# Router and Routing in Details

Presented by
Omid Panahi
Part-2

Champlain
COLLEGE SAINT-LAMBERT

# Goals of this section

- Explain how routers work
- Describe dynamic routing technologies
- Install and configure a router successfully

# Default Route entry

- Although it might be technically possible for routers to have a record of every network in the Internet, having such large routing tables isn't practical. To solve this dilemma, routers can have a special routing table entry called a default route, which tells a router where to send a packet with a destination network that can't be found in the routing table.

# Network Unreachable

- Most routers are configured with a default route, but not always. If a router receives a packet with a destination network address that <u>isn't in its routing table</u> and no default route is configured, the router simply discards the packet. The router may also send a message to the sending station informing it that the network is unreachable

# Default Gateway

- Just as a router must know where to forward a packet it receives, a workstation must know when to send a packet to the router instead of simply addressing the packet and sending it to the local LAN.
- When a workstation sends a packet, it compares its IP address with the destination's.
  If both are on the same network, it sends the packet directly using the destination's MAC address.
  If they're on different networks, the workstation sends the packet to its **default gateway (router)**, which forwards it toward the destination.

# Routing Tables In Depth

- The routing table in most routers contains the following information for each table entry:

- Destination Network(Usually expressed in CIDR)
- Next hub(indicates an interface name or the address of the next router)
- Metric or Cost (a numeric value that tells the router how “far away” the destination network is)
- How the route is derived (dynamic Route , static Route, direct connect)
- Timestamp(A timestamp tells the router how long it has been since the routing protocol. Not all routing protocols require a timestamp.)

# Routing Protocols

- As mentioned in previous slides, routing tables are filled in three ways:
- **directly connected networks**,
- **static routes**,
- **dynamic routes**

- Routing protocols use rules that let routers **exchange information** and **maintain accurate routing tables** across the network.

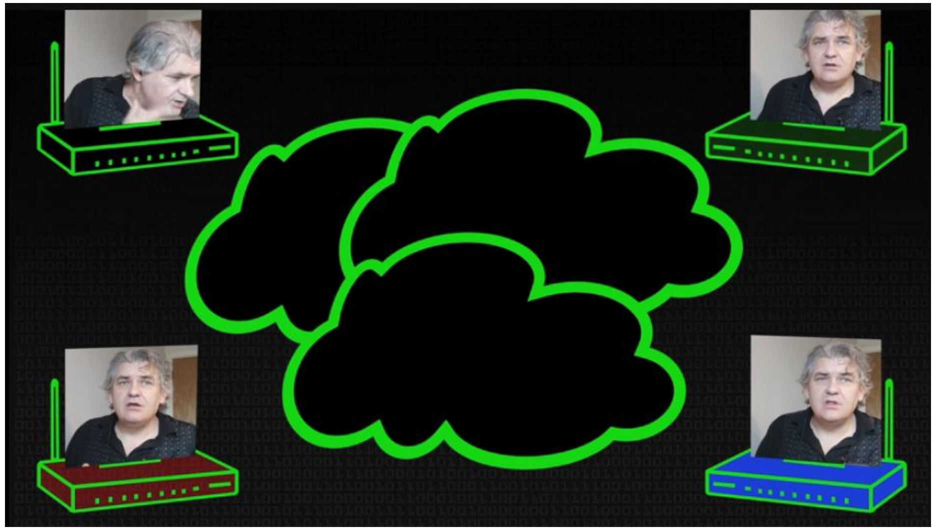
# Distance vector Algorithm (Bellman-Ford)

The algorithm was first proposed by **Alfonso Shimbel (1955)**, but is instead named after **Richard Bellman** and **Lester Ford** Jr., who published it in 1958 and 1956, respectively.

**Bellman-Ford Algorithm**: This is the foundational algorithm for Distance Vector protocols. It enables each router to determine the best path to a destination based on the information from its neighbors

**Richard Bellman**

**Lester Ford**



# Distance-vector protocols

- Distance-vector protocols share information about an internetwork's status by copying a router's routing table to other routers with which they share a network with direction
- Routers sharing a network are called ***neighbors***.
- Distance-vector protocols use metrics based on factors such as hop count, bandwidth of the links between networks, network congestion, and delays
- **Routing by Rumor**: Routers make routing decisions based on the information provided by their neighbours without verifying the information's accuracy. This is sometimes referred to as "routing by rumour."

# Distance vector protocols

**Periodic Updates**: Typically, routers periodically send the entire routing table to their neighbours. If there's a change in the network, it might take a while to propagate to all routers, leading to slower convergence.

