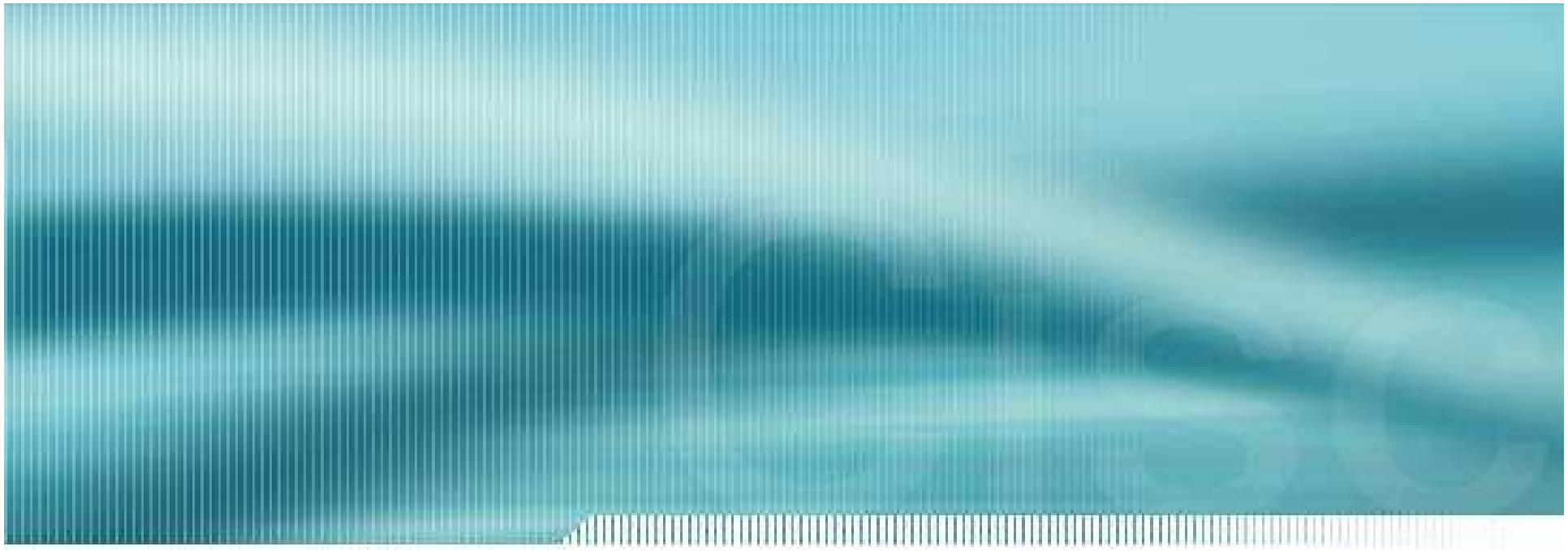


Router and Routing Basics

Malin Bornhager

Halmstad University

Routing Protocols and Concepts – CCNA2

- Routing and packet forwarding
- Static routing
- Dynamic routing protocols
- Distance vector routing protocols
- RIP version 1
- VLSM and CIDR
- RIP version 2
- The routing table
- EIGRP
- Link-state routing protocols
- OSPF

Objectives

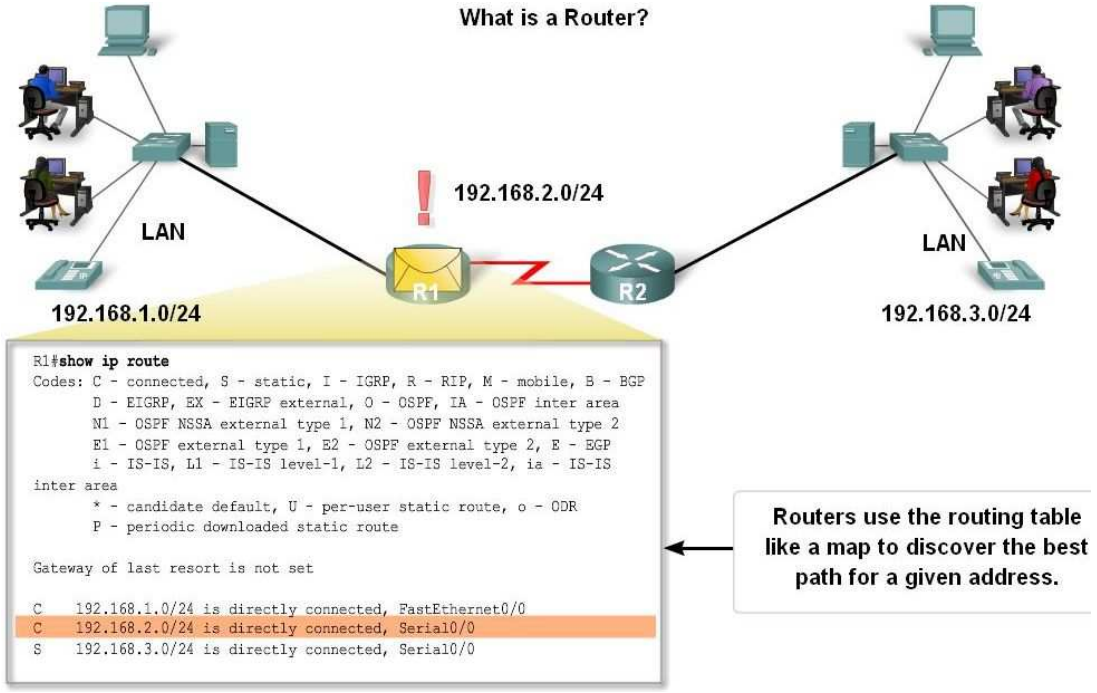
- **Identify a router as a computer with an operating system (OS) and hardware designed for the routing process**
- **Describe how a router determines a path and switches packets**
- **Static routing**
- **Routing protocols (dynamic routing)**

