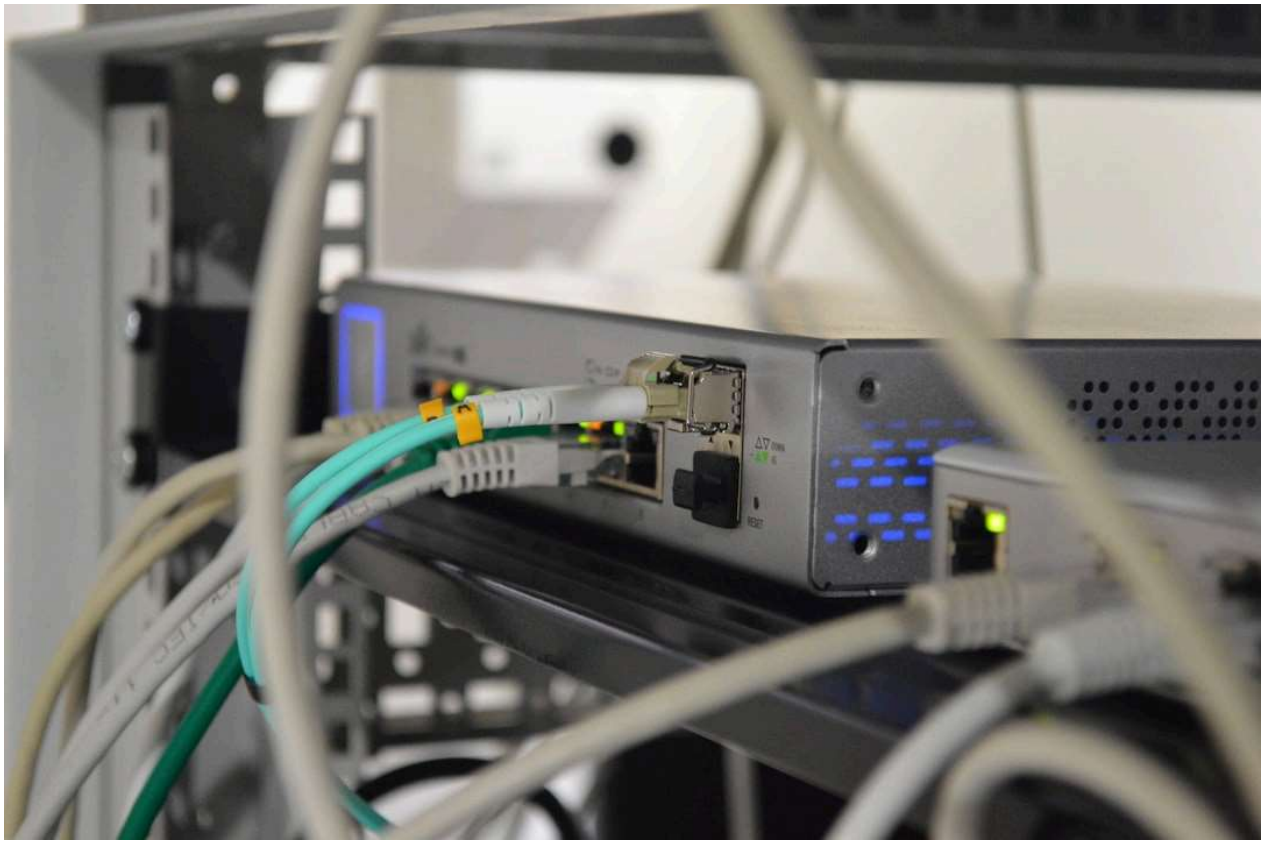
Locked: Content & Points

Routing Concepts



From Switching to Routing

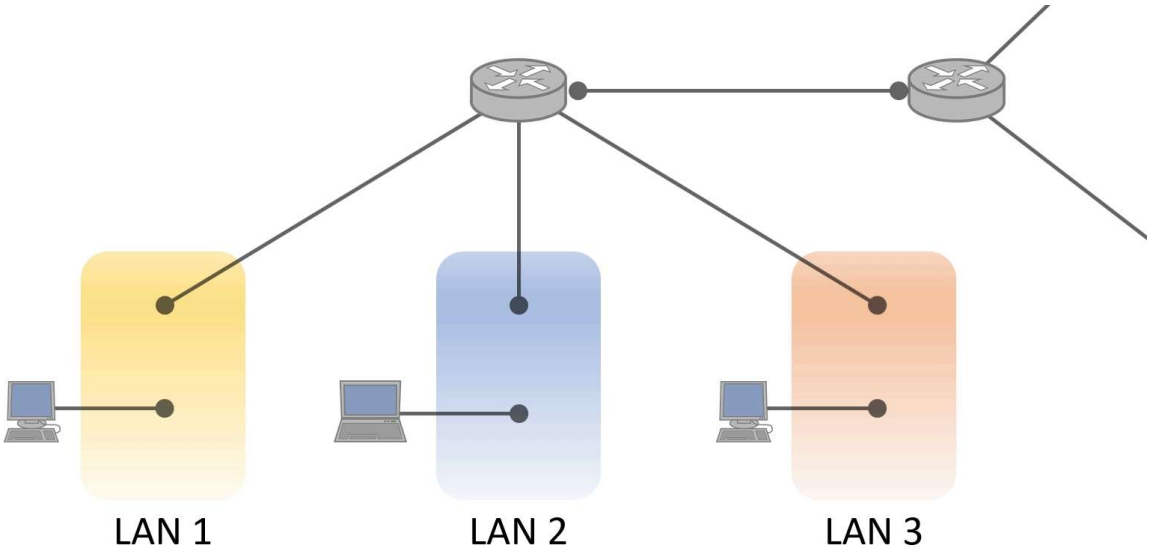
Switching is all about pushing data frames around within LANs. This all occurs at Layer 2 of the OSI model.