**Count to Infinity Problem**: One of the challenges with basic Distance Vector algorithms is the potential for "count to infinity" loops. If a network goes down, routers can end up in a loop where they continuously increment the hop count to a destination, which leads to very slow convergence.

**Route Poisoning and Split Horizon**: To combat the count-to-infinity problem, two techniques are often used.

Route poisoning involves setting the distance to a failed network to an infinite metric.

Split Horizon prevents information about routes from being advertised back in the direction from which the original update came.

They are the most well-known distance-vector routing protocols. RIP and RIPv2 consider only hop count in path selection, with Multiple path the lower hop count is selected . Maximum number of hop is 15

- Routing Information Protocol (RIP)
- Routing Information Protocol version 2 (RIPv2)

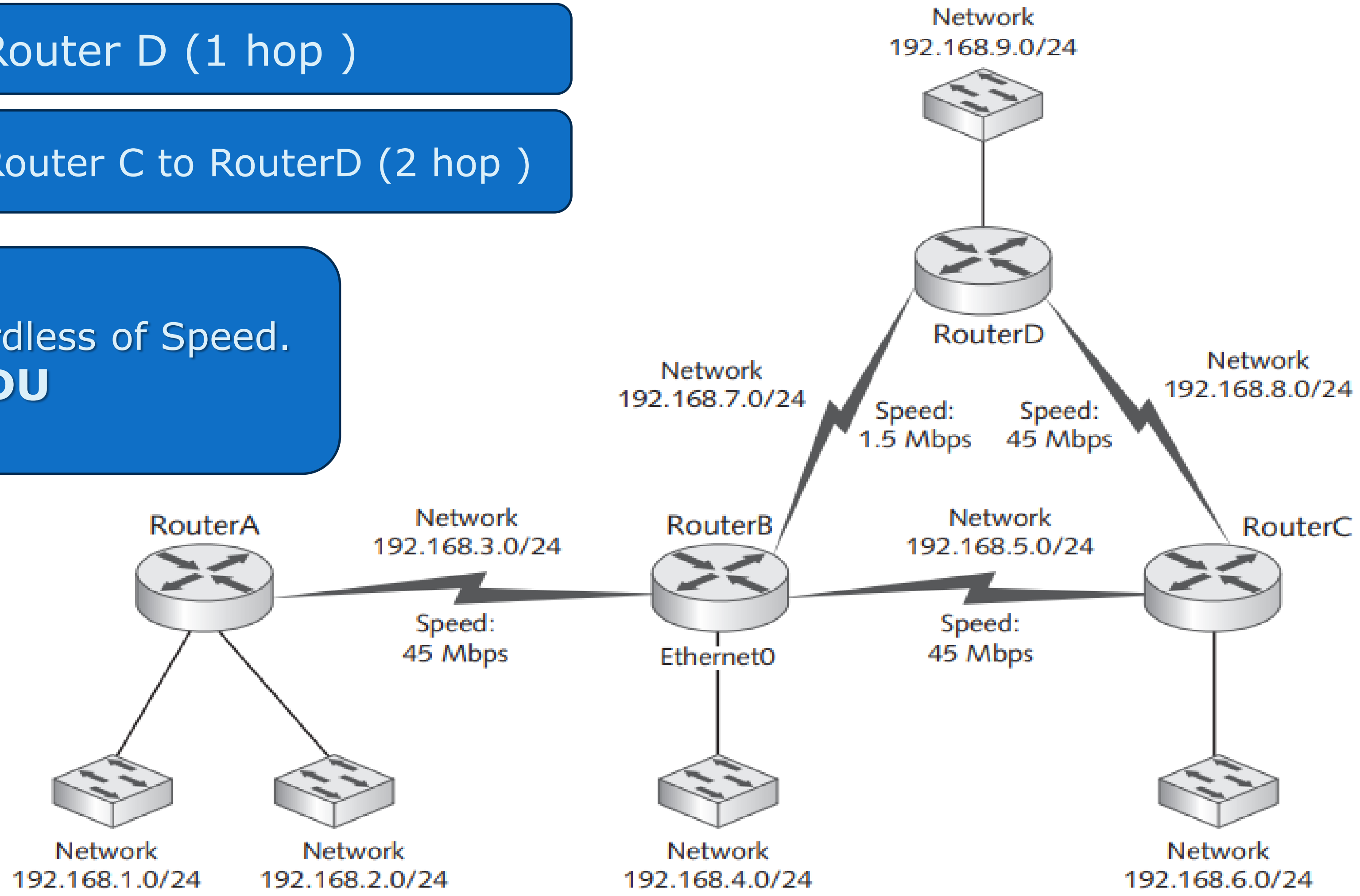
When using RIP, a router always chooses the path with the lower hop count

