Router and Routing in Details

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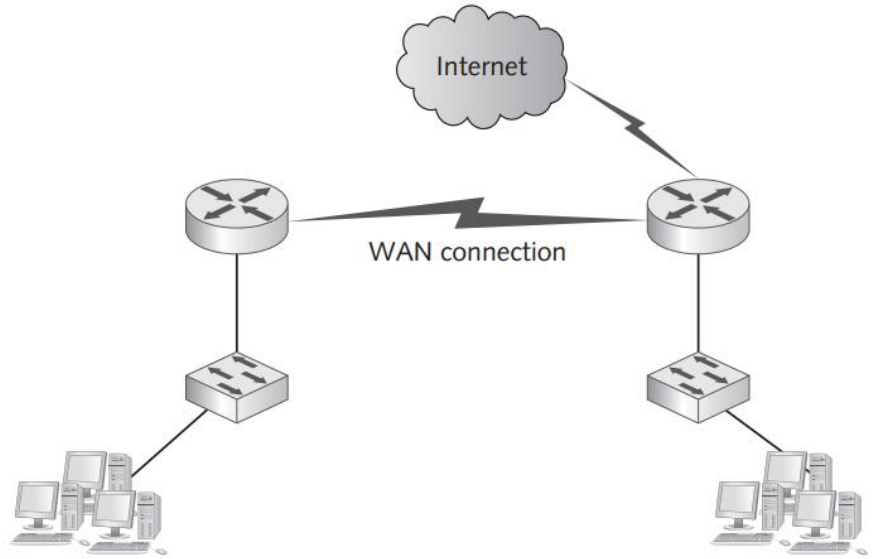
Goals of this section

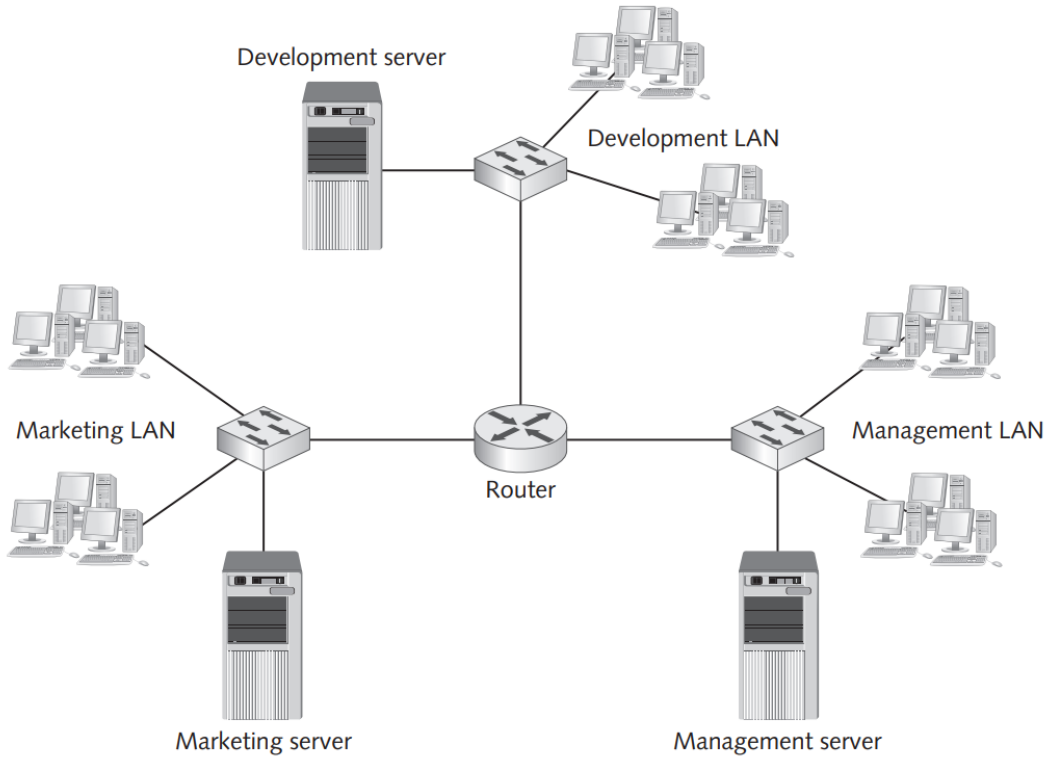
- Explain how routers work
- Describe dynamic routing technologies
- Install and configure a router successfully

