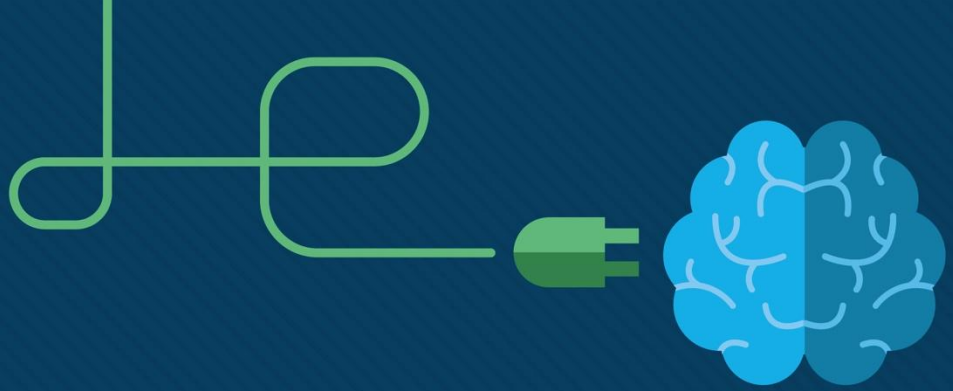


# Module 5: Network Layer (Part-3)

Introduction to Networks v7.0 (ITN)

# 5.9: Routing Concepts

# Forwarding & Routing

**Two Keys of Network-Layer Functions:**

1. Forwarding
2. Routing

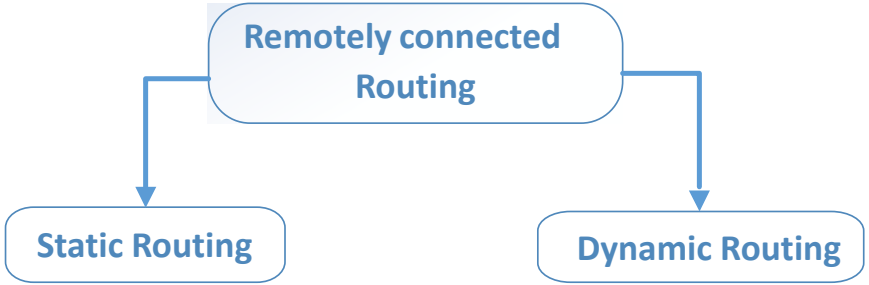
**FORWARDING:** is to place the packet in its route to its destination. Forwarding requires a host or a router to have a routing table. When a host has a packet to send or when a router has received a packet to be forwarded, it looks at this table to find the route to the final destination.

**ROUTING:** is forwarding of packets from one network to another network choosing the best path from the routing table. So the **Routing table** consist of only the best routes for every destination.

# Types of Routing

The networks can either be directly connected to the router or remotely connected.

- **Directly connected** to the router, which can identify it on its own without assistance.
- **Remotely connected** subnets that connect to other router devices that it can recognize either:
  1. **Manually** (statically), with the help of the network engineer and writing a static route for it.
  2. **Automatically** (Dynamically) using automatic routing protocols (Dynamic Routing Protocol).



# Static vs Dynamic Routing

| Static Routing | Dynamic Routing |
|---|---|
| Static routing is ideal for small networks | Dynamic routing is suitable for large networks |
| Configuring static routes involve less cost and can be easily maintained by the network administrator. | Dynamic routing involves the cost in terms of CPU processes and bandwidth on the network links. |
| Routes cannot be changed until authorized by the network administrator. | Routing protocols find the routes for traversing the packets. |
| Routers are not updated dynamically in the routing table and hence cannot detect inactive routes. | Routing protocols update the routing table with the updates routes. |

# 5.10: Static Routing

# Static Routing

**Static routing is a process in which we have to manually add routes to the routing table with the help of the network engineer and writing a static route for it.**

- To manually identify the “Router” device with the remote networks (Remote Subnets) and the ports (Interfaces) that it will use to access these networks, we create a static route using the IP Route command or the IPv6 Route command as follows: -

**IP Route [Network ID] [mask] [Interface Type/Number]**

**IPv6 Route [Network ID] /[Prefix] [Interface Type/Number]**

# Static Routing

## Advantages

- No routing overhead for the router CPU which means a cheaper router can be used to do routing.
- It adds security because an only administrator can allow routing to particular networks only.
- No bandwidth usage between routers.