Data frames from one device are sent over the LAN to the MAC address of another device.

The problem: Data is limited to travelling within the LAN (or VLAN) that it originated from. We want to be able to connect LANs together and allow communication between them.

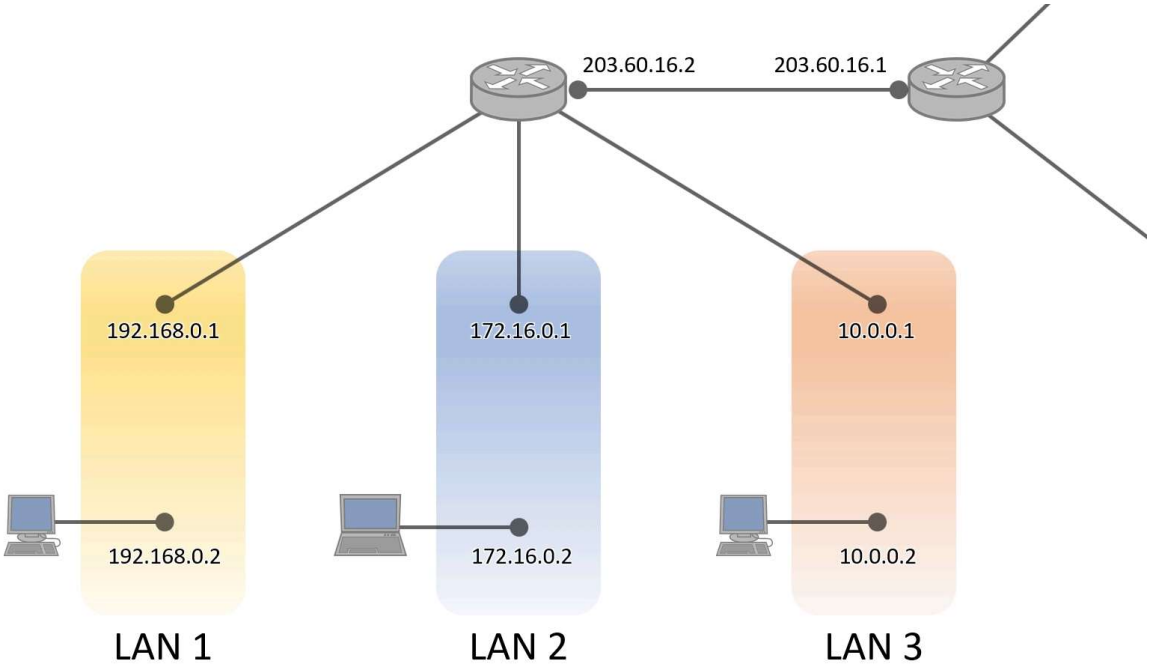
This is where **routing** comes in!

Routers and Routing



Routers have physical connections to LANs and to other routers.

They have an IP address on each one of these connection:

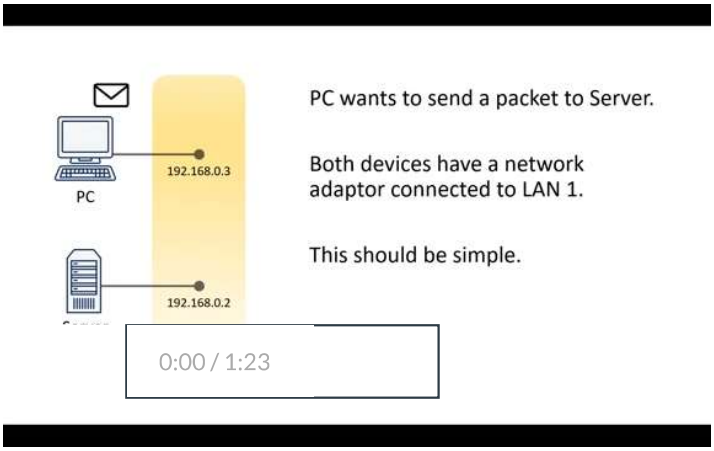


They can forward IP packets between connected networks and other routers.

While switches operate at Layer 2 using **ethernet frames** and **MAC addresses**, routers operate at Layer 3 using **IP packets** and **IP addresses**.

When IP packets travel across a LAN, they are actually encapsulated and transported within ethernet frames.