Two paths from RouterB to network 192.168.9.0

**Path 1**: from Router B to Router D (1 hop )

**Path 2**: from RouterB to RouterC and Router C to RouterD (2 hop )

RIP protocol uses less hop counts regardless of Speed.
So, **path 1 is selected to send PDU**

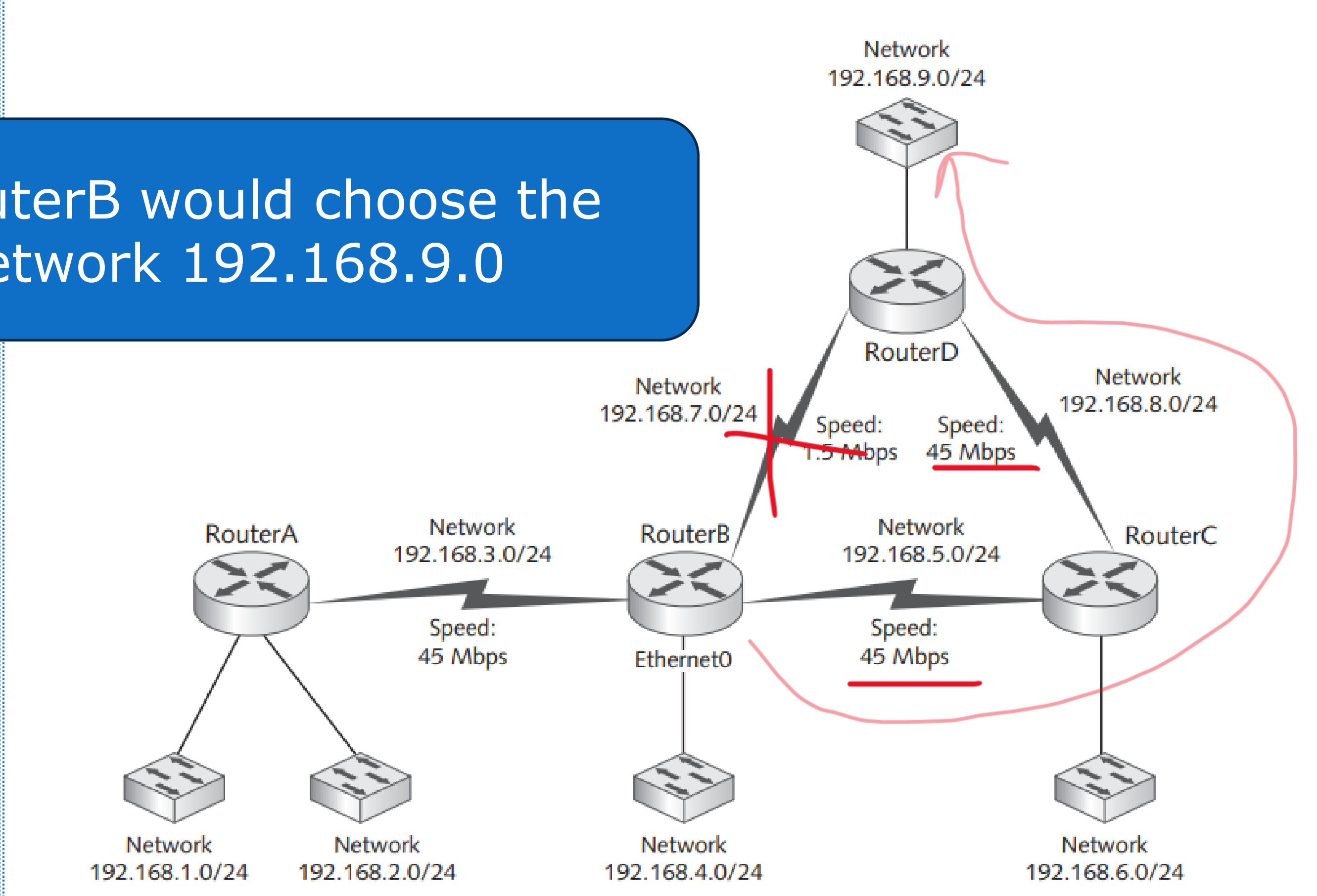


# Link-state protocols (OSFP)

- Routers using **link-state protocols** share the status of their links (speed, state, and network number) with other routers only when changes occur.
  They run an **algorithm** to calculate the best path to each network, using link speed as the main **metric**.
  This method needs more processing power but provides more accurate routing decisions
- **Open Shortest Path First (OSPF)** is a common example.