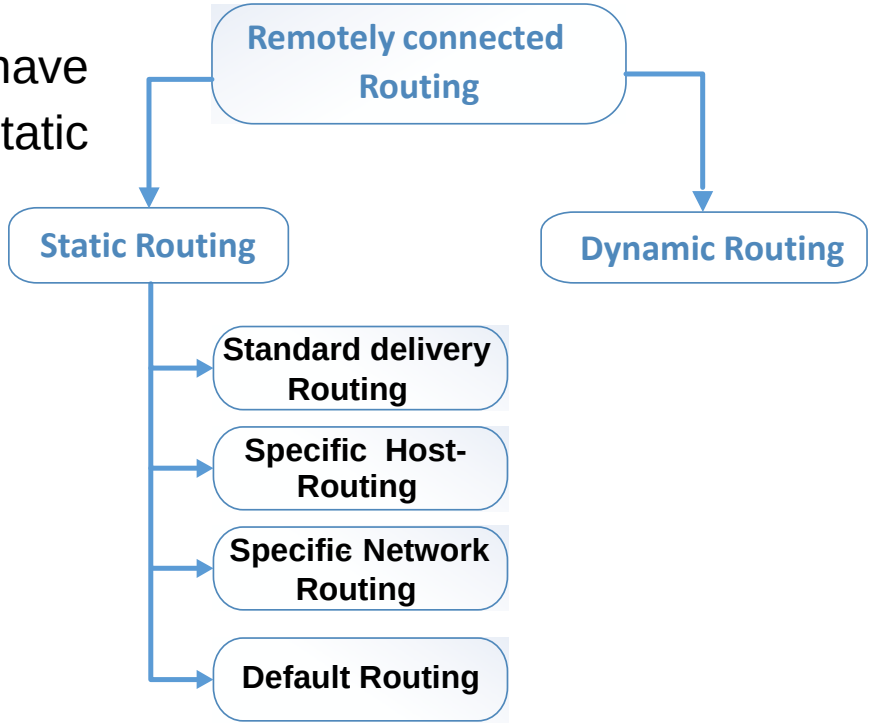
## Disadvantages

- For a large network, it is a difficult task for administrators to manually add each route for the network in the routing table on each router.
- The administrator should have good knowledge of the topology. If a new administrator comes, then he has to manually add each route so he should have very good knowledge of the routes of the topology.

# Static Routing types

To form the routing table we must have knowledge of the different types of static routes:

1. Standard Delivery Routing
2. Host-Specific Routing
3. Network-Specific Routing
4. Default Routing

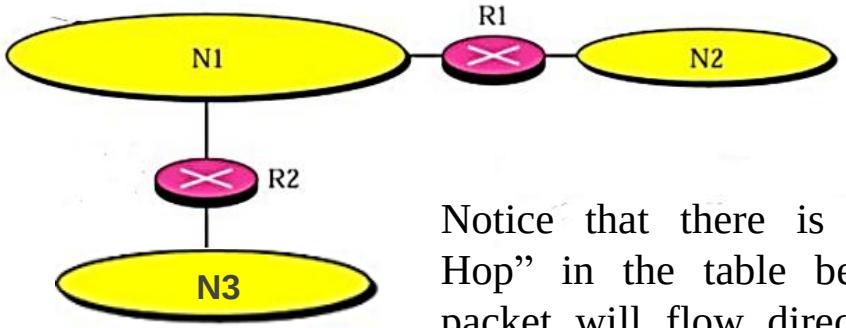


# Standard-Delivery routing

This type of static route is used to route packet directly to the interfaced networks without using a mediator.

