Refresher on Routers

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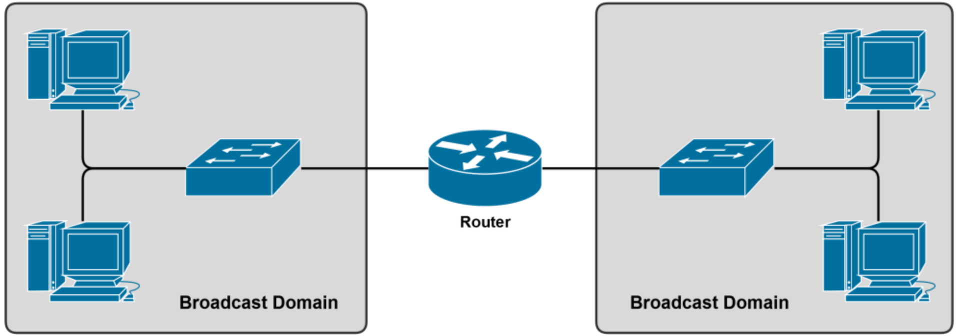
- Used to Connect Different Networks Together
- Routes Traffic Between Networks using **IP Addresses**
- Uses Intelligent Decisions (Routing Protocols) to Find the Best Way to Get a Packet of Information from One Network to Another.
- Break Up Broadcast Domains
- **OSI Layer 3 Device**
    - Layer 3 = Router
    - Layer 2 = Switch
    - Layer 1 = Hub



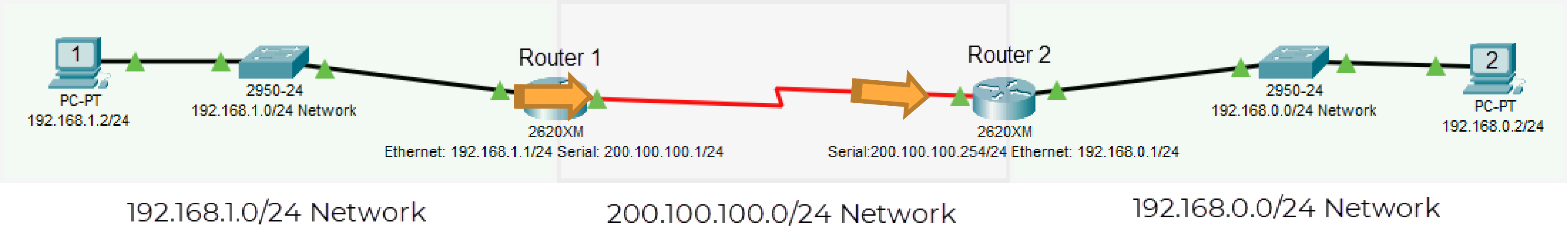
The Routing Process

Step 1: The Routing Process (Simplified)

192.168.1.0/24 Network 200.100.100.0/24 Network 192.168.0.0/24 Network

- PC 1 creates a packet destined for PC 2
  - **Source IP**: 192.168.1.2/24
  - **Destination IP**: 192.168.0.2/24
- Because it is destined for another network, it is sent to PC 1's default gateway, which is the Ethernet interface of Router 1 (192.168.1.1/24).
- If PC 1 doesn't know Router 1's MAC Address, PC 1 will send out an ARP request.

Step 2: The Routing Process (Simplified)



- Once Router 1 receives the packet, it'll inspect its destination IP address and then make a routing decision based on its routing table to identify which route to send it to.
- In this case, it's Router 1's serial interface with an IP address of 200.100.100.1/24.

```
Router1#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

S    192.168.0.0/24 [1/0] via 200.100.100.254
C    192.168.1.0/24 is directly connected, FastEthernet0/0
C    200.100.100.0/24 is directly connected, Serial0/0
```

Step 3: The Routing Process (Simplified)

