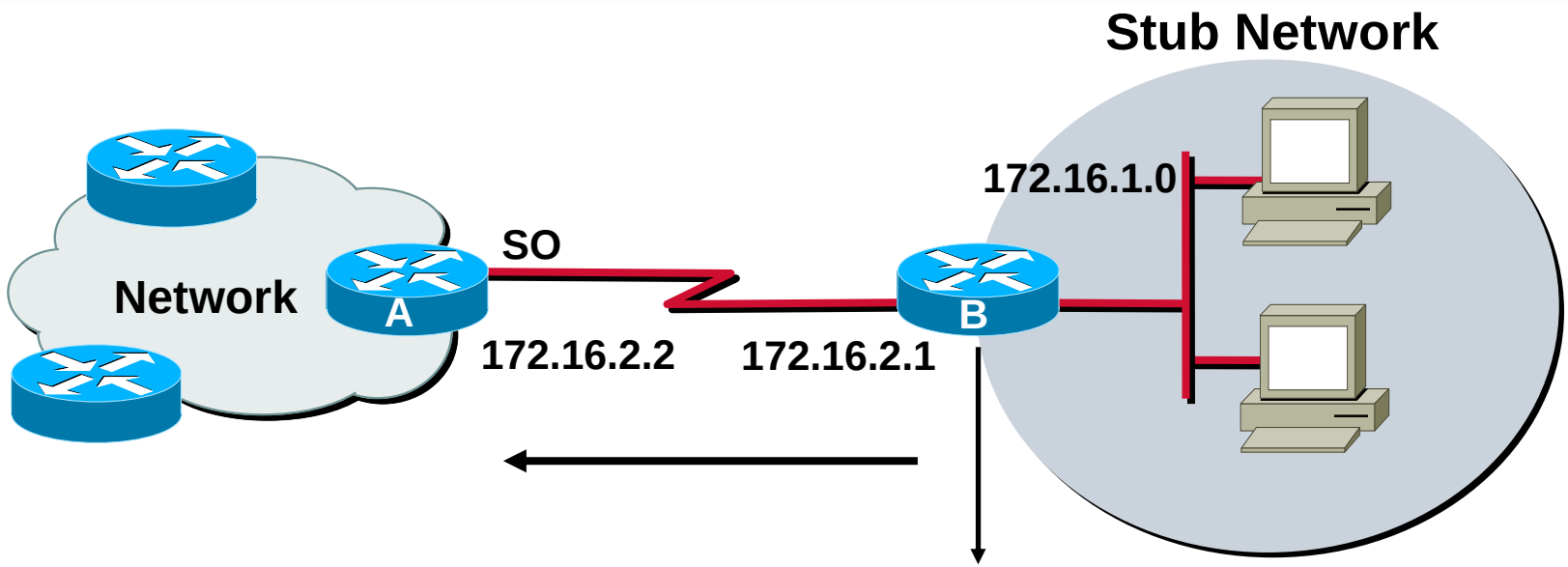
Static Route Example




```
Router(config)#
Router(config)#ip route 172.16.1.0 255.255.255.0 172.16.2.1
```

This is a unidirectional route. You must have a route configured in the opposite direction.

Default Routes



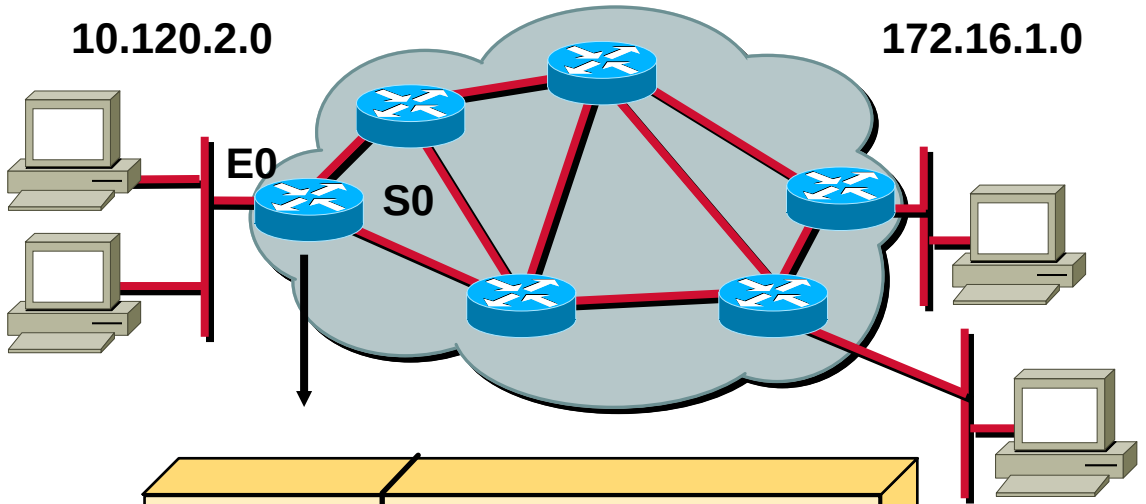

```
Router(config)#
Router(config)#ip route 0.0.0.0 0.0.0.0 172.16.2.2
```

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

What is a Routing Protocol?

Routing protocols are used between routers to determine paths and maintain routing tables.

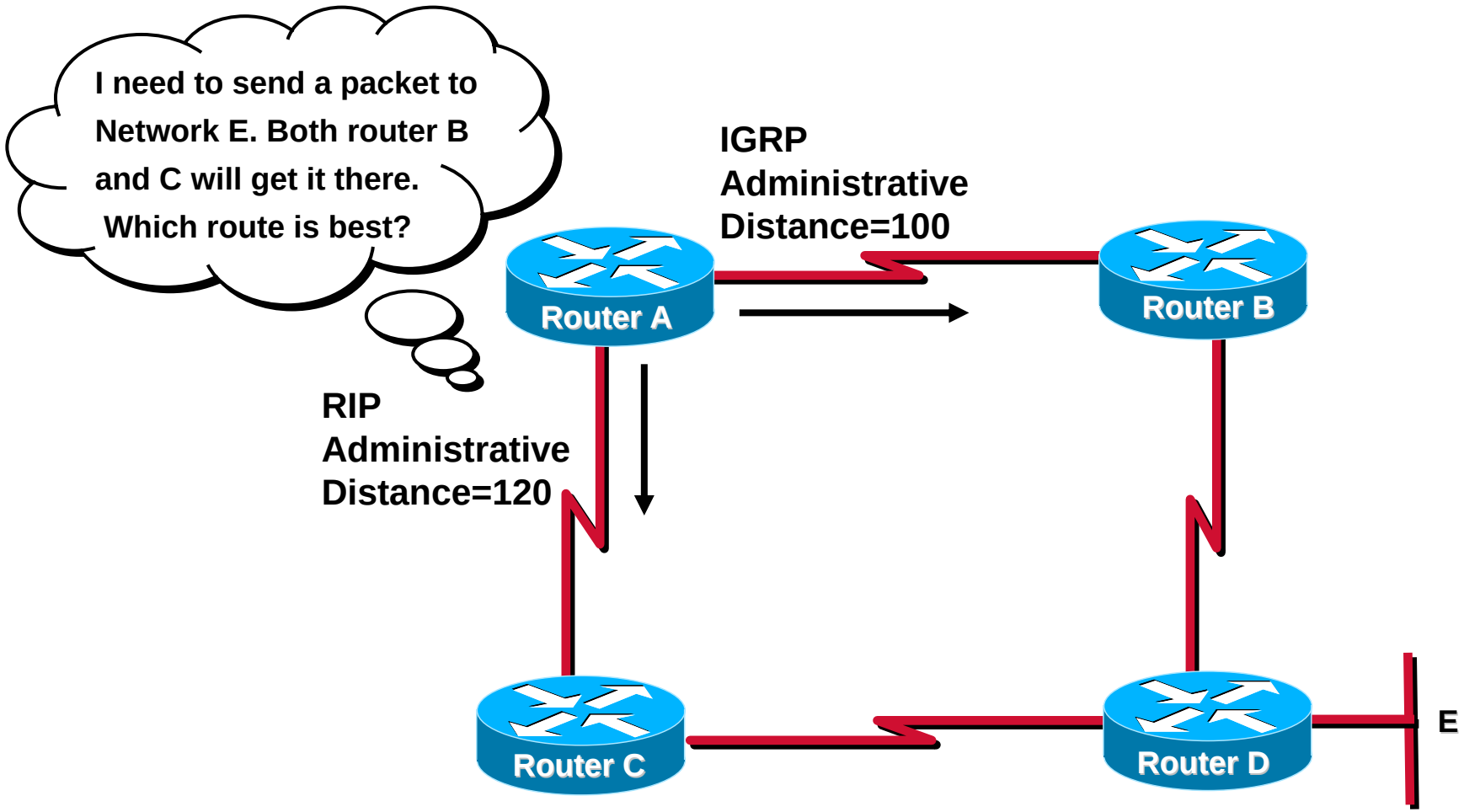
Once the path is determined a router can route a routed protocol.



Network Protocol	Destination Network	Exit Interface
Connected	10.120.2.0	E0
RIP	172.16.2.0	S0
IGRP	172.17.3.0	S1

Routed Protocol: IP/IPX
Routing protocol: RIP, IGRP,OSPF

Administrative Distance: Ranking Routes



Administrative Distance

- Administrative distance is a selection method for IP routing protocols
- The lower the administrative distance, the more trusted the learning mechanism
  - Manually entered routes are preferred to dynamically learned routes
  - Routing protocols with sophisticated metrics are preferred over protocols with simple metric structures

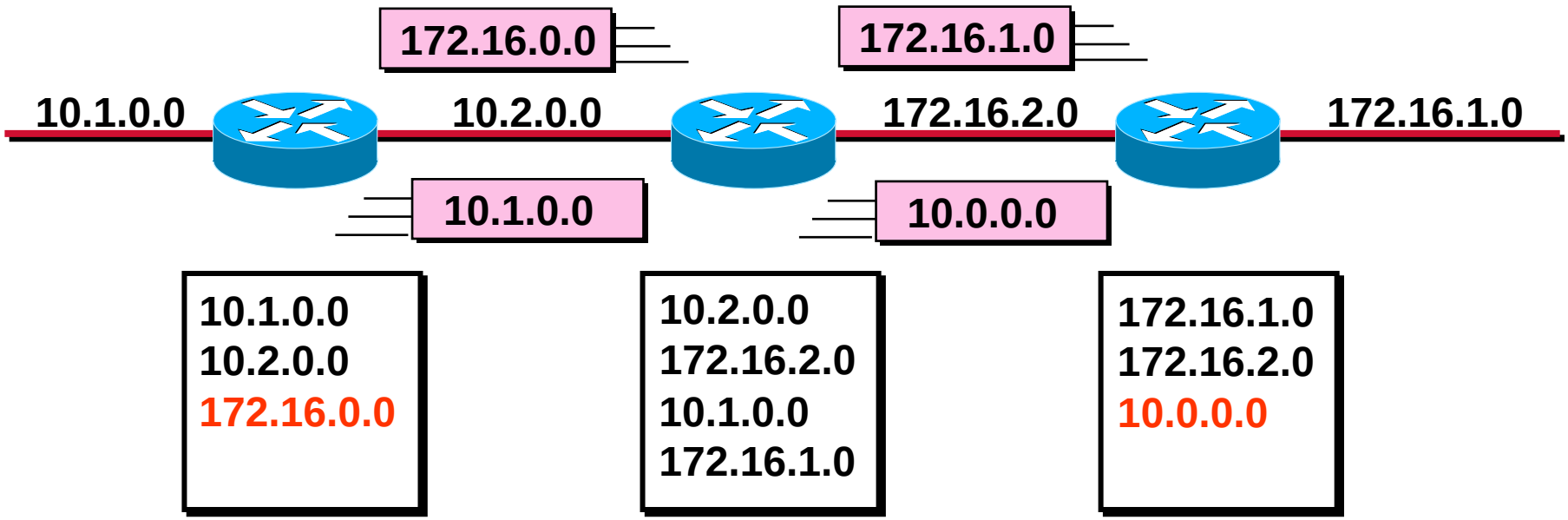
Administrative Distance Comparison Chart

Route Source	Default Distance
Connected interface	0
Static route out an interface	0
Static route to a next hop	1
EIGRP summary route	5
External BGP	20
Internal EIGRP	90
IGRP	100
OSPF	110
IS-IS	115
RIP v1, v2	120
EGP	140
External EIGRP	170
Internal BGP	200
Unknown	255

Classful Routing Overview

- Classful routing protocols are a consequence of the distance vector method of route calculation
  - RIPv1
  - IGRP
- Routing masks are not carried within the periodic routing updates
  - Within a network, consistency of masks is assumed

Classful Routes

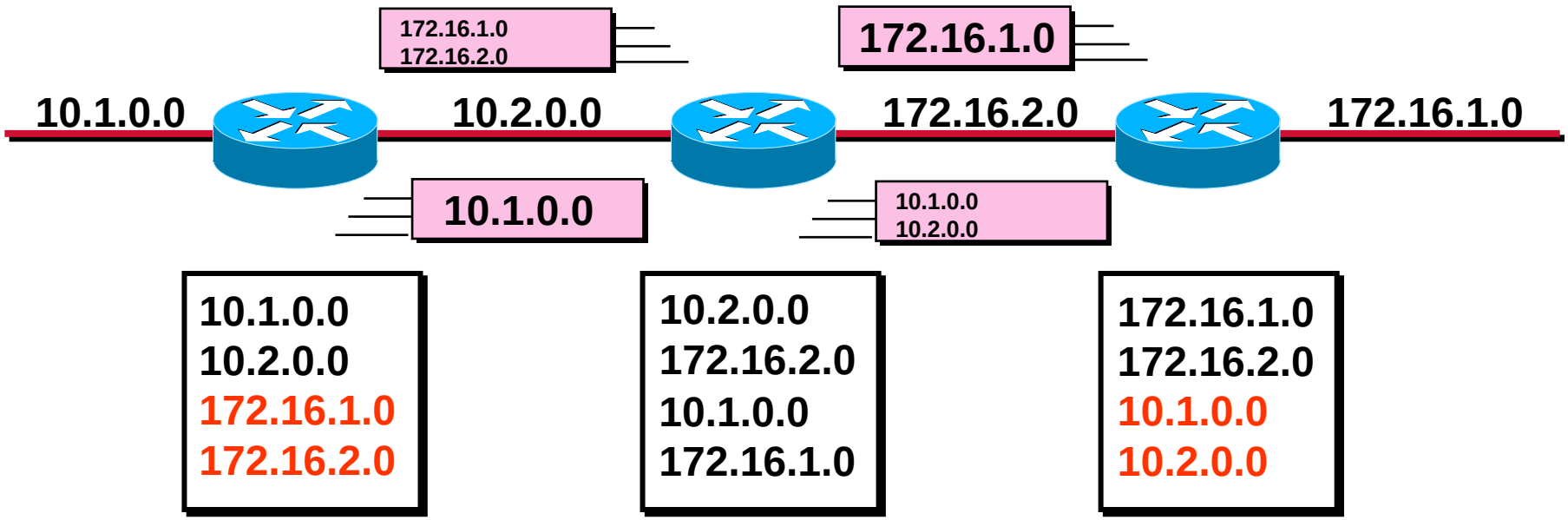


- Subnetwork routes are shared by devices within the same network
- Summary routes are exchanged between foreign networks
  - Summary routes are automatically created at Class A, B, and C network boundaries

Classless Routing Overview

- **Classless routing protocols include the routing mask with the route advertisement**
  - **OSPF**
  - **EIGRP**
  - **RIPv2**
  - **IS-IS**
  - **BGP**
- **Summary routes can be manually controlled within the network**

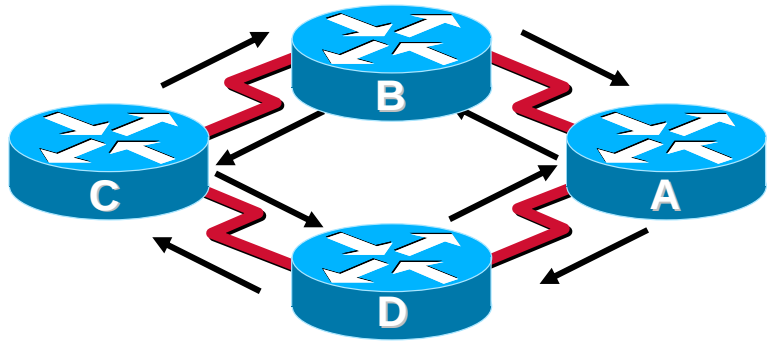
Classless Routes



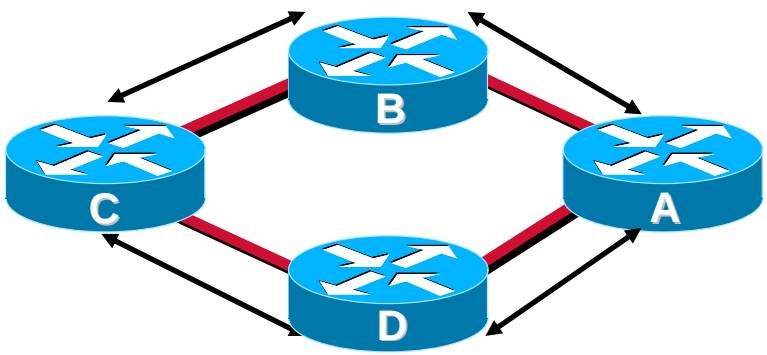
- Subnetwork routes are shared by devices within the same network
- Summary routes are exchanged between foreign networks
  - Summary routes are automatically created at Class A, B, and C network boundaries

Classes of Routing Protocols

Distance Vector

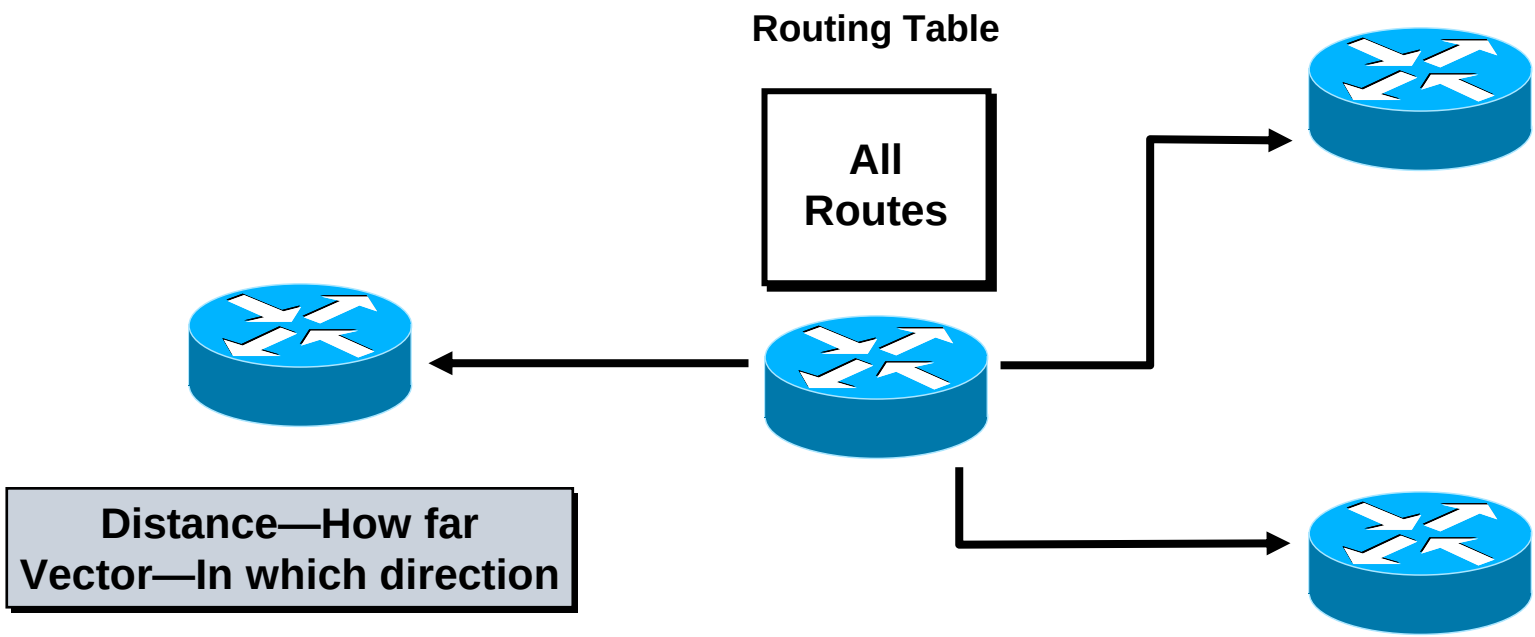


Hybrid Routing



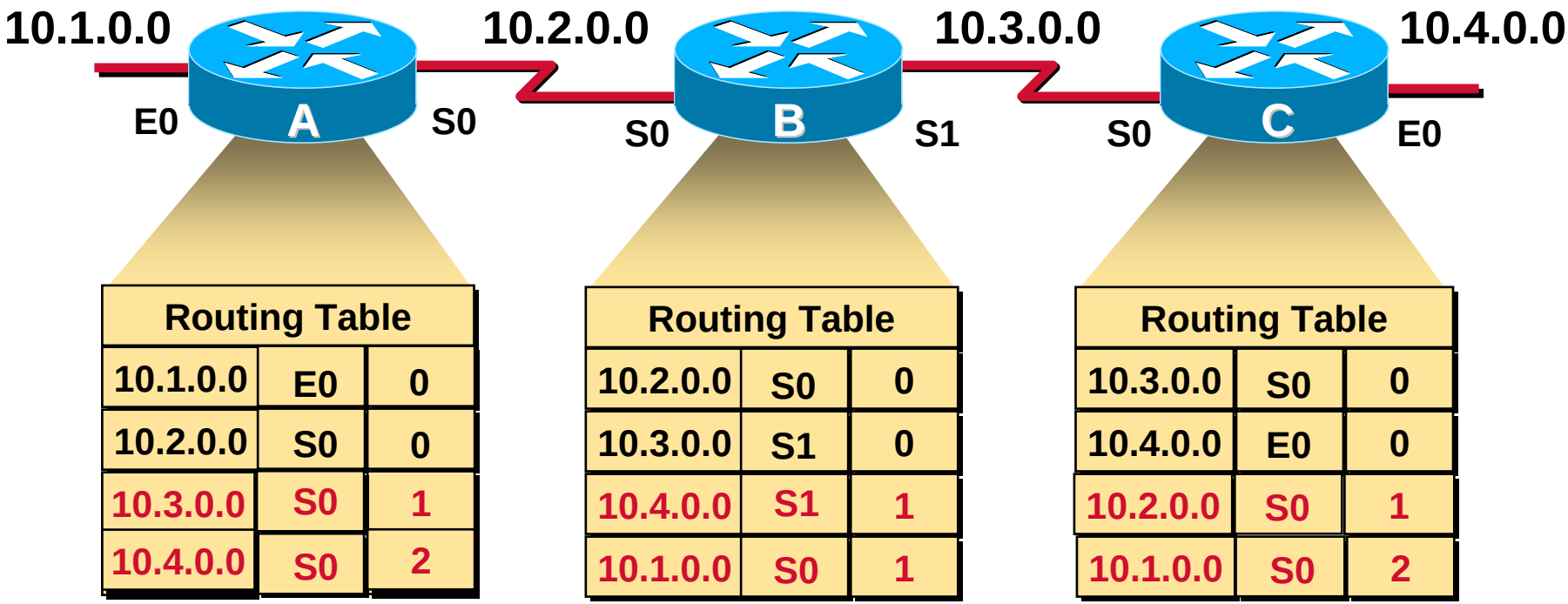
Link State

Distance Vector Routing Protocols



- In a distance vector environment, routing updates are propagated only to directly connected neighbors
- Pass periodic copies of full routing table to neighbor routers and accumulate distance vectors

Distance Vector—Sources of Information and Discovering Routes



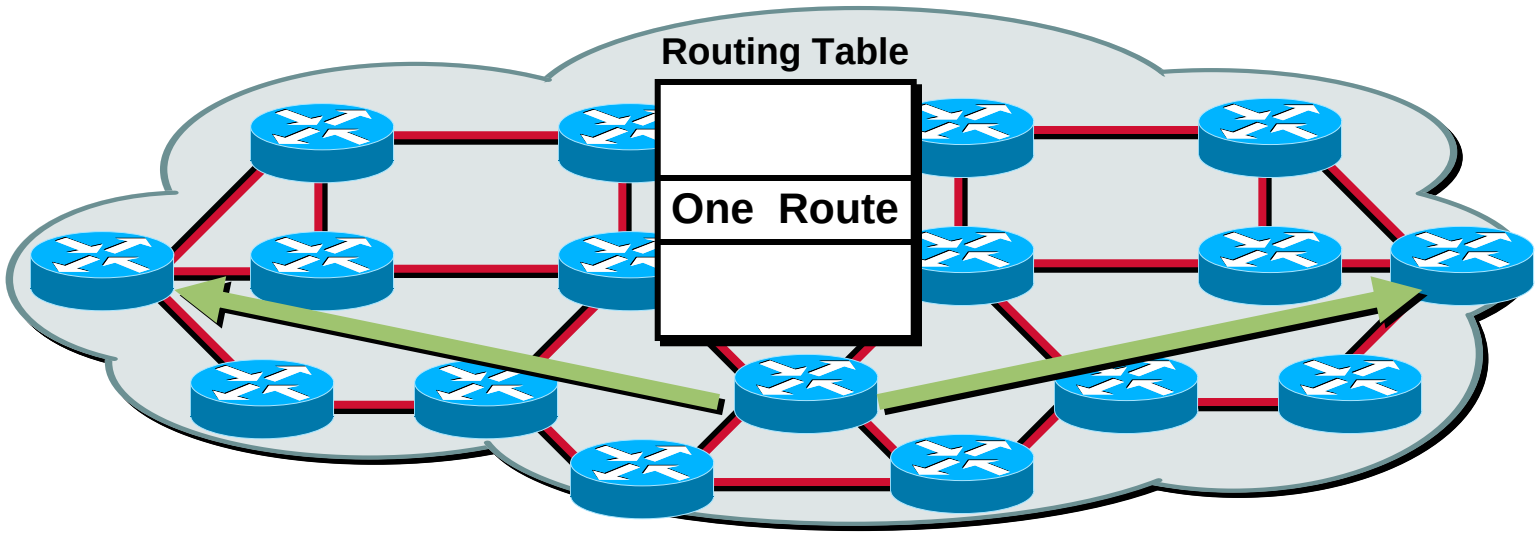
Routing Table		
10.1.0.0	E0	0
10.2.0.0	S0	0
10.3.0.0	S0	1
10.4.0.0	S0	2

Routing Table		
10.2.0.0	S0	0
10.3.0.0	S1	0
10.4.0.0	S1	1
10.1.0.0	S0	1

Routing Table		
10.3.0.0	S0	0
10.4.0.0	E0	0
10.2.0.0	S0	1
10.1.0.0	S0	2

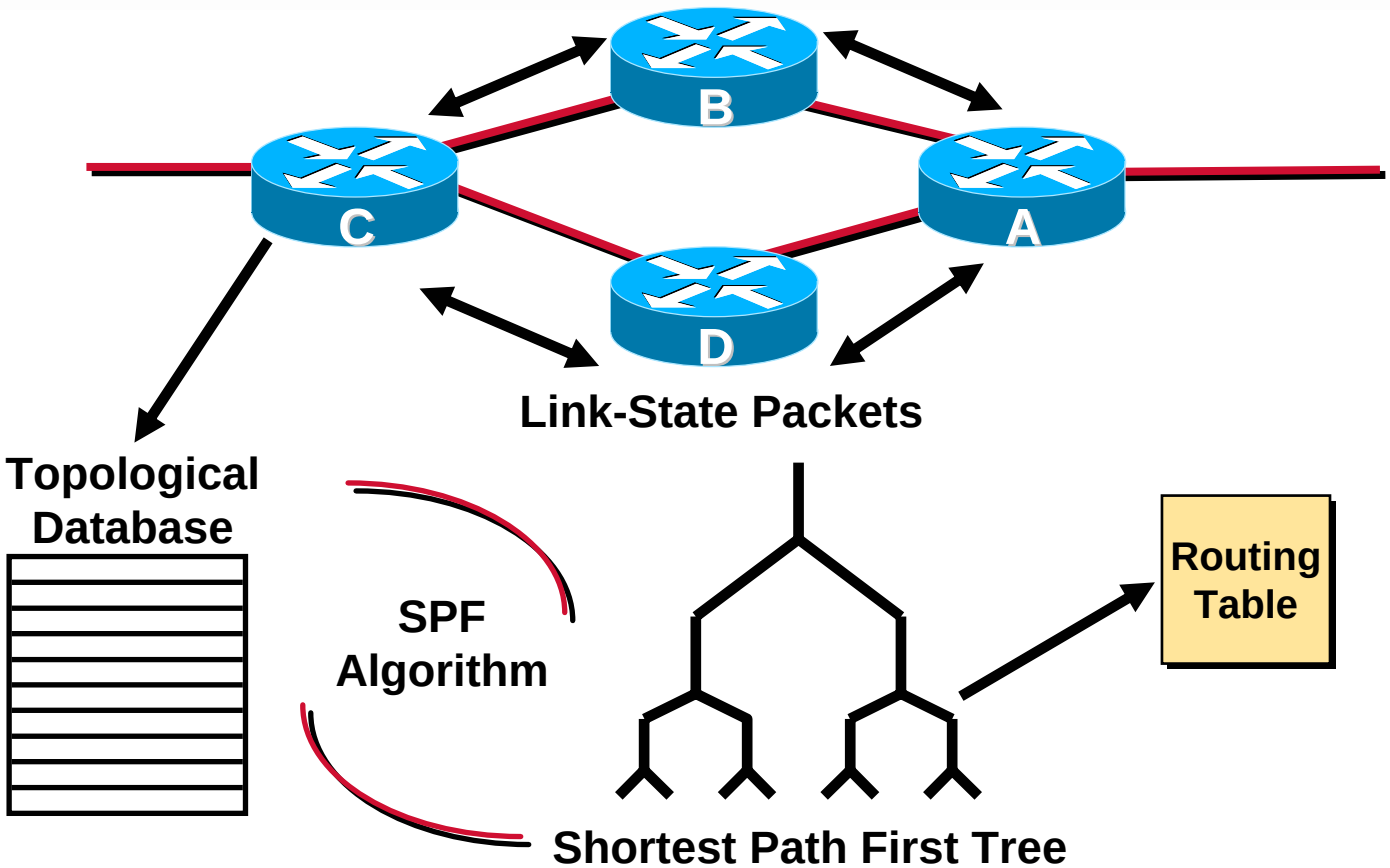
Routers discover the best path to destinations from each neighbor