Routing table for R1

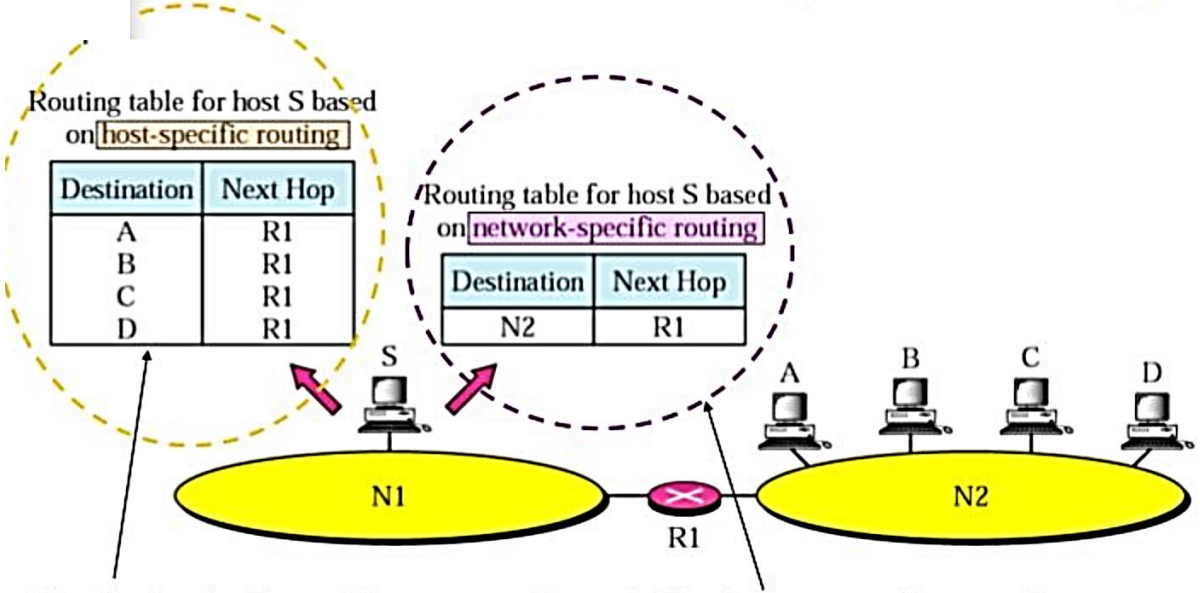
| Destination | Next Hop |
|---|---|
| N1 | ----- |
| N2 | ----- |
| ---- | ----- |




Notice that there is no “Next Hop” in the table because the packet will flow directly to the interfaced network.

# Static Routing

## Host-specific & Network-specific routing



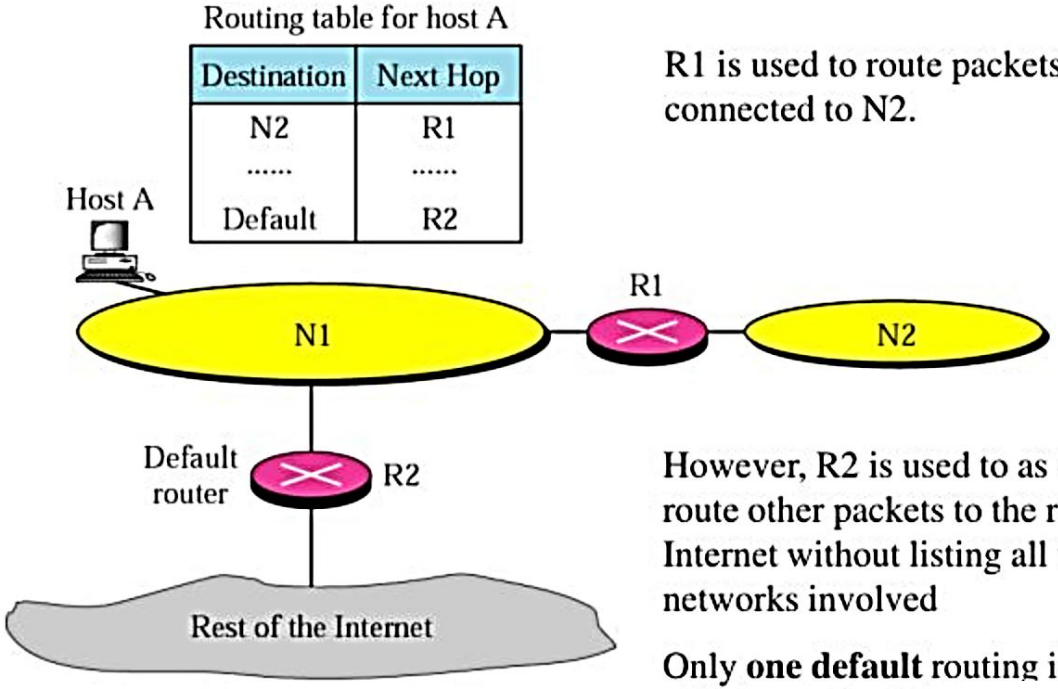

The destination host address is given in the routing table; to have greater control over routing.