192.168.1.0/24 Network   200.100.100.0/24 Network   192.168.0.0/24 Network

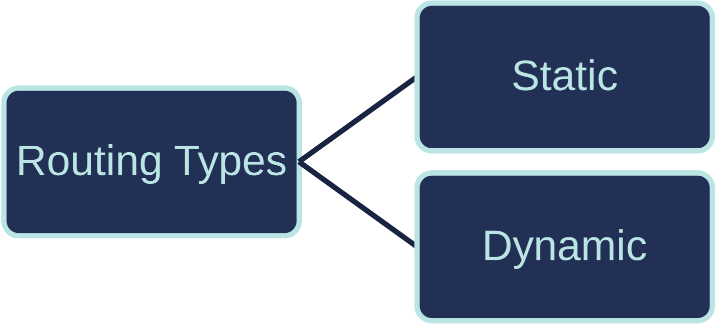
- Once Router 2 receives the packet, it'll inspect its destination IP address and then make a routing decision based on its routing table to identify which route to send it to.
- In this case, it's its directly connected Ethernet interface with an IP address of 192.168.0.1/24.

```
Router2#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    192.168.0.0/24 is directly connected, FastEthernet0/0
S    192.168.1.0/24 [1/0] via 200.100.100.1
C    200.100.100.0/24 is directly connected, Serial0/0
```

Static versus Dynamic Routing

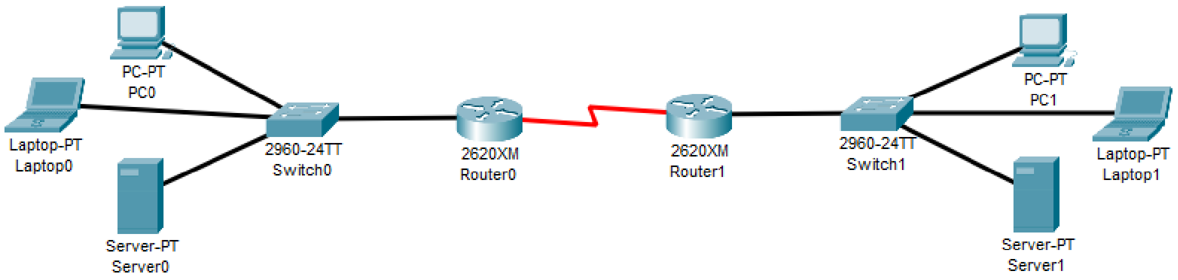
Static vs. Dynamic Routing

- Routing can be broken up into two primary categories:



Static Routing

- The simplest form of routing
- Static routes that are manually entered by a network administrator
- Ideal for small networks with very few routes that rarely change
    - There’s no overhead like there is with dynamic routing.
- Can be problematic for larger networks or if the network regularly changes
    - All changes must be made manually, which is time-consuming and can be error-prone.



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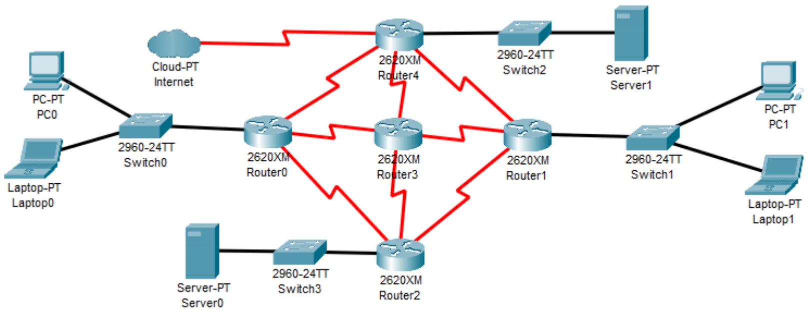
Dynamic Routing

- An automated form of routing that uses routing protocols to:
  - Populate router's routing table
  - Make the most efficient routing decision
  - Updating the routing table whenever the network changes
- Automatic & Hands-Off
  - All routing decisions are handled by the protocol
- Ideal for larger, and more complex networks



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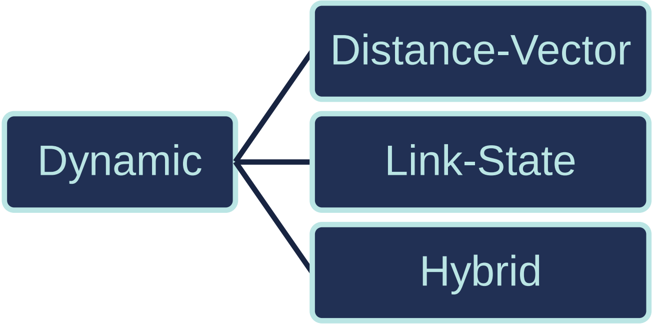
Types of Dynamic Routing Protocols