Routers

- Special type of computer
- Connect and allow communication between two networks
- Determine the best path through the network
- Configuration files to control the traffic
- Generally have two connection types:
  - WAN connection (connection to ISP)
  - LAN connection

Routers

- Data is sent in form of packets between two end devices
- Routers are used to direct packets to its destination
- Routers examine a packets destination IP address and determine the best path by using a routing table



Cisco IOS Software

Operating system in all of the Cisco routers or switches, which provides the following network services:

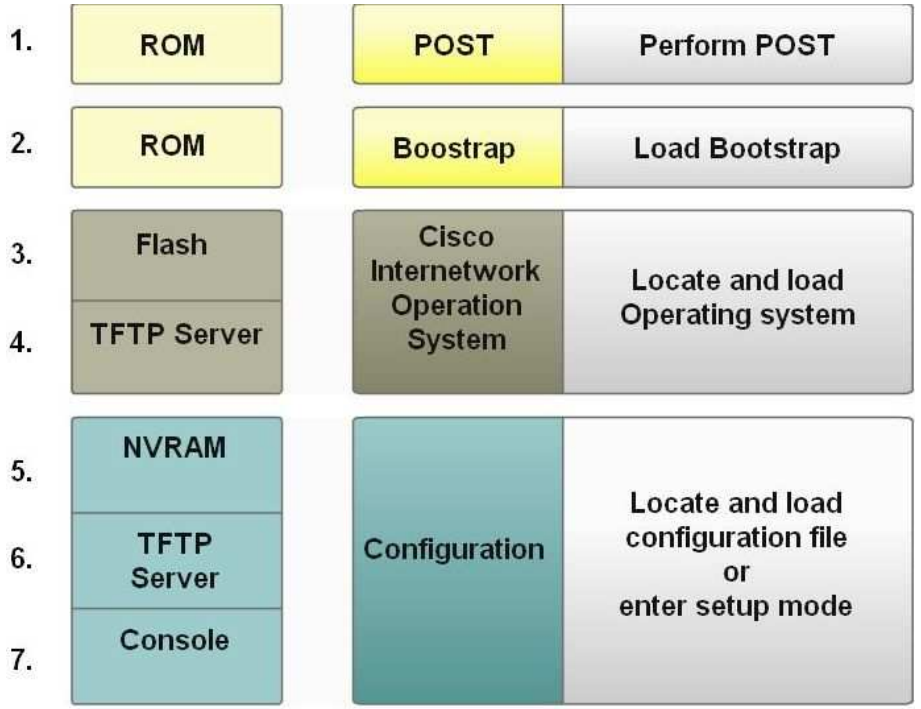
- **Basic routing and switching functions**
- **Reliable and secure access to networked resources**
- **Network scalability**

Router components

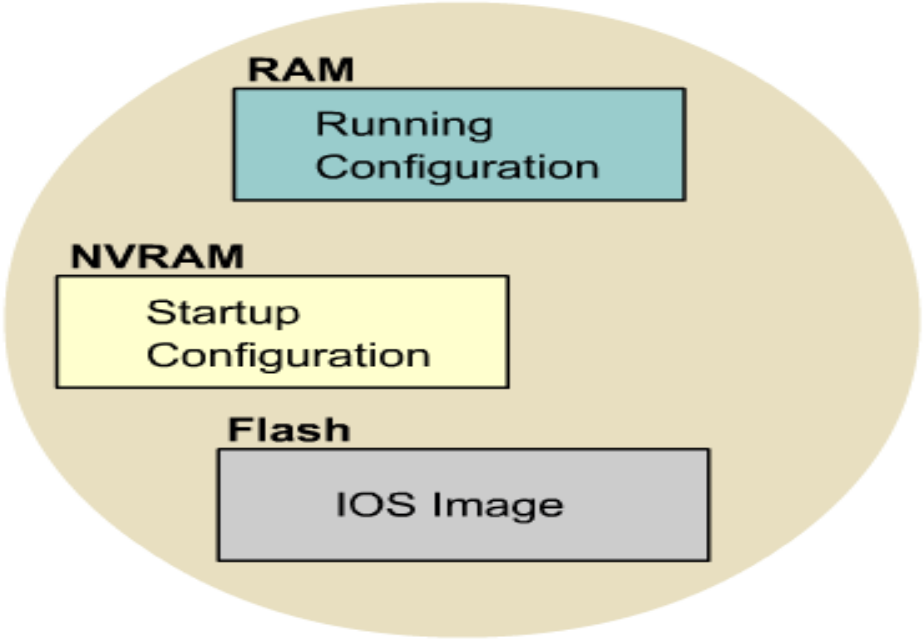
- CPU
  - Executes operation systems instructions
- RAM
  - Stores instructions and data needed for CPU
- ROM
  - Boot instructions, scaled-down vers. of IOS
- Flash
  - Stores IOS, copied into RAM during bootup proc.
- NVRAM
  - Startup configuration file

Router Boot-up process

- **Major phases to the router boot-up process**
  - **Test router hardware**
    - **Power-On Self Test (POST)**
    - **Execute bootstrap loader**
  - **Locate & load Cisco IOS software**
    - **-Locate IOS**
    - **-Load IOS**
  - **Locate & load startup configuration file or enter setup mode**
    - **-Bootstrap program looks for configuration file**



IOS File System Overview



Router interfaces

- **Interface: a physical connector on the router, main purpose to receive and forward packets**
- **Interfaces connects to various types of networks, and different types of media and connectors are required**
- **Each interface connects to a separate network**