# OSPF will calculate the speed of links

if OSPF were the routing protocol, RouterB would choose the route through RouterC to get to network 192.168.9.0



# Distance vector protocols Limitations

**Scalability**: Distance Vector protocols tend to be less scalable than Link State protocols because of their periodic updates and limitations like the hop count restriction in RIP.

**Slow Convergence**: As mentioned, changes in the network might take a while to propagate to all routers, leading to slower convergence and potentially incorrect routing decisions in the interim.

**Advantages:**

- **Simplicity**: They are generally simpler to configure and understand than Link State protocols.

- **Lower CPU and Memory Usage**: Since they don't keep a complete topology map of the network like Link State protocols, they usually consume less CPU and memory resources.

In summary, Distance Vector protocols determine the best path to a destination based on distance metrics and directions provided by neighbouring routers. While they have limitations and are less common in modern large networks than Link State protocols, they still hold a place in smaller network setups and educational contexts.

# Link State Protocol(IS-IS)

(Intermediate System to Intermediate System)

- Another widely adopted **Link State protocol**, used predominantly in large ISPs and carrier networks. ***IS-IS*** operates in a similar manner to OSPF but has a different history and slightly different technical specifications.

# Distance-vector versus link-state routing protocols

| Protocol type | CPU use | Network use | Memory use | Speed of convergence | Size of network | When is routing data transferred? |
|---|---|---|---|---|---|---|
| Distance-vector | Lower | Higher | Lower | Slower | Small | Periodically |
| Link-state | Higher | Lower | Higher | Faster | Large | Only when a change occurs |

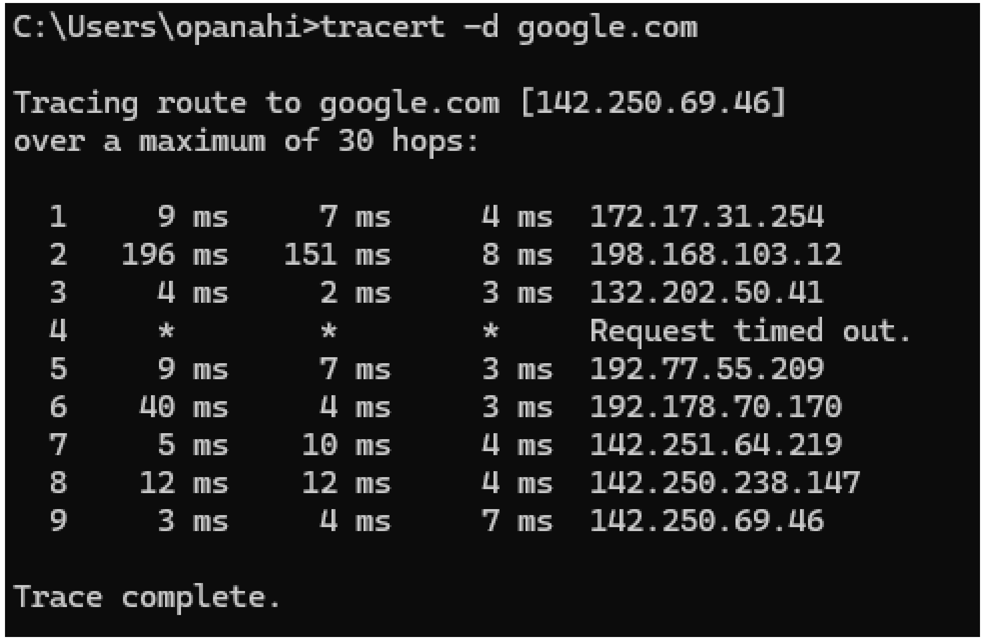
# Let’s see a router **route command** tool

```
C:\Users\opanahi>route print
===========================================================================
Interface List
 23...60 5b 30 4a 46 97 ......Realtek USB GbE Family Controller #2
  3...00 09 0f aa 00 01 ......Fortinet SSL VPN Virtual Ethernet Adapter
  7...0a 00 27 00 00 07 ......VirtualBox Host-Only Ethernet Adapter
 18...14 85 7f e2 ea 00 ......Microsoft Wi-Fi Direct Virtual Adapter
 22...16 85 7f e2 ea ff ......Microsoft Wi-Fi Direct Virtual Adapter #2
 20...00 09 0f fe 00 01 ......Fortinet Virtual Ethernet Adapter (NDIS 6.30)
 21...14 85 7f e2 ea ff ......Intel(R) Wi-Fi 6 AX201 160MHz
 19...14 85 7f e2 eb 03 ......Bluetooth Device (Personal Area Network)
  1...........................Software Loopback Interface 1
 73...00 15 5d 62 dc 65 ......Hyper-V Virtual Ethernet Adapter
===========================================================================

IPv4 Route Table
===========================================================================
Active Routes:
Network Destination        Netmask          Gateway       Interface  Metric
          0.0.0.0          0.0.0.0    172.17.31.254    172.17.30.87     45
        127.0.0.0        255.0.0.0         On-link         127.0.0.1    331
        127.0.0.1  255.255.255.255         On-link         127.0.0.1    331
  127.255.255.255  255.255.255.255         On-link         127.0.0.1    331
       172.17.0.0    255.255.224.0         On-link      172.17.30.87    301
     172.17.30.87  255.255.255.255         On-link      172.17.30.87    301
    172.17.31.255  255.255.255.255         On-link      172.17.30.87    301
     172.26.128.0    255.255.240.0         On-link      172.26.128.1   5256
     172.26.128.1  255.255.255.255         On-link      172.26.128.1   5256
   172.26.143.255  255.255.255.255         On-link      172.26.128.1   5256
     192.168.56.0    255.255.255.0         On-link      192.168.56.1    281
     192.168.56.1  255.255.255.255         On-link      192.168.56.1    281
   192.168.56.255  255.255.255.255         On-link      192.168.56.1    281
        224.0.0.0        240.0.0.0         On-link         127.0.0.1    331
        224.0.0.0        240.0.0.0         On-link      192.168.56.1    281
        224.0.0.0        240.0.0.0         On-link      172.17.30.87    301
        224.0.0.0        240.0.0.0         On-link      172.26.128.1   5256
  255.255.255.255  255.255.255.255         On-link         127.0.0.1    331
  255.255.255.255  255.255.255.255         On-link      192.168.56.1    281
  255.255.255.255  255.255.255.255         On-link      172.17.30.87    301
```