- There are three different types of dynamic routing protocols, which we'll discuss in detail later in this section



IGPs & EGPs

AS (Autonomous System)

- Autonomous = Independent Entity (*Organization*)
  - University, Corporation, Governmental Agency
- Routers are usually part of an Autonomous System (AS)
  - IP routes under common control

- An **AS** is a connected group of one or more IP prefixes run by one or more network operators with a **single** and **clearly defined** routing policy (*Single Organization*)

- Important point of reference for discussing Interior Gateway Protocols (IGP) and Exterior Gateway Protocols (EGP)

IGP (Interior Gateway Protocol)

- Used within a single AS (*Your Organization*)
  - Not intended to route between Autonomous Systems
    - That's why there's Exterior Gateway Protocols (EGPs)

- IGP Protocols
  - RIP (Routing Information Protocol)
  - OSPF (Open Shortest Path First)
  - EIGRP (Enhanced Interior Gateway Routing Protocol)

EGP (Exterior Gateway Protocol)

- Used to route between Autonomous Systems
  - Internet Service Providers (ISPs)

- BGP (Border Gateway Protocol)
  - Almost all ISPs uses BGP as their EGP

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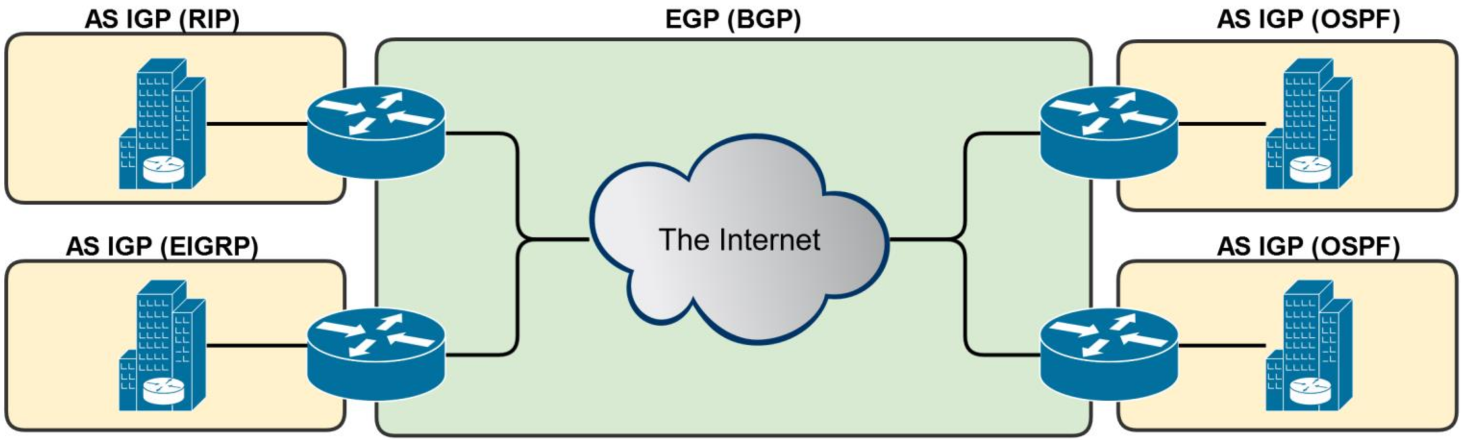
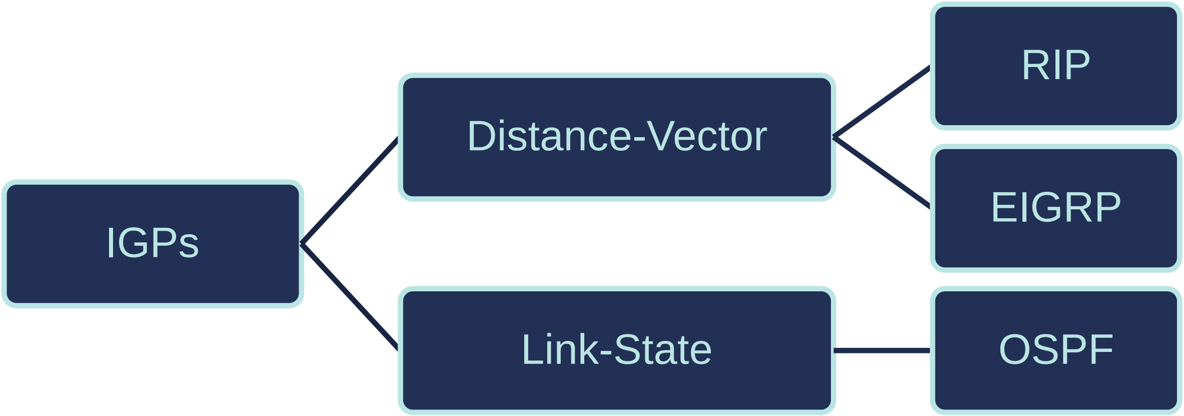
EGP & IGPs Working Together