Link-State Routing Update Traffic



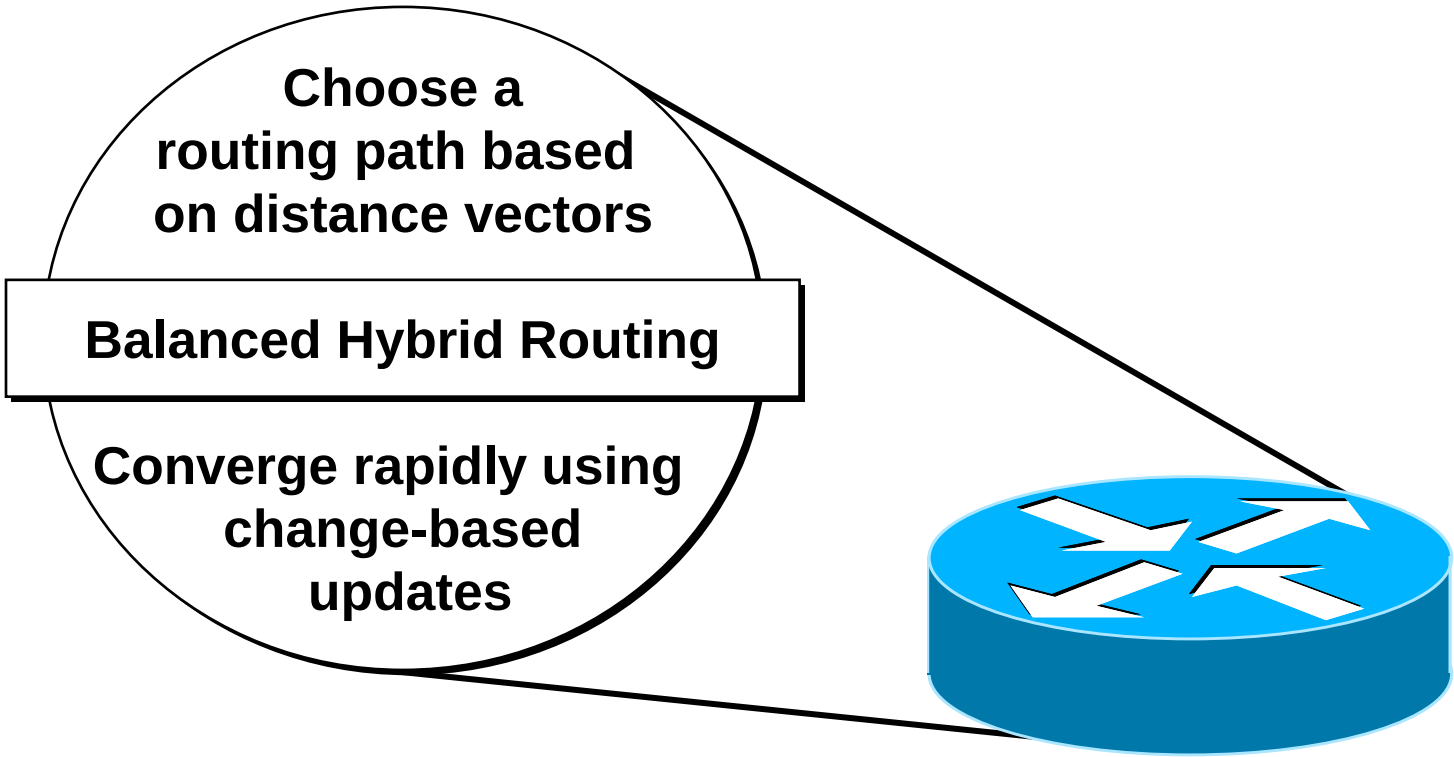
- **In a link-state environment, link-state announcements are propagated to all devices in the routing domain**
  - **Hierarchical design can limit the requirement to notify all devices**

Link-State Routing Protocols



After initial flood, pass small event-triggered link-state updates to all other routers

Hybrid Routing

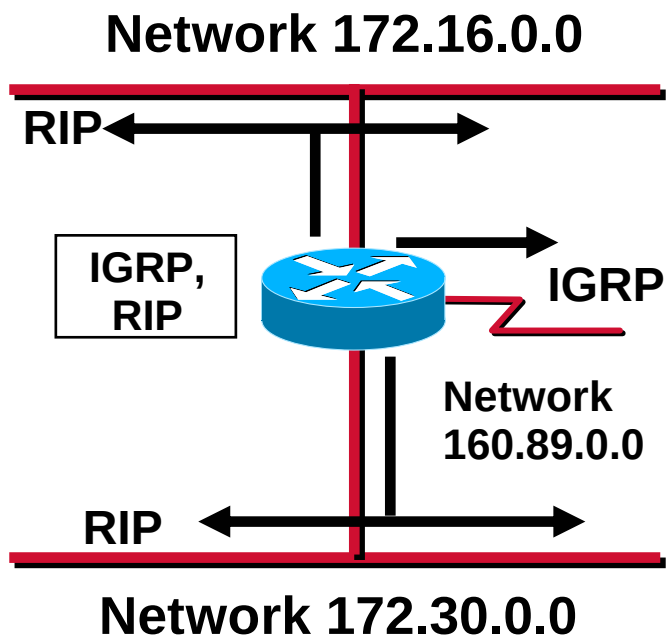


Share attributes of both distance-vector and link-state routing

IP Routing Configuration Tasks

Router configuration

- Select routing protocols
- Specify networks or interfaces



Dynamic Routing Configuration

Router(config)#router *protocol* [*keyword*]

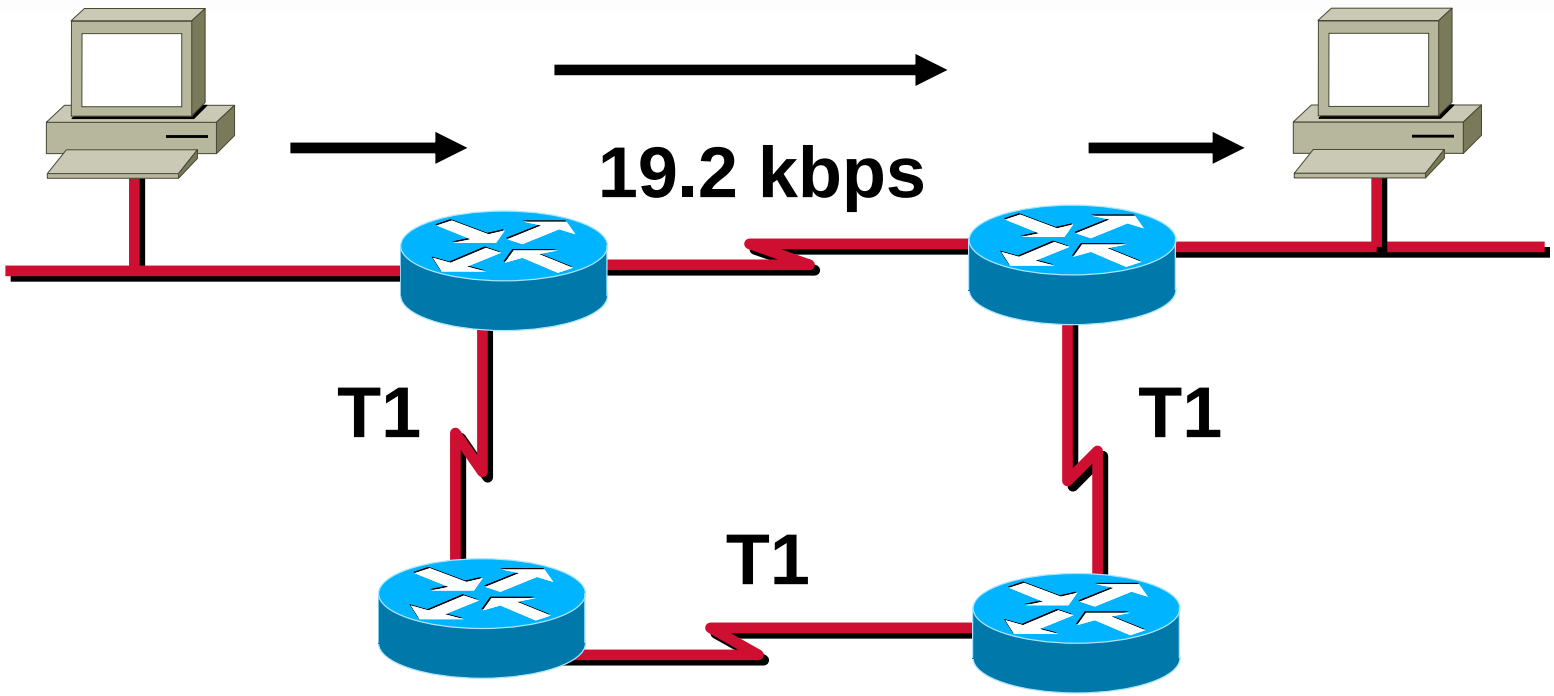
- **Defines an IP routing protocol**

Router(config-router)#network *network-number*

- **Mandatory configuration command for each IP routing process**
- **Identifies the physically connected network that routing updates are forwarded to**

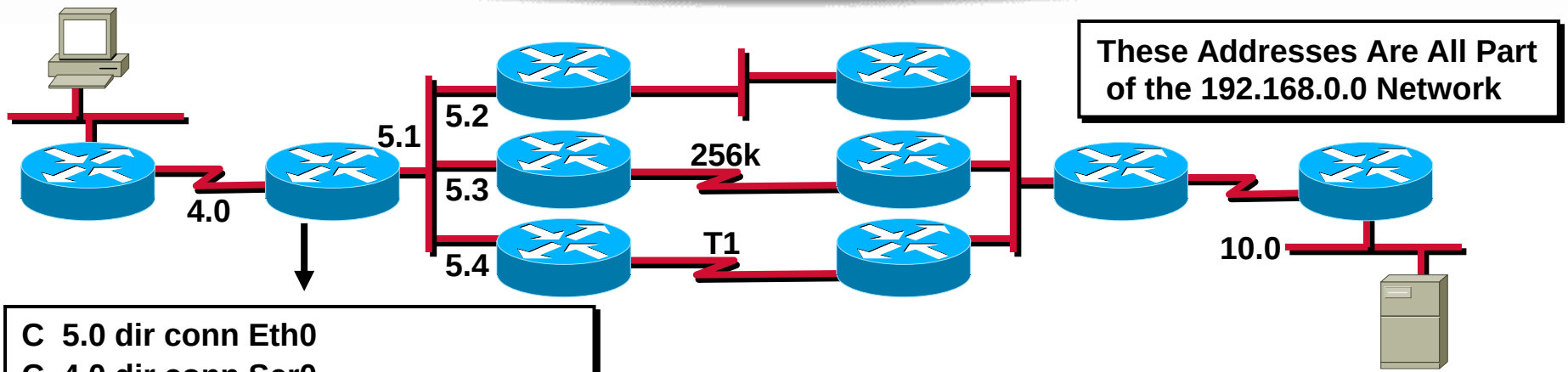
RIP Overview

RIP Overview



- Hop count metric selects the path
- Routes update every 30 seconds
- Hop count to infinity = 16

RIP Routing Metrics



- **Routing metric used by RIP is hop count**
  - **Using a neighboring router interface is a hop**
- **Routing process arbitrarily selects a path from several possible equal metric paths**
  - **IP load balancing is enabled by default**

RIP Configuration

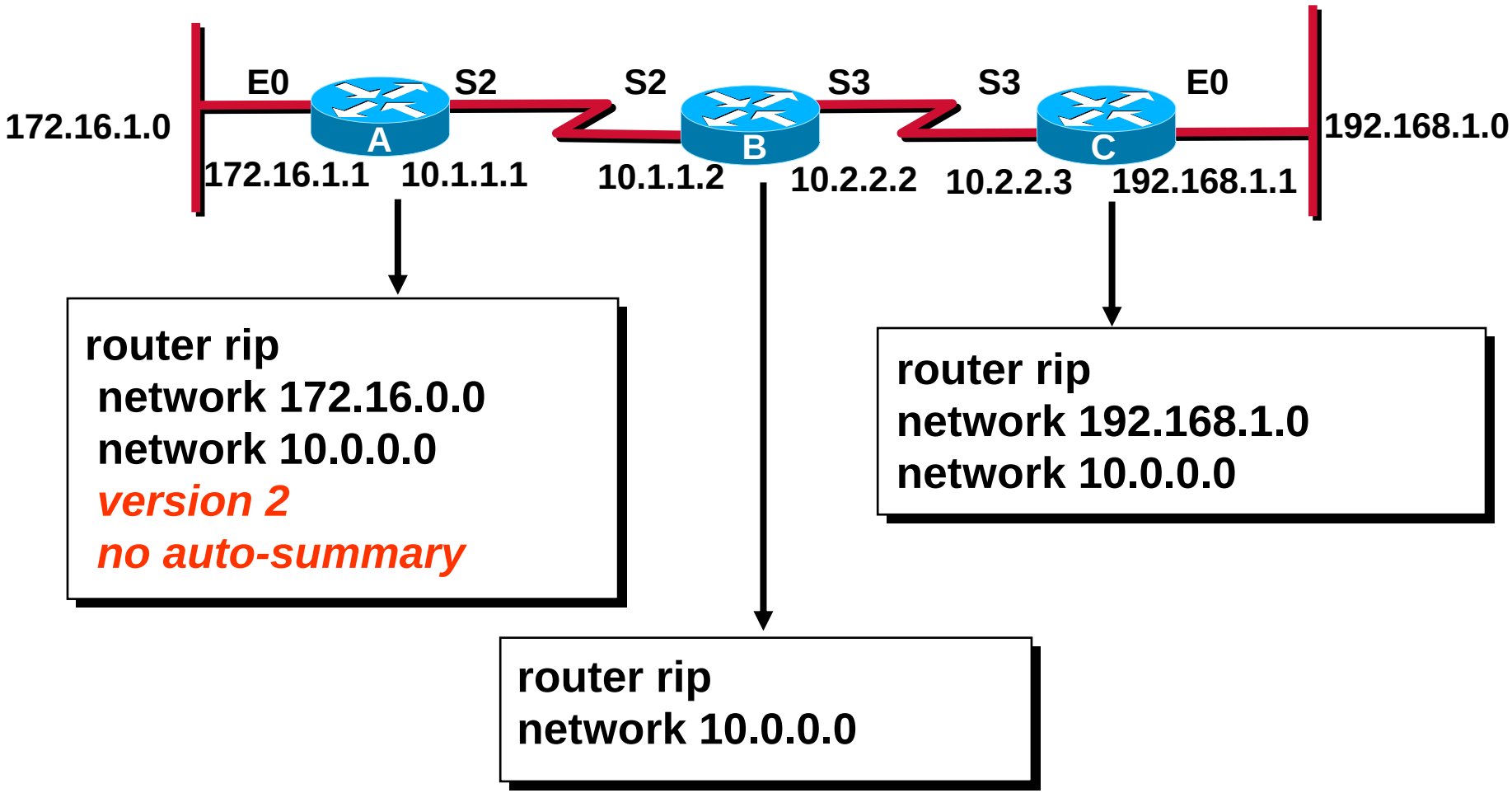
Router(config)#*router rip*

- **Starts the RIP routing process**

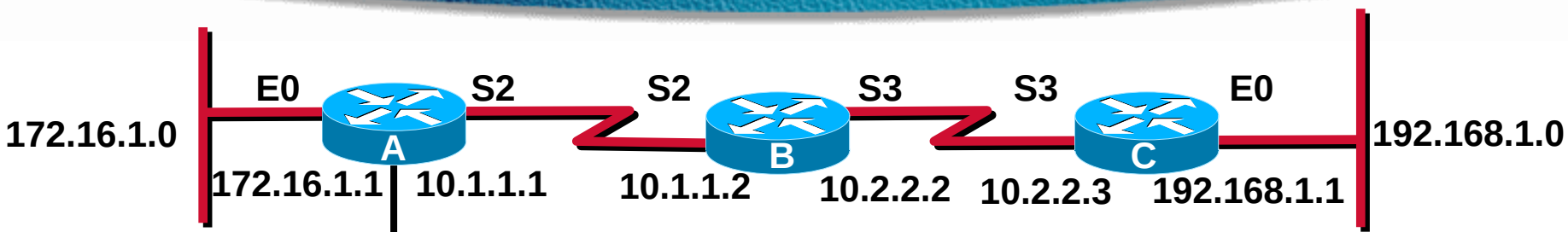
Router(config-router)#*network network-number*

- **Selects participating attached networks**
- **The network number must be a major classful network number**

RIP1/2 Configuration Example

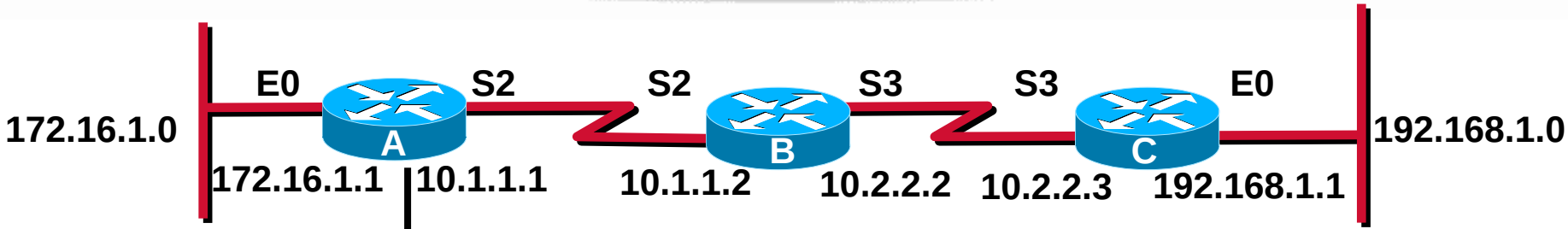


Verifying the Routing Protocol—RIP




```
RouterA#sh ip protocols
Routing Protocol is "rip"
  Sending updates every 30 seconds, next due in 0 seconds
  Invalid after 180 seconds, hold down 180, flushed after 240
  Outgoing update filter list for all interfaces is
  Incoming update filter list for all interfaces is
  Redistributing: rip
  Default version control: send version 1, receive any version
    Interface         Send  Recv  Key-chain
    Ethernet0         1     1 2
    Serial2           1     1 2
  Routing for Networks:
    10.0.0.0
    172.16.0.0
  Routing Information Sources:
    Gateway         Distance      Last Update
    10.1.1.2            120      00:00:10
  Distance: (default is 120)
```

Displaying the IP Routing Table




```
RouterA#sh ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, * - candidate default
       U - per-user static route, o - ODR
       T - traffic engineered route

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 1 subnets
C       172.16.1.0 is directly connected, Ethernet0
     10.0.0.0/24 is subnetted, 2 subnets
R       10.2.2.0 [120/1] via 10.1.1.2, 00:00:07, Serial2
C       10.1.1.0 is directly connected, Serial2
R    192.168.1.0/24 [120/2] via 10.1.1.2, 00:00:07, Serial2
```

EIGRP Overview

What Is Enhanced IGRP (EIGRP)?

- **EIGRP supports:**
  - **Hybrid Routing Protocol**
  - **Rapid convergence**
  - **Reduced bandwidth usage**
  - **Cisco propritary**

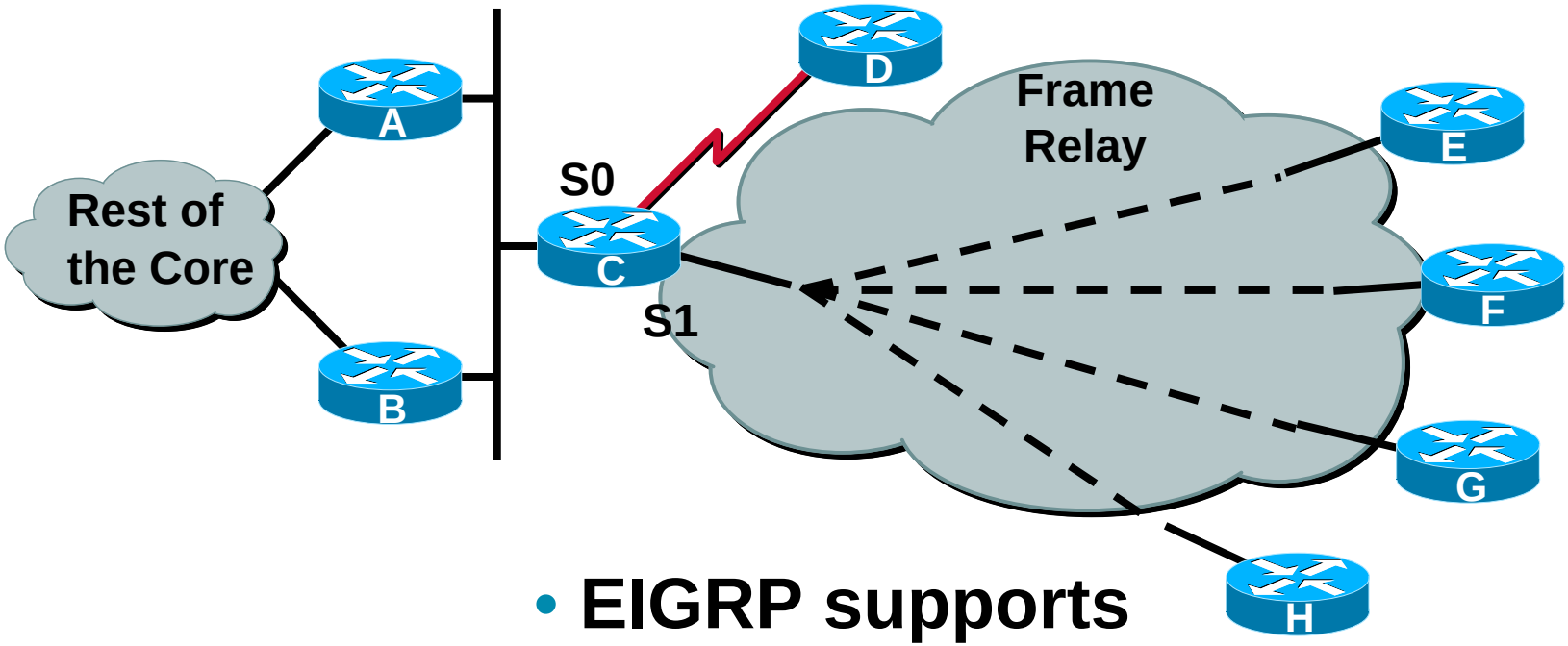
EIGRP Features

- Advanced distance vector
- 100% loop free
- Fast convergence
- Easy configuration
- Less network design constraints than OSPF
- Incremental updates
- Supports VLSM and discontiguous networks
- Classless routing
- Compatible with existing IGRP networks

Advantages of EIGRP

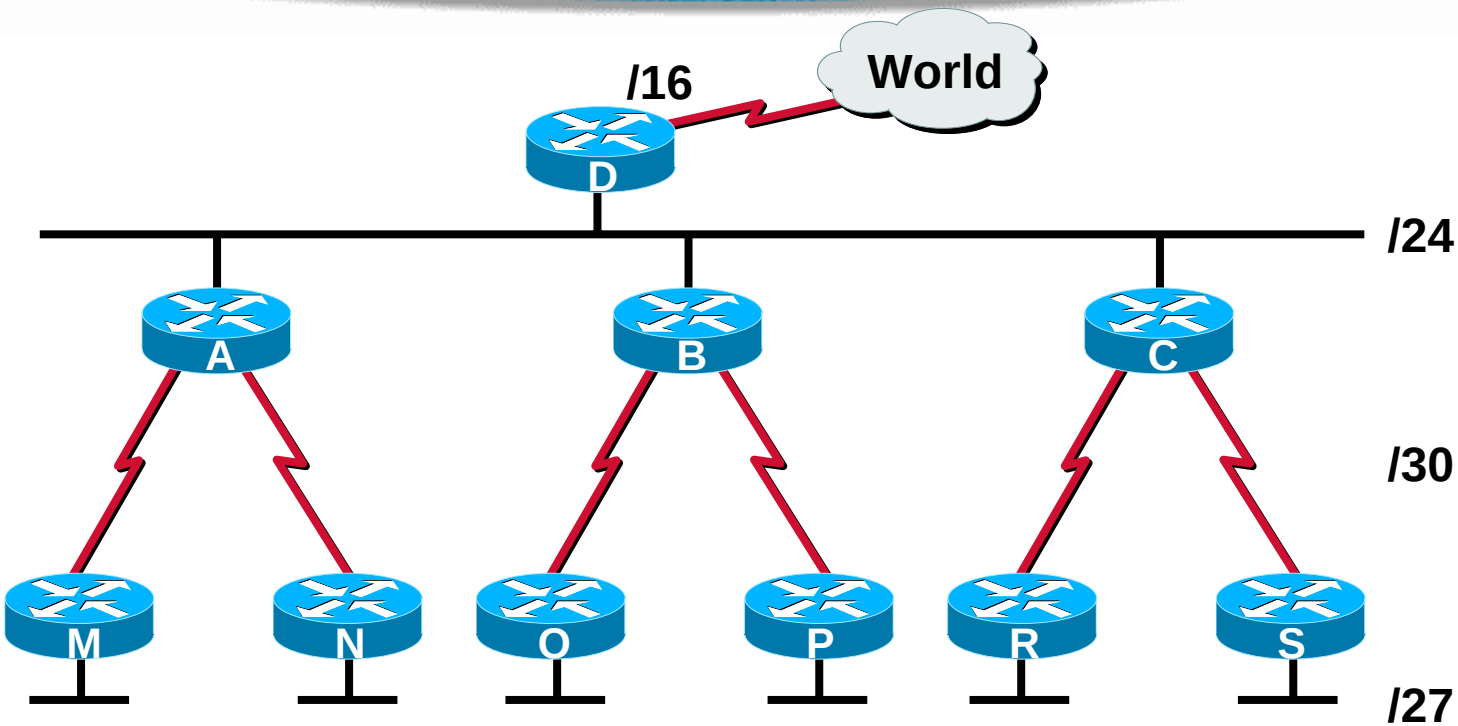
- Uses multicast instead of broadcast
- Unequal cost path load balancing
- Easy configuration
- More flexible than OSPF
  - Manual summarization can be done in any interface at any router within the network

EIGRP Support for Different Topologies



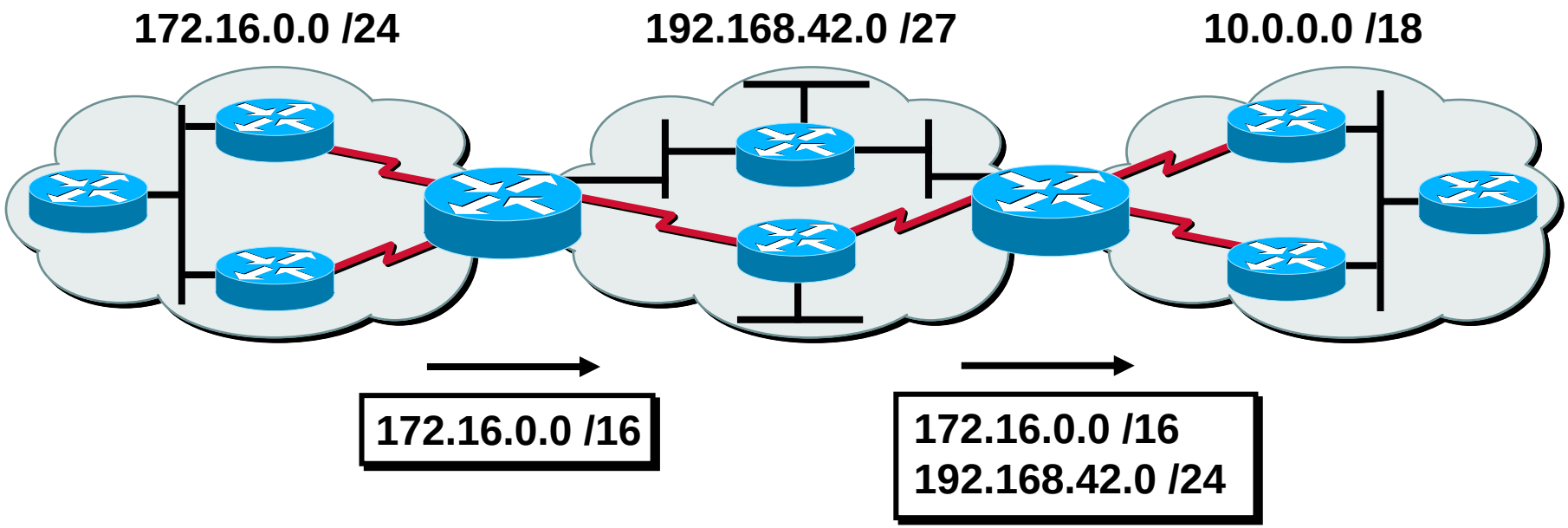
- **EIGRP supports**
  - **Multiaccess (LANs)**
  - **Point-to-point (HDLC)**
  - **NBMA (Frame Relay)**

EIGRP Support for IP Addresses



- **EIGRP supports**
  - **Variable-length subnet masks (VLSMs)**
  - **Hierarchical designs**

EIGRP Support for Route Summarization



- **EIGRP performs route summarization**
  - **Classful network boundaries (default)**
  - **Arbitrary network boundaries (manual)**

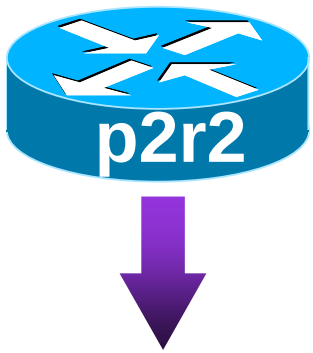
EIGRP Operations

- **Hello: Establish neighbor relationships**
- **Update: Send routing updates**
- **Query: Ask neighbors about routing information**
- **Reply: Response to query about routing information**
- **ACK: Acknowledgement of a reliable packet**

EIGRP Neighbor Relationship

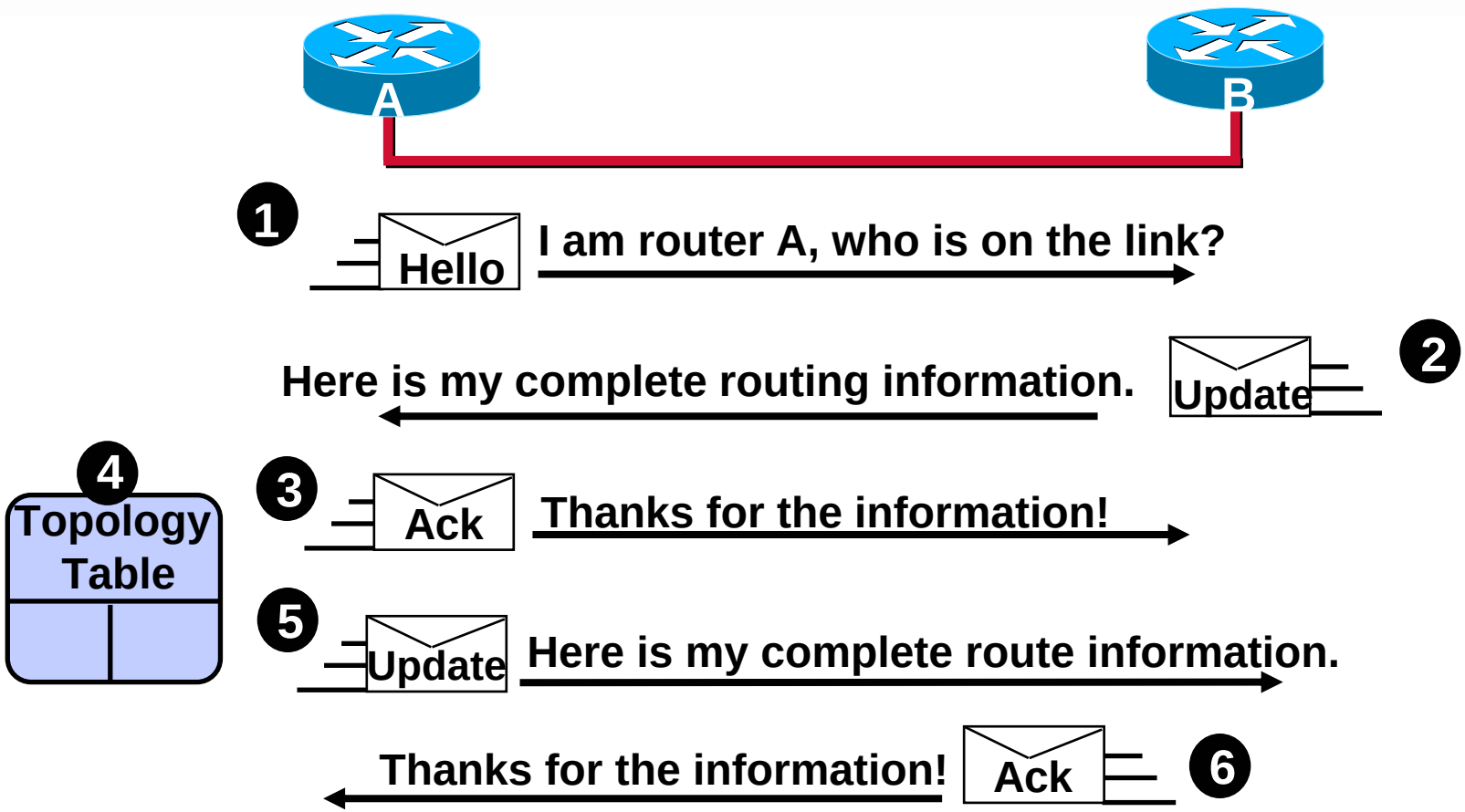
- Two routers become neighbors when they see each other's hello packet
  - Hello address = 224.0.0.10
- Hellos sent periodically (5 or 30 seconds)
- Neighbor declared dead when no EIGRP packets are received within hold interval
  - Not only hello can reset the hold timer
- Hold time by default is three times the hello time

What Is in a Neighbor Table?