Router

- Routing enables us to interconnect individual LANs into WANs. (Or one network to a different network).
- Routers, interconnection points, have all the built-in smarts to inspect incoming WAN packets and forward them toward their eventual LAN destination.

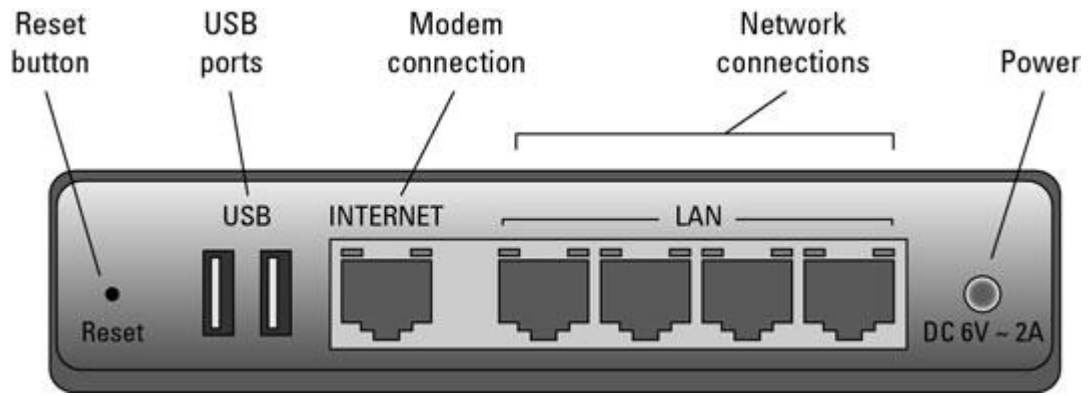
A WAN with a connection to the Internet





Router Ports

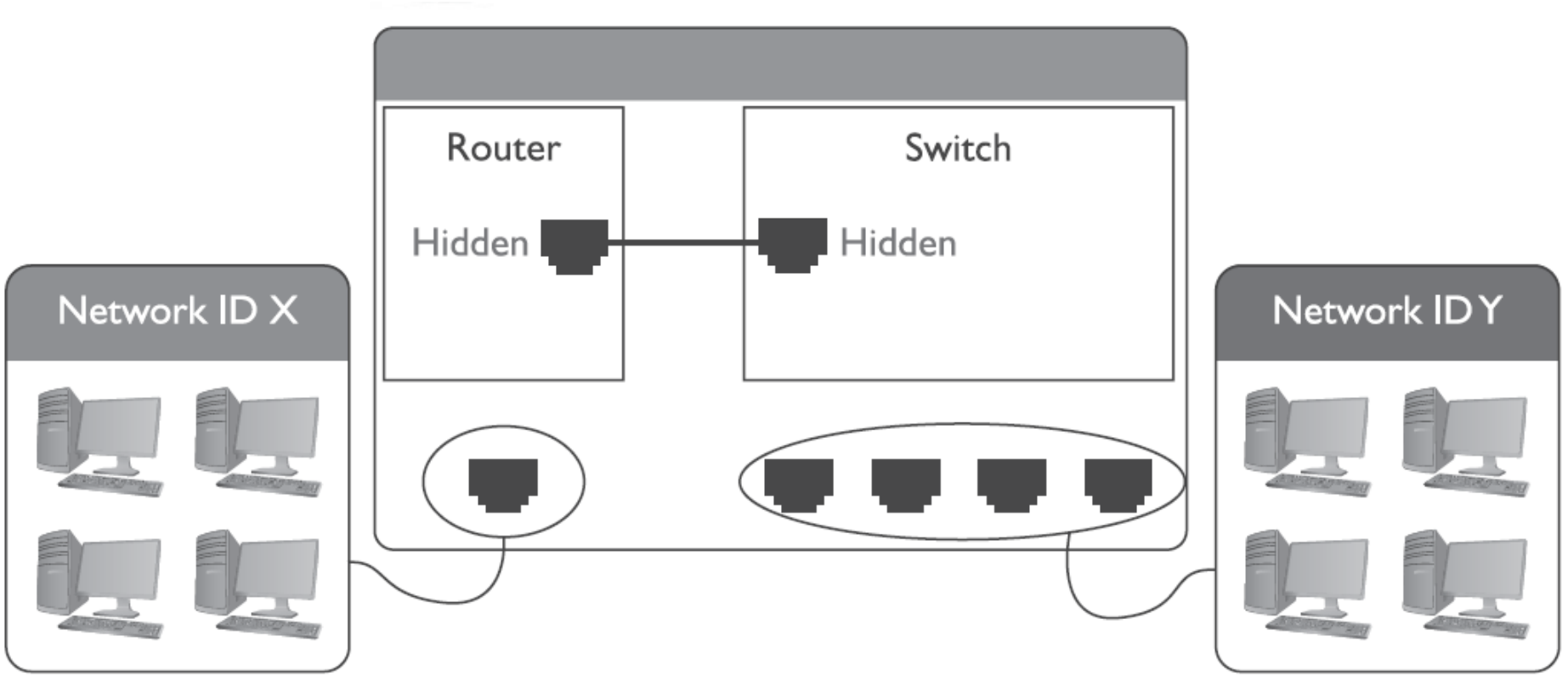
- Common Configuration
  - 1 Port to WAN (Internet)
  - 1 or more ports to internal LAN. (Usually 3 or 4).



Difference between Router and Bridge

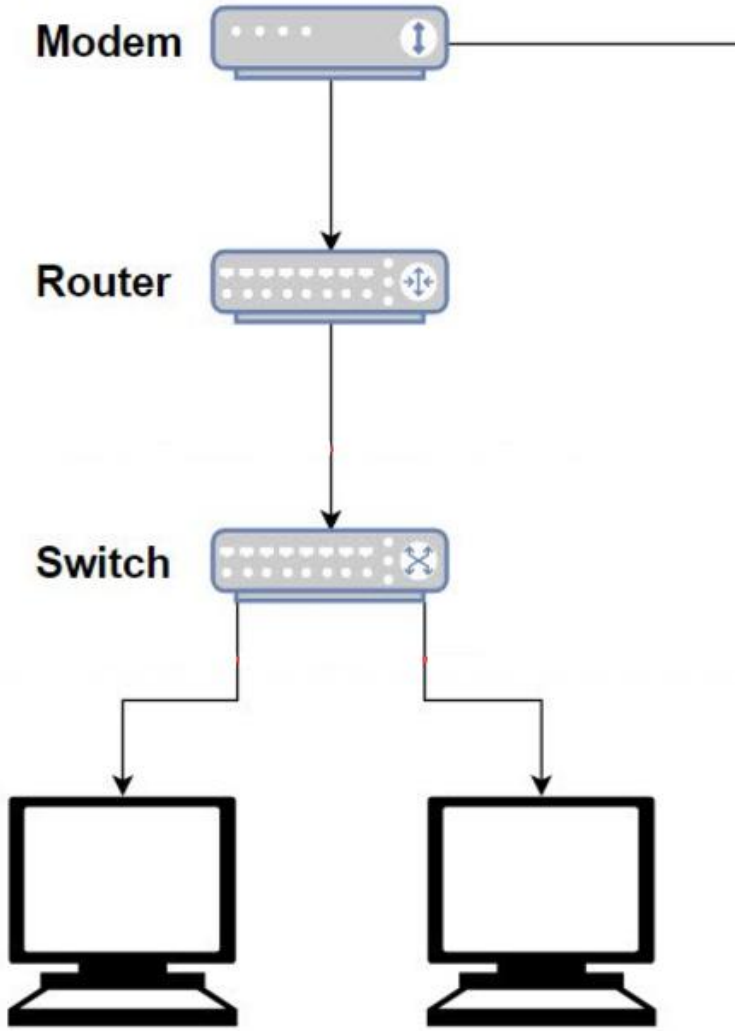
- Routers are **more intelligent** than bridges.
- Routers allow hosts that aren't practically on the same logical network to be able to communicate with each other, while bridges can only connect networks that are logically the same.
- **Routers operate at the layer 3** (network layer) of the OSI model, while **bridges are only at the layer 2** (Data link layer).
- **Routers understand and consider IP** and IPX addresses, while **bridges do not, and instead they recognize MAC** addresses.
- Special purpose bridges commonly also connect networks of different types (like a Hue IOT network, and your LAN).