Interior Gateway Protocols (IGPs)

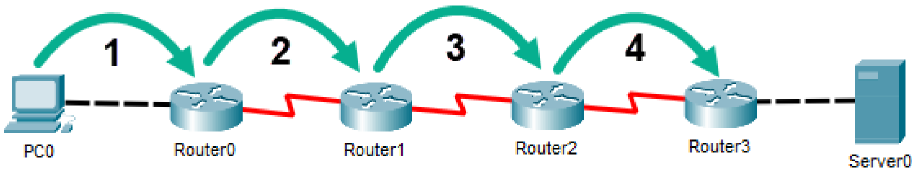
Interior Gateway Protocols (IGPs)

- There are three different types of IGPs:



Distance-Vector

- Like its name implies, distance-vector routing protocols use distance as their metric for making routing decisions.
    - Distance = Hop Count
    - Hops are the number of routers that a packet passes through from its source to its destination.



- Distance-Vector Routing Protocols:
    - Router Information Protocol (RIP)
    - Enhanced Interior Gateway Routing Protocol (EIGRP)

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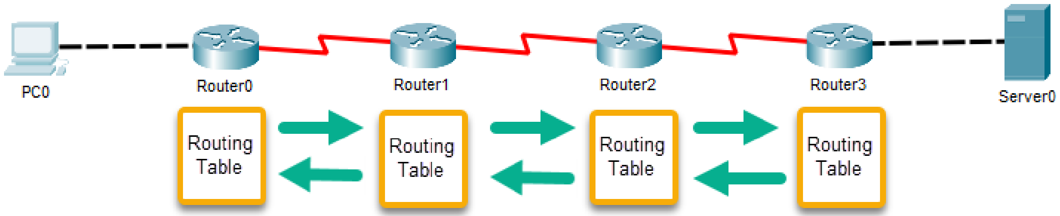
Router-Information Protocol (RIP)

- A long-established distance-vector protocol with three versions
- Supports a maximum of 15 hops to prevent routing loops
  - Doesn’t scale well due to 15 hop limitation.
- Sends a full copy of its routing table to directly connected routers every 30 seconds
  - Slow network convergence times, which can lead to potential routing loop issues
  - For example: router 3 may need to wait up to 90 seconds to get router 0’s full routing table
  - Lead to unnecessary network traffic and high router CPU utilization



Enhanced Interior Gateway Routing Protocol (EIGRP)

- A Cisco proprietary routing protocol that only works on Cisco routers.
- Not a true distance-vector routing protocol
  - Utilizes hop count metrics, but also reliability, bandwidth, load, and delay metrics.
  - Can be considered an ***advanced distance-vector*** or ***hybrid*** routing protocol

- Has a default hop count of 100 and a maximum of 255
- Supports classless routing and VLSM
- Very fast converging and very scalable for larger networks

Link-State

- Link-state routing protocols build a map of the entire network.
- Utilize link-state advertisements (LSAs) to accomplish this:
  - Routers share information with all other routers on the network via LSAs.
  - This allows them to build a complete network map.
- Once the network map is built, routers only update each other when there is a change to the network.
- Otherwise, they don't communicate, except with a periodic "*hello*" packet, so the other routers know they are up and functioning.
- This leads to faster network convergence times that support larger networks.
- Link-State Routing Protocol:
  - Open Shortest Path First (OSPF)