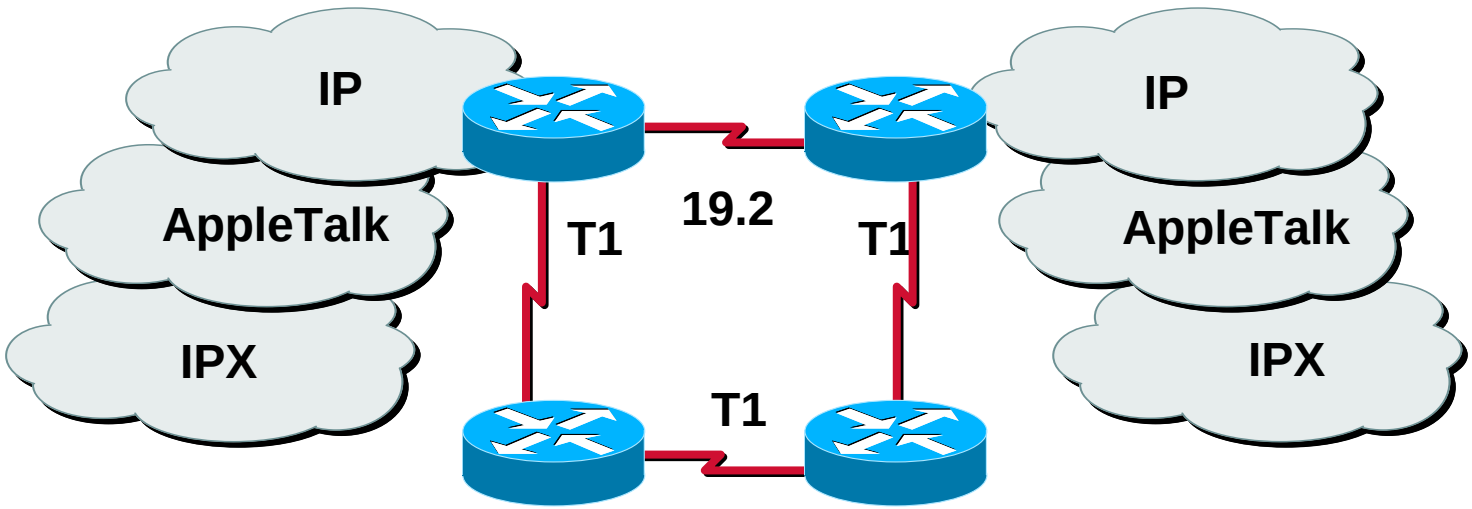



```
p2r2#show ip eigrp neighbors
IP-EIGRP neighbors for process 400
H Address       Interface  Hold Uptime  SRTT  RTO Q    Seq
                           (sec)        (ms)      Cnt  Num
1 172.68.2.2    To0        13 02:15:30   8    200 0    9
0 172.68.16.2   Se1        10 02:38:29   29   200 0    6
```

Initial Route Discovery

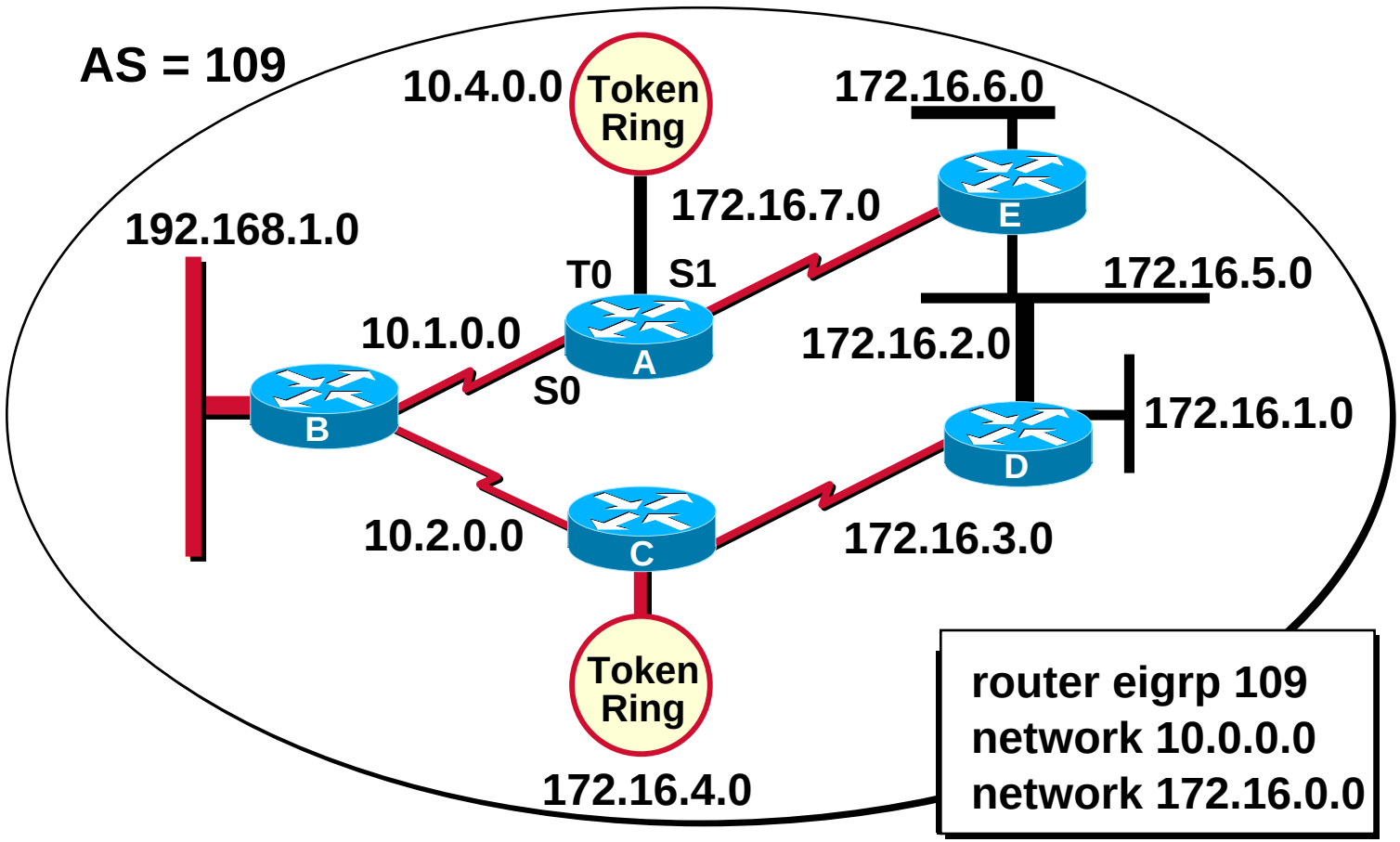


EIGRP Route Selection



- **EIGRP uses a composite metric to pick the best path**

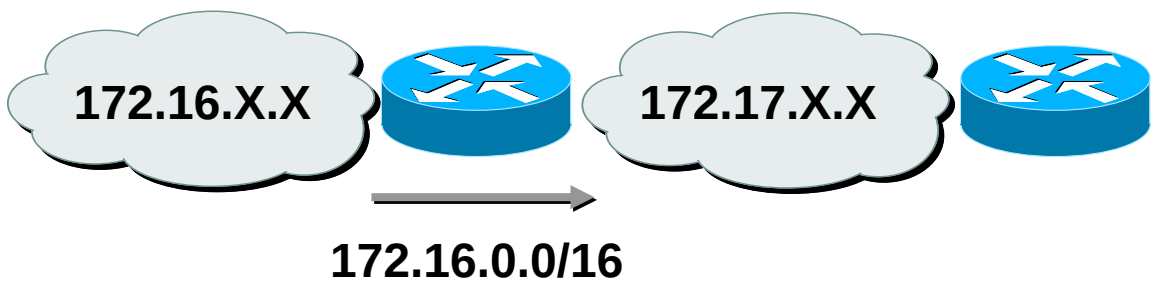
Configuring EIGRP



- Network 192.168.0.0 is not configured on Router A because it is not directly connected to Router A

EIGRP Summarization—Automatic

- **Purpose: Smaller routing tables, smaller updates, query boundary**
- **Autosummarization:**
  - **On major network boundaries, subnetworks are summarized to a single classful (major) network**
  - **Autosummarization is turned on by default**



EIGRP Summarization—Manual

- **Manual summarization**
  - **Configurable on a per-interface basis in any router within network**
  - **When summarization is configured on an interface, the router immediate creates a route pointing to null zero**
    - **Loop prevention mechanism**
  - **When the last specific route of the summary goes away, the summary is deleted**
  - **The minimum metric of the specific routes is used as the metric of the summary route**

Configuring Summarization

(config-router)#

```
no auto-summary
```

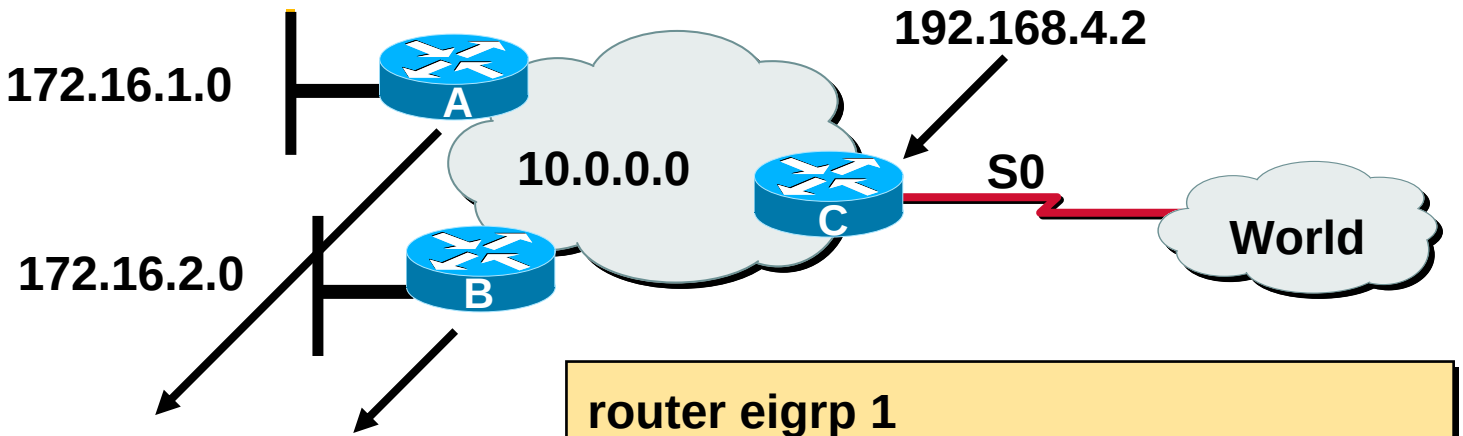
- Turns off autosummarization for the EIGRP process

(config-if)#

```
ip summary-address eigrp <as-number>
  <address> <mask>
```

- Creates a summary address to be generated by this interface

Summarizing EIGRP Routes




```
router eigrp 1
network 10.0.0.0
network 172.16.0.0
no auto-summary
```

```
router eigrp 1
network 10.0.0.0
network 192.168.4.0
!
int s0
ip address 192.168.4.2 255.255.255.0
ip summary-address eigrp 1
172.16.0.0 255.255.0.0
```

Verifying EIGRP Operation

Router#

```
show ip eigrp neighbors
```

Router#

```
show ip eigrp topology
```

Router#

```
show ip route eigrp
```

Router#

```
show ip protocols
```

Router#

```
show ip eigrp traffic
```

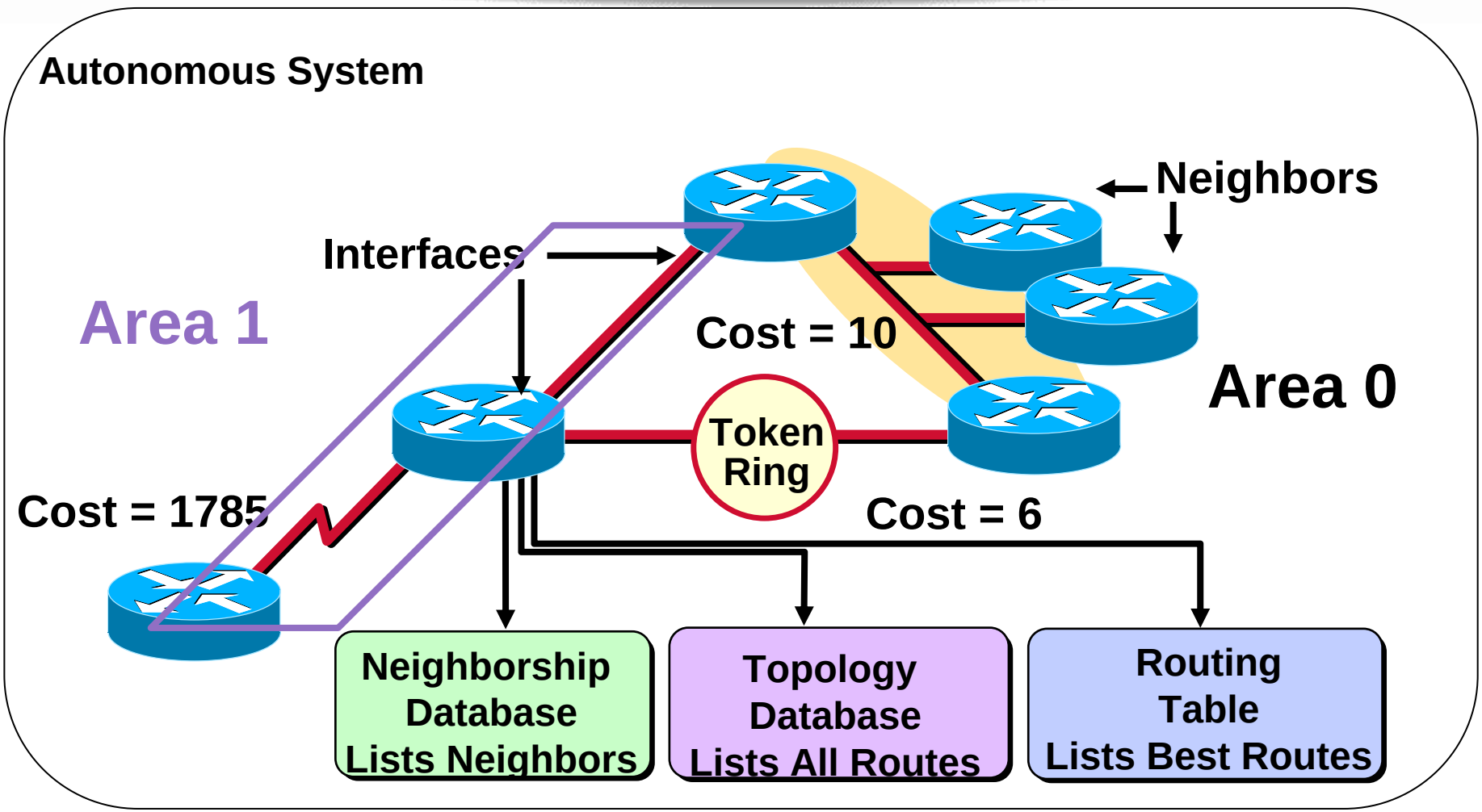
- Displays the neighbors discovered by IP EIGRP
- Displays the IP EIGRP topology table
- Displays current EIGRP entries in the routing table
- Displays the parameters and current state of the active routing protocol process
- Displays the number of IP EIGRP packets sent and received

OSPF Overview

What Is OSPF?

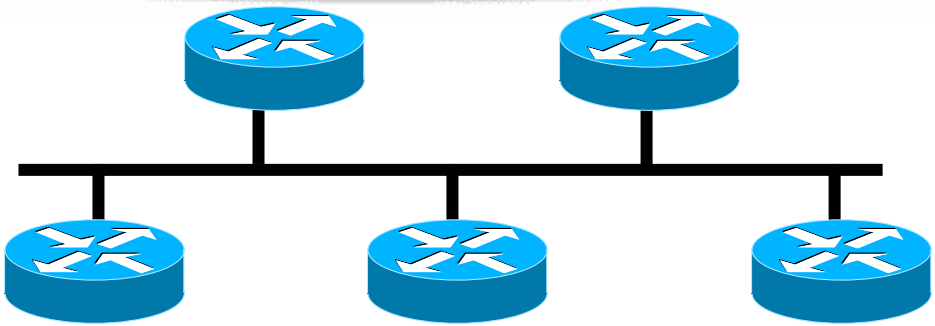
- Open Shortest Path First
- Has fast convergence
- Hierarchical Routing
- Supports VLSM
- Processes updates efficiently
- Selects paths based on bandwidth
- Supports equal-cost multipath

OSPF Terminology



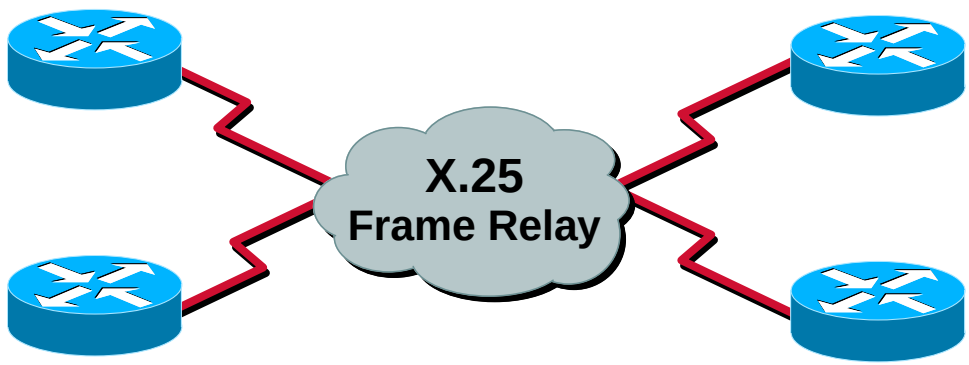
OSPF Topologies

Broadcast Multiaccess

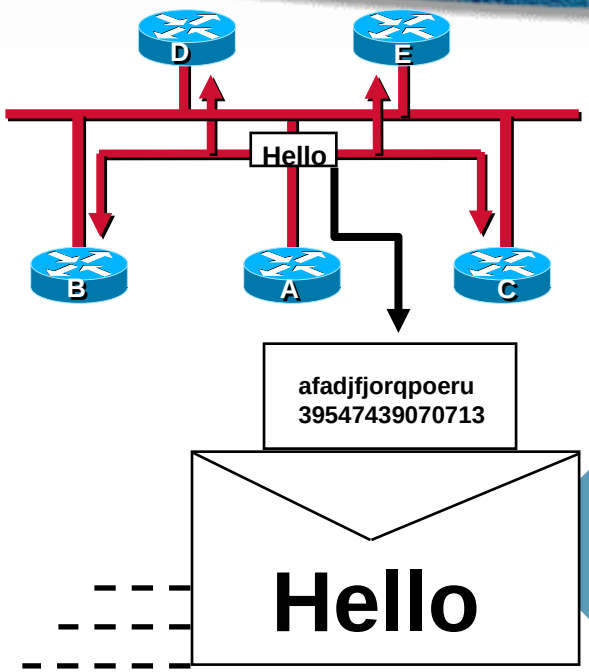


Point-to-Point

NBMA



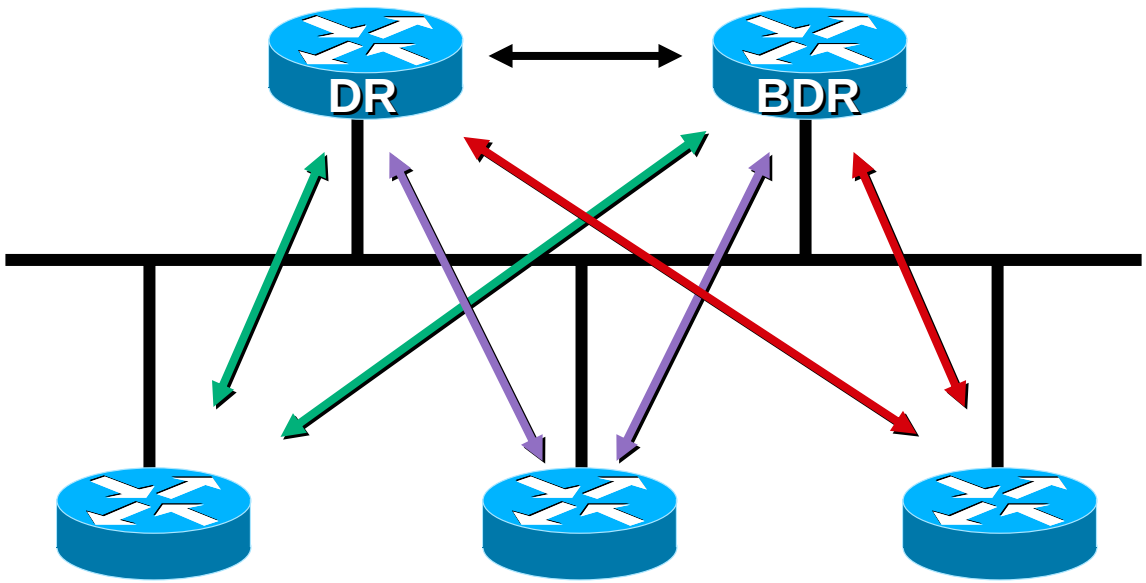
Neighborship



- Router ID
- Hello/dead intervals *
- Neighbors
- Area-ID *
- Router priority
- DR IP address
- BDR IP address
- Authentication password*
- Stub area flag *

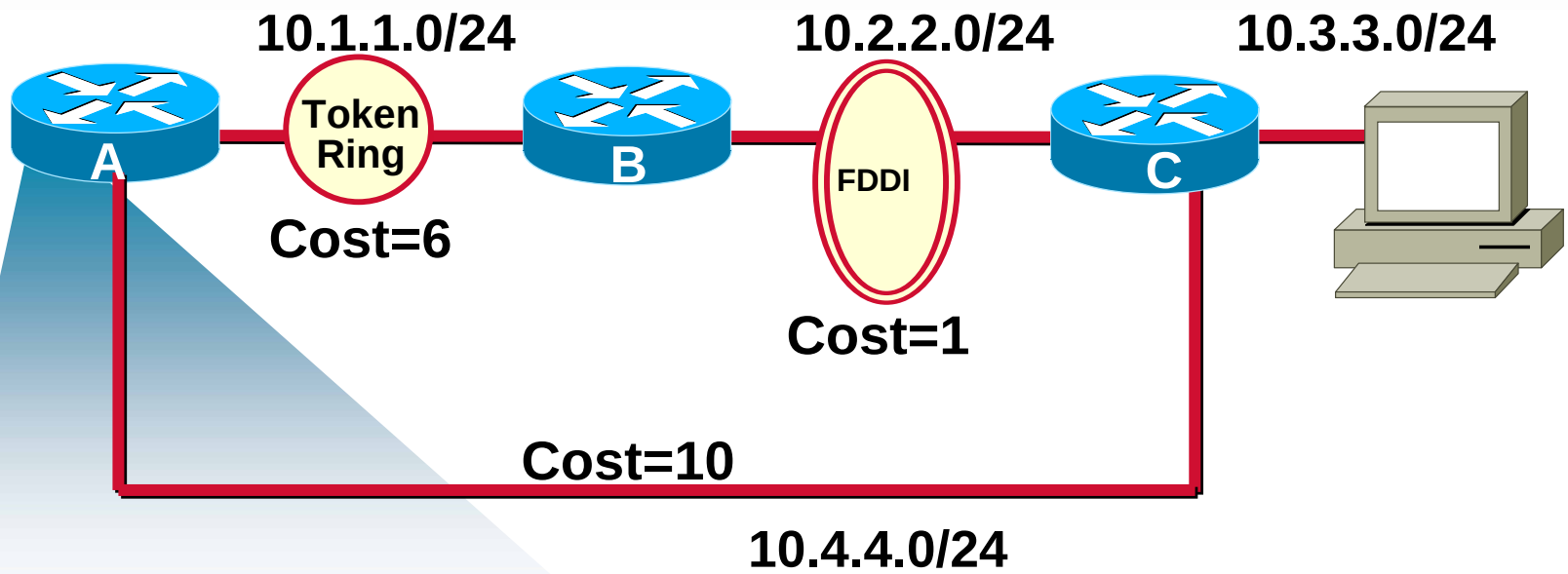
* Entry must match on neighboring routers

DR and BDR



- Hellos elect DR and BDR to represent segment
- Each router then forms adjacency with DR and BDR

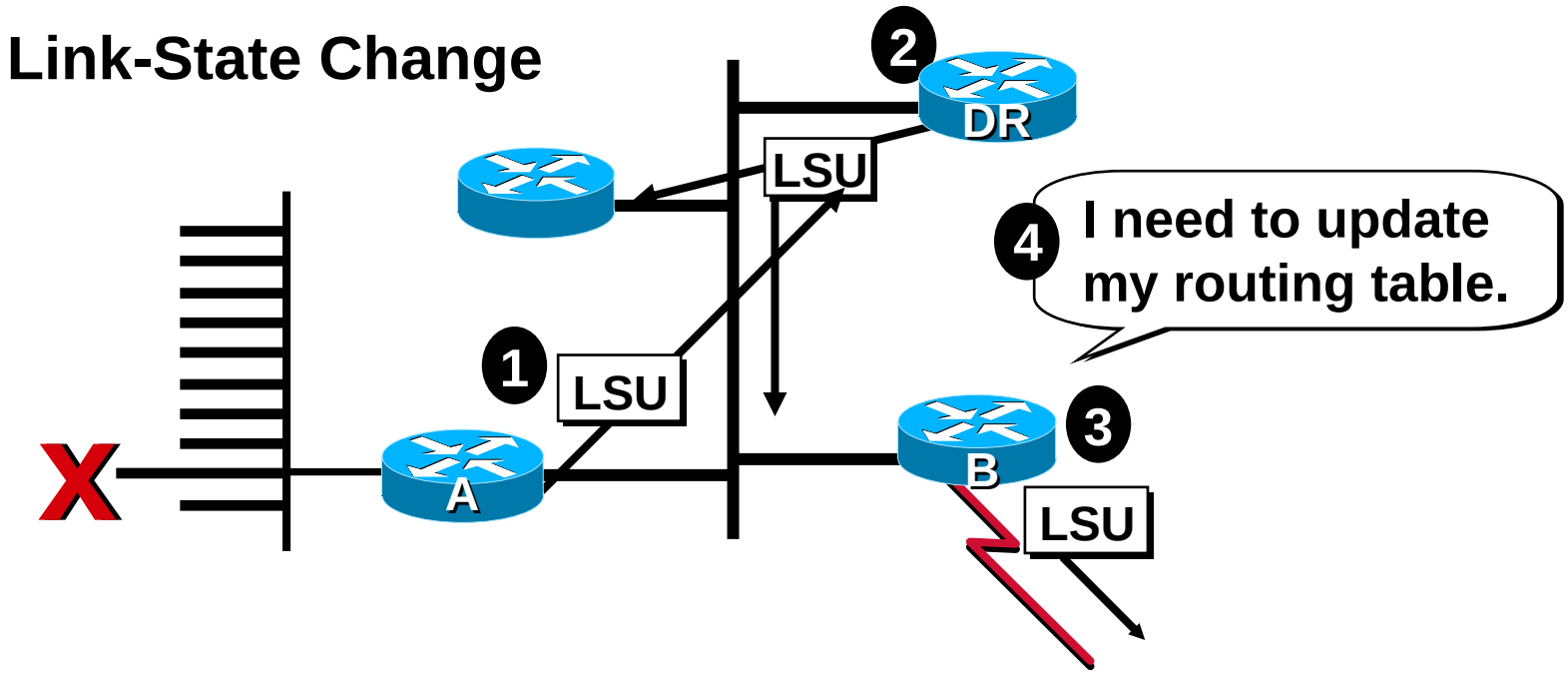
Choosing Routes



Topology Table		
Net	Cost	Out Interface
10.2.2.0	6	To0
10.3.3.0	7	To0
10.3.3.0	10	E0

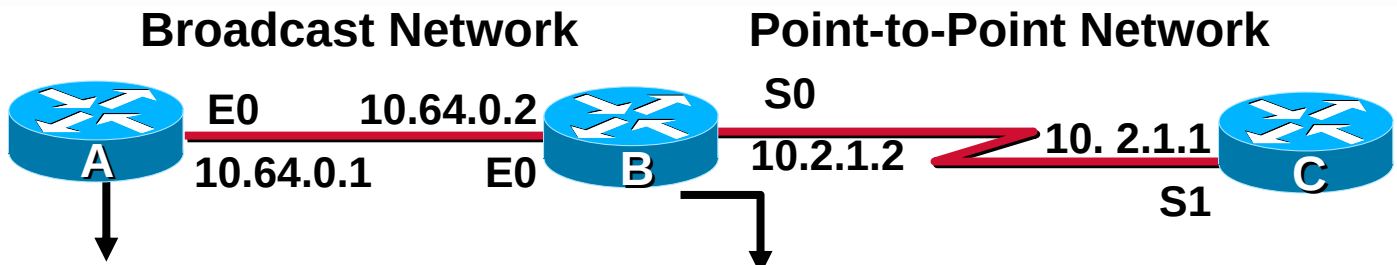
This is the best route to 10.3.3.0.

Maintaining Routing Information



- Router A tells all OSPF DRs on 224.0.0.6
- DR tells others on 224.0.0.5

Configuring OSPF on Internal Routers




```
<Output Omitted>
interface Ethernet0
 ip address 10.64.0.1 255.255.255.0
!
<Output Omitted>
router ospf 1
 network 10.0.0.0 0.255.255.255 area 0
```

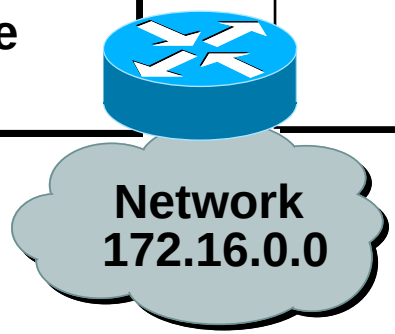
```
<Output Omitted>
interface Ethernet0
 ip address 10.64.0.2 255.255.255.0
!
interface Serial0
 ip address 10.2.1.2 255.255.255.0
<Output Omitted>
router ospf 50
 network 10.2.1.2 0.0.0.0 area 0
 network 10.64.0.2 0.0.0.0 area 0
```

Can Assign Network or Interface Address.