Routers have a built-in switch

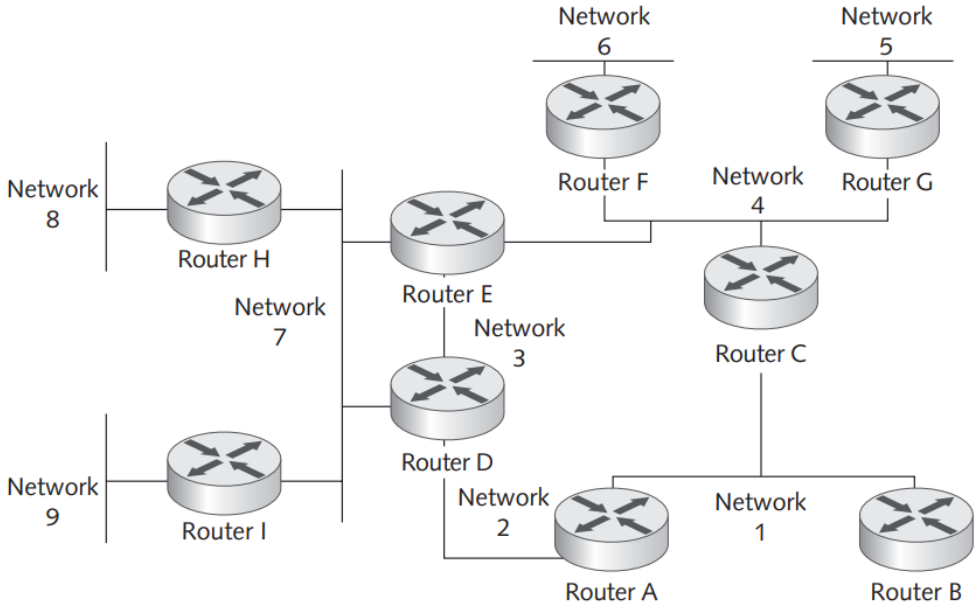


Business Routers

- Generally from Modem->Router->Switch (Separate Units)
- In general terms we can sometimes refer to a router as a firewall. (Firewall has more security features).



- In addition to dividing large networks into smaller broadcast domains, routers are used to create complex internetworks so that LANs in a large international corporation, for example, can communicate efficiently. ; these multiple paths are used for fault tolerance and load sharing. If a network link goes down, an alternate path can be chosen to get a packet to its destination. Furthermore, if a path becomes congested, additional paths can be used to ease congestion



Router In Depth

- Routers are also used to control network access by inspecting source and destination address information of packets they handle. Based on rules an administrator defines; a router can forward a packet or discard it. The processing done by routers depends on the following features found on most routers:

- Router interfaces
- Routing tables
- Routing protocols

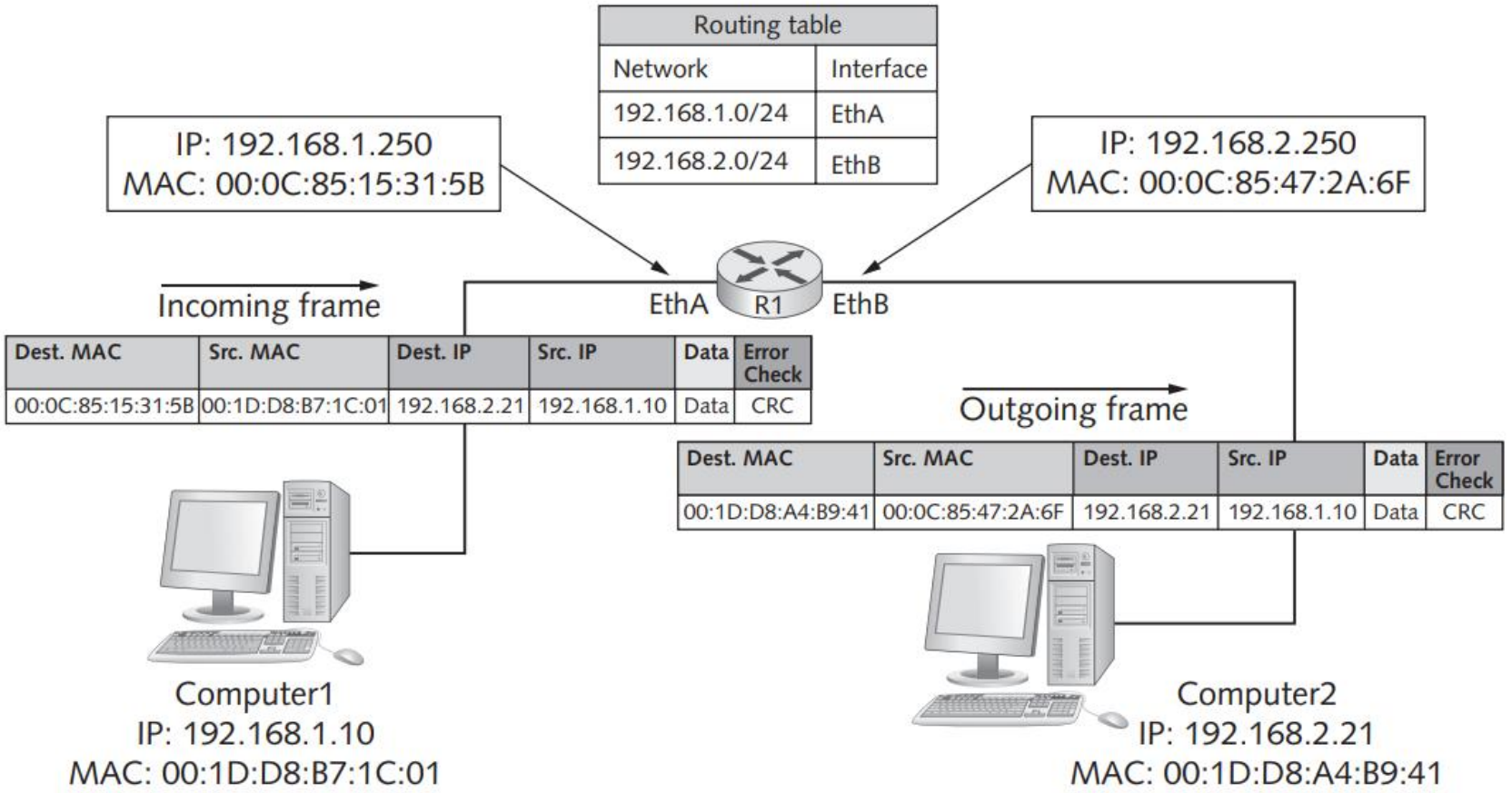
Router Interfaces

- Routers must have two or more interfaces, or ports, to be able to take packets coming from one network and forward them to another network. Each interface on a router has full Layer 3 functionality, including both an IP address and a MAC address. In fact, you can look at a router interface as just a NIC with the IP protocol bound to it.
- Each interface has **Layer 3 functionality** (IP + MAC address).
- Router gets a frame → **checks destination MAC** against its own interface MAC.
- If it matches → **removes frame header/trailer**; otherwise → **discards** the frame.
- Then, router **checks destination IP address**:
  - ❑ If it matches the router's own IP → packet is **processed locally**.
  - ❑ If the network ID differs → packet is **forwarded to another network**.

Packet Forwarding

- The process of moving a packet from the incoming interface to the outgoing interface is called packet forwarding, or just “forwarding.”
- Before the packet can be sent out the outgoing interface, however, it must be encapsulated in a new frame header and trailer.
- The new header includes:
  - Source: **outgoing interface’s MAC address**
  - Destination: **next router or target device’s MAC address**
- A new **CRC** is calculated and added to the trailer’s **FCS field**.
- **See the next page to illustrate the packet forwarding**