Instead of having an entry for every host connected to the same network, only one entry is needed to defined the address of the network itself. All host connected to the same network as one single entity.

5

# Static Routing

## Default routing




R1 is used to route packets to hosts connected to N2.

However, R2 is used to as default to route other packets to the rest of Internet without listing all the networks involved

Only **one default** routing is allowed with network addres "any"

# Routing table

a) Generally, a routing table needs a minimum of (4) columns: mask, destination network address, next hop address and interace.

b) When a packet arrives, the router applies the mask to the destination address it receives (one-by-one until a match is found) in order to find the corresponding destination network address.

c) So, the mask serves as essential tool to match destination address in routing table and the address it receives.

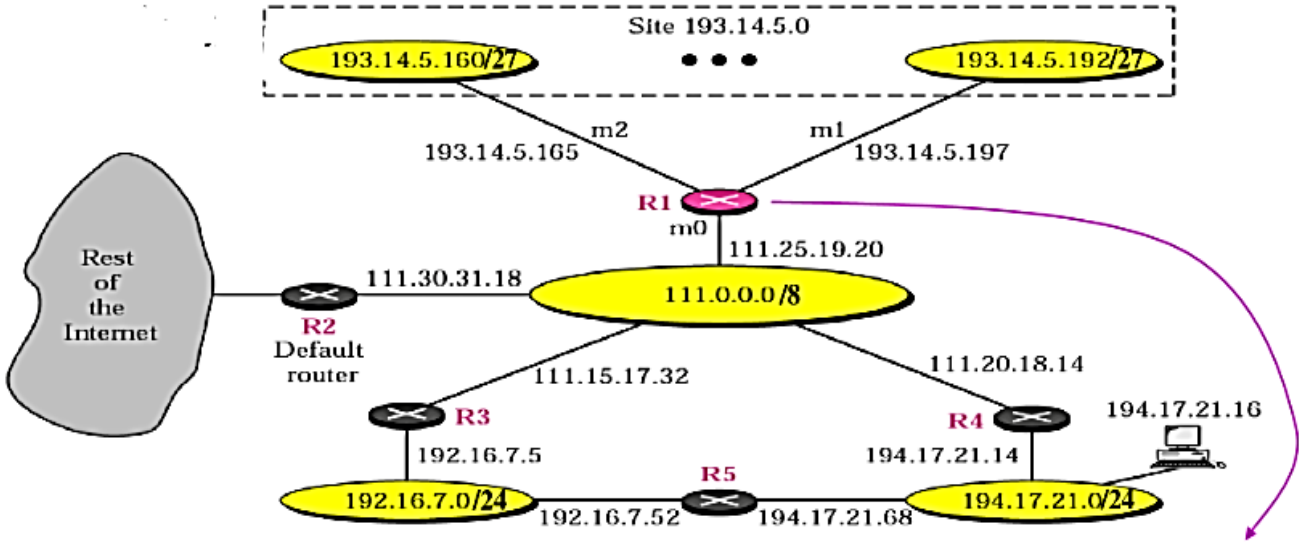
d) If found, the packet is sent out from the corresponding interlace in the table. If not found, the packet is delivered to the default interface which carries the packet to default router.

| Mask | Destination address | Next-hop address | Flags | Reference count | Use | Interface |
|---|---|---|---|---|---|---|
| 255.0.0.0 | 124.0.0.0 | 145.6.7.23 | UG | 4 | 20 | m2 |