Configuring Optional Commands

Unadvertised Loopback Address
Ex: 192.168.255.254
- **Not in OSPF table**
- **Saves address space**
- **Cannot use ping**

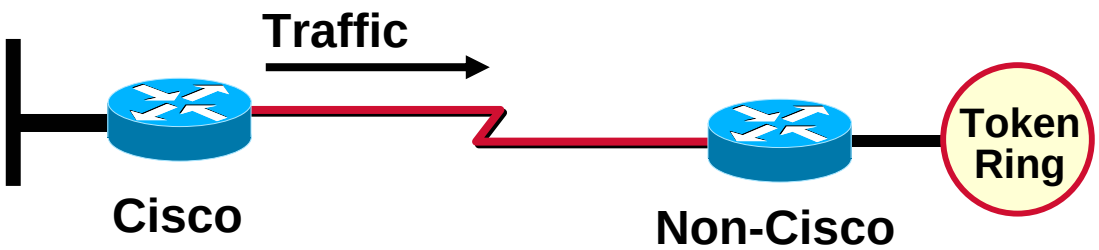
Advertised Loopback Address
Ex: 172.16.17.5
- **In OSPF table**
- **Uses address space**
- **Can use ping**



Router ID:

- **Number by which the router is known to OSPF**
- **Default: The highest IP address on an active interface at the moment of OSPF process startup**
- **Can be overridden by a loopback interface: Highest IP address of any active loopback interface**

Configuring Optional Commands (cont.)

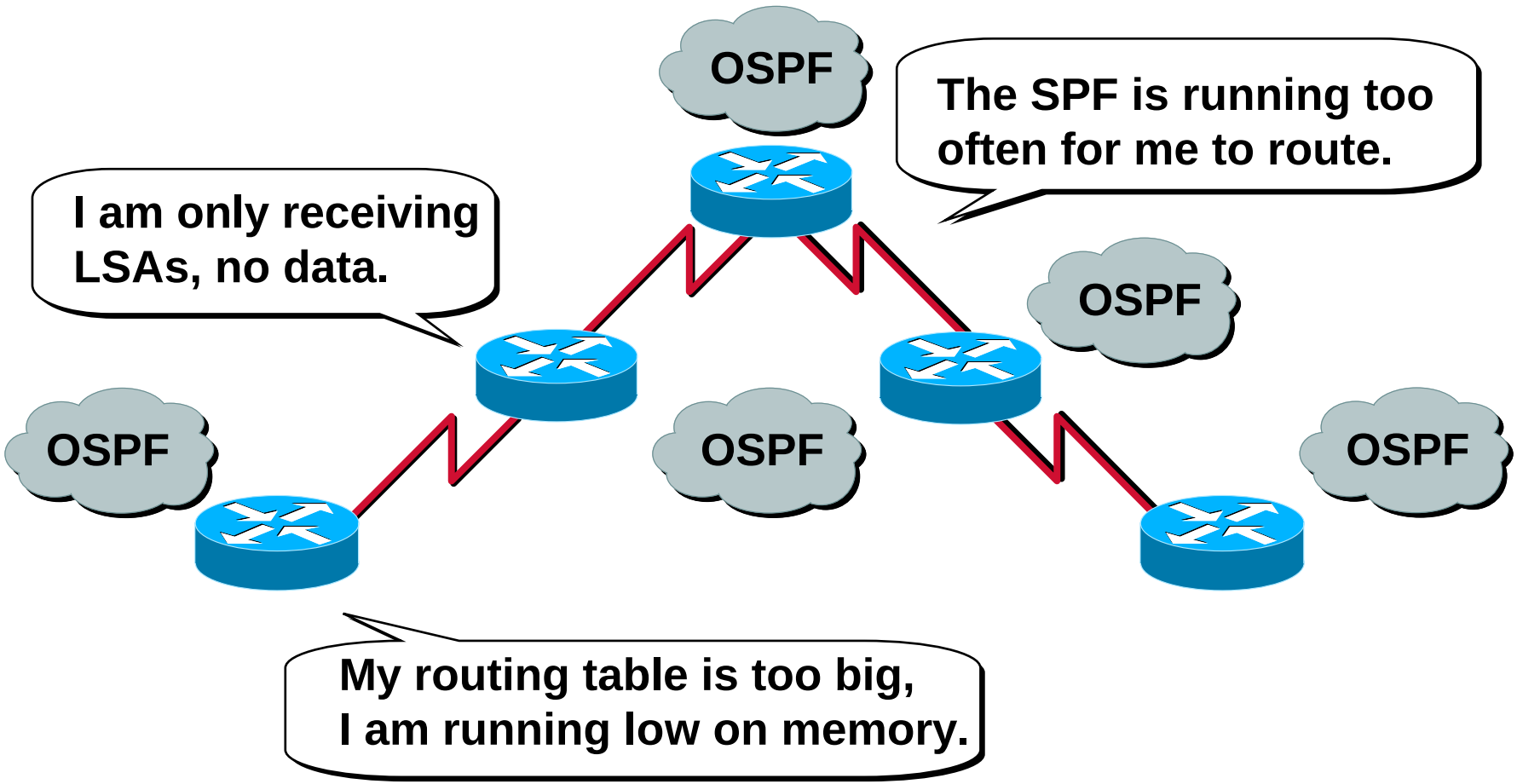


Router(config-if)#

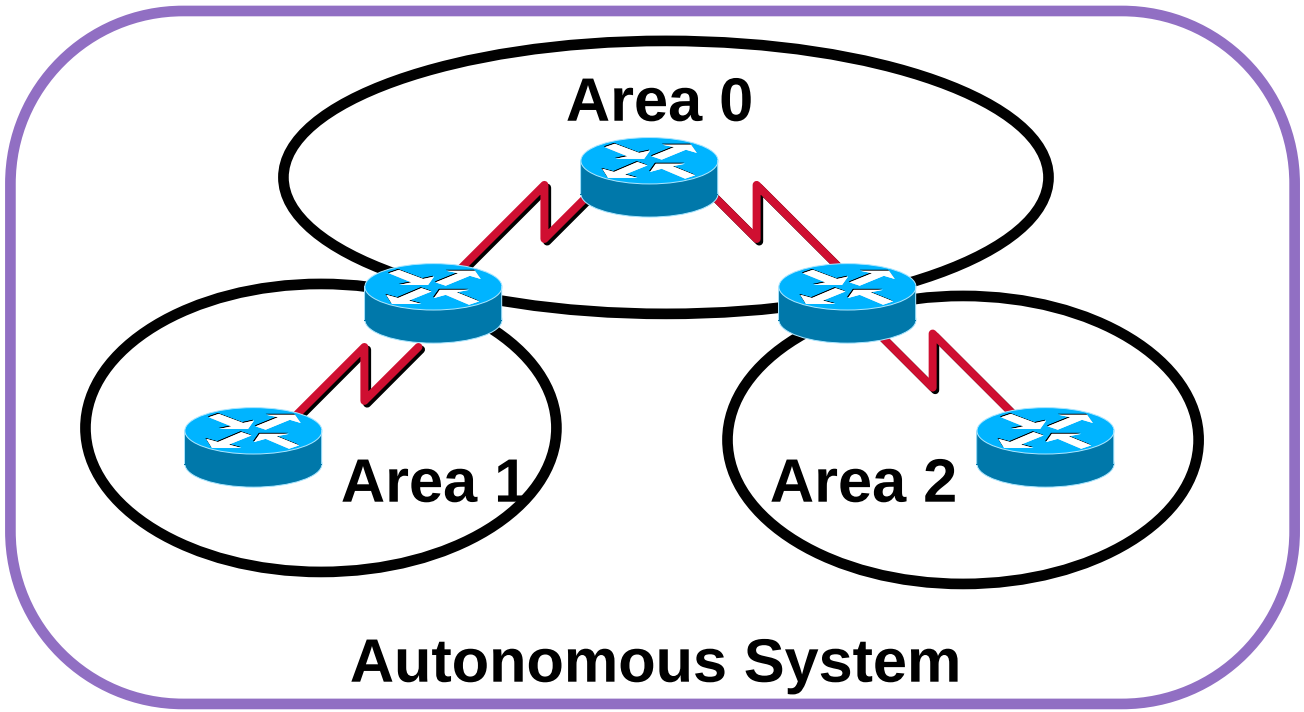
ip ospf cost *cost*

- **Assigns a cost to an outgoing interface**
- **May be required for interoperability**
- **Use default cost between Cisco devices**

Issues with Maintaining a Large OSPF Network

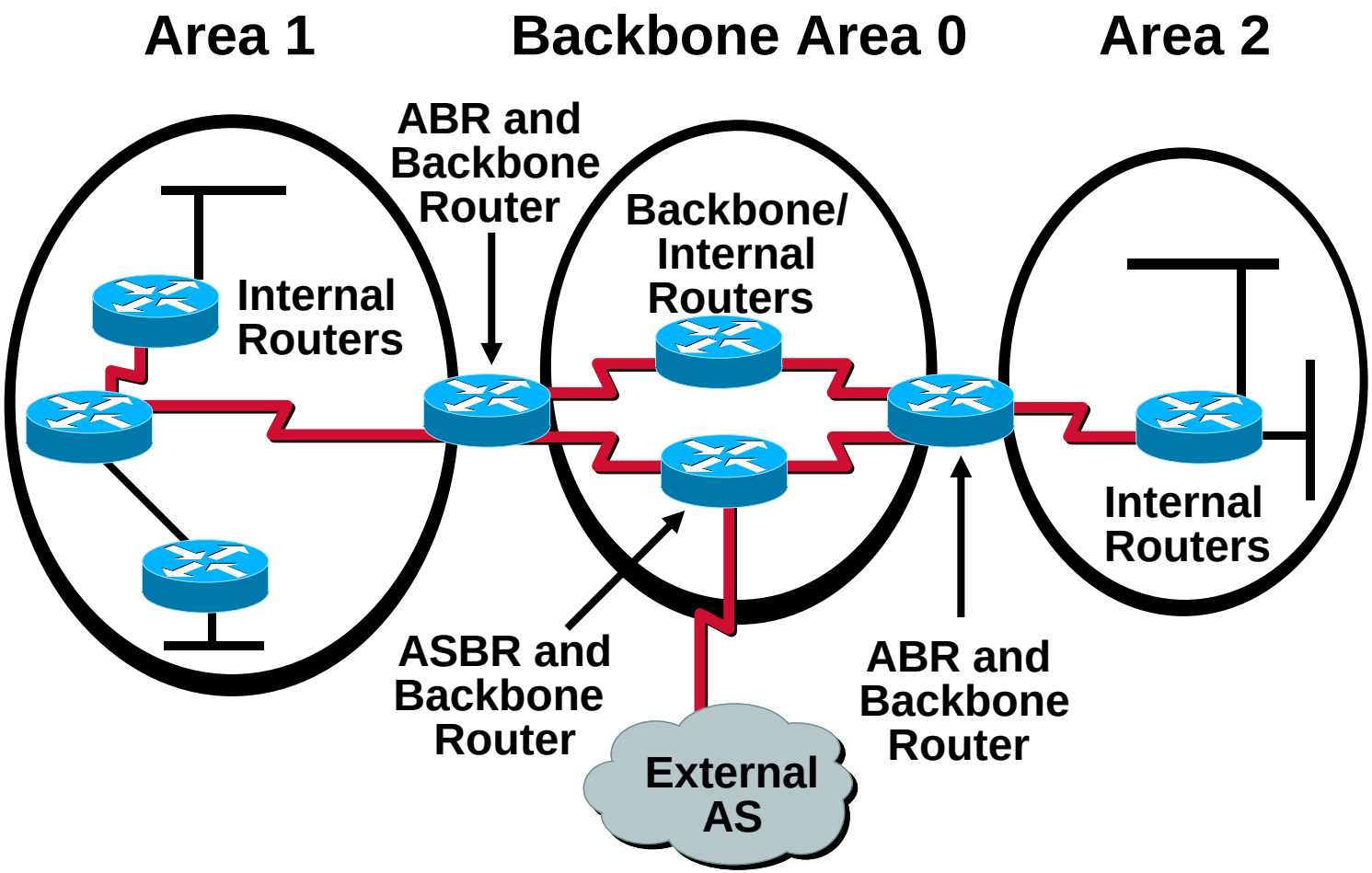


OSPF Hierarchical Routing



- Consists of areas and autonomous systems
- Minimizes routing update traffic

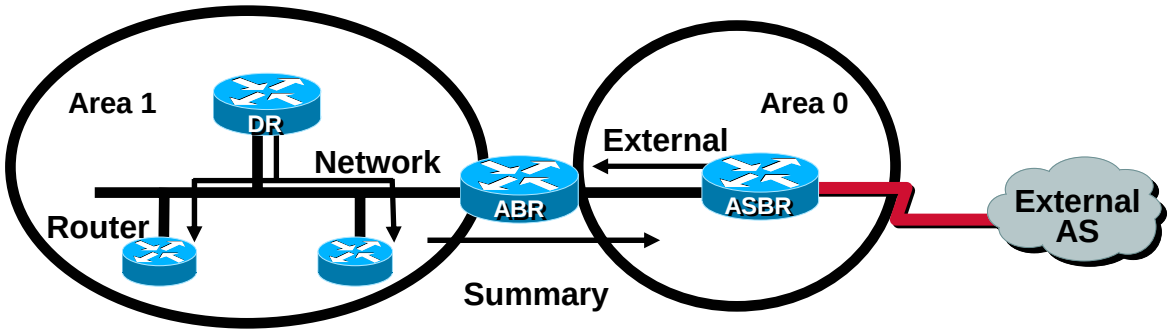
Types of OSPF Routers



Types of Link-State Advertisements

- Type 1: Router link entry
- Type 2: Network link entry
- Type 3 and 4: Summary link entry
- Type 5: AS external link entry

LSAs in OSPF Database



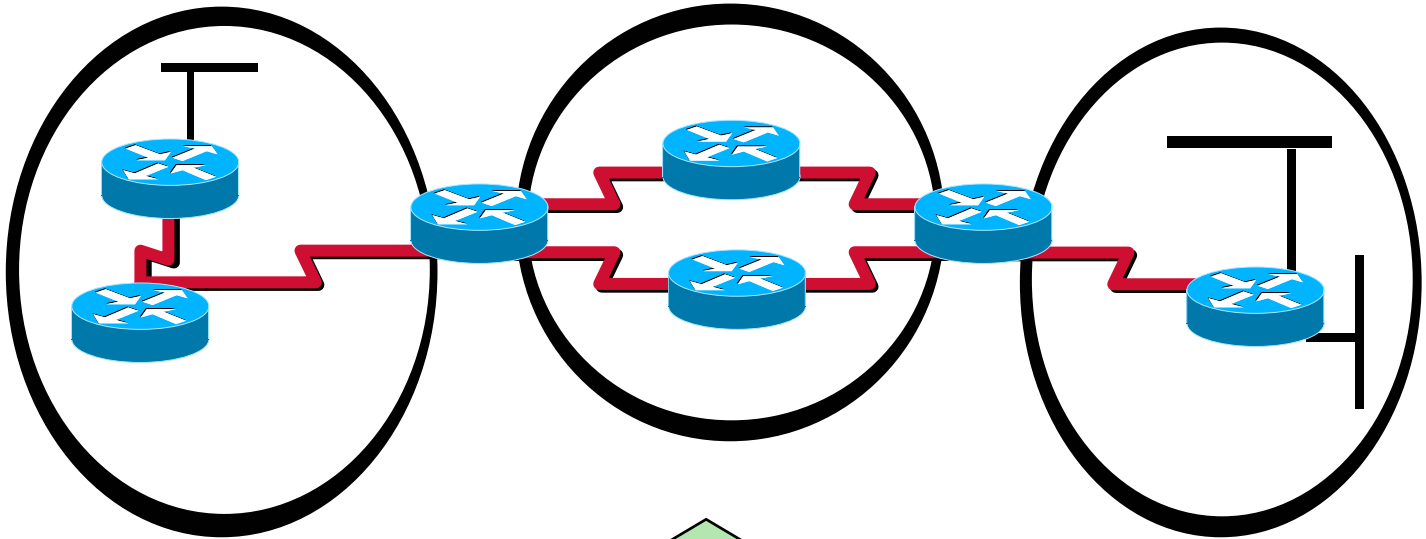

```
p1r3#show ip ospf database
       OSPF Router with ID (10.64.0.1) (Process ID 1)

                Router Link States (Area 1)
Link ID         ADV Router      Age         Seq#       Checksum Link count
10.1.2.1        10.1.2.1        651         0x80000005 0xD482   4

                Net Link States (Area 1)
Link ID         ADV Router      Age         Seq#       Checksum
10.64.0.1       10.64.0.1       538         0x80000002 0xAD9A

                Summary Net Link States (Area 1)
Link ID         ADV Router      Age         Seq#       Checksum
10.2.1.0        10.2.1.2        439         0x80000002 0xE6F8
```

Types of Areas

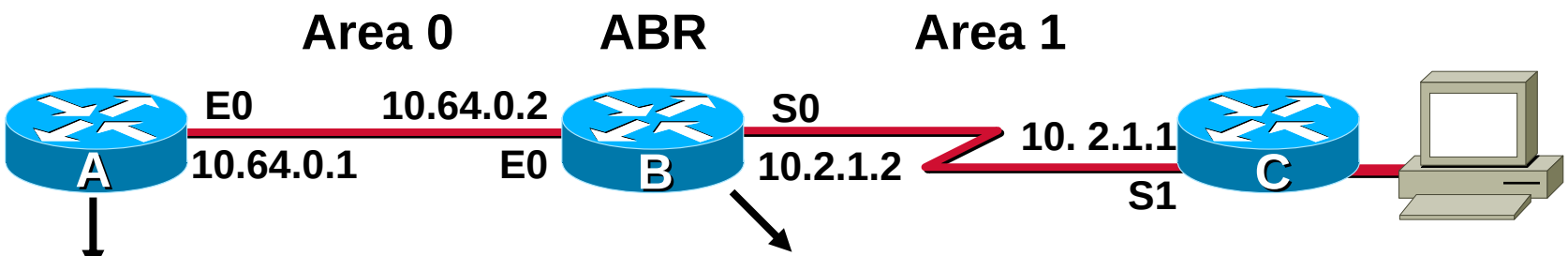


Does not accept external LSAs.

Interconnects areas; accepts all LSAs.

Does not accept external or summary LSAs.

Configuring OSPF ABRs




```
<Output Omitted>
interface Ethernet0
 ip address 10.64.0.1 255.255.255.0
!
<Output Omitted>
router ospf 77
 network 10.0.0.0 0.255.255.255 area 0
```

```
<Output Omitted>
interface Ethernet0
 ip address 10.64.0.2 255.255.255.0
!
interface Serial0
 ip address 10.2.1.2 255.255.255.0
<Output Omitted>
router ospf 50
 network 10.2.1.2 0.0.0.0 area 1
 network 10.64.0.2 0.0.0.0 area 0
```

Configuring Route Summarization

Router(config-router)#

area *area-id* range *address mask*

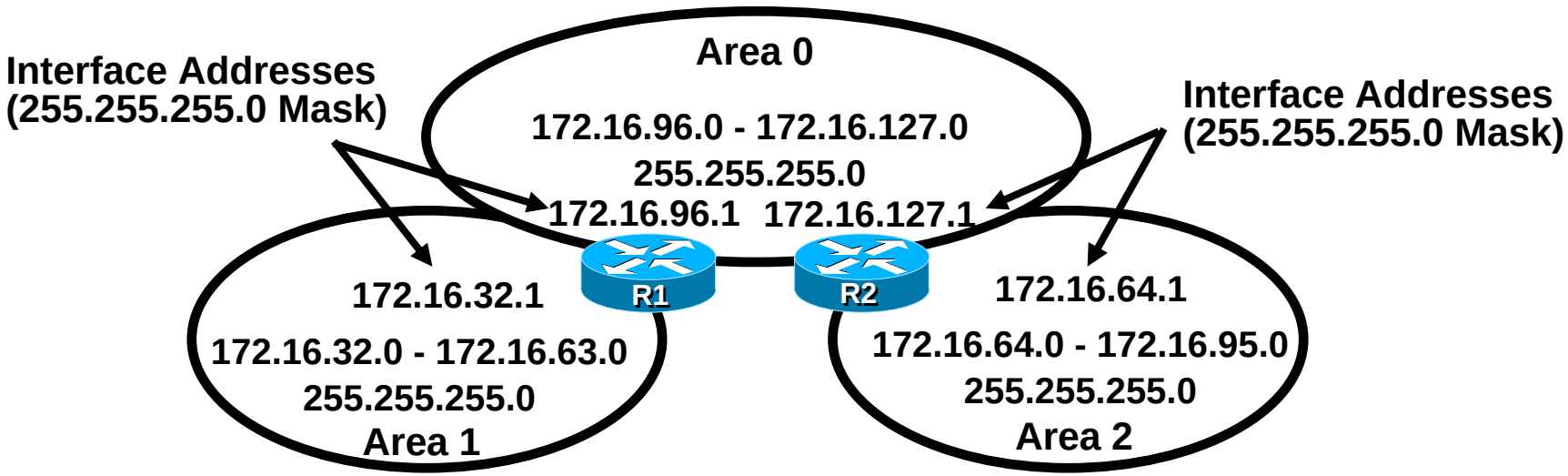
- **Consolidates intra-area (IA) routes on an ABR**

Router(config-router)#

summary-address *address mask* [not-advertise] [tag *tag*]

- **Consolidates external routes on an ASBR**

Route Summarization Configuration Example



R1#
router ospf 100
network 172.16.32.1 0.0.0.0 area 1
network 172.16.96.1 0.0.0.0 area 0
area 0 range 172.16.96.0 255.255.224.0
area 1 range 172.16.32.0 255.255.224.0

R2#
router ospf 100
network 172.16.64.1 0.0.0.0 area 2
network 172.16.127.1 0.0.0.0 area 0
area 0 range 172.16.96.0 255.255.224.0
area 2 range 172.16.64.0 255.255.224.0

Verifying OSPF Operation

```
Router#
show ip protocols
```

- **Verifies that OSPF is configured**

```
Router#
show ip route
```

- **Displays all the routes learned by the router**

```
Router#
show ip ospf interface
```

- **Displays area ID and adjacency information**

Verifying OSPF Operation (cont.)

```
Router#
show ip ospf
```

- Displays OSPF timers and statistics

```
Router#
show ip ospf neighbor detail
```

- Displays information about DR, BDR and neighbors

```
Router#
show ip ospf database
```

- Displays the link-state database

Verifying OSPF Operation (cont.)

```
Router#
clear ip route *
```

- Allows you to clear the IP routing table (for all routing protocol)

show ip ospf interface

```
R2#sh ip ospf int e0
Ethernet0 is up, line protocol is up
  Internet Address 192.168.0.12/24, Area 0
  Process ID 1, Router ID 192.168.0.12, Network Type BROADCAST, Cost: 10
  Transmit Delay is 1 sec, State DROTHER, Priority 1
  Designated Router (ID) 192.168.0.11, Interface address 192.168.0.11
  Backup Designated router (ID) 192.168.0.13, Interface address 192.168.0.13
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:04
  Neighbor Count is 3, Adjacent neighbor count is 2
    Adjacent with neighbor 192.168.0.13  (Backup Designated Router)
    Adjacent with neighbor 192.168.0.11  (Designated Router)
  Suppress hello for 0 neighbor(s)
```

show ip ospf database

R2#**show ip ospf database**

OSPF Router with ID (192.168.0.12) (Process ID 1)

Router Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
192.168.0.10	192.168.0.10	817	0x80000003	0xFF56	1
192.168.0.11	192.168.0.11	817	0x80000003	0xFD55	1
192.168.0.12	192.168.0.12	816	0x80000003	0xFB54	1
192.168.0.13	192.168.0.13	816	0x80000003	0xF953	1
192.168.0.14	192.168.0.14	817	0x80000003	0xD990	1

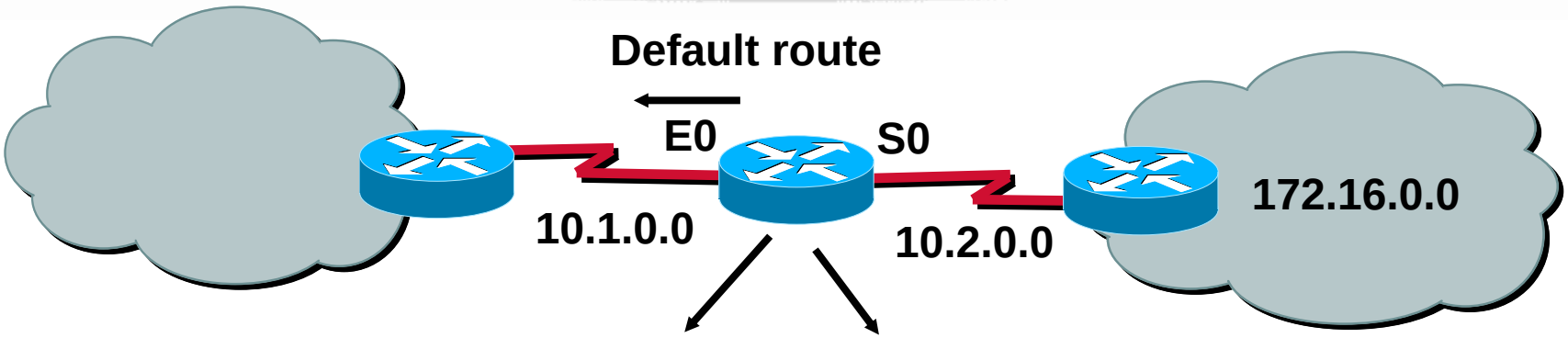
Net Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
192.168.0.14	192.168.0.14	812	0x80000002	0x4AC8

show ip route ospf

```
R2#sh ip route ospf
     163.24.0.0/16 is variably subnetted, 16 subnets, 3 masks
O E2    163.24.0.0/16 [110/20] via 163.24.165.254, 1w5d, Vlan1
     10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
O E2    10.163.96.0/19 [110/20] via 163.24.165.254, 1w5d, Vlan1
O E2 210.60.38.0/24 [110/20] via 163.24.165.254, 1w5d, Vlan1
O E2 203.71.77.0/24 [110/20] via 163.24.165.254, 1w5d, Vlan1
```

ip classless Command




```
Router(config)#ip classless
```

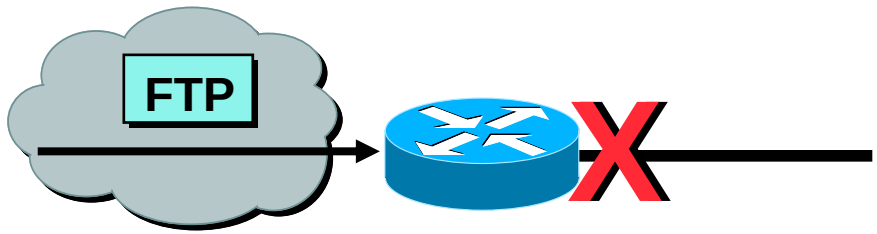
Network Protocol	Destination Network	Exit Interface
C	10.1.0.0	E0
C	10.2.0.0	S0
RIP	172.16.0.0 via	S0
	0.0.0.0	E0

To get to 10.7.1.1:

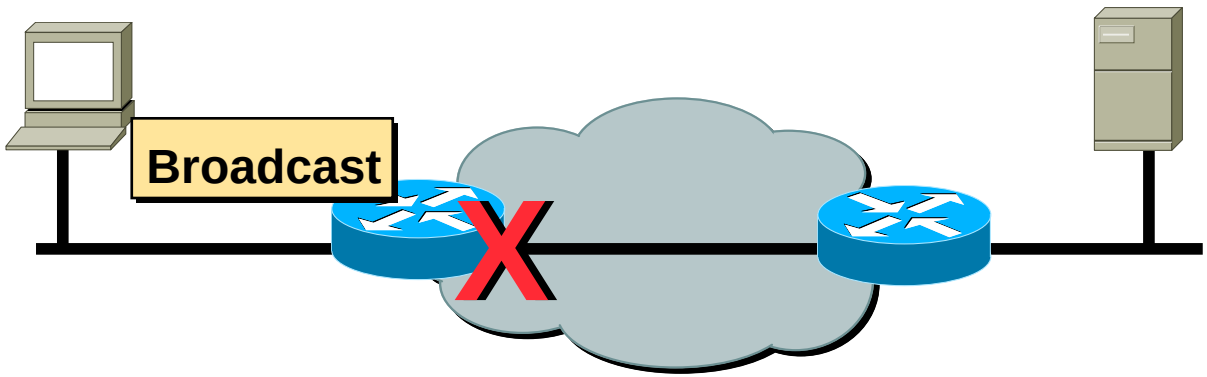
- **With *ip classless* → Default**
- **With *no ip classless* → Drop**

Configuring IP Access Lists

Managing IP Traffic Overview

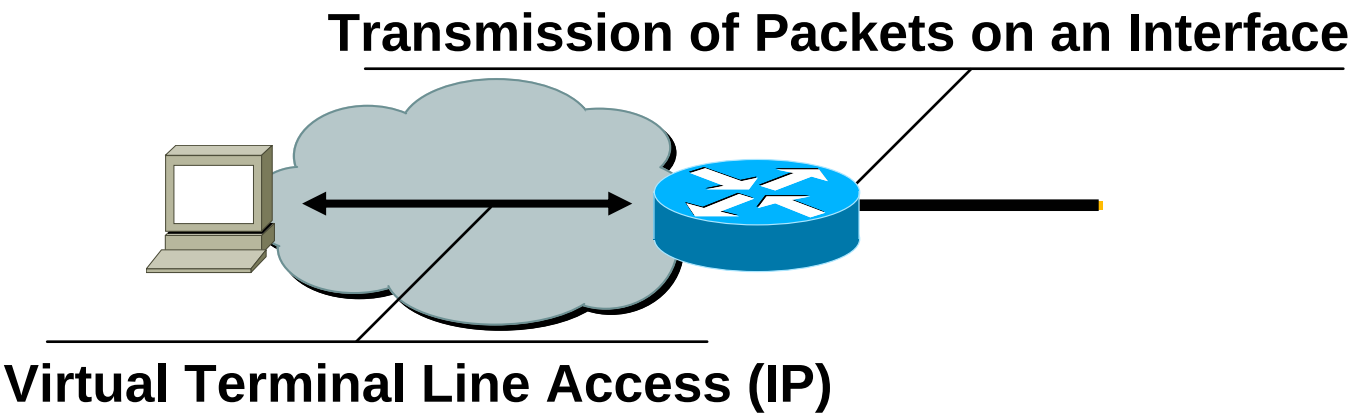


- **Limit traffic and restrict network use**



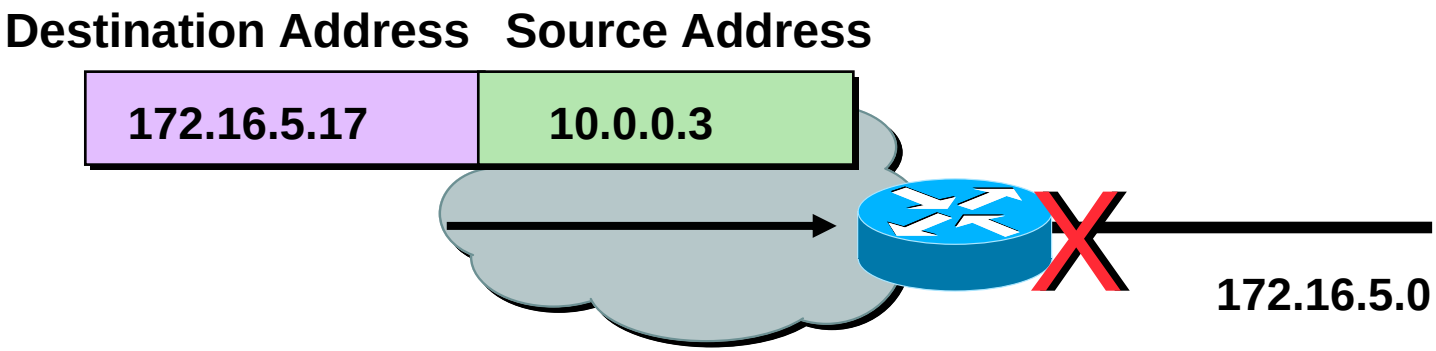
- **Enable directed forwarding of broadcasts**