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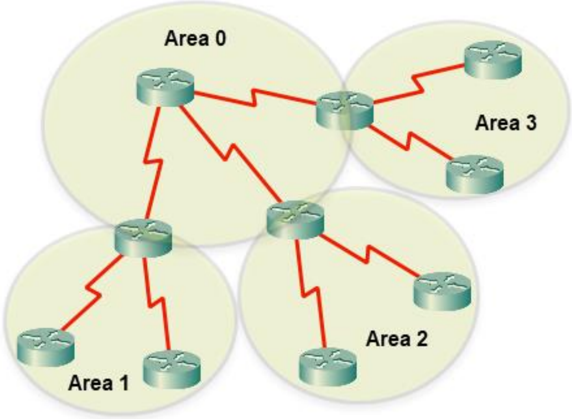
Open Shortest Path First (OSPF)

- Open standard link-state routing protocol
- Well suited for large networks with multiple redundant paths.
- It builds a topological routing tree, call a shortest-path tree.
- Sub-divides a larger network into areas where routers share information with other routers in their designated area:
    - Minimizes routing update traffic and improves network convergence times
- Uses “cost” metrics to determine the “best” route by including link state and speed.
- Supports classless addressing and VLSM
- Has an unlimited hop count



Border Gateway Protocol (BGP)

Border Gateway Protocol (BGP)

- The only EGP in widespread use today
- Considered the Internet's core routing protocol
  - Supports IPv4 and IPv6
  - Highly Scalable
- Often called a path-vector (hybrid) routing protocol
  - Each ISP is assigned a unique Autonomous System (AS) number
  - Uses the number of AS hops rather than individual router hops as its metric
- Utilizes the BGP Best Path Selection algorithm to identify the best route
- Routing protocol from AS to AS
  - When you connect to the Internet, you're moving from one AS to another

Routing Tables and AD

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Routing Table Entries

Routing table categories:

- **Directly Connected Routes**
  - Networks that are directly connected to the router.
- **Remote Network Routes**
  - Networks that aren’t directly connected to the router.
- **Default Routes**
  - Routes when no match is found in the routing table.

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Routing Table Components

- Routing tables, at a minimum, will include the following information:
    - Type
    - Destination Network ID & Subnet Mask
    - Router Interface
    - Metric

Type	Network	Interface	Metric
Connected	192.168.1.0/24	FastEthernet0/0	0
Connected	200.100.100.0/24	Serial0/0	0
Static	192.168.0.0/24	Serial0/0	1
Static	0.0.0.0/0	Serial0/0	1

Administrative Distance (AD)

- Routers use administrative distance (AD) to rate the overall trustworthiness of a route.
- AD's can have a value ranging from 0 to 255, where lower is better, based on the type of route.
- If a router receives routing table updates from two different sources, it'll utilize the one with the lower AD.

Type	Default AD
Connected Interface	0
Static Route	1
EIGRP	90
OSPF	110
RIP	170
Unknown	255

The Default Route

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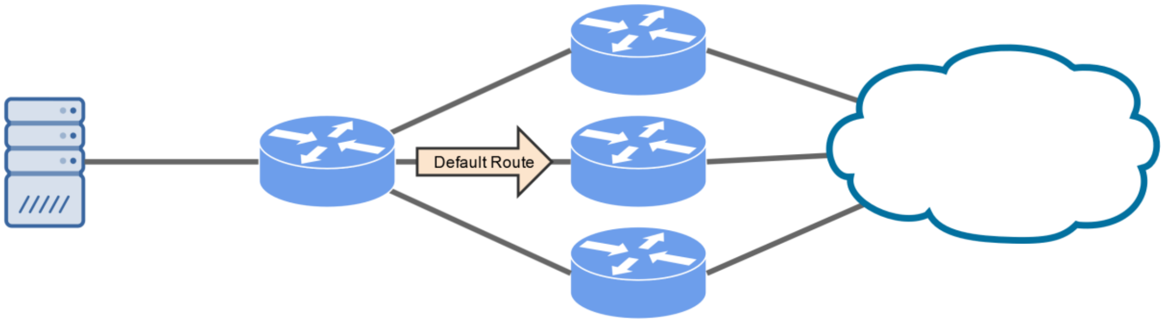
The Default Route



- A static route that's utilized when a packet's destination IP address has no known match in a router's routing table.
- If there's no match → forward the packet on via the default route.
- Commonly called the gateway of last resort.
- The following addresses are used to represent the default route in a routing table:
    - **IPv4:** 0.0.0.0/0
    - **IPv6:** ::/0