# Let’s trace a request with **traceroute** tool over Routers

- In Windows you can use **tracert** tool
- In Mac and Linux you can use traceroute
- If you see the example goes over 30 hops



```
C:\Users\opanahi>tracert -d google.com

Tracing route to google.com [142.250.69.46]
over a maximum of 30 hops:

  1     9 ms     7 ms     4 ms  172.17.31.254
  2   196 ms   151 ms     8 ms  198.168.103.12
  3     4 ms     2 ms     3 ms  132.202.50.41
  4     *        *        *     Request timed out.
  5     9 ms     7 ms     3 ms  192.77.55.209
  6    40 ms     4 ms     3 ms  192.178.70.170
  7     5 ms    10 ms     4 ms  142.251.64.219
  8    12 ms    12 ms     4 ms  142.250.238.147
  9     3 ms     4 ms     7 ms  142.250.69.46

Trace complete.
```

# Routing Table

| Destination LAN IP | Subnet Mask | Gateway | COST | Interface |
|---|---|---|---|---|
| 10.12.14.0 | 255.255.255.0 | 0.0.0.0 | 6 | WAN1 |
| 76.30.4.0 | 255.255.254.0 | 0.0.0.0 | | |
| 10.12.14.0 | 255.255.255.0 | 0.0.0.0 | 3 | WAN2 |
| 00.0.0.0 | 0.0.0.0 | 76.30.4.1 | | |

10.12.14.2 -> 10.12.14.5
10.12.14.2 -> 8.8.8.8

## Interior Gateway Protocol (IGP) Versus Exterior Gateway Protocol(EGP)

- **Interior Gateway Protocol (IGP):**

  IGPs are used in an autonomous system, which is an internetwork managed by a single organization

- **Exterior Gateway Protocol(EGP)**

  EGPs are used between autonomous systems, such as between an organization's network and an ISP or between two ISPs

# When to Use a Routing Protocol vs Static Routes?

- **Network Changes Frequently:**
  - Use a routing protocol if networks are added or removed often.
  - Use static routes if the network is stable.
- **Multiple Paths Exist:**
  - Routing protocols automatically reroute traffic around failures or congestion.
  - *Static routes* must be updated manually by an administrator.
- **Large or Complex Internetwork:**
  - Routing protocols handle routing table updates automatically.
  - Static routes become difficult to manage as the network grows.

# Hands-On Lab for Router: Communicating over a Route

Champlain

COLLEGE SAINT-LAMBERT