Packet forwarded between 2 networks

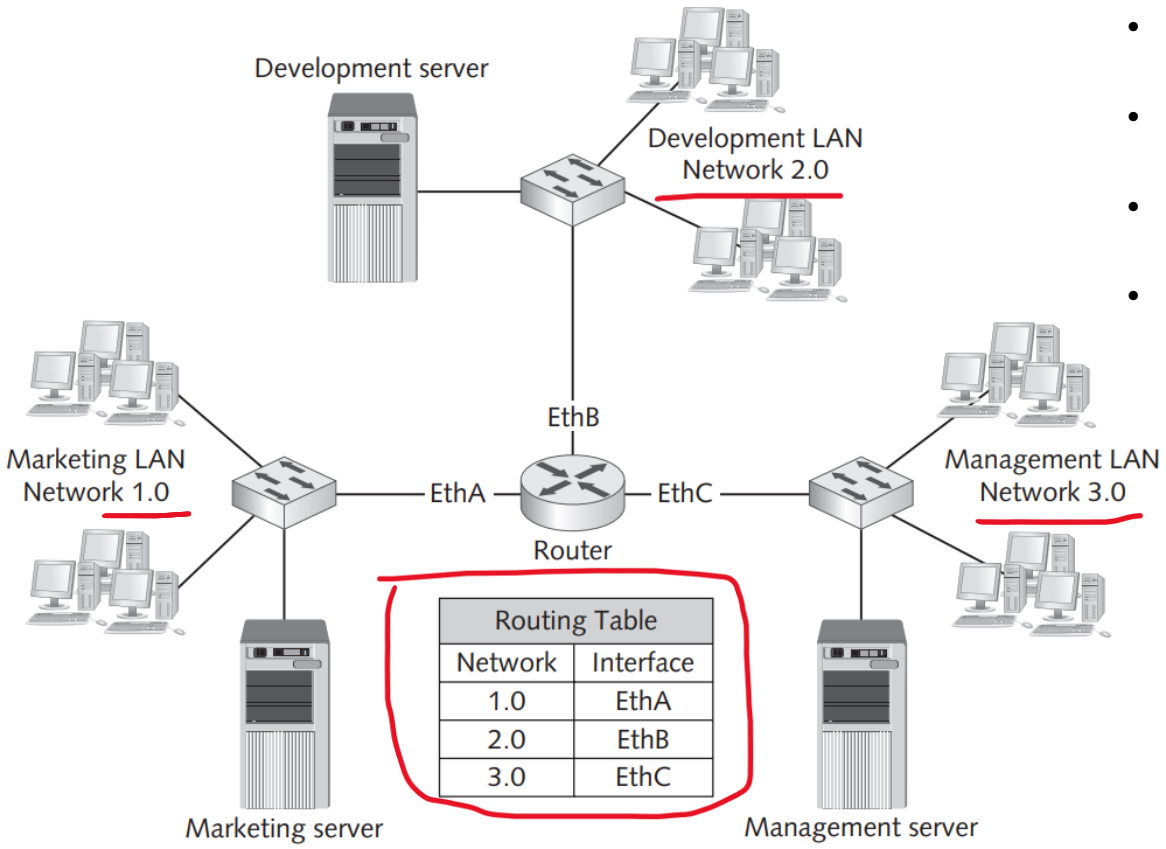


Summarize of Packet forwarding

1. A router receives a frame on an interface.
2. The router checks the frame’s destination MAC address.
3. If the destination MAC address matches the interface’s address, the router reads the frame; otherwise, the frame is discarded.
4. The frame header and trailer are stripped to create a packet.
5. The destination IP address is checked.
6. If the IP address’s network ID is different from the interface’s network ID, the packet should be routed.