Access List Applications



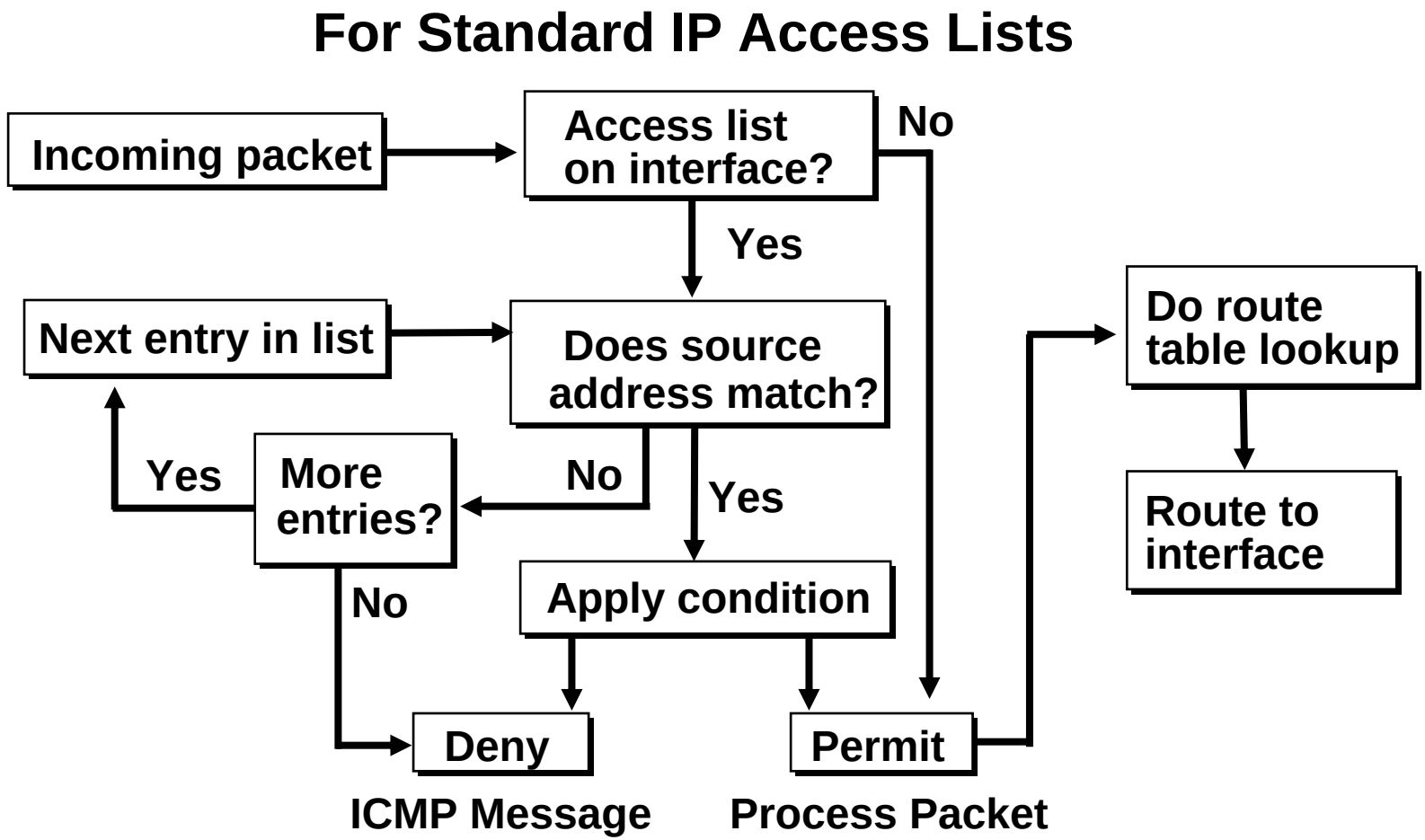
- **Access lists control packet movement through a network**

IP Standard Access Lists Overview

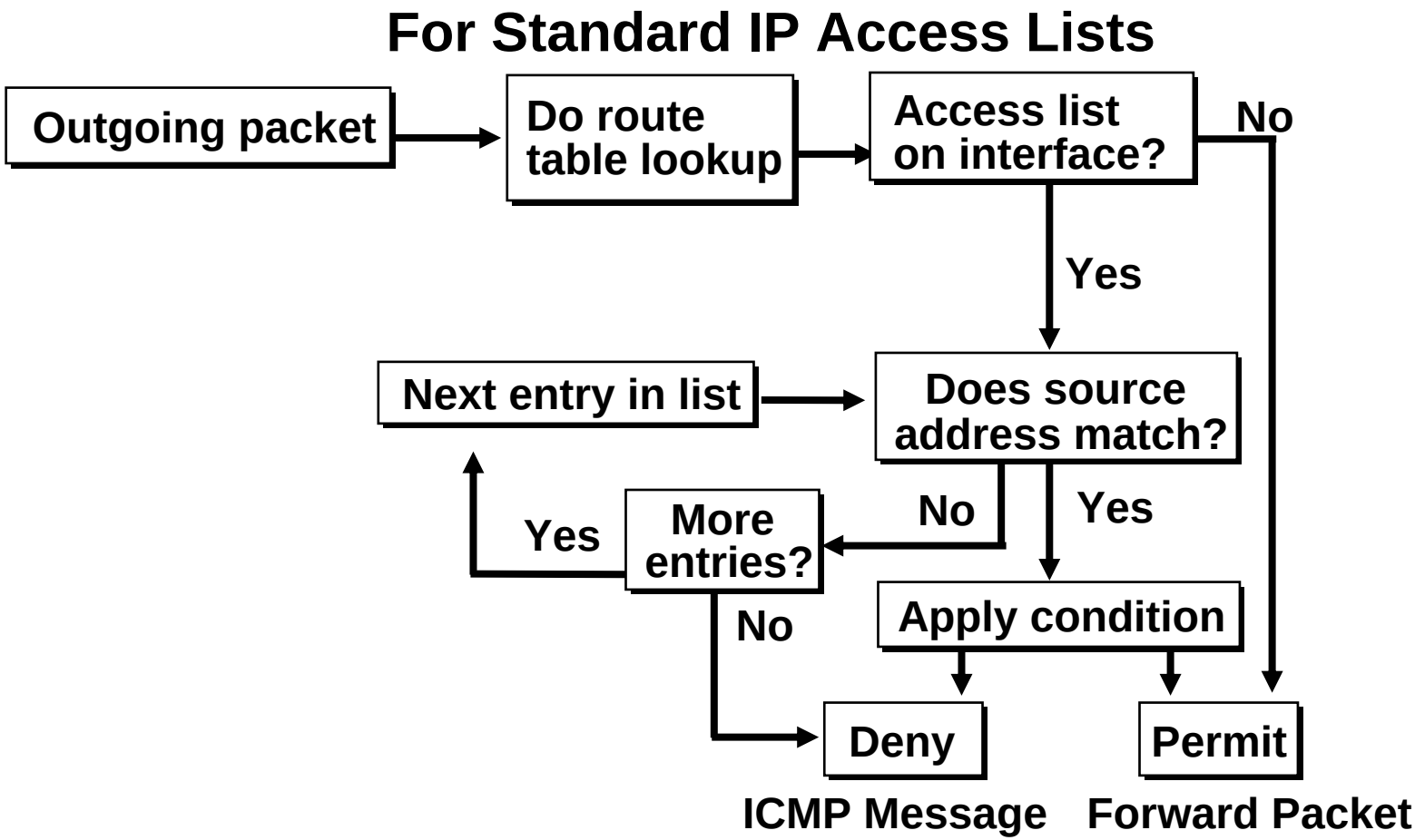


- Use source address only
- Access list range: 1 to 99

Inbound Access List Processing



Outbound Access List Processing



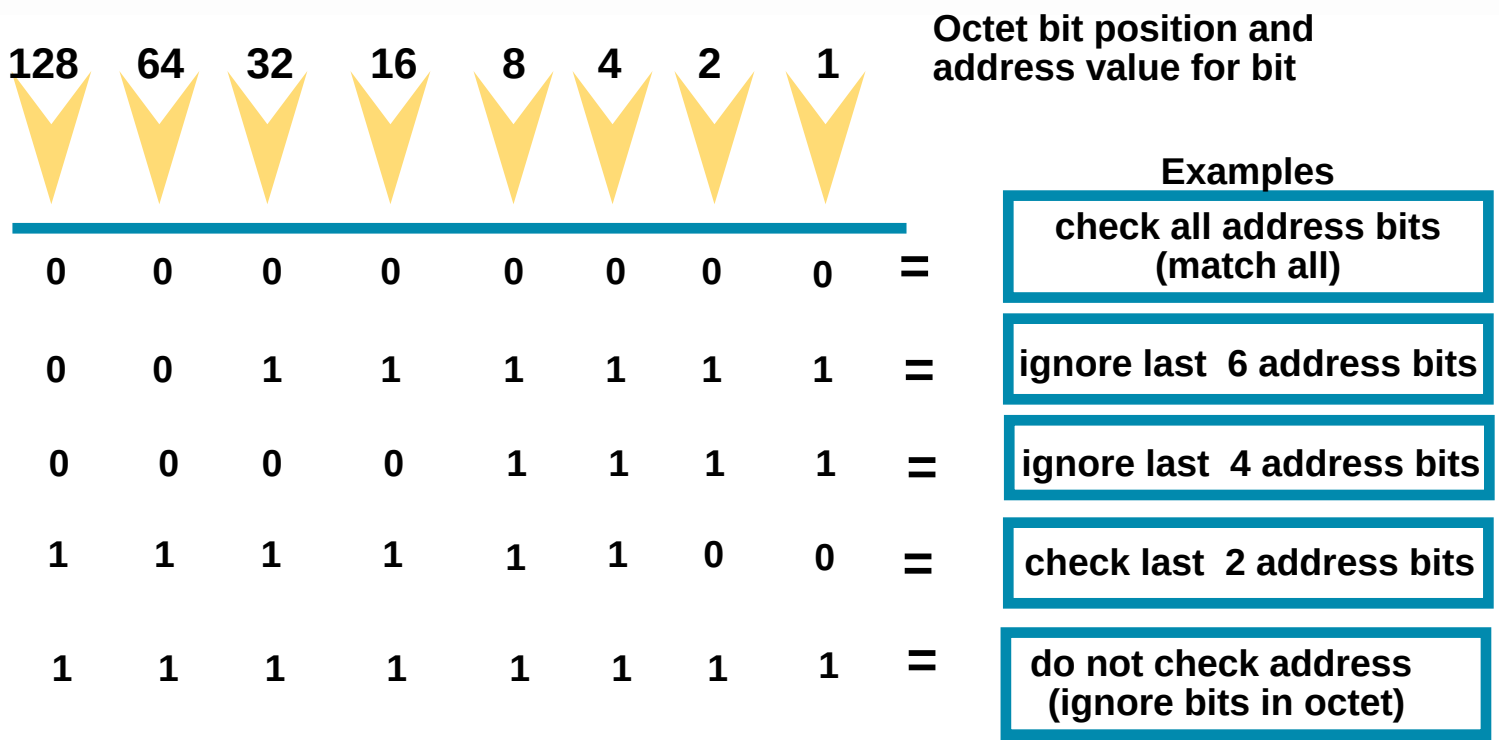
Access Lists Use Wildcard Mask

Address	Mask	Matches
0.0.0.0	255.255.255.255	any address
131.108.0.0/16	0.0.255.255	network 131.108.0.0
131.104.7.11/16	0.0.0.0	host or subnet address
255.255.255.255	0.0.0.0	local broadcast
131.111.8.0	0.0.7.255	only subnet 131.111.8.0 *

- 0 bit = must match bits in addresses
- 1 bit = no need to match bits in addresses

* Assuming subnet mask of 255.255.248.0

Wildcard Bits: How to Check the Corresponding Address Bits



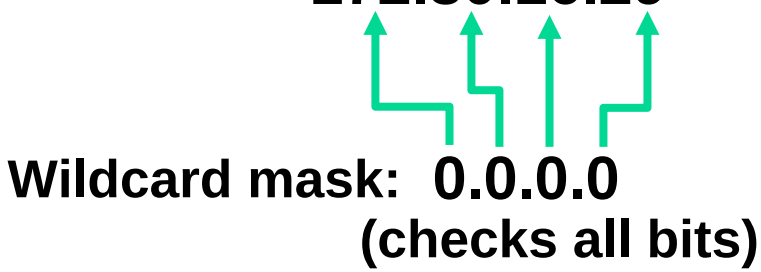
- 0 means check corresponding address bit value
- 1 means ignore value of corresponding address bit

Wildcard Bits to Match a Specific IP Host Address

Test conditions: Check all the address bits (match all)

An IP host address, for example:

172.30.16.29



- **Example 172.30.16.29 0.0.0.0 checks all the address bits**
- **Abbreviate this wildcard mask using the IP address preceded by the keyword *host* *(host 172.30.16.29)***

Wildcard Bits to Match Any IP Address

Test conditions: Ignore all the address bits (match any)

Any IP address
0.0.0.0

Wildcard mask: 255.255.255.255
(ignore all)

- **Accept any address: 0.0.0.0 255.255.255.255**
- **Abbreviate the expression using the keyword *any***

Wildcard Bits to Match IP Subnets

Check for IP subnets 172.30.16.0/24 to 172.30.31.0/24

Address and wildcard mask:

172.30.16.0 0.0.15.255

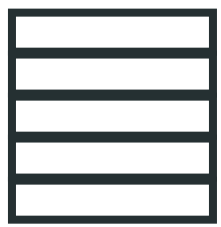
Network .host

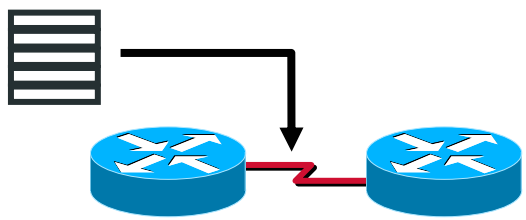
172.30.16.0

	0	**0**	**0**	**1**	**0**	**0**	**0**	**0**	
Wildcard mask:	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	
	|<---- match ---->|<----- don't care ----->|								
	0	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**= 16**
	0	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**= 17**
	0	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**= 18**
				:					**:**
	0	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**= 31**

Access List Configuration Tasks

- **To create an access list, perform the following tasks:**
  - **Define an access list**
  - **Apply the list to an interface**





Standard Access List Commands

Router(config)#

access-list *access-list-number* { permit | deny }
{ *source* [*source-wildcard*] | any }

- **Defines a standard access list (numbered 1-99)**

Router(config-if)#

ip access-group *access-list-number* { in | out }

- **Applies an access list to a specific interface**

Implicit Masks

For Standard IP Access Lists

Correct

```
access-list 1    permit    131.108.5.17
!
```

Common Errors

```
access-list 1    permit    0.0.0.0
access-list 1    permit    131.108.0.0
```

Not Needed

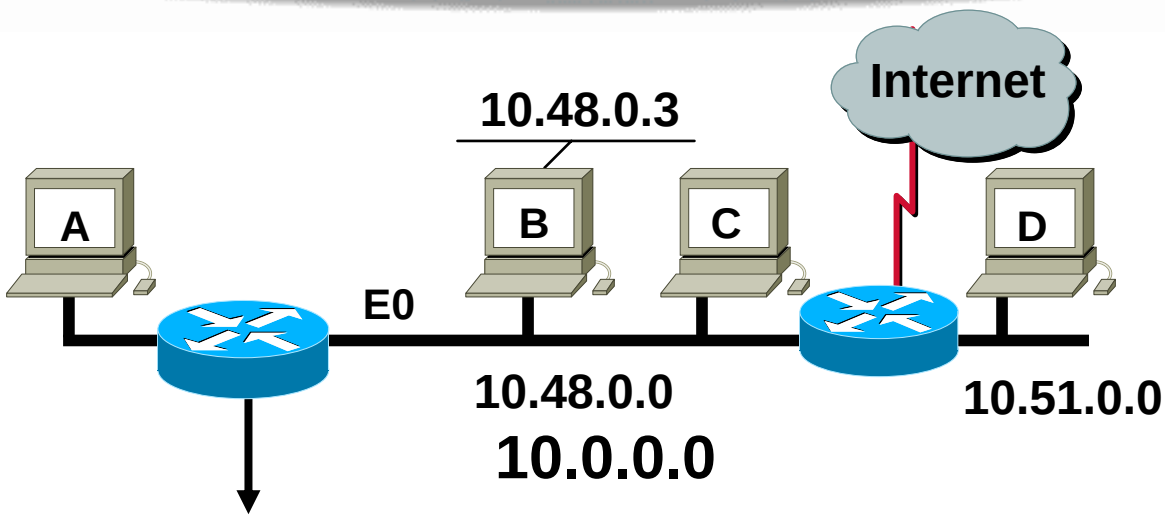
```
access-list 1    deny      any
access-list 1    deny      0.0.0.0 255.255.255.255
```

- Omitted mask assumed to be 0.0.0.0
- Last two lines unnecessary (implicit deny any)

Configuration Principles

- Top-down processing
  - Place more specific references first
- Implicit deny any
  - Unless access list ends with explicit permit any
- New lines added to the end
  - Cannot selectively add/remove lines
- Undefined access list = permit any
  - Need to create access list lines for implicit deny any

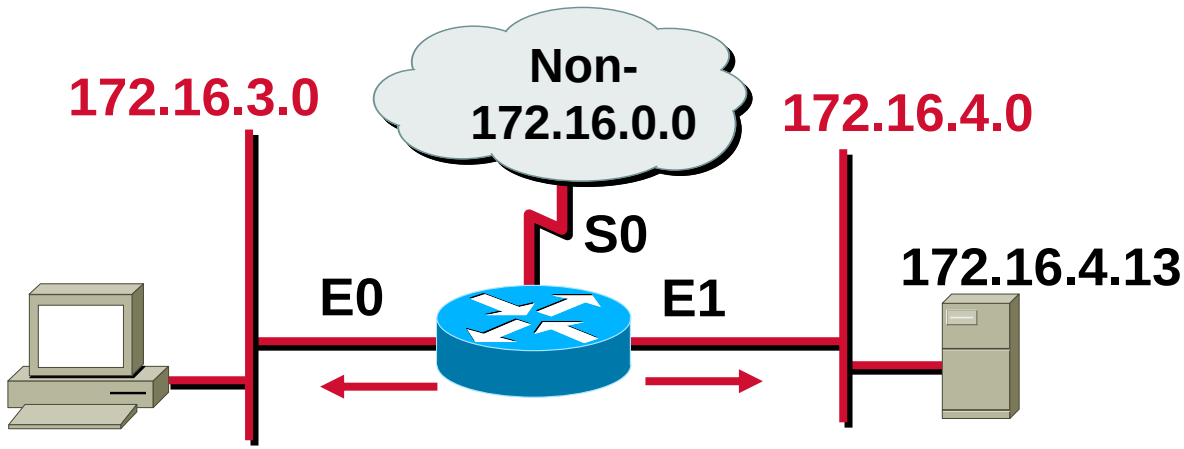
Standard IP Access List Example 1




```
Router(config)#access-list 2 permit 10.48.0.3
Router(config)#access-list 2 deny 10.48.0.0 0.0.255.255
Router(config)#access-list 2 permit 10.0.0.0 0.255.255.255
Router(config)#!(Note: all other access implicitly denied)
Router(config)#interface ethernet 0
Router(config-if)#ip access-group 2 in
```

- **Who can connect to A?**

Standard IP Access List Example 2

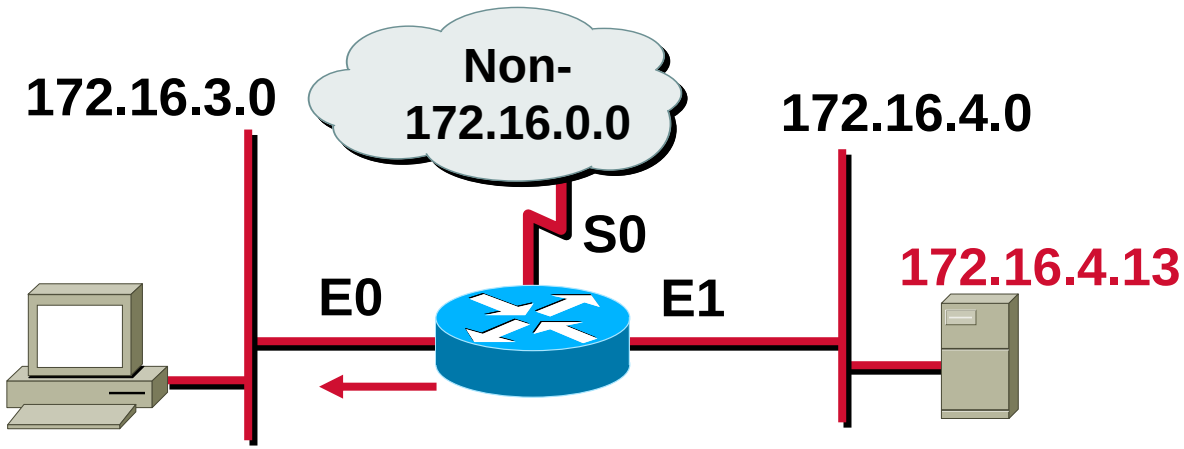



```
access-list 1 permit 172.16.0.0  0.0.255.255
(implicit deny all - not visible in the list)
(access-list 1 deny 0.0.0.0   255.255.255.255)

interface ethernet 0
ip access-group 1 out
interface ethernet 1
ip access-group 1 out
```

- **Permit my network only**

Standard IP Access List Example 3

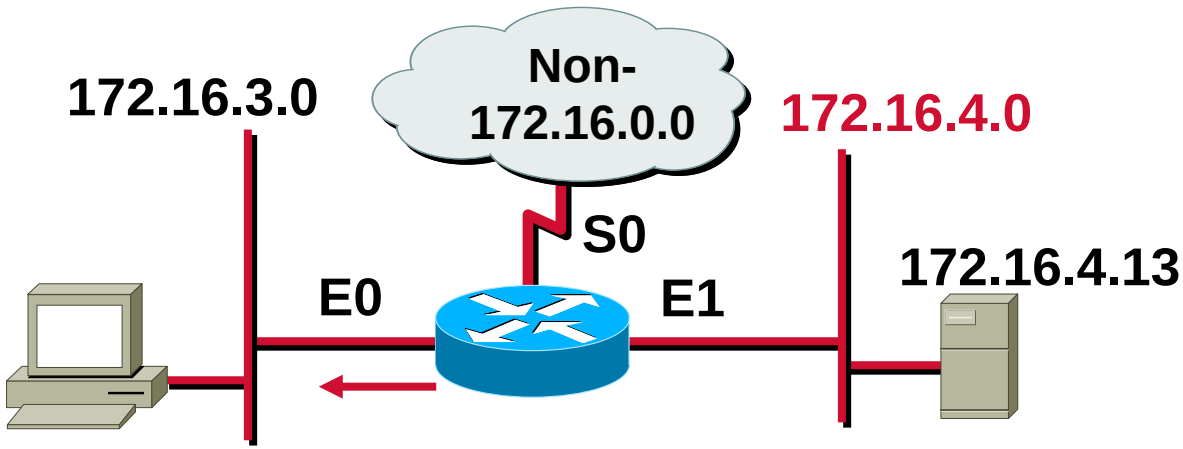



```
access-list 1 deny 172.16.4.13 0.0.0.0
access-list 1 permit 0.0.0.0  255.255.255.255
(implicit deny all)
(access-list 1 deny 0.0.0.0   255.255.255.255)

interface ethernet 0
ip access-group 1 out
```

- **Deny a specific host**

Standard IP Access List Example 4

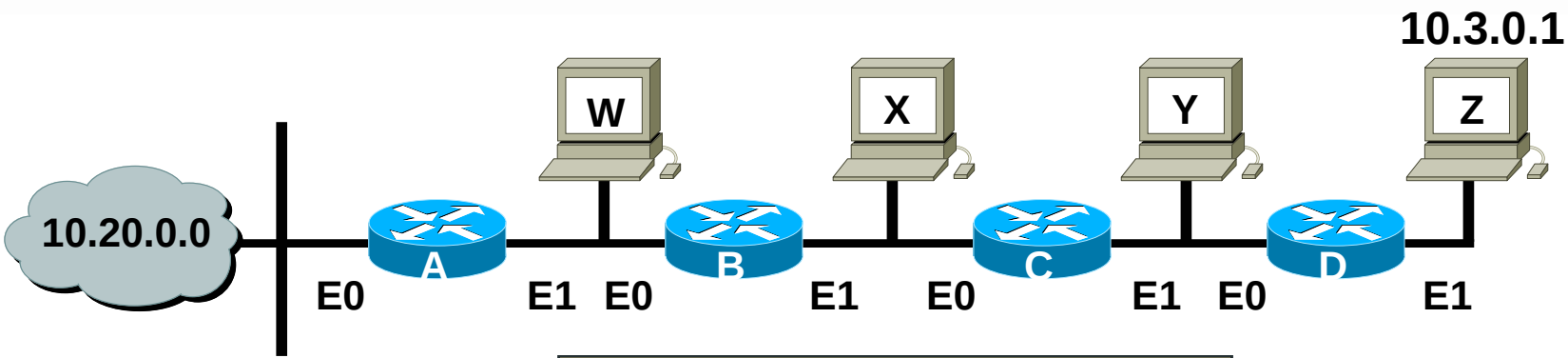



```
access-list 1 deny 172.16.4.0  0.0.0.255
access-list 1 permit any
(implicit deny all)
(access-list 1 deny 0.0.0.0   255.255.255.255)

interface ethernet 0
ip access-group 1 out
```

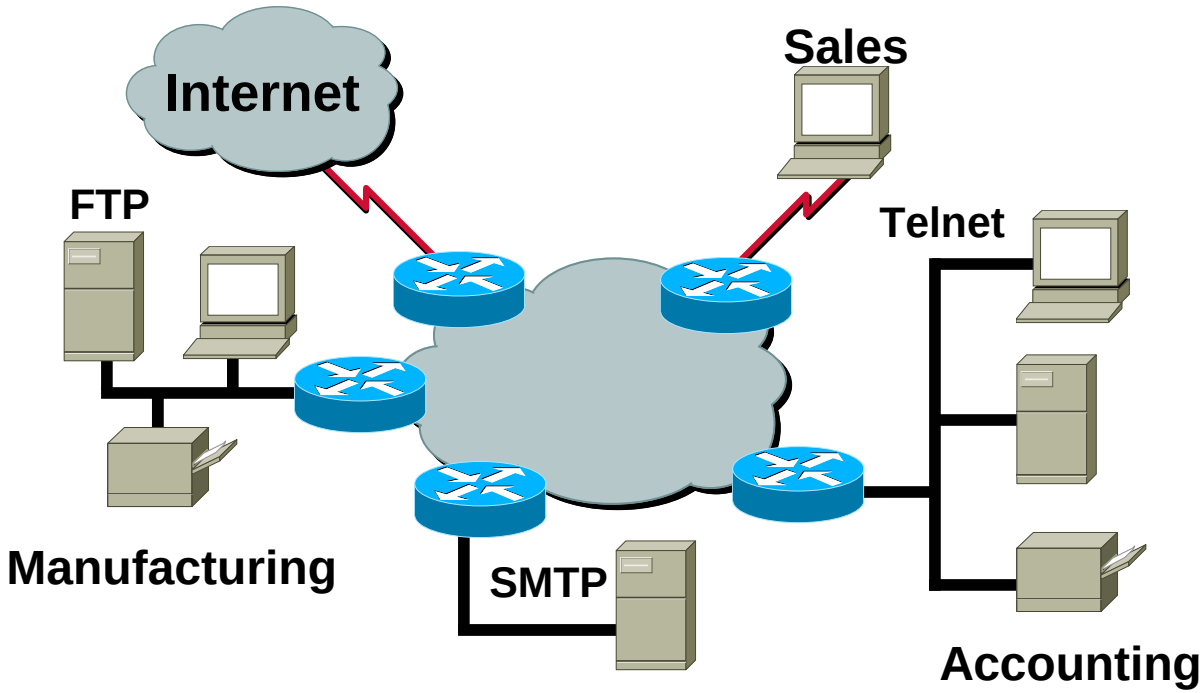
- **Deny a specific subnet**

Location of Standard Access Lists



- On which router should the access list be configured to deny host Z access to network 10.20.0.0?
- How does location of a standard access list change the policy implemented?

IP Extended Access List Overview

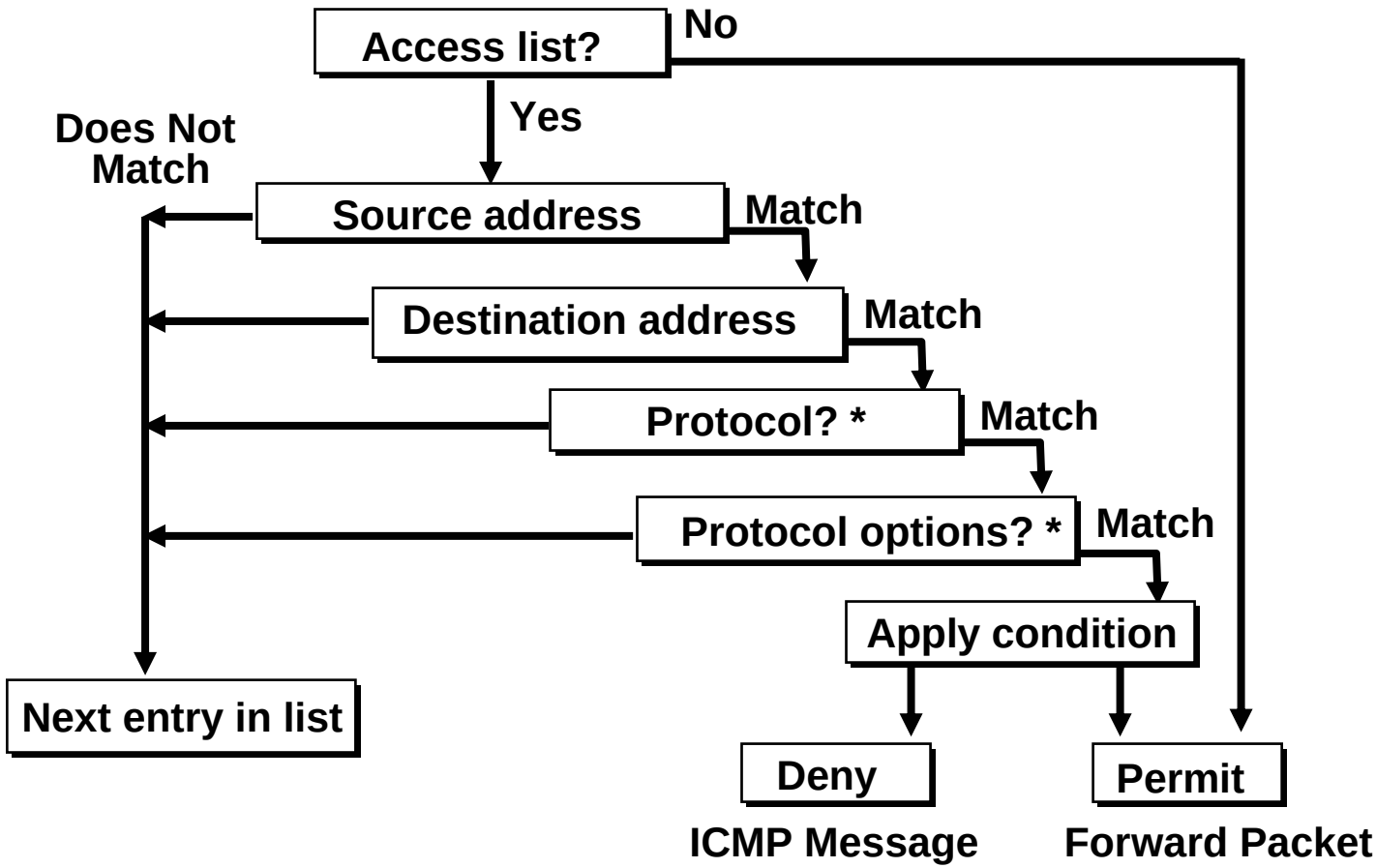


- **Control traffic by application, not just address**

Standard versus External Access List

Standard	Extended
Filters Based on Source.	Filters Based on Source and destination.
Permit or deny entire TCP/IP protocol suite.	Specifies a specific IP protocol and port number.
Range is 1 through 99	Range is 100 through 199.