Router interfaces

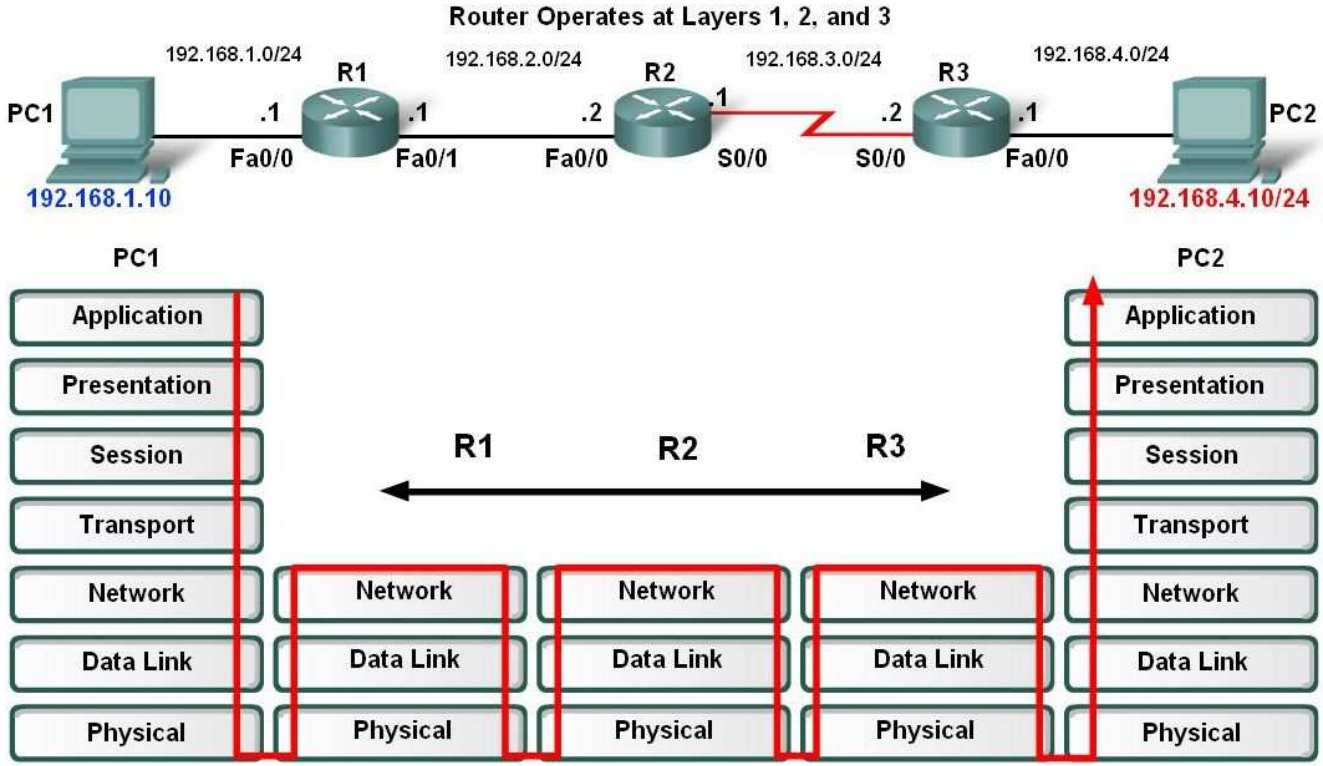
- **LAN interfaces**
  - **Ethernet, fastEthernet**
  - **Connects the router to a LAN**
- **WAN interfaces**
  - **Serial, ISDN, Frame Relay**
  - **Connects the router to external networks, interconnect LANs**

Routing

- Process to forward packets to destination networks
- Layer 3 device
- Examines destination IP address (Layer 3)
- Routing table is used to find best path to destination

Routing

- **Forwarding decisions based on Layer 3**
- **Operates at Layer 1, 2 and 3**



Routing Table

- Data file in RAM
- Stores information about directly connected and remote networks
- Contains network/next hop associations
- Directly connected networks
- Remote networks
  - Static routes (manually configured)
  - Dynamic routing protocols (learned from other routers)

Static Routing

- **Configured manually**
- **Specifies network address and subnet mask of remote network, and IP address of next hop router or exit interface**
- **Use static routes when:**
  - **Network only consists of few routers**
  - **Network is connected to Internet only through one ISP**

Static Routing

Advantages:

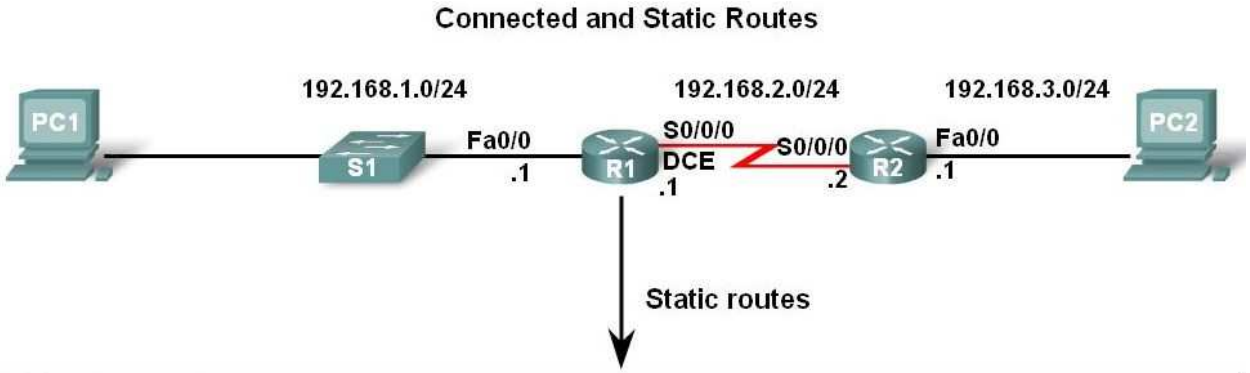
- **Minimal CPU processing**
- **Easy to configure**
- **Easier for administrator to understand**