# Static Routing

## Example 5-1

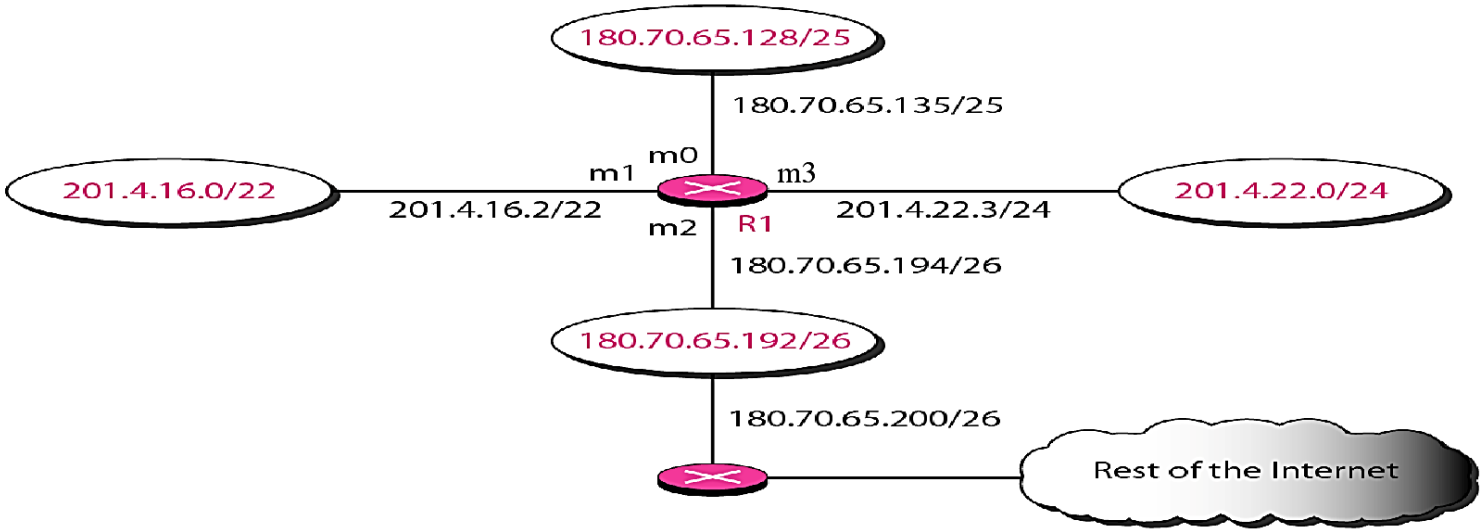
Make the routing table for router R1 using the configuration shown in the figure:




| | Mask | Dest | Next Hop | I. |
|---|---|---|---|---|
| Standard delivery | /8 | 111.0.0.0 | -- | m0 |
| | /27 | 193.14.5.160 | - | m2 |
| | /27 | 193.14.5.192 | - | m1 |
| Host-specific | /24 | 194.17.21.16 | 111.20.18.14 | m0 |
| Network-specific | /24 | 192.16.7.0 | 111.15.17.32 | m0 |
| | /24 | 194.17.21.0 | 111.20.18.14 | m0 |
| Default | /0 | 0.0.0.0 | 111.30.31.18 | m0 |

## Example 5-2

Make the routing table for router R1 using the configuration shown in the figure below:



# Static Routing

## Example 5-2 (contd.)

Solution

***Routing table for router R1 in Figure above***

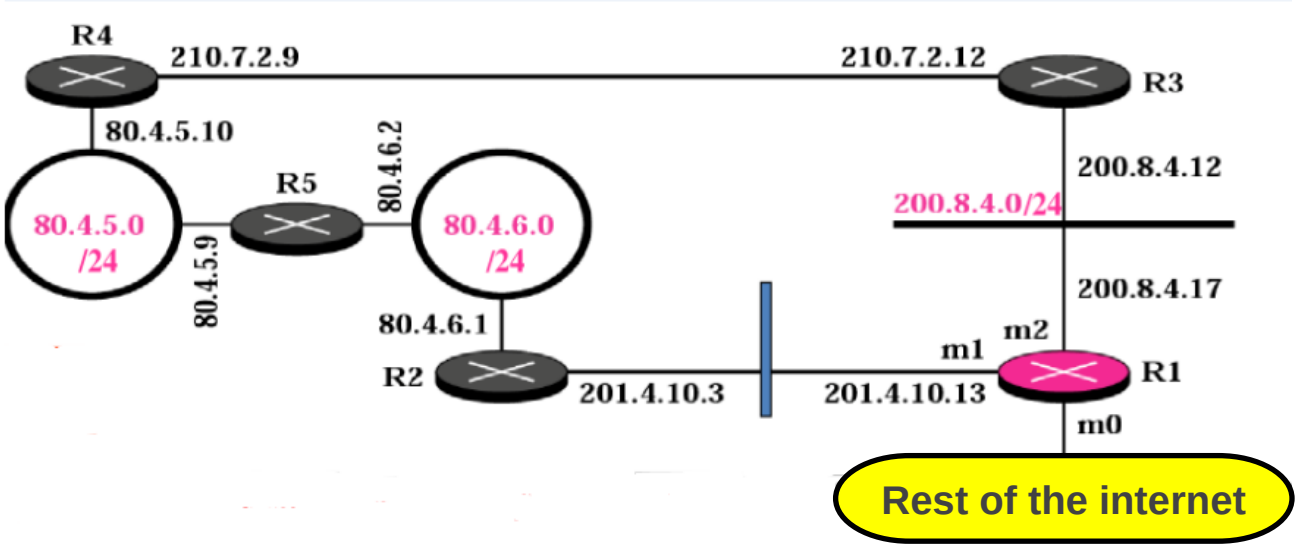
| | Mask | Network Address | Next Hop | Interface |
|---|---|---|---|---|
| Standard Delivery | /26 | 180.70.65.192 | — | m2 |
| | /25 | 180.70.65.128 | — | m0 |
| | /24 | 201.4.22.0 | — | m3 |
| | /22 | 201.4.16.0 | .... | m1 |
| Default | /0 | 0.0.0.0 | 180.70.65.200 | m2 |