Extended Access List Processing



* If present in access list

Extended IP Access List Command

Router(config)#

access-list *access-list-number* { permit | deny }

{ *protocol* | *protocol-keyword* }

{ *source source-wildcard* | any }

{ *destination destination-wildcard* | any }

[protocol-specific options] [log]

- **Defines an extended access list (numbered 100 to 199)**
- **Protocol keywords icmp, tcp, and udp**

  define alternate syntax with protocol-specific options

Extended Mask Keywords

```
access-list 101 permit ip  0.0.0.0  255.255.255.255  0.0.0.0  255.255.255.255
! (alternate configuration)
access-list 101 permit ip any any
```

- **The keyword *any* can be used in place of the address 0.0.0.0. with mask 255.255.255.255**

```
access-list 101 permit ip  0.0.0.0  255.255.255.255  172.16.5.17  0.0.0.0
! (alternate configuration)
access-list 101 permit ip any host 172.16.5.17
```

- **The keyword *host* preceding an *ip-address* can be used in place of the mask 0.0.0.0**

ICMP Command Syntax

Router(config)#

access-list *access-list-number* { permit | deny } icmp

{ *source source-wildcard* | any }

{ *destination destination-wildcard* | any }

[*icmp-type* [*icmp-code*] | *icmp-message*]

- **Filters based on ICMP messages**

ICMP Message and Type Names

administratively-prohibited	information reply	port unreachable
alternate-address	mask-reply	reassembly-timeout
conversion-error	mask-request	redirect
dod-host-prohibited	mobile-redirect	router-advertisement
dod-net-prohibited	net-redirect	router-solicitation
echo	net-tos-redirect	source-quench
echo-reply	net-tos-unreachable	source-route-failed
general-parameter-problem	net-unreachable	time-exceeded
host-isolated	network-unknown	traceroute
host-tos-redirect	no-room-for-option	ttl-exceeded
host-tos-unreachable	option-missing	unreachable
host-unknown	packet-too-big	
host-unreachable	parameter-problem	

- **Names simplify configuration**

TCP Syntax

Router(config)#

access-list *access-list-number* { permit | deny } tcp
{ *source source-wildcard* | any }
[*operator source-port* | *source-port*]
{ *destination destination-wildcard* | any }
[*operator destination-port* | *destination-port*]
[established]

- **Filters based on tcp/tcp port number or name**

TCP Port Names

bgp	gopher	sunrpc
chargen	hostname	syslog
daytime	irc	tacacs-ds
discard	klogin	talk
domain	kshell	telnet
echo	lpd	time
finger	nntp	uucp
ftp control	pop2	whois
ftp-data	pop3	www

- Enter *?* to get port numbers corresponding to names
- Other port numbers found in the Assigned Numbers RFC

UDP Syntax

Router(config)#

access-list *access-list-number* { permit | deny } udp

{ *source source-wildcard* | any }

[*operator source-port* | *source-port*]

{ *destination destination-wildcard* | any }

[*operator destination-port* | *destination-port*]

- **Filters based on UDP protocol or UDP port number or name**

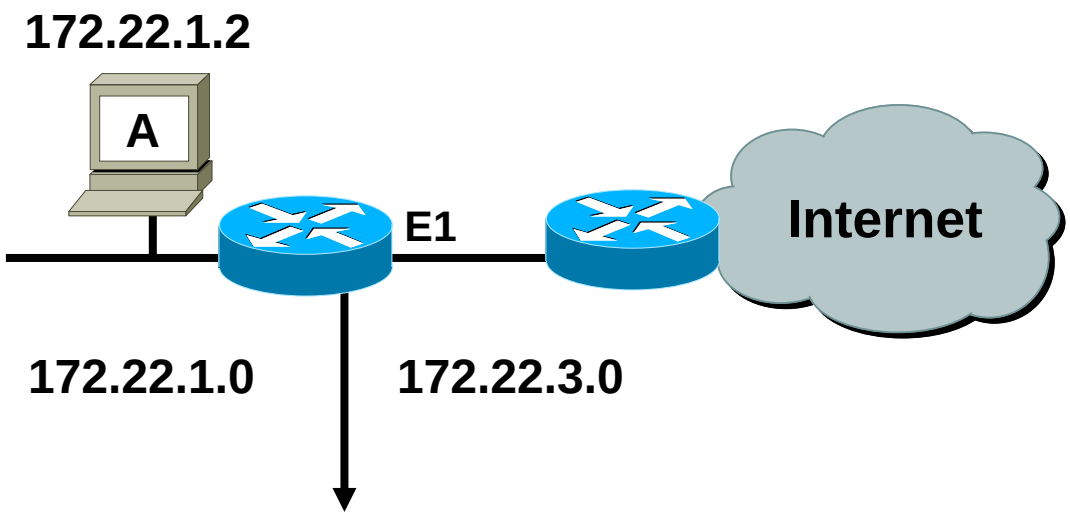
UDP Port Names

biff	nameserver	syslog
bootpc	netbios-dgm	tacasds-ds
bootps	netbios-ns	talk
discard	ntp	tftp
dns	rip	time
dnsix	snmp	whois
echo	snmptrap	xdmcp
mobile-ip	sunrpc	

- Enter *?* to get port numbers corresponding to the name
- Other port numbers found in the Assigned Numbers RFC

Extended Access List Example 1

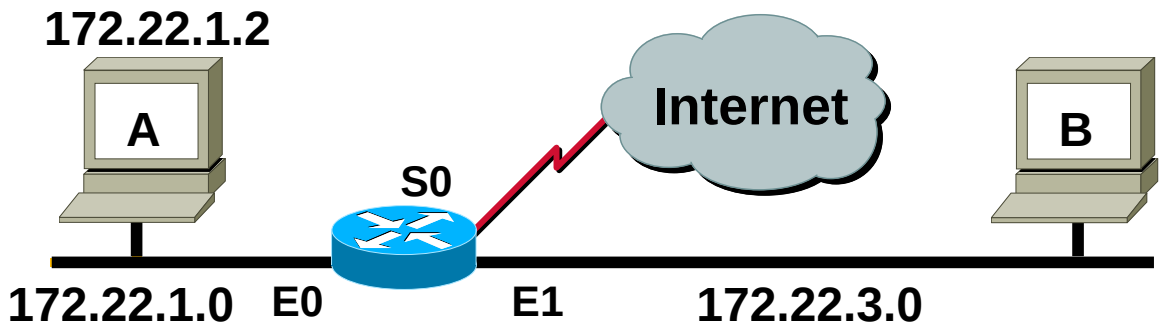
Providing Internet Mail




```
access-list 103 permit      tcp any 172.22.0.0    0.0.255.255 established
access-list 103 permit      tcp any   host  172.22.1.2  eq smtp
!
interface ethernet 1
ip access-group 103 in
```

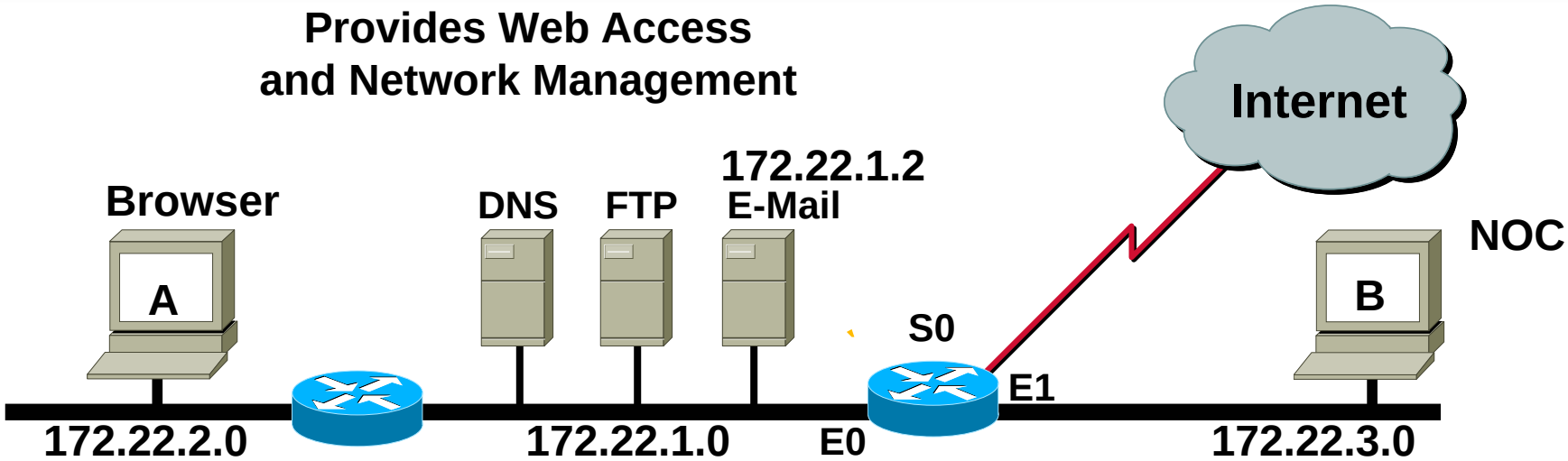
Extended Access List Example 2

Also Providing DNS and Ping




```
access-list 104 permit tcp any 172.22.0.0 0.0.255.255 established
access-list 104 permit tcp any host 172.22.1.2 eq smtp
access-list 104 permit udp any any eq dns
access-list 104 permit icmp any any echo
access-list 104 permit icmp any any echo-reply
!
interface serial 0
ip access-group 104 in
```

Extended Access List Example 3

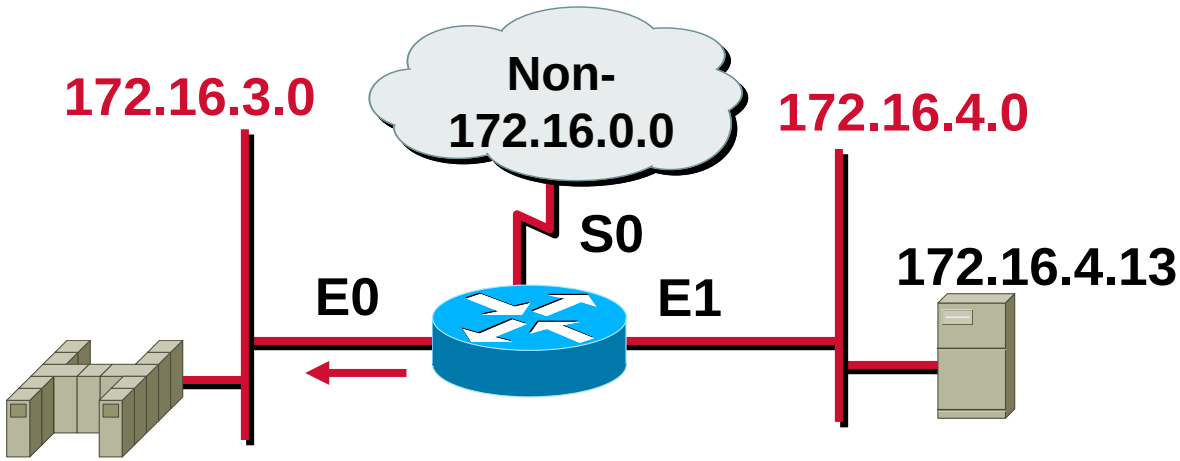



```
access-list 118 permit tcp any 172.22.0.0  0.0.255.255 eq www established
access-list 118 permit tcp any host 172.22.1.2 eq smtp

access-list 118 permit udp any any eq dns
access-list 118 permit udp 172.22.3.0  0.0.0.255 172.22.1.0 0.0.0.255 eq snmp

access-list 118 deny icmp any 172.22.0.0  0.0.255.255 echo
access-list 118 permit icmp any any echo-reply
!
interface ethernet 0
ip access-group 118 out
```

Extended Access List Example 4

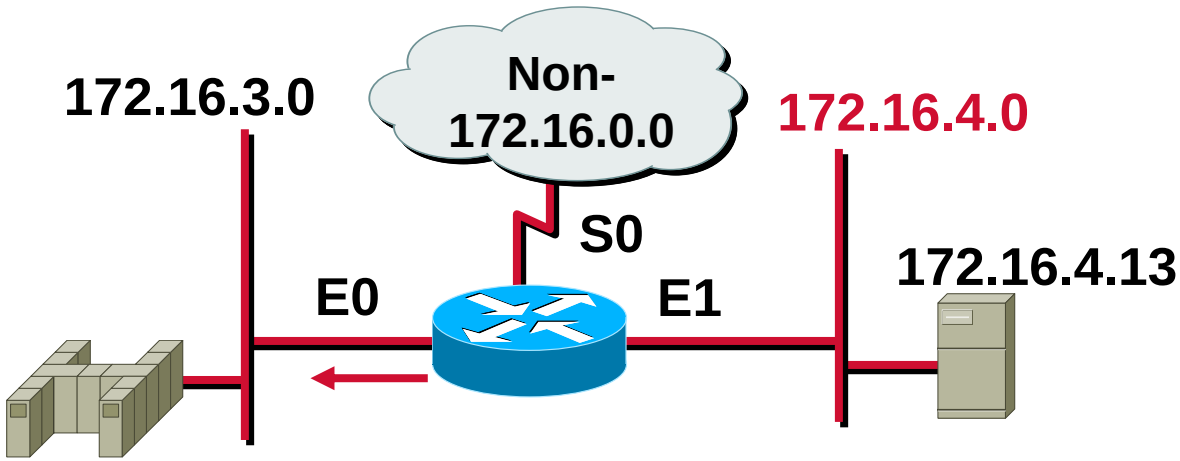



```
access-list 101 deny tcp 172.16.4.0 0.0.0.255 172.16.3.0 0.0.0.255 eq 21
access-list 101 deny tcp 172.16.4.0 0.0.0.255 172.16.3.0 0.0.0.255 eq 20
access-list 101 permit ip any any
(implicit deny all)
(access-list 101 deny ip 0.0.0.0 255.255.255.255 0.0.0.0 255.255.255.255)

interface ethernet 0
ip access-group 101 out
```

- Deny FTP from subnet 172.16.4.0 to subnet 172.16.3.0 out of E0
- Permit all other traffic

Extended Access List Example 5

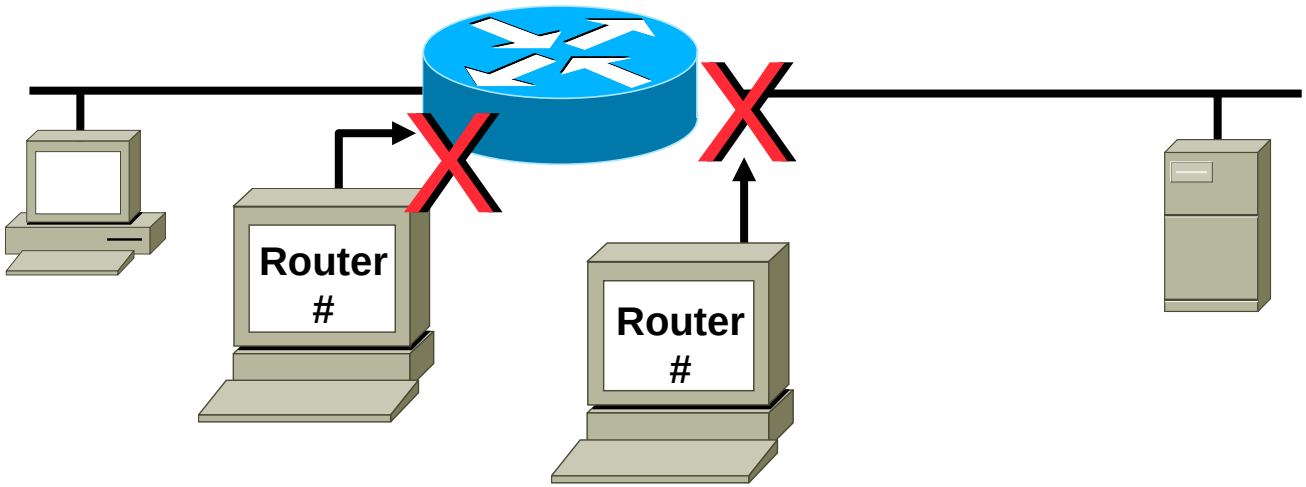



```
access-list 101 deny tcp 172.16.4.0  0.0.0.255  any eq 23
access-list 101 permit ip any any
(implicit deny all)

interface ethernet 0
ip access-group 101 out
```

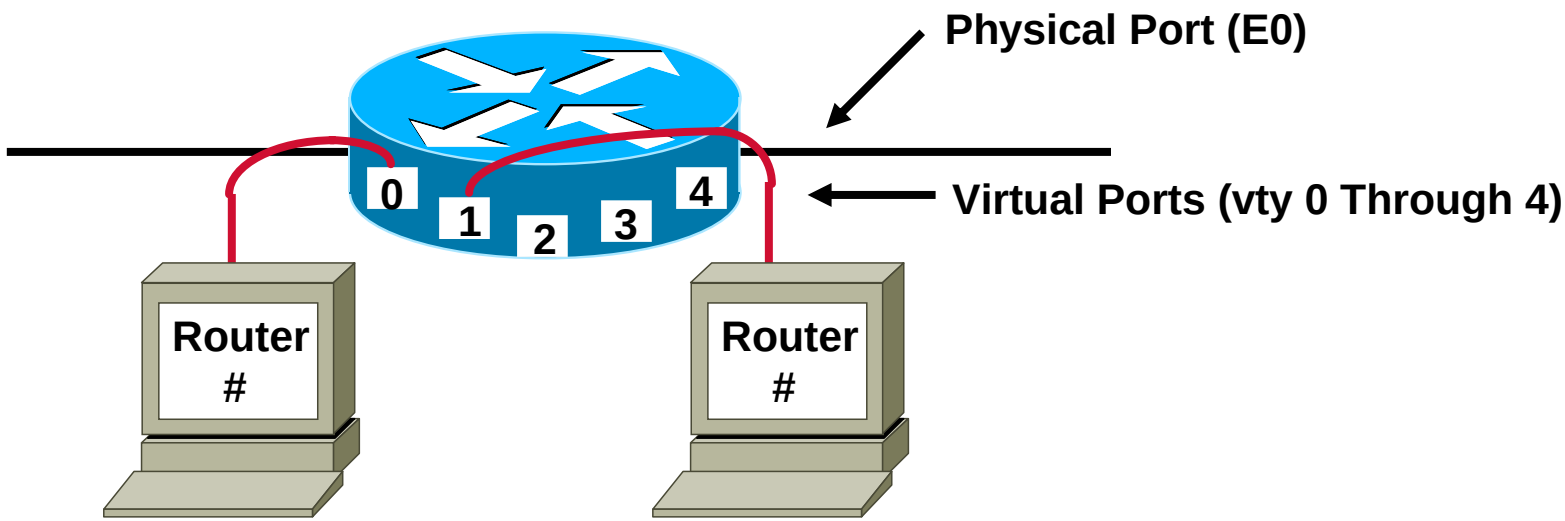
- Deny only Telnet from subnet 172.16.4.0 out of E0
- Permit all other traffic

Virtual Terminal Access Overview



- **Standard and extended access lists will not block access from the router**
- **For security, virtual terminal (vty) access can be blocked to or from the router**

How to Control vty Access



- **Five virtual terminal lines (0 through 4)**
- **Set identical restrictions on all the virtual terminal lines**

Virtual Terminal Line Commands

Router(config)#

line vty { *vty-number* | *vty-range* }

- **Enters configuration mode for a terminal line or a range of lines**

Router(config-line)#

access-class *access-list-number* { in | out }

- **Restricts incoming and outgoing connections between a particular virtual terminal line (into a device) and the addresses in an access list**

Virtual Terminal Access Example

Controlling Inbound Access

```
access-list 12 permit 192.89.55.0 0.0.0.255
!
line vty 0 4
access-class 12 in
```

- **Permits only hosts in network 192.89.55.0 to connect to the virtual terminal ports on the router**

Access List show Commands

Router#

```
show access-list
```

- Displays access lists from all protocols

Router#

```
show ip access-list [ access-list-number ]
```

- Displays a specific IP access list

Router#

```
clear access-list counters [ access-list-number ]
```

- Clears packet counts

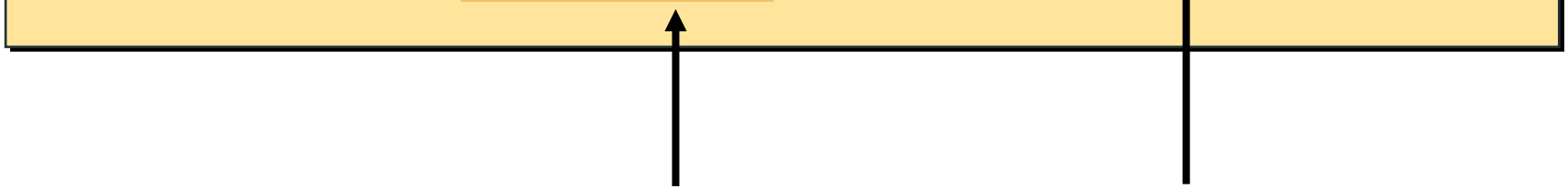
Router#

```
show line
```

- Displays line configuration

show ip access-lists Command

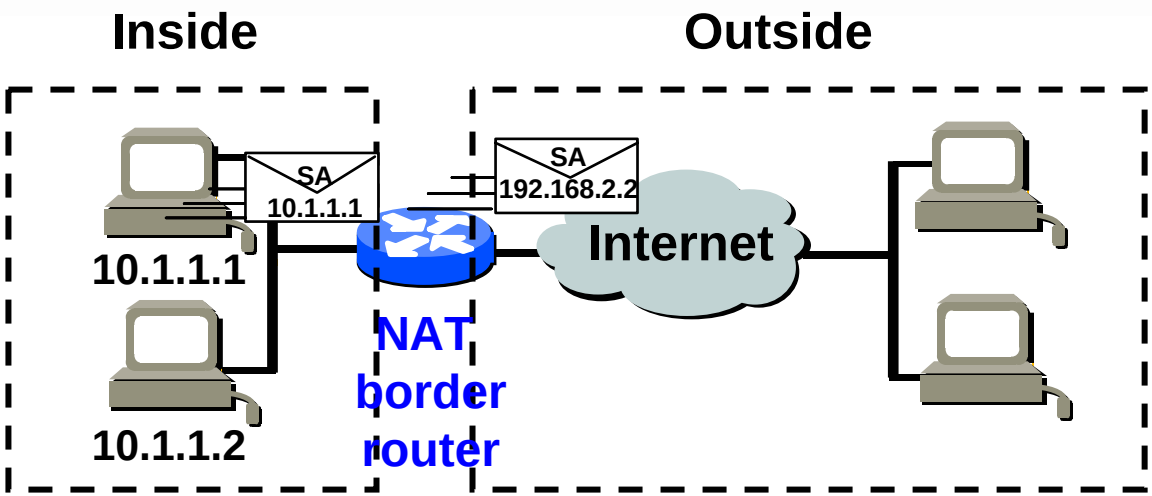
```
p1r1#show access-lists
Extended IP access list 100
    deny tcp host 10.1.1.2 host 10.1.1.1 eq telnet (3 matches)
    deny tcp host 10.1.2.2 host 10.1.2.1 eq telnet
    permit ip any any (629 matches)
```



- **Matches are shown for extended access lists**

Network Address Translation

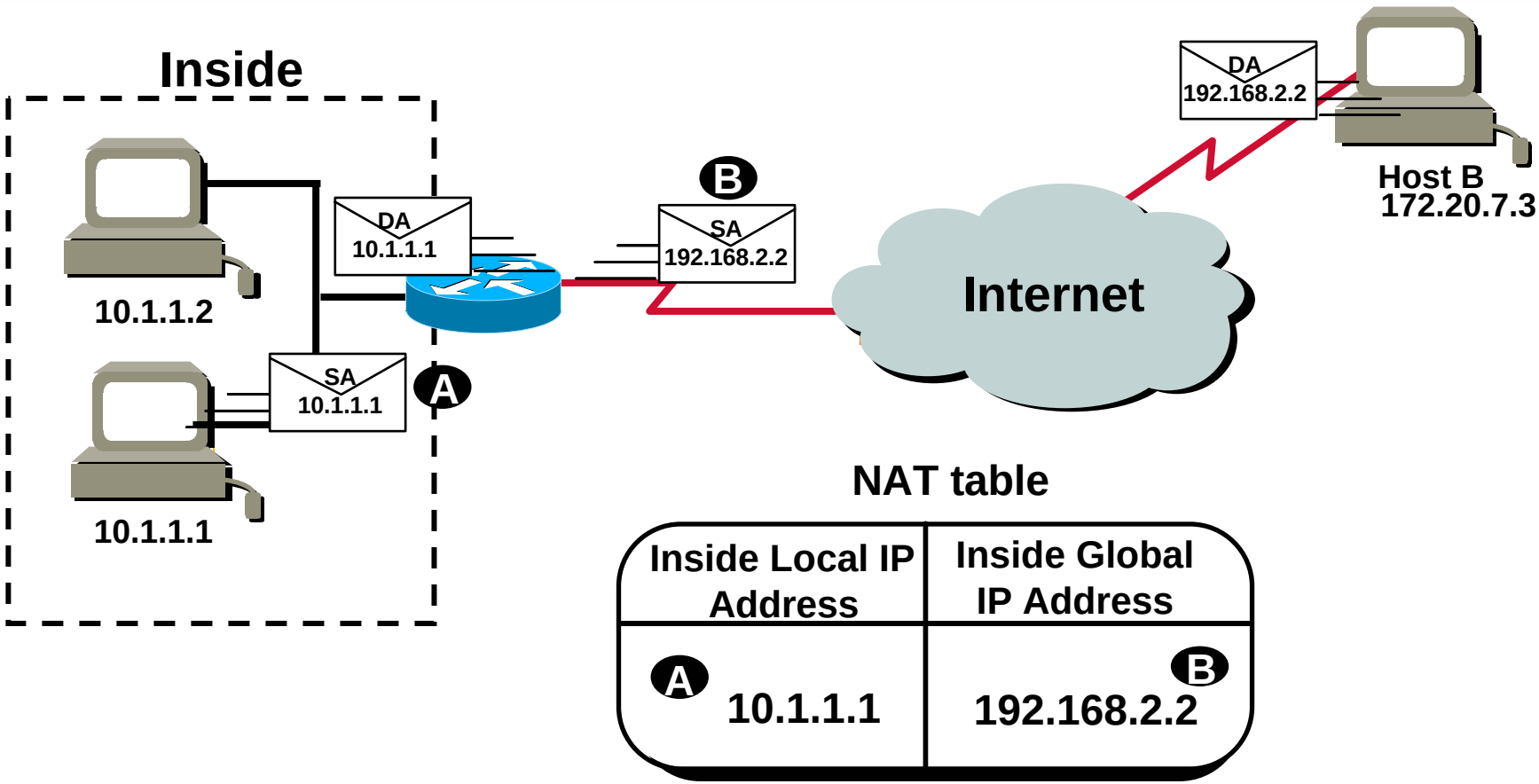
Why Use NAT?



Use NAT if:

- **You need to connect to the Internet and your hosts do not have globally unique IP addresses**
- **You change over to a new ISP that requires you to renumber your network**
- **Two intranets with duplicate addresses merge**
- **You want to support basic load sharing**

NAT Overview and Terminology



NAT Overview and Terminology

•Inside local address

—The IP address that is assigned to a host on the inside network. The address is probably not a legitimate IP address assigned by the Network Information Center (NIC) or service provider.

•Inside global address

—A legitimate IP address (assigned by the NIC or service provider) that represents one or more inside local IP addresses to the outside world.

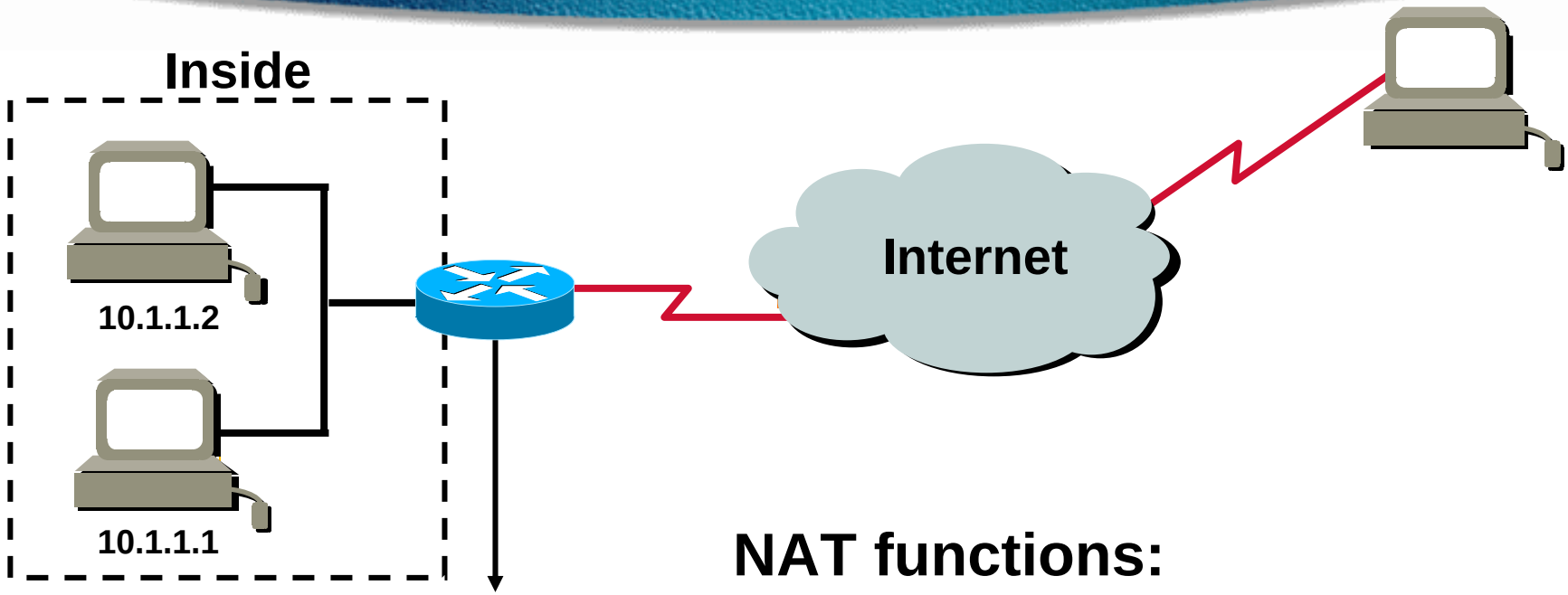
•Outside local address

—The IP address of an outside host as it appears to the inside network. Not necessarily a legitimate address, it was allocated from address space routable on the inside.

•Outside global address

—The IP address assigned to a host on the outside network by the host's owner. The address was allocated from globally routable address or network space.