Static Routing

Disadvantages:

- **Configuration and maintenance is time-consuming**
- **Does not scale well with growing networks**
- **Requires complete knowledge of the whole network for proper implementation**

Static Routing




```
R1#show 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, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

C    192.168.1.0/24 is directly connected, FastEthernet0/0
C    192.168.2.0/24 is directly connected, Serial0/0
S    192.168.3.0/24 [1/0] via 192.168.2.2
```

Dynamic routing

- **Added to routing table by using a dynamic routing protocol**
- **Used by routers to share information about the reachability and status of remote networks**
- **Perform several activities:**
  - **Network discovery**
  - **Updating and maintaining routing tables**

Dynamic routing

Advantages:

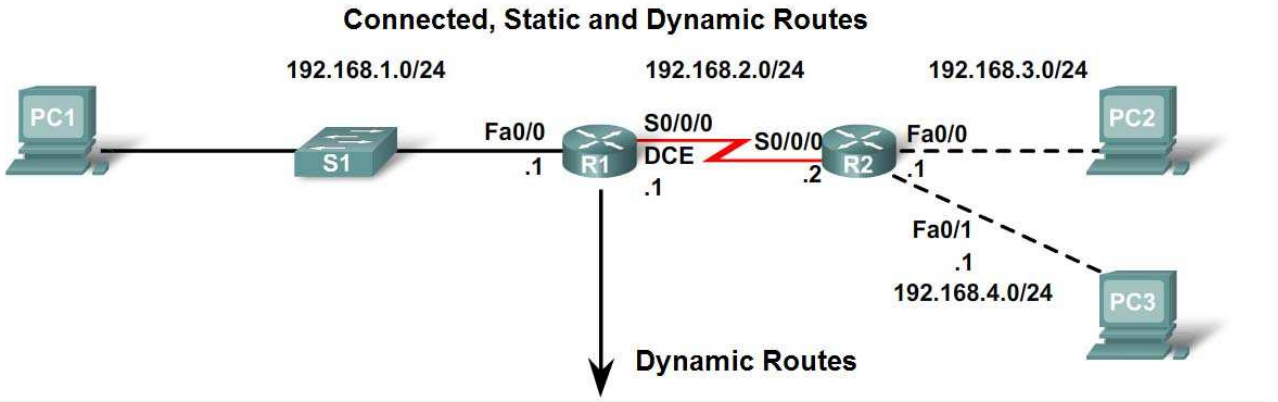
- **Less administrative overhead when adding or deleting a network**
- **Protocols automatically react to the topology changes**
- **More scalable**

Dynamic Routing

Disadvantages:

- **Router resources are used (CPU cycles, memory and link bandwidth)**
- **More administrator knowledge is required for configuration, verification and troubleshooting**