The table is sorted from the longest mask to the shortest mask.

# Static Routing

## HOMEWORK

Make the routing table for router R1 using the configuration shown in the figure:



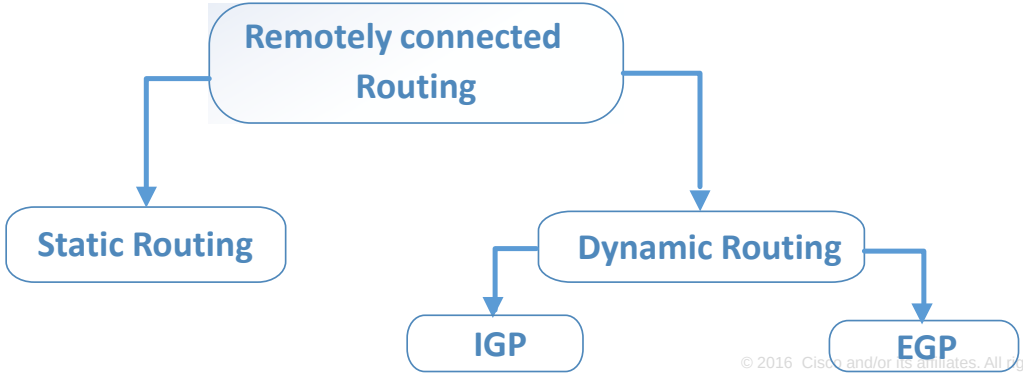
# 5.11 Dynamic Routing

# Dynamic vs Static Routing (Rep.)

| Dynamic Routing | Static Routing |
|---|---|
| Dynamic routing is suitable for large networks | Static routing is ideal for small networks |
| Dynamic routing involves the cost in terms of CPU processes and bandwidth on the network links. | Configuring static routes involve less cost and can be easily maintained by the network administrator. |
| Routing protocols find the routes for traversing the packets. | Routes cannot be changed until authorized by the network administrator. |
| Routing protocols update the routing table with the updates routes. | Routers are not updated dynamically in the routing table and hence cannot detect inactive routes. |