NAT Operation



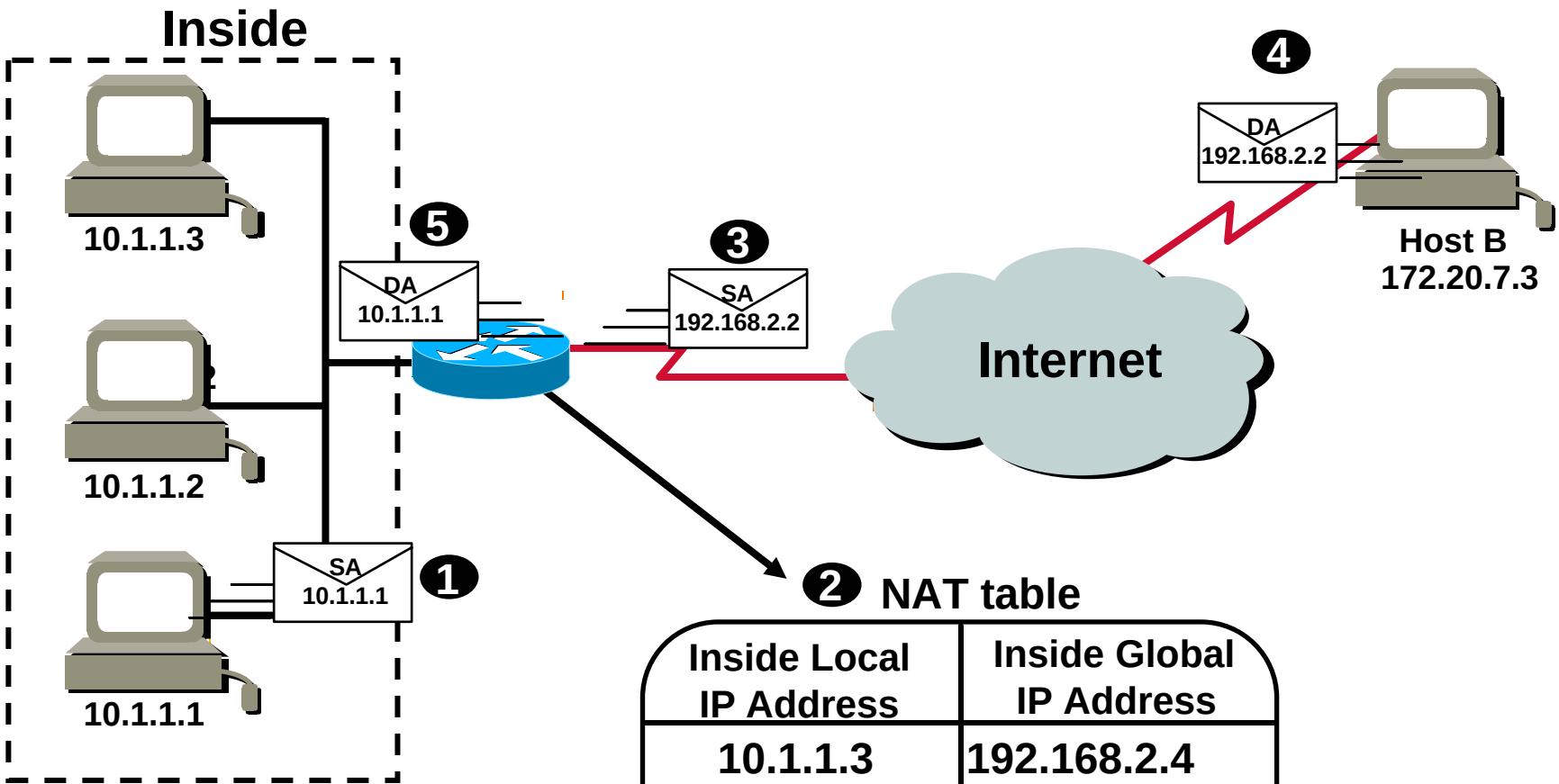
NAT table

Inside Local IP Address	Inside Global IP Address
10.1.1.1	192.168.2.2
10.1.1.2	192.168.2.3

NAT functions:

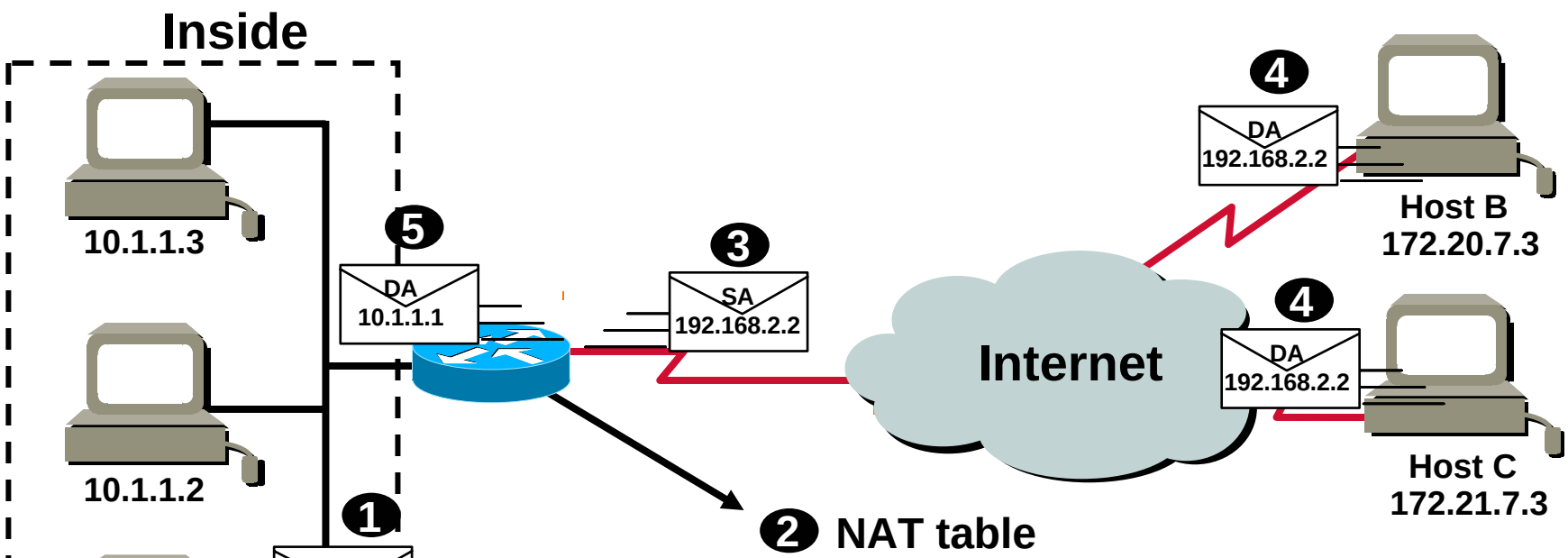
- **Translation inside local addresses**
- **Overloading inside global addresses**

Translating Inside Local Addresses



Inside Local IP Address	Inside Global IP Address
10.1.1.3	192.168.2.4
10.1.1.2	192.168.2.3
10.1.1.1	192.168.2.2

Overloading Inside Global Addresses



Protocol 10.1.1.1	Inside Local IP Address: Port	Inside Global IP Address: Port	Outside Global IP Address: Port
TCP	10.1.1.3:1723	192.168.2.2:1492	172.21.7.3:23
TCP	10.1.1.2:1723	192.168.2.2:1723	172.21.7.3:23
TCP	10.1.1.1:1024	192.168.2.2:1024	172.20.7.3:23

Static NAT Configuration Example

```
ip nat inside source static 10.1.1.1 192.168.2.2
!
interface Ethernet0
 ip address 10.1.1.10 255.255.255.0
 ip nat inside
!
interface Serial0
 ip address 172.16.2.1 255.255.255.0
 ip nat outside
!
```

This interface connected to the inside network.

This interface connected to the outside world.

Maps the inside local address to the inside global address.

Dynamic NAT Configuration

```
ip nat pool dyn-nat 192.168.2.1 192.168.2.254
    netmask 255.255.255.0
ip nat inside source list 1 pool dyn-nat
!
interface Ethernet0
 ip address 10.1.1.10 255.255.255.0
 ip nat inside
!
interface Serial0
 ip address 172.16.2.1 255.255.255.0
 ip nat outside
!
access-list 1 permit 10.1.1.0 0.0.0.255
!
```

This interface connected to the inside network.

This interface connected to the outside world.

Translate between inside hosts addressed from 10.1.1.0/24 to the globally unique 192.168.2.0/24 network.

Configuring Inside Global Address Overloading

```
ip nat pool ovrld-nat 192.168.2.1 192.168.2.2
            netmask 255.255.255.0
ip nat inside source list 1 pool ovrld-nat overload
!
interface Ethernet0/0
 ip address 10.1.1.10 255.255.255.0
 ip nat inside
!
interface Serial0/0
 ip address 172.16.2.1 255.255.255.0
 ip nat outside
!
access-list 1 permit 10.1.1.0 0.0.0.255
```

Verifying NAT

Basic IP address translation

```
Router#show ip nat trans
Pro Inside global     Inside local       Outside local Outside global
---  192.2.2.1        10.1.1.1           ---  ---
---  192.2.2.2        10.1.1.2           ---  ---
```

IP address translation with overloading

```
Router#sh ip nat trans
Pro Inside global     Inside local       Outside local      Outside global
tcp 192.168.2.1:11003 10.1.1.1:11003     172.16.2.2:23      172.16.2.2:23
tcp 192.168.2.1:1067  10.1.1.1:1067      172.16.2.3:23      172.16.2.3:23
```

Unique TCP port numbers are used to distinguish between hosts.

A translation for a Telnet is still active.
Two different inside hosts appear on the outside with a single IP address.

Clearing NAT Translation Entries

```
Router#sh ip nat trans
Pro Inside global     Inside local       Outside local      Outside global
tcp 192.168.2.1:11003  10.1.1.1:11003     172.16.2.2:23      172.16.2.2:23
tcp 192.168.2.1:1067   10.1.1.1:1067      172.16.2.3:23      172.16.2.3:23
router#clear ip nat trans *
router#
router#show ip nat trans
```

All entries are cleared.

```
router#show ip nat trans
Pro Inside global          Inside local       Outside local          Outside global
udp 192.168.2.2:1220       10.1.1.2:1120      171.69.2.132:53        171.69.2.132:53
tcp 192.168.2.1:1100310.1.1.1:11003 172.16.2.2:23     172.16.2.2:23
tcp 192.168.2.1:1067 10.1.1.1:1067  172.16.2.3:23     172.16.2.3:23
router#clear ip nat trans udp inside 192.168.2.2 10.1.1.2 1220 171.69.2.132 53 171.69.2.132 53
router#show ip nat trans
Pro Inside global          Inside local       Outside local          Outside global
tcp 192.168.2.1:11003  10.1.1.1:11003     172.16.2.2:23      172.16.2.2:23
tcp 192.168.2.1:1067   10.1.1.1:1067      172.16.2.3:23      172.16.2.3:23
```

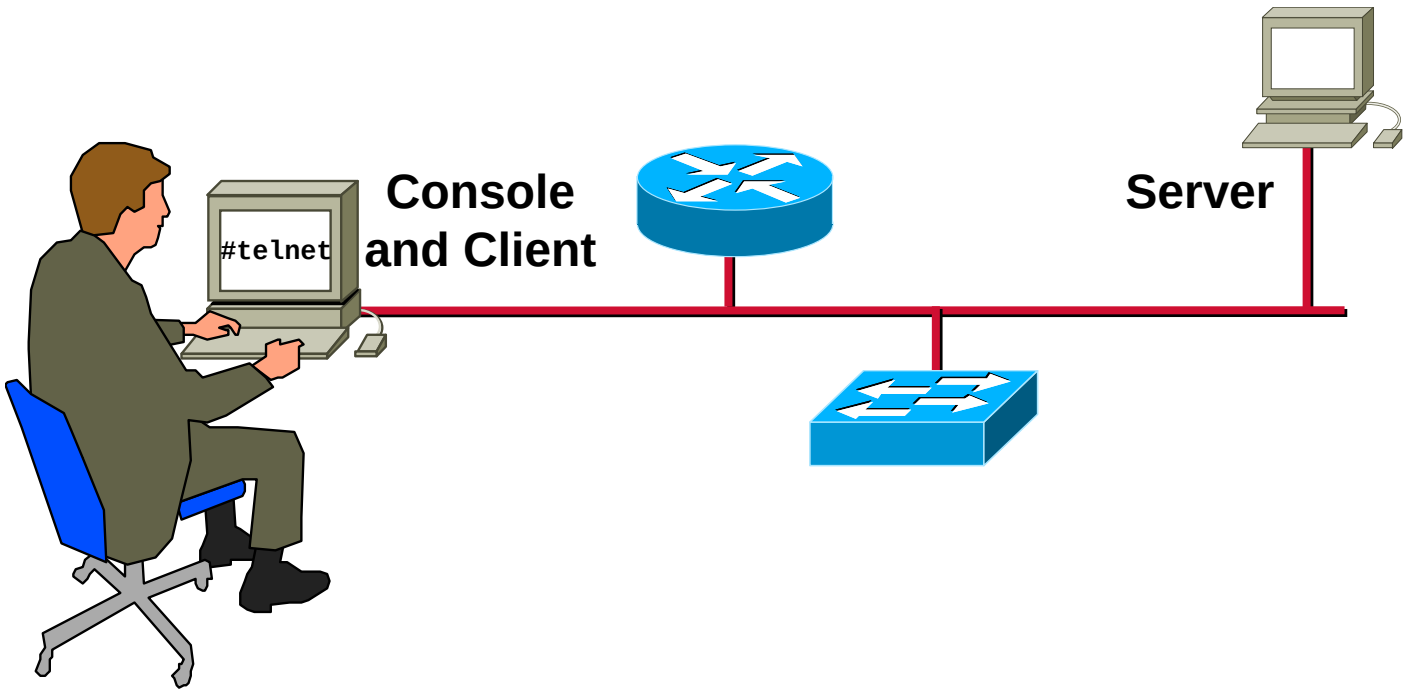
192.168.2.2 is cleared.

Troubleshooting Tools

Troubleshooting Tools

- Cisco IOS tools and commands in the router
- Password recovery
- Router IOS Backup & Upgrade

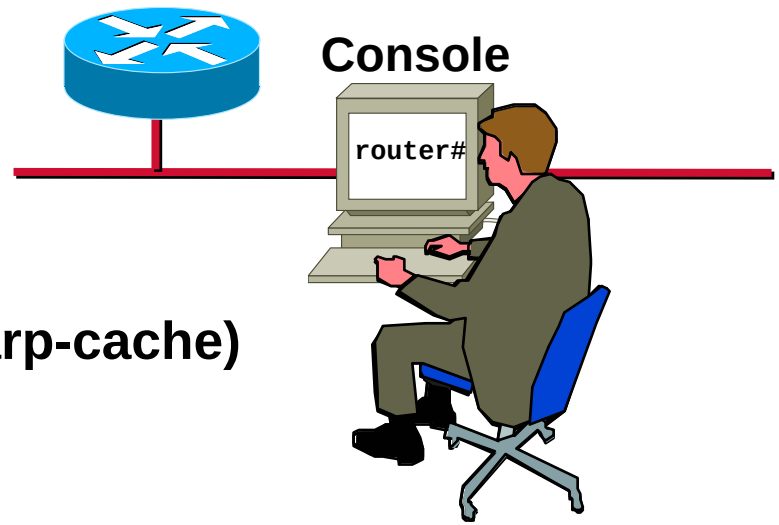
Use Built-In Tools for Troubleshooting



- Cisco IOS tools and commands in the router
- TCP/IP tools included with Windows

Cisco IOS Software Tools and Commands

- show ip interface
- clear counter
- show ip route
- show ip traffic
- show cdp neighbor
- show ip arp (and clear arp-cache)
- ping ip (privileged)
- Tracerotue (privileged)
- show process
- Show ip accounting
- Show ip
- show logging
- show ip account

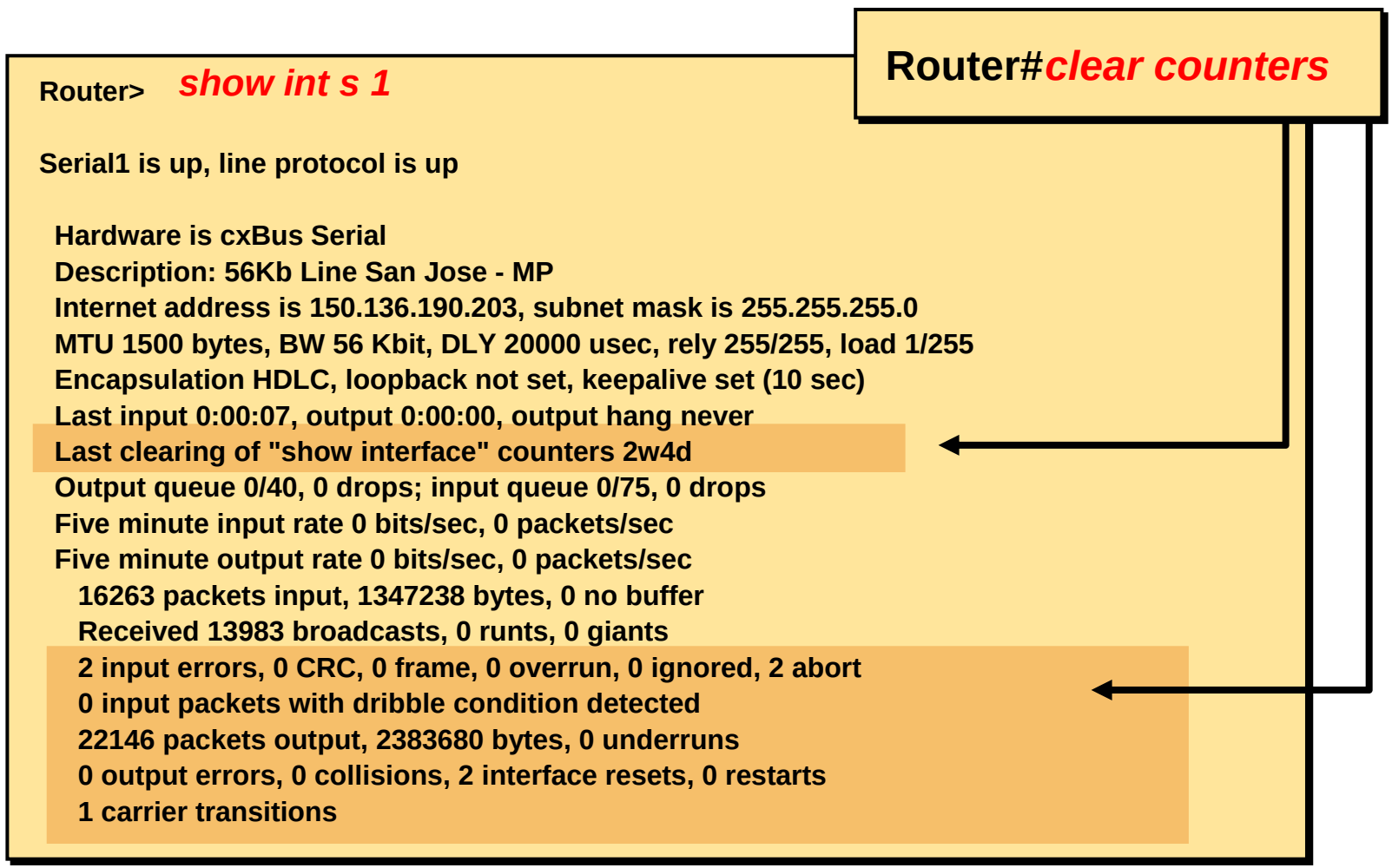


show interfaces ethernet Command

Router>*show interfaces ethernet 0*

Ethernet 0 is up, line protocol is up
Hardware is MCI Ethernet, address is aa00.0400.0134 (bia 0000.0c00.4369)
Internet address is 131.108.1.1, subnet mask is 255.255.255.0
MTU 1500 bytes, BW 10000 Kbit, DLY 1000 usec, rely 255/255, load 1/255
Encapsulation ARPA, loopback not set, keepalive set (10 sec)
ARP type: ARPA, PROBE, ARP Timeout 4:00:00
Last input 0:00:00, output 0:00:00, output hang never
Last clearing of "show interface" counters 0:56:40
Output queue 0/40, 0 drops; input queue 0/75, 2 drops
Five minute input rate 6100 bits/sec, 4 packets/sec
Five minute output rate 1000 bits/sec, 2 packets/sec
2295197 packets input, 305539992 bytes, 0 no buffer
Received 1925500 broadcasts, 0 runts, 0 giants
3 input errors, 3 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
0 input packets with dribble condition detected
3594664 packets output, 436549843 bytes, 0 underruns
8 output errors, 1790 collisions, 10 interface resets, 0 restarts

clear counters Command



Using show cdp neighbors

```
routerA#show cdp neighbors
Capability Codes: R - Router, T - Trans Bridge,
                  B - Source Route Bridge,
                  S - Switch, H - Host, I - IGMP

Device ID     Local Intrfce  Holdtme  Capability Platform  Port ID
routerB.cisco.com   Eth 0       151       R T       AGS       Eth 0
routerB.cisco.com   Ser 0       165       R T       AGS       Ser 3

routerA#show cdp neighbors detail
-------------------------
Device ID: routerB.cisco.com
Entry address(es):
  IP address: 198.92.68.18
  CLNS address: 490001.1111.1111.1111.00
  Appletalk address: 10.1
Platform: AGS,  Capabilities: Router Trans-Bridge
Interface: Ethernet0,  Port ID (outgoing port): Ethernet0
Holdtime : 143 sec
```

show ip arp Command

```
Router>show ip arp

Protocol  Address  Age(min)  Hardware Addr  Type   Interface
Internet  171.69.233.22  9  0000.0c59.f892   ARPA   Ethernet0/0
Internet  171.69.233.21  8  0000.0c07.ac00   ARPA   Ethernet0/0
Internet  171.69.233.19  -  0000.0c63.1300   ARPA   Ethernet0/0
Internet  171.69.233.30  9  0000.0c36.6965   ARPA   Ethernet0/0
Internet  172.19.168.11  -  0000.0c63.1300   SNAP   Ethernet0/0
Internet  172.19.168.254 9  0000.0c36.6965   ARPA   Ethernet0/0
Internet  172.19.168.17   0  Incomplete       ARPA   Ethernet0/0
```

Clear arp-cache Command

```
Router#clear arp-cache
Protocol  Address  Age(min)  Hardware Addr  Type   Interface
Internet  171.69.233.22  0  0000.0c59.f892    ARPA   Ethernet0/0
Internet  171.69.233.21  0  0000.0c07.ac00    ARPA   Ethernet0/0
Internet  171.69.233.19  -  0000.0c63.1300    ARPA   Ethernet0/0
Internet  171.69.233.30  0  0000.0c36.6965    ARPA   Ethernet0/0
Internet  172.19.168.11  -  0000.0c63.1300    SNAP   Ethernet0/0
Internet  172.19.168.254 0  0000.0c36.6965    ARPA   Ethernet0/0
```

Reachability and Step-by-Step Path Tests

Test reachability:

- **ping ip**

Test step-by-step path:

- **trace**

These tests operate in two levels: user mode and privileged mode

ping Command (User) IP

```
R4#ping 10.36.195.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.36.195.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 4/4/8 ms
R4#ping 10.36.195.95

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.36.195.95, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
```

ping Command (Privileged) IP

```
Router# ping
Protocol [ip]:
Target IP address: fred
Repeat count [5]:
Datagram size [100]:
Timeout in seconds [2]
Extended commands [n]: y
Source address:10.36.195.148
Type of service [0]:
Set DF bit in IP header? [no]:
Data pattern [0xABCD]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Number of hops [9]:
Loose, Strict, Record, Timestamp, Verbose[RV]:
Sweep range of sizes [n]:
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 131.108.1.115, timeout is 2
seconds:
!!!!!
```

trace Command (User) IP

```
Router# trace ip ABA.NYC.mil
Type escape sequence to abort.
Tracing the route to ABA.NYC.mil (26.0.0.73)
1 DEBRIS.CISCO.COM (131.108.1.6) 1000 msec 8 msec 4 msec
2 BARRNET-GW.CISCO.COM (131.108.16.2) 8 msec 8 msec 8 msec
3 EXTERNAL-A-GATEWAY.STANFORD.EDU (192.42.110.225) 8 msec 4 msec 4 msec
4 BB2.SU.BARRNET.NET (131.119.254.6) 8 msec 8 msec 8 msec
5 SU.ARC.BARRNET.NET (131.119.3.8) 12 msec 12 msec 8 msec
6 MOFFETT-FLD-MB.in.MIL (192.52.195.1) 216 msec 120 msec 132 msec
7 ABA.NYC.mil (26.0.0.73) 412 msec 628 msec 664 msec
```

trace Command (Privileged) IP

```
Router# trace
Protocol [ip]:
Target IP address: mit.edu
Source address:
Numeric display [n]:
Timeout in seconds [3]:
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port number[33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to MIT.EDU (18.72.2.1)
  1 ICM-DC-2-V1.ICP.NET (192.108.209.17) 72 msec 72 msec 88 msec
  2 ICM-FIX-E-H0-T3.ICP.NET (192.157.65.122) 80 msec 128 msec 80 msec
  3 192.203.229.246 540 msec 88 msec 84 msec
  4 T3-2.WASHINGTON-DC-CNSS58.T3.ANS.NET (140.222.58.3) 84 msec 116 msec 88 msec
  5 T3-3.WASHINGTON-DC-CNSS56.T3.ANS.NET (140.222.56.4) 80 msec 132 msec 88 msec
  6 T3-0.NEW-YORK-CNSS32.T3.ANS.NET (140.222.32.1) 92 msec 132 msec 88 msec
  7 T3-0.HARTFORD-CNSS48.T3.ANS.NET (140.222.48.1) 88 msec 88 msec 88 msec
```

show processes command

```
Router#show processes
CPU utilization for one minute: 38%; for five minutes: 37%
 PID Q T     PC Runtime (ms)   Invoked   uSecs   Stacks  TTY Process
   1 M E   122DE       62812      4897   12826  780/1000   0 Net Background
   2 M E   22842           8        19     421  804/1000   0 Logger
 809 M E   74AF0      272808    489888     556 1504/2000  36 Exec
   4 H E    67C0      373540    630248     592  628/900    0 IP Input
   5 M E   3E124       26044    630201      41  824/1000   0 IP Protocols
   6 M E   46BA2         592    255178       2  794/1000   0 TCP Timer
   7 L E   47CE6        1736      1635    1061  776/1000   0 TCP Protocols
   8 L E    67C0           0         1       0  958/1000   0 ARP Input
 813 M *     768         384        93    4129 1456/2000  42 Virtual Exec
  10 M E   3F51E           0         1       0  894/1000   0 BOOTP Server
  11 H E    67C0       25096    194823     128  426/500    0 Net Input
  12 M T    36FA        5420    277303      19  850/1000   0 TTY Background
  13 L E   5444E       65996     24907    2649  686/1000   0 SNMP Server
  14 M E   6E842           0         1       0  966/1000   0 Serial Line IP
```

- Add argument cpu to show detailed CPU utilization
- Add argument memory to show memory usage

show ip accounting command

Router(config)#*interafce int_id*
Router(config-int)#*ip accounting output-packets*

Router#*sh ip accounting*

Source	Destination	Packets	Bytes
192.168.206.26	218.145.30.108	4005	256571
192.168.206.25	134.208.10.102	1020	1164464
192.168.206.25	207.157.91.50	1	92
192.168.206.1	210.242.194.193	35978	45950896
192.168.206.26	63.241.199.50	4594	325046
192.168.206.30	64.4.15.117	29	1419
192.168.206.30	67.128.31.226	15	875
192.168.206.26	203.66.227.80	706	49264
192.168.206.26	209.69.32.137	4629	280846

- Output packets accounting with source and destination address

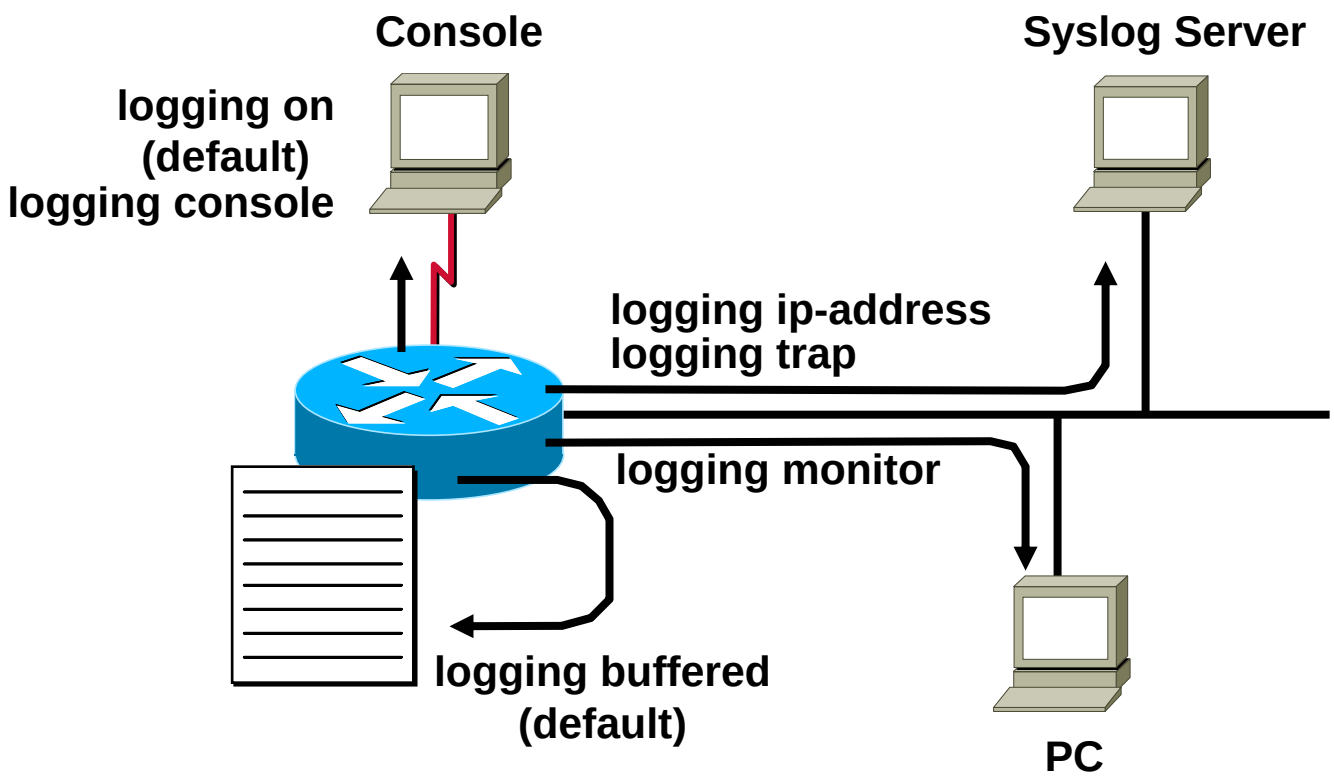
show ip cache flow command

```
   Router(config)#interafce int_id
   Router(config-int)#ip route-cache flow
Router#sh ip cache flow
… (omitted)
Protocol         Total    Flows   Packets Bytes  Packets Active(Sec) Idle(Sec)
--------         Flows     /Sec     /Flow  /Pkt    /Sec     /Flow     /Flow
TCP-WWW         4489203      1.1        28   752    33.4      4.7       7.2
TCP-SMTP        6851085      1.7        34   737    61.4      6.9       6.2
UDP-DNS         4687104      1.2         6    62     7.9      2.6      14.1
ICMP            7076822      1.8         1   191     2.7      0.7      15.2
IP-other           2519      0.0        22   494     0.0     13.5      14.2
Total:         395612036    103.4         6   552   716.1      3.6       6.9

SrcIf       SrcIPaddress    DstIf       DstIPaddress    Pr  SrcP  DstP   Pkts
Se0/0        210.71.184.250 Et0/0       202.39.206.201  06  1201  01BB   571
Et0/0        10.10.32.9     Null        10.10.255.255   11  008A  008A   8
Et1/0        219.137.120.198 Et0/0      61.67.10.21     06  1AE1  1341   2262
…
```