Dynamic Routing

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Gateway of last resort is not set
C    192.168.1.0/24 is directly connected, FastEthernet0/0
C    192.168.2.0/24 is directly connected, Serial0/0/0
S    192.168.3.0/24 [1/0] via 192.168.2.2
R    192.168.4.0/24 [120/1] via 192.168.2.2, 00:00:20, Serial0/0/0
```

Best Path and Metric

- Multiple path to same destination
- Best path is selected by the routing protocol, based on a specific value (metric)
- Each protocol uses its own rules and metrics to build and update routing tables
- Metric is used to measure the distance to the destination network
- Lowest metric = best path, placed in routing table

Metrics

- **Hop cont: counts the number of routers a packet must traverse**
- **Bandwidth: preferring the path with highest bandwidth**
- **Load: traffic utilization on a link**
- **Delay: time for a packet to traverse a path**
- **Reliability: probability of a link failure**
- **Cost: determined by IOS or administrator to indicate preference for a route**

Path Determination

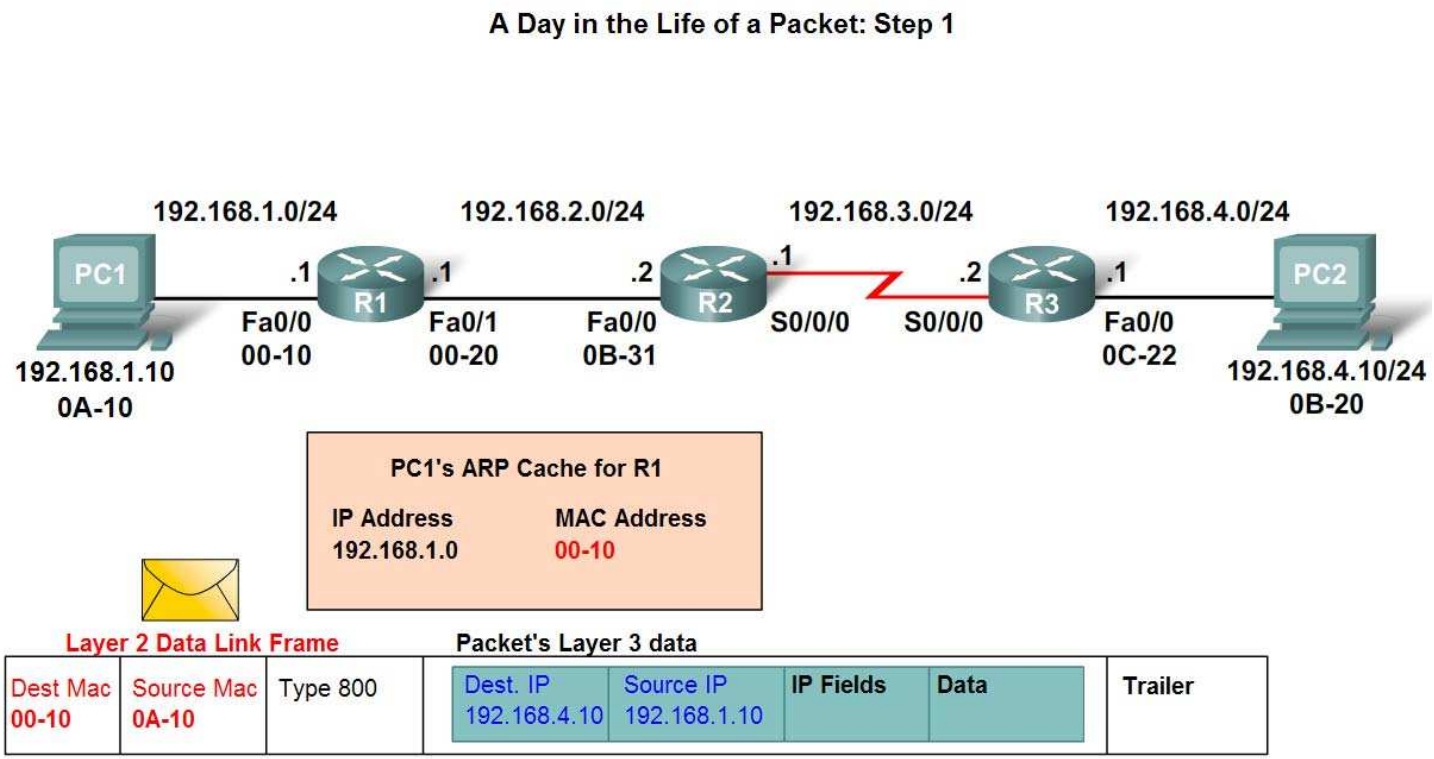
- The process of how the router determines which path to use when forwarding a packet
- Directly connected
  - Forwarded directly to the destination
- Remote network
  - Forwarded to another router
- No route determined
  - Packet discarded, ICMP unreachable sent

Switching Function