A device like a PC can make use of a router by setting it's own Default Gateway setting to the IP address of the router that is on it's LAN.



The router in a home typically has two connections:

1. Your home network
2. The router of your ISP (via a WAN connection like VDSL2)

It forwards packets between these two connections when required.

Enterprise routers can range from small and simple like your home router, up to big, complex and expensive routers with many connections.

They can also support trunking to enable Inter-VLAN Routing.

The Routing Table

The primary function of a router is to forward a packet toward its destination network, which is the destination IP address of the packet. To do this, a router needs to search the routing information stored in its routing table.

A routing table is a data file in the RAM of the router that is used to store route information about directly connected and remote networks.

The routing table contains a list of possible destination networks and how to get to them.

In the case of each network **directly connected** to a router, there will be a routing table entry with the ***network address*** and ***subnet mask*** of that network as well as the ***router interface*** that is connected to that network. This interface is called an **Exit Interface**.

Here is an example of a routing table from a router *directly connected* to three networks:

```
Router#show ip route
Codes: L - local, C - connected, S - static, 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

     192.168.10.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.10.0/24 is directly connected, GigabitEthernet0/0
L       192.168.10.1/32 is directly connected, GigabitEthernet0/0
     192.168.20.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.20.0/24 is directly connected, GigabitEthernet0/1
L       192.168.20.1/32 is directly connected, GigabitEthernet0/1
     192.168.30.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.30.0/24 is directly connected, GigabitEthernet0/2
L       192.168.30.1/32 is directly connected, GigabitEthernet0/2
```

In the case of a **remote network**, a routing table entry will include the ***network address*** and ***subnet mask*** of that network as well as the **IP address of the next router** in line towards that network. This IP address is called the **Next Hop**.

Here is an example of a routing table from a router containing two *directly connected* networks and one *remote network*:

```
Router#sho ip route
Codes: L - local, C - connected, S - static, 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

     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C       172.16.0.4/30 is directly connected, GigabitEthernet0/3/0
L       172.16.0.5/32 is directly connected, GigabitEthernet0/3/0
     192.168.10.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.10.0/24 is directly connected, GigabitEthernet0/0
L       192.168.10.1/32 is directly connected, GigabitEthernet0/0
S    192.168.40.0/24 [1/0] via 172.16.0.6
```

Routing table entries for directly connected networks appear automatically when router interfaces are connected to those networks.

Entries for remote networks can be manually entered (**static routes**) or discovered using a routing protocol (**dynamic routes**).

When three or more routers are connected together (such as with the Internet) and they are using a routing protocol (dynamic routing), they can work together determine the optimal path for packets to traverse the network.

They can isolate certain paths for packets where there is a faulty connection. This is part of what makes the Internet so resilient.

We will discuss static and dynamic routing more in later topics.

Additional features

Some common features of routers beyond IP packet routing:

- **Firewalling**
  Access Control Lists allow you to filter traffic as it is forwarded between networks.

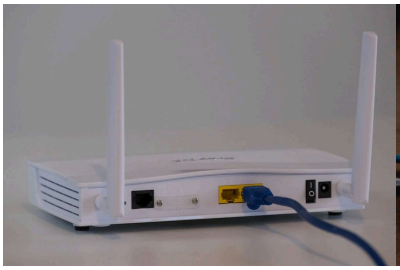
- **Quality of Service (QoS)**
  Allows for prioritization of certain network traffic.

- **DHCP Server**
  A router can act as a DHCP server, or a DHCP relay for an existing server on another network.

- **VPN Server or Client**
  Connect one router to another over the internet using VPN. This opens up a range of routing possibilities.

Types of routers

Home/SOHO routers




These all-in-one devices are designed and built for home and small-office environments. In terms of routing, they typically have just two connections/interfaces: your home network (wired and wireless), and your ISP/The Internet.

Enterprise routers


These routers have more advanced features, more flexibility, more power, and much greater reliability than a home/SOHO router. These are suited for small to large enterprises. They typically connect to two or more networks, and can also perform Inter-VLAN Routing.

Layer 3 switches

A Layer 3 switch is a special network device that has the functionality of a router and a switch combined into one device.

It has all the functionality of a Layer 2 switch but with routing capabilities as well. If you are using a Layer 3 switch in a network it usually removes the need to have a separate router.

Interface Types

Enterprise routers often come with two interfaces (such Gigabit Ethernet) built-in as well as empty slots to install different interface cards for different types of connections such as fibre-optic, VDSL2, serial, ISDN. Routers can be connected to other routers over a range of different types of WAN connections, so this modular approach makes sense.

Interface slots are often proprietary to one particular vendor, so you have to buy their interface cards. They can also be specific to the model of router.

There is one standard of interface card that many vendors feature in their routers and switches: The small form-factor pluggable (**SFP**) module.

You will often see SFP ports as the last few ports on a switch.

Some models of router will take an SFP module but only if you install and SFP interface card first, then insert the SFP module into it.

(https://canvas.tastafe.tas.edu.au/courses/19275/modules/items/691826)

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