7. The router consults the routing table to determine to which of its interfaces the packet should be forwarded.
8. The packet is encapsulated in a new frame header and trailer.
9. The packet is forwarded to the destination computer or the next router in the path

Routing Tables

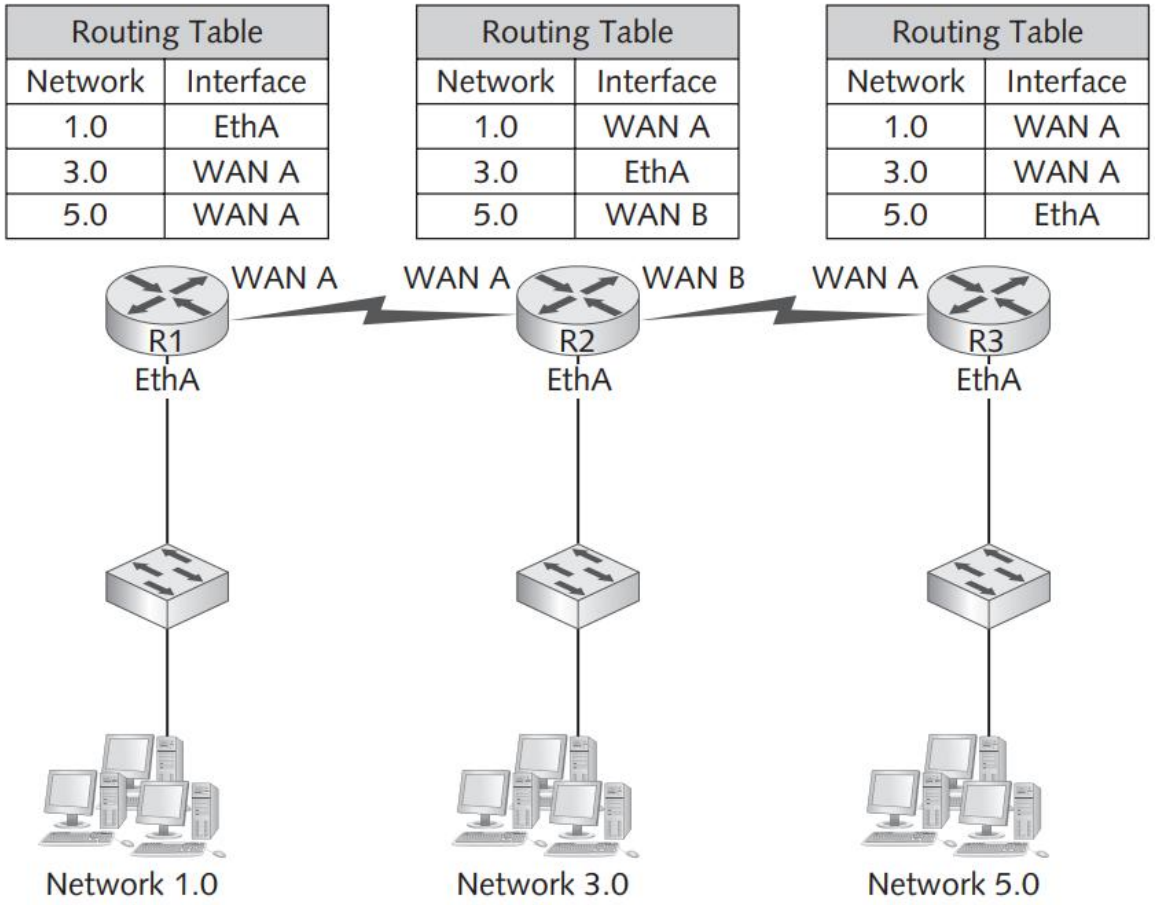
- We will learn more about Routing table in coming slides but first let's imagine we have 3 networks connected to 1 Router. Simple routing table will be as following