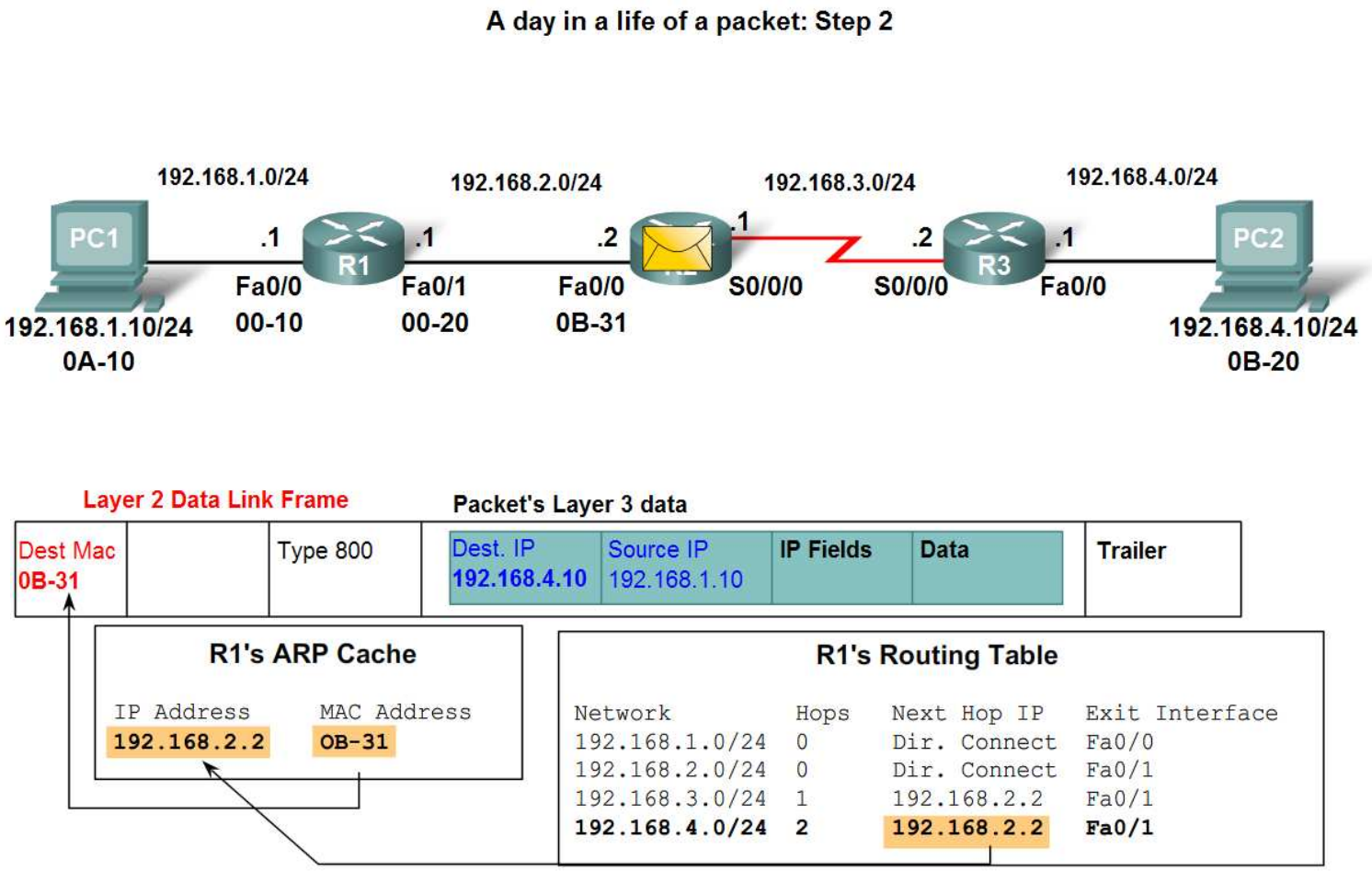
- Process used by a router to accept a packet on one interface and forward it out another interface
- Decapsulate the Layer 3 packet by removing Layer 2 frame header and trailer
- Examines destination IP address of the packet to find best path in routing table
- Encapsulate Layer 3 packet into a new Layer 2 frame and forwards on correct interface

Example

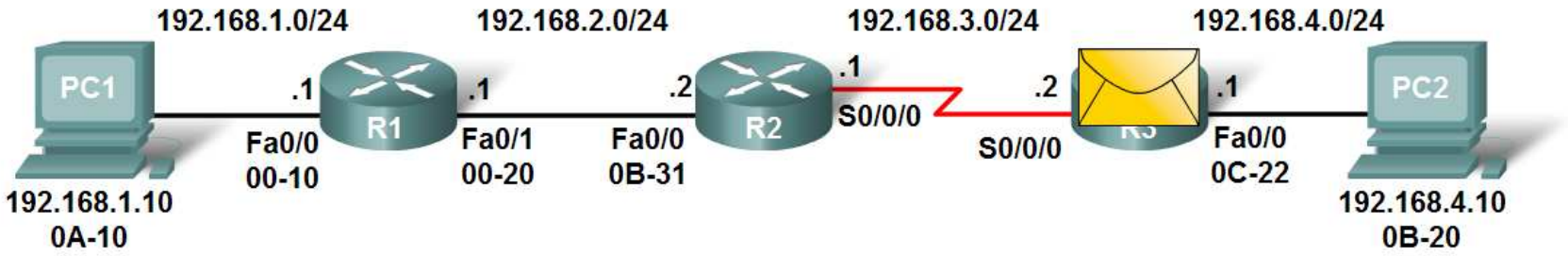
- **PC 1 will send a packet to PC 2**



Example cont.



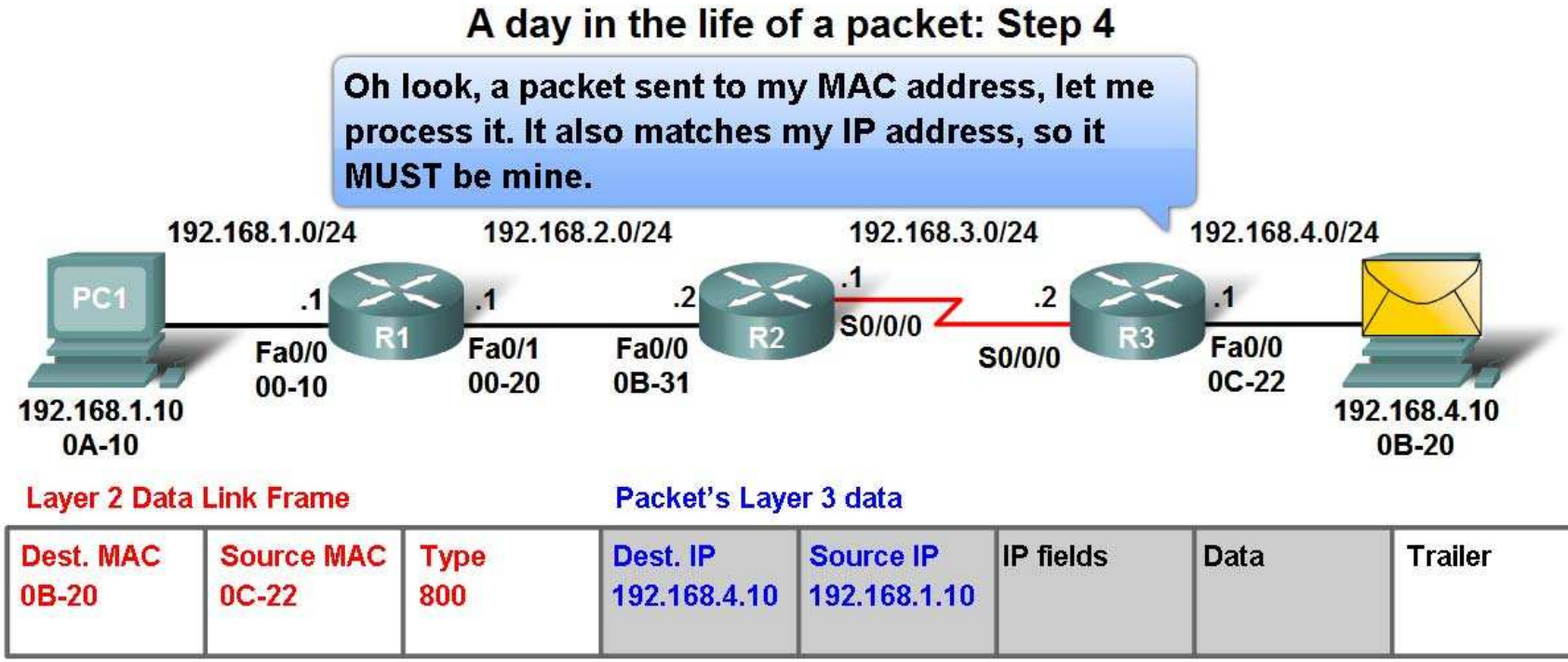
Example cont.



Layer 2 Data Link Frame | Packet's Layer 3 data

		Type 800	Dest. IP 192.168.4.10	Source IP 192.168.1.10	IP fields	Data	Trailer

Example cont.

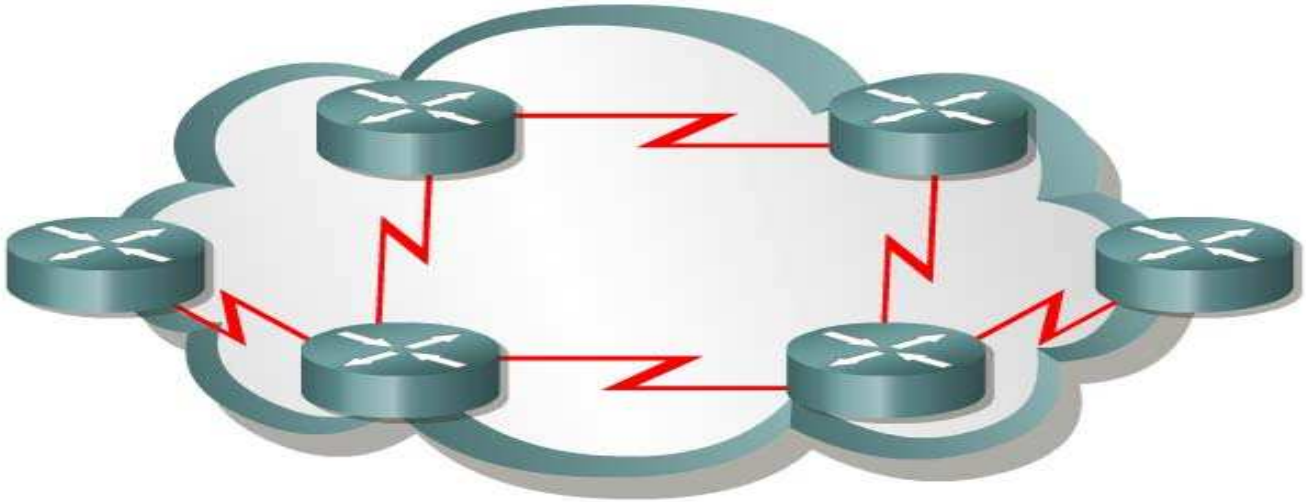


IP Routing protocol

- RIP (Routing Information Protocol)
- IGRP (Interior Gateway Routing Protocol)
- EIGRP (Enhanced IGRP)
- OSPF (Open Shortest Path First)
- IS-IS (Intermediate System-to-Intermediate System)
- BGP (Border Gateway Protocol)

Autonomous System (AS)

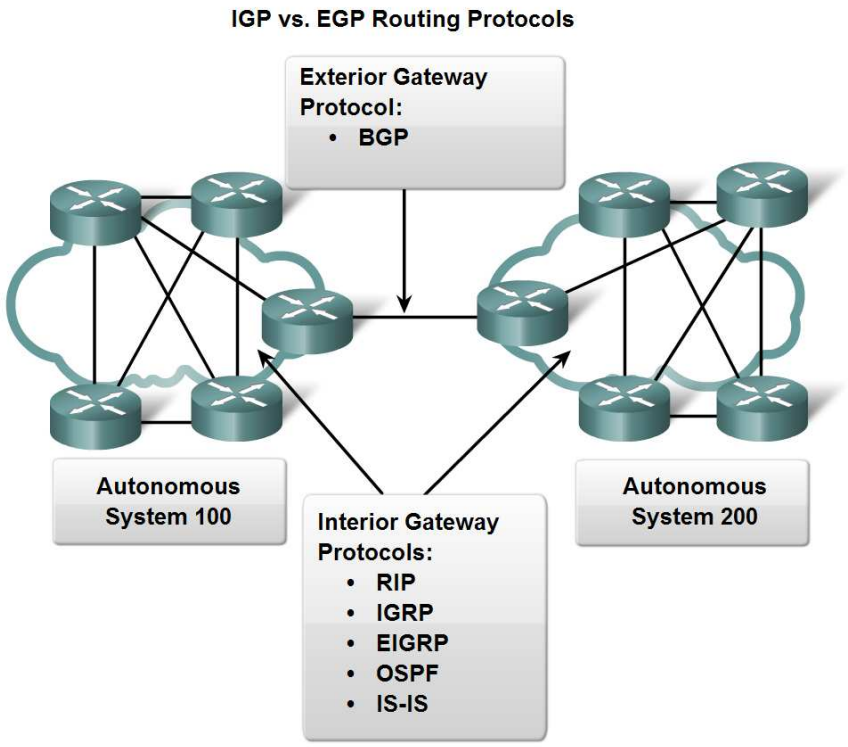
- **Collection of networks/routers**
- **Share a common routing strategy**
- **Viewed as a single entity from the outside world**



Routers under a common administration

Routing Protocols

- **Routing protocols can be classified into different groups according to their characteristics**
  - **Interior Gateway Protocols (IGP)**
  - **Exterior Gateway Protocols (EGP)**