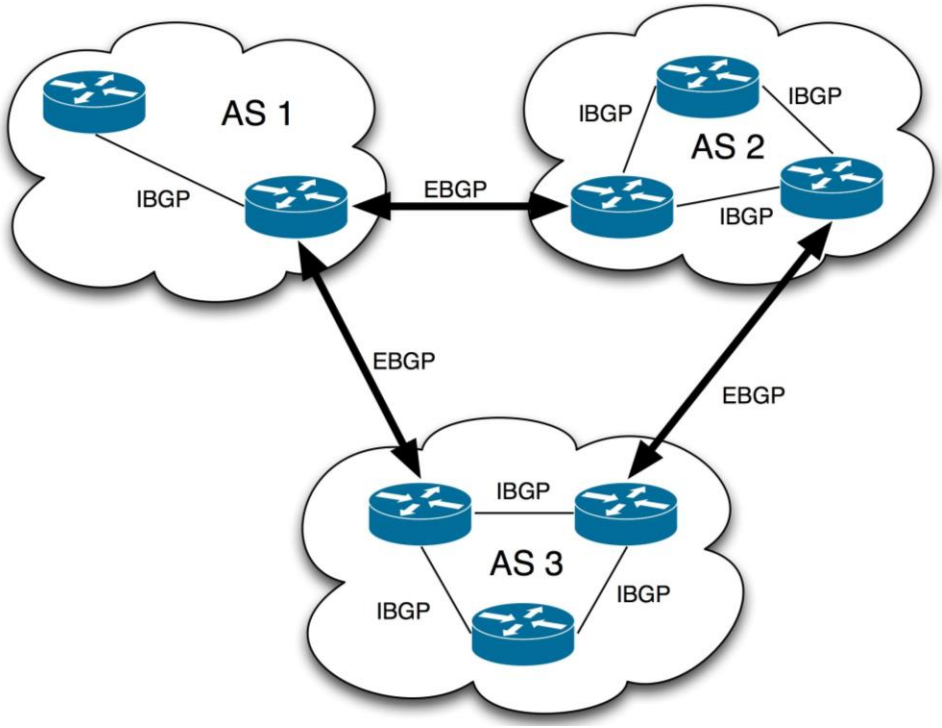
# Dynamic Routing
# Interior vs Exterior Gateway Protocol

| Interior Gateway Protocols (IGP) | Exterior Gateway Protocols (EGP) |
|---|---|
| Used in LANs | Used in WANs |
| RIP, OSPF, EIGRP,IS-IS | BGP |
| Choose the best path according to best (or minimum) **Administrative Distance** (AD) (which is a number between 0 and 255). | Used **Autonomous System** (AS) which is a group of routers and networks working under a single administrative domain (which is a number between 1 and 65535). |



# Autonomous Systems (AS)

- The Autonomous System (AS) is a group of networks and routers under the authority of a single administrator.
- AS number (ASN) is a globally unique 16-digit identification number assigned by IANA (Internet Assigned Numbers Authority)
- ASN range is 1 to 65535. From 1 to 64511 are available by IANA for global use called public AS number. And the 64512 to 65535 series is reserved for private communication purposes more like private IP addresses.



# Administrative Distance(AD)

- **Administrative distance** (**AD**) or **route** preference is a number of arbitrary unit assigned to dynamic routes, static routes, and directly -connected routes. The value is used in routers to rank routers from most preferred (low AD value) to least preferred (high AD value).

- AD is a number between 0 and 255 as shown in the table.

- When multiple paths to the same destination are available in its routing table, the router uses the route with the lowest administrative distance.

| Route Source | Default Distance Values |
|---|---|
| Connected interface | 0 |
| Static route | 1 |
| Enhanced Interior Gateway Routing Protocol (EIGRP) summary route | 5 |
| External Border Gateway Protocol (BGP) | 20 |
| Internal EIGRP | 90 |
| IGRP | 100 |
| OSPF | 110 |
| Intermediate System-to-Intermediate System (IS-IS) | 115 |
| Routing Information Protocol (RIP) | 120 |
| Exterior Gateway Protocol (EGP) | 140 |
| On Demand Routing (ODR) | 160 |
| External EIGRP | 170 |
| Internal BGP | 200 |
| Unknown* | 255 |

# 5.12: Routing Protocol vs. Routing Algorithm

# Routing Protocol vs. Routing Algorithm

## Routing Protocol vs. Routing Algorithm

- A **Routing Protocol** is a combination of rules and procedures that lets routers in an internet inform each other of changes.
- A **Routing Algorithm** is that part of network layer software responsible for deciding which output line and incoming packet should be transmitted on.

# Routing Protocol vs. Routing Algorithm

## What is a routing algorithm?

Routing algorithm is a set of rules that determine the path of a data packet to reach it from source to destination.

## Why do we use routing algorithm?

The primary function of routing algorithm is to find the shortest and optimal path between source and destination in computer Networks.

## What are the main types of Dynamic routing algorithms?

There are mainly two types of routing algorithms: **Interior Gateway (IGP)** and **Exterior Gateway Protocols (EGP)**. IGP subdivided to two algorithms: **1. Distance Vector Routing algorithms (DVR)** and **2. Link State Routing algorithms (LSR)**, while EGP have a single algorithm, **Path Vector Routing algorithm (PVR).**

# Routing Protocol vs. Routing Algorithm