- **Flow records with detailed information.**

Error Message Loggin

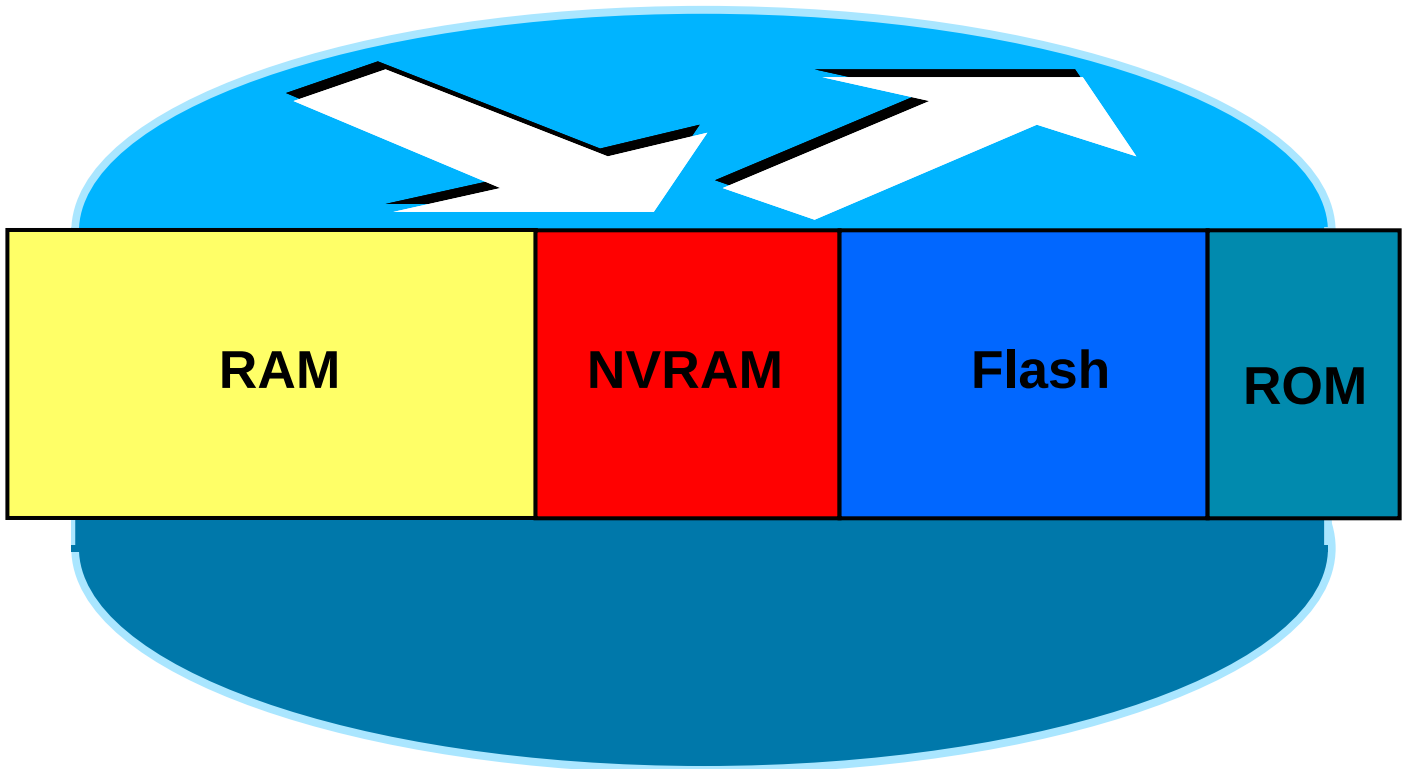


show logging Command

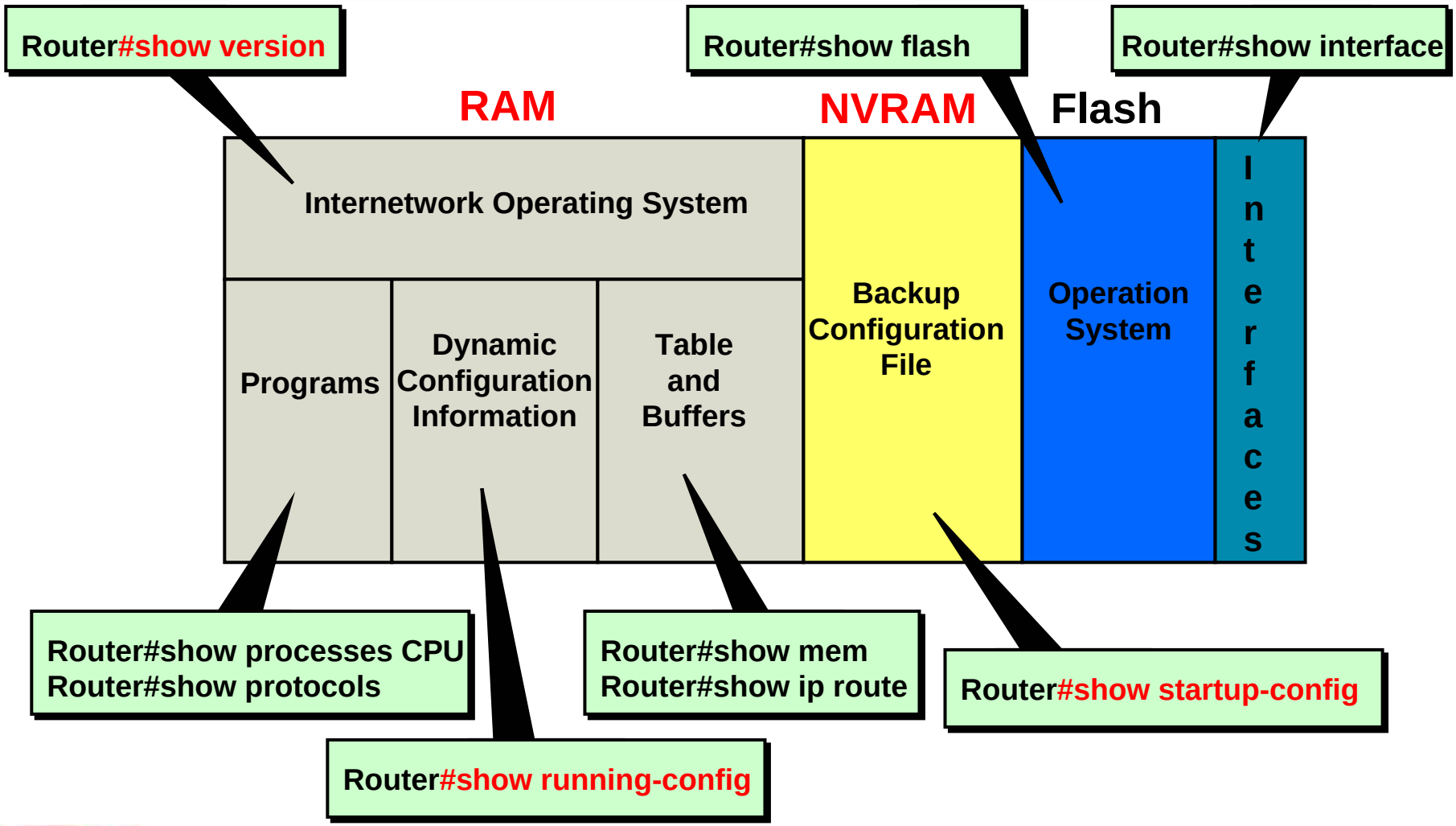
```
Router#show logging
Syslog logging: enabled
    Console logging: disabled
    Monitor logging: level debugging, 18 messages logged.
    Trap logging: level informational, 18 messages logged.
    Logging to 192.31.7.19
SNMP logging: enabled, retransmission after 30 seconds
    741 messages logged
    Logging to 131.108.1.27, 0/10
Feb 18 19:49:50 %SYS-5-CONFIG_I: Configured from console by vty0 (10.36.195.154)
Feb 18 20:05:13 %SYS-5-CONFIG_I: Configured from console by vty0 (10.36.195.154)
…
```

Password Recovery

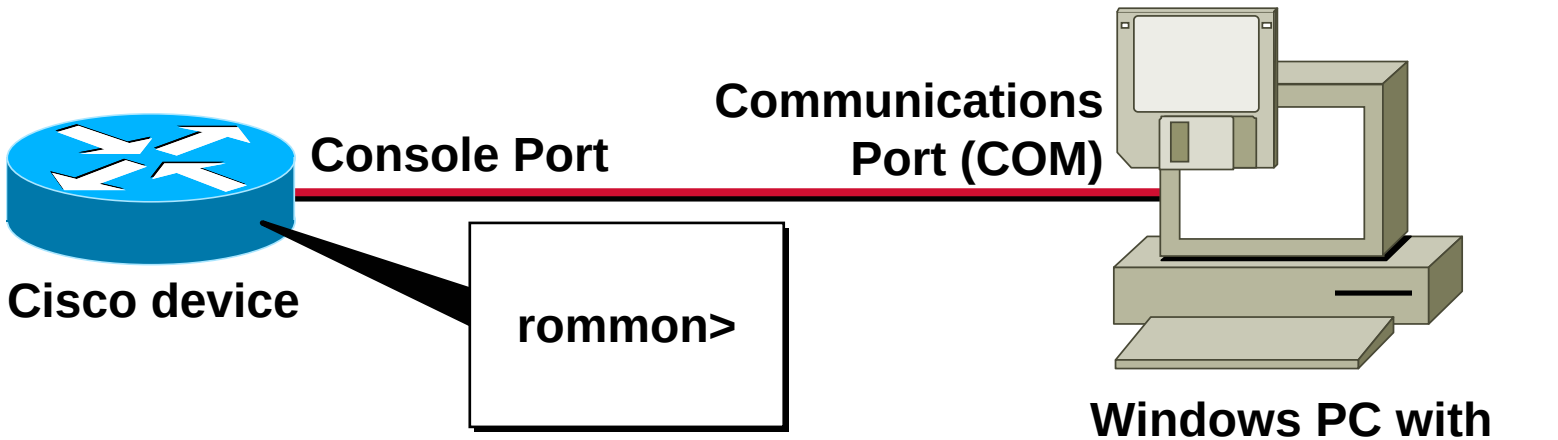
Internal Configuration Components



Router Status Commands



Break Boot Procedure



- Attach a terminal to the console port of the router.
- Power off/on router
- Press ***Break-key*** on the terminal keyboard after power-up to put the router into ROMMON.

Break Key Map

Software	*Operating System*	*Try This*
Hyperterminal	Windows	Ctrl-Break
Netterm	Windows	Edit/ Send short break
SecureCRT	Windows	Ctrl-Break
Telix	DOS	Ctrl-End

http://www.cisco.com/en/US/partner/products/hw/routers/ps133/products_tech_note09186a0080174a34.shtml

Configuration Register Values

```
rommon>confreg 0x2142
rommon>reset
```

Configuration Register Boot Field Value	Meaning
0x2142	Boot from flush *without* loading configuration
0x2102	Boot from flush *with* loading configuration

Boot to Setup Mode

--- System Configuration Dialog ---

Continue with configuration dialog? [yes/no]: y

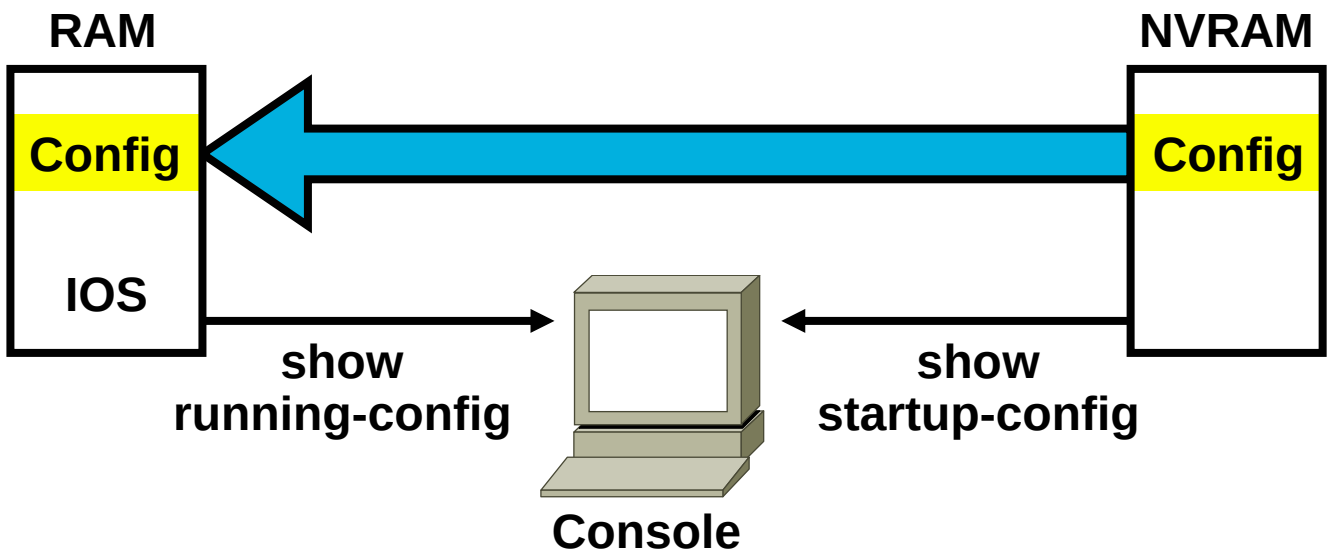
At any point you may enter a question mark '?' for help.
Use ctrl-c to abort configuration dialog at any prompt.
Default settings are in square brackets '[]'.

Basic management setup configures only enough connectivity for management of the system, extended setup will ask you to configure each interface on the system

Would you like to enter basic management setup? [yes/no]: n

Loading the Configuration

```
Roter>en
Router#config memory
or
Rotuer#copy startup-config running-config
```



- **Load and execute config from NVRAM**

show running

In RAM

```
wg_ro#show running-config
Building configuration...
Current configuration:
!
version 12.0
!
      -- More --
```

Configuration is restored !

Changing Enable Password

Enable Password

wg_ro(config) #*enable secret cisco*

- **Old password cannot get back.**
- **Set a new enable password.**

Enabling the Interfaces

Router#***show ip interface brief***

Interface	IP-Address	OK?	Method	Status	Protocol
Ethernet0/0	10.200.40.37	YES	TFTP	**administratively down**	down
Serial0/0	unassigned	YES	TFTP	**administratively down**	down
Ethernet0/1	unassigned	YES	TFTP	**administratively down**	down
Serial0/1	unassigned	YES	TFTP	**administratively down**	down

wg_ro *#configure term*
wg_ro (config)*#interface serial 0/0*
wg_ro (config-if)*#no shutdown*
%LINK-3-UPDOWN: Interface Seria0, changed state to up
%LINEPROTO-5-UPDOWN: Line Protocol on Interface Serial0, changed state to up

Enables an interface that are administratively shutdown

Configuration Register Values

```
wg_ro(config)#config-reg 0x2102
wg_ro(config)#end
```

Configuration Register Boot Field Value	Meaning
0x2142	Boot from flush *without* loading configuration
0x2102	Boot from flush *with* loading configuration

Verifying Register Values

```
wg_ro#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), …..

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 0x2142 (will be 0x2102 at next reload)
```

Saving Configurations

```
wg_ro#telnet ……
wg_ro#write memory
Building configuration…
wg_ro#reload
```

- Telnet to itself to double confirm.
- Copy the current configuration to NVRAM

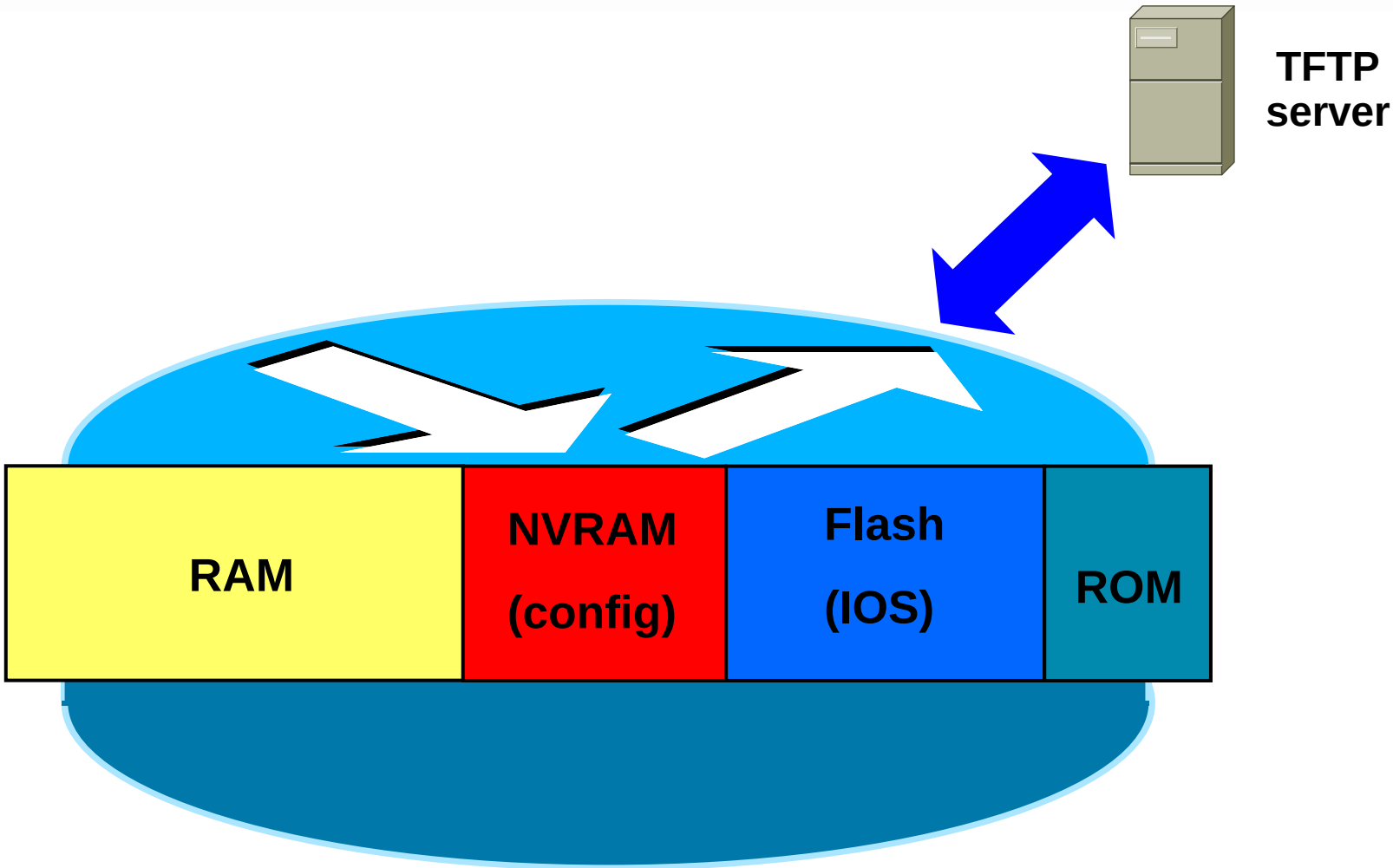
Summary

- **More password recovery procedure:**

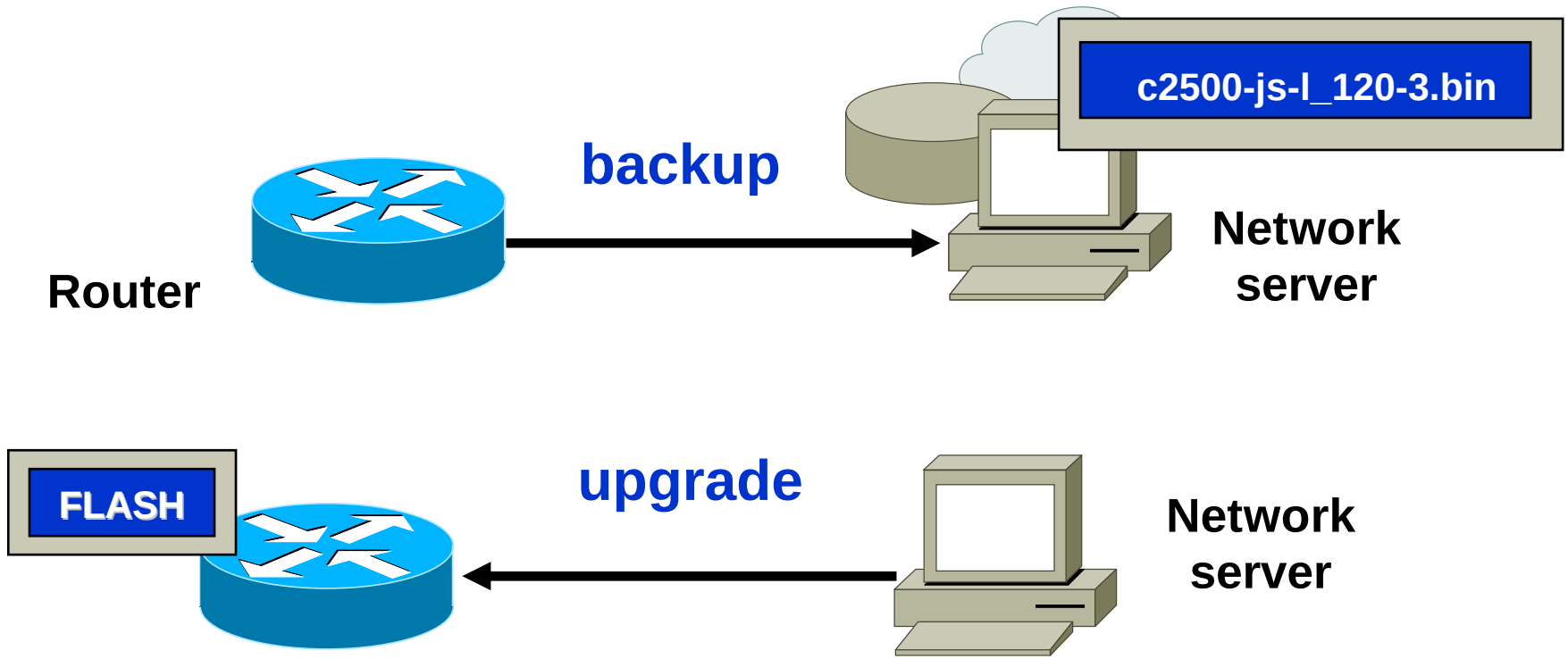
  http://www.cisco.com/warp/customer/474/

IOS Backup & Upgrade

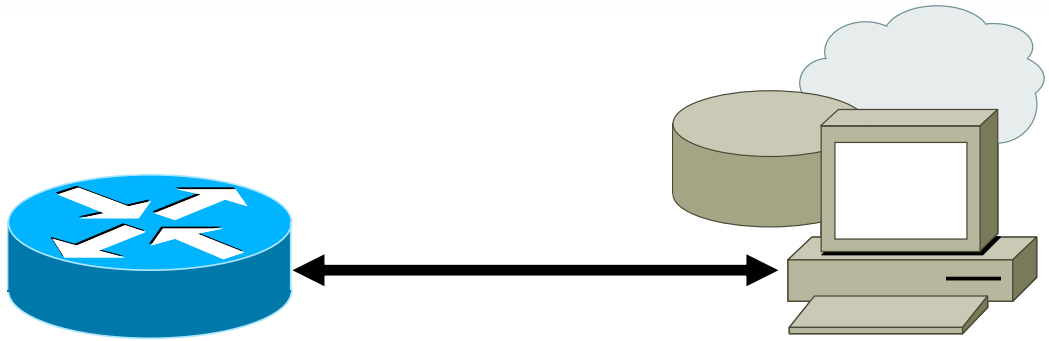
Cisco IOS File Systems and Devices



Managing IOS Images



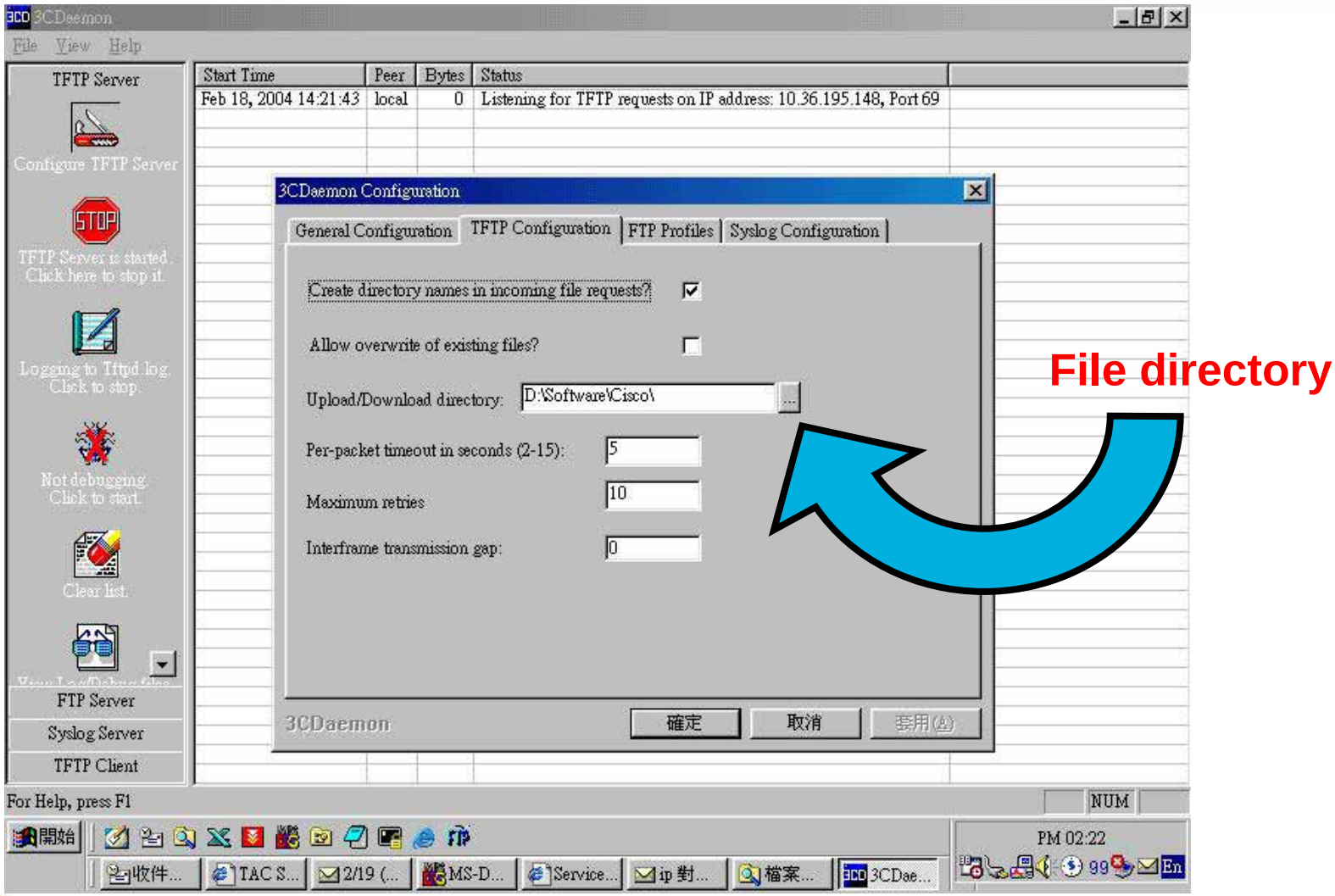
Preparing for a Network Transmissation



- Check connectivity between router and tftp server
- Check flash/space available on the router/server
- Check file naming convention
- Create file on server if required
- TFTP utility

http://support.3com.com/software/utilities_for_windows_32_bit.htm

TFTP server


3CDaemon
File View Help
TFTP Server
Configure TFTP Server
TFTP Server is started. Click here to stop it.
Logging to Tftpd.log. Click to stop.
Not debugging. Click to start.
Clear list.
FTP Server
Syslog Server
TFTP Client
Start Time
Peer
Bytes
Status
Feb 18, 2004 14:21:43
local
0
Listening for TFTP requests on IP address: 10.36.195.148, Port 69
3CDaemon Configuration
General Configuration
TFTP Configuration
FTP Profiles
Syslog Configuration
Create directory names in incoming file requests?
Allow overwrite of existing files?
Upload/Download directory:
D:\Software\Cisco\
Per-packet timeout in seconds (2-15):
5
Maximum retries
10
Interframe transmission gap:
0
3CDaemon
確定
取消
套用(A)
File directory
For Help, press F1
NUM
開始
PM 02:22

Verifying Memory and Deciphering Image Filenames

```
wg_ro#sh flash

System flash directory:
File  Length   Name/status
  1   10084696  c2500-js-l_120-3.bin
[10084760 bytes used, 6692456 available, 16777216 total]
16384K bytes of processor board System flash (Read ONLY)
```

- Check the current IOS in flash memory.
- Verify Flash memory has room for the IOS image

show version Command

```
Wg_ro>show version
Cisco Internetwork Operating System Software
IOS (tm) C2600 Software (C2600-IS-M), Version 12.1(20), RELEASE SOFTWARE (fc2)
...
ROM: System Bootstrap, Version 11.3(2)XA4, RELEASE SOFTWARE (fc1)
...
System image file is "flash:c2600-is-mz.121-20.bin"


cisco 2611 (MPC860) processor (revision 0x202) with 26624K/6144K bytes of memory.
...
2 Serial(sync/async) network interface(s)
32K bytes of non-volatile configuration memory.
8192K bytes of processor board System flash (Read/Write)
```

- **Make sure flash and DRAM sizes meet the minimal requirement for IOS**

Upgrading the Image from the Net

wg_ro#*copy tftp flash*
Address or name of remote host []?*10.1.1.1*
Source filename []? *c2500-js-l_120-3.bin*
Destination filename [c2500-js-l_120-3.bin]?
Accessing tftp://10.1.1.1/c2500-js-l_120-3.bin...
Erase flash: before copying? *[confirm]*
Erasing the flash filesystem will remove all files! Continue? *[confirm]*
Erasing device... eeeee *(output omitted)* ...erased
Erase of flash: complete
Loading c2500-js-l_120-3.bin from 10.1.1.1 (via Ethernet0): !!!!!!!!!!!!!!!!!!!
(output omitted)
[OK - 10084696/20168704 bytes]
Verifying checksum... OK (0x9AA0)
10084696 bytes copied in 309.108 secs (32636 bytes/sec)
wg_ro#*reload*

Define a Booting IOS file

```
wg_ro#sh flash:

System flash directory:
File  Length   Name/status
  1   7724588  c2600-i-mz.121-20.bin
  2   9923856  c2600-is-mz.121-20.bin

wg_ro#config t
wg_ro(config)#boot system flash c2600-is-mz.121-20.bin
```

- New IOS will take effect after reload.

Creating a Software Image Backup


```
wg_ro#copy flash tftp
Source filename []? c2500-js-l_120-3.bin
Address or name of remote host []? 10.1.1.1
Destination filename [c2500-js-l_120-3.bin]?
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
<output omitted>
10084696 bytes copied in 709.228 secs (14223 bytes/sec)
wg_ro#
```

- **Back up current files prior to updating Flash**

Backup Configuration

```
wg_ro_a#copy running-config tftp
Address or name of remote host []? 10.1.1.1
Destination filename [running-config]? wgroa.cfg
.!!
1684 bytes copied in 13.300 secs (129 bytes/sec)

wg_ro_a#copy tftp running-config
Address or name of remote host []? 10.1.1.1
Source filename []? wgroa.cfg
Destination filename [running-config]?
Accessing tftp://10.1.1.1/wgroa.cfg...
Loading wgroa.cfg from 10.1.1.1 (via Ethernet0): !
[OK - 1684/3072 bytes]

1684 bytes copied in 17.692 secs (99 bytes/sec)
```

Q & A

Thanks you !