IGP Routing Protocols

Two classes of routing protocols:

- **Distance vector**
  - **Determines the direction and distance to any link in the internetwork**
- **Link-state**
  - **Recreates the exact topology of the entire internetwork**

Distance Vector Routing Protocol

- Periodic updates
- Slow convergence
- Routing table from directly connected neighbor routers
- Add distances before passing it to other neighbors
- Distance is defined in terms of a metric, such as hop count

Link-state Routing Protocol

- Complex database of topology information
- Knowledge of the entire network
- Uses SPF to calculate the best path
- Updates when changes in the topology occurs
- Fast Convergence
- More memory and processor overhead

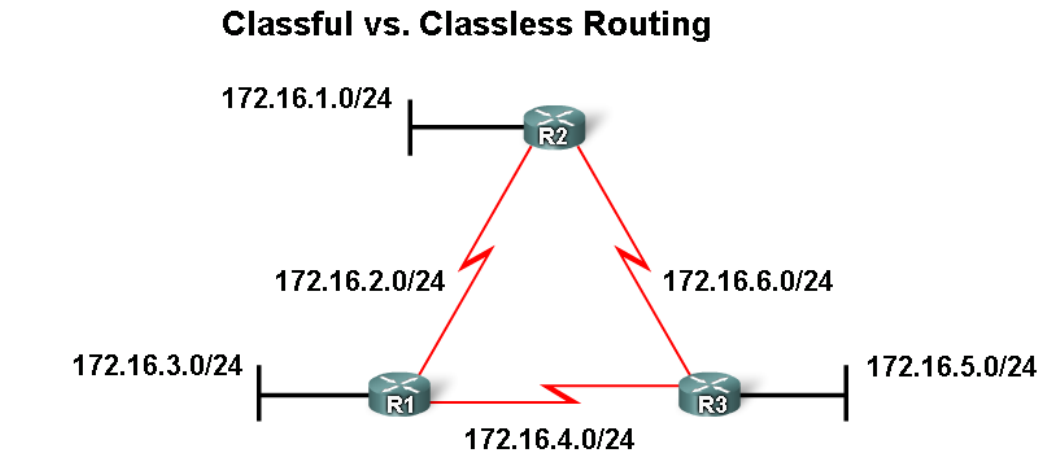
Classful Routing Protocols

- **Do not send subnet mask information in routing updates**
- **Do not support variable length subnet masks (VLSM) and discontiguous networks**

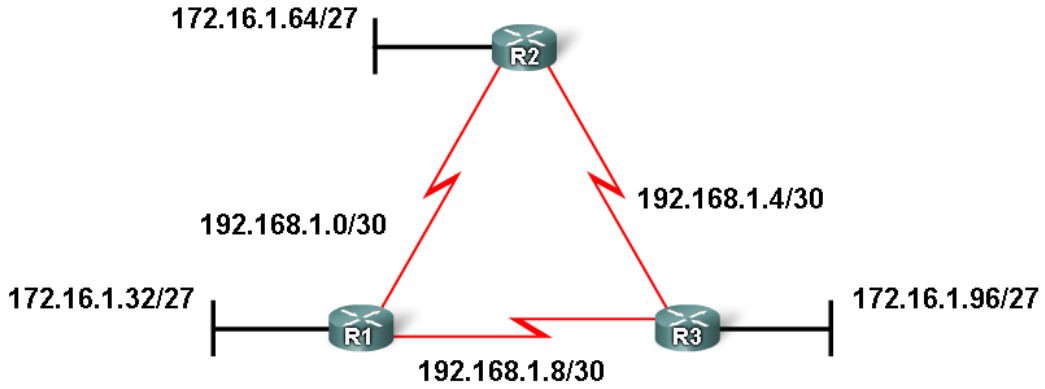
Classless Routing Protocols

- **Include the subnet mask in routing updates**
- **Supports both VLSM and discontiguous networks**
- **Required in most networks today**

Classful vs. Classless Routing



Classful: Subnet mask is the same throughout the topology



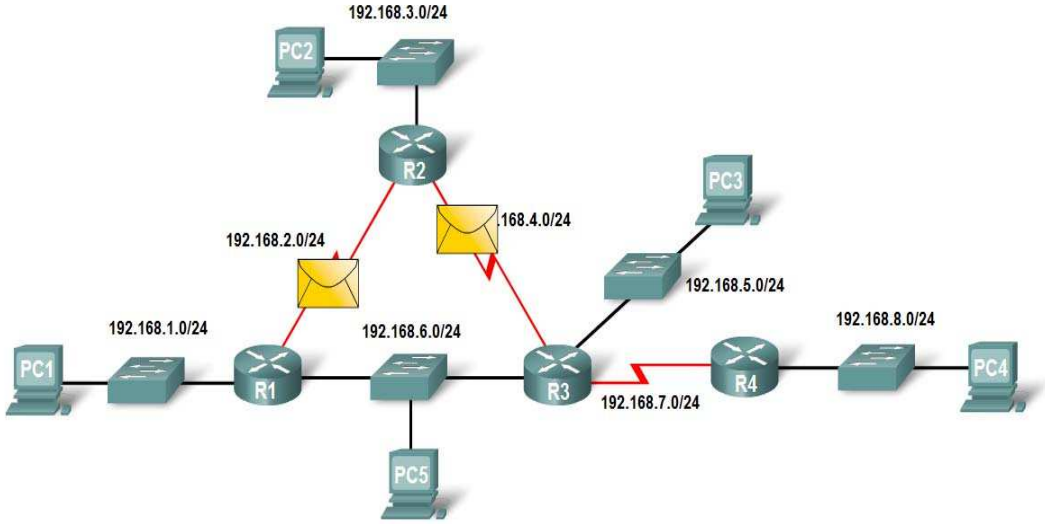
Classless: Subnet mask can vary in the topology

Convergence

- When all routers routing tables are at a state of consistency
- All routers have complete and accurate information about the network
- Convergence time is the time it takes routers to share information, calculate best paths, and update their routing tables
- A network is not completely operable until the network has converged. Short convergence times are required

Load Balancing

- **The ability for a router to distribute packets among multiple same cost paths**




```
R2#show ip route
<output omitted>

R    192.168.6.0/24 [120/1] via 192.168.2.1, 00:00:24, Serial0/0/0
                    [120/1] via 192.168.4.1, 00:00:26, Serial0/0/1
```

Administrative Distance

- **Administrative distance is used to determine the best path to a particular destination, when the same path is learned from two or more different routing sources**
- **Measures the trustworthiness of a routing source**
- **Lowest AD is inserted in the routing table**

Protocols	Default Administrative Distances
Connected	0
Static	1
EIGRP summary route	5
eBGP	20
EIGRP (Internal)	90
IGRP	100
OSPF	110
IS-IS	115
RIP	120
EIGRP (External)	170
iBGP (external)	200

Default Routes

- Used when the router is unable to match a destination network
- Do not have to maintain a routing table entry for every Internet network
- Statically entered by an administrator
  - ip route 0.0.0.0 0.0.0.0
- Dynamically learned using a routing protocol
  - ip default-network