- When a router gets a packet for **Network 3.0** from **Network 1.0**, it checks its **routing table**.
- The table shows that **Network 3.0** is reachable via the **EthC interface**.
- The router then **forwards the packet** through **EthC** to its destination.
- (Note: real routing tables contain **more details** than just network numbers and interfaces.

Simple Routing table

- You might wonder what happens when a router isn't connected to the network the packet is addressed to. Following image illustrates this situation and shows what the routing table would look like on each router between the source and destination networks.



Default Router

- 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 isn't in its routing table 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.)

Destination	Gateway	Genmask	Flags	Metric	Ref	Use	Iface
0.0.0.0	192.168.0.1	0.0.0.0	UG	0	0	0	wlan0
172.16.35.0	0.0.0.0	255.255.255.0	U	0	0	0	vmnet1
192.168.0.0	0.0.0.0	255.255.255.0	U	9	0	0	wlan0
192.168.82.0	0.0.0.0	255.255.255.0	U	0	0	0	vmnet8

1.Destination: This column indicates the IP address of the destination network or host.

2.Gateway: The IP address to which the packet should be forwarded next.

3.Genmask: Represents the subnet mask associated with the network or subnet. It determines how many addresses are in the destination range.

4.Flags:

1. U indicates that the route is up.
2. G indicates that the route is a gateway (or uses a gateway).

5.Metric: A value used to rank routes from most preferred to least preferred when multiple routes to the same destination exist.

6.Ref: The reference count typically indicates how many sockets or connections are currently using that specific route

7.Use: The "Use" column shows how many times a particular route has been used since the last system boot or the last time the routing table was reset.

8.Iface: This indicates the network interface used for the route.

This is a routing table on the computer 192.168.0.2 NOT the router.

- What are the qualities of this network?
- Can this reach the internet? How?

- A message from 192.168.0.2 to 192.168.0.3 takes what route?
- A message from 192.168.0.2 to 192.168.82.10 takes what route?
- A message from 192.168.0.2 to 172.16.35.10 takes what route?
- A message from 192.168.0.2 to 172.20.20.10 goes where?

Destination	Gateway	Genmask	Flags	Metric	Ref	Use	Iface
0.0.0.0	192.168.0.1	0.0.0.0	UG	0	0	0	wlan0
172.16.35.0	0.0.0.0	255.255.255.0	U	0	0	0	vmnet1
192.168.0.0	0.0.0.0	255.255.255.0	U	9	0	0	wlan0
192.168.82.0	0.0.0.0	255.255.255.0	U	0	0	0	vmnet8

Answers

Source → Destination	Route Taken	Interface	Gateway
192.168.0.2 → 192.168.0.3	Direct	wlan0	—
192.168.0.2 → 192.168.82.10	Direct	vmnet8	—
192.168.0.2 → 172.16.35.10	Direct	vmnet1	—
192.168.0.2 → 172.20.20.10	Default route	wlan0	192.168.0.1

Complete Lab-router-part-1

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