DAY 11 - Routing Fundamental

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Routing Fundamental

What is Routing

1. Routing is the process that routers use to determine the path that IP packets should take over a network to reach their destination.
   (a) Routers store routes to all of their known destinations in a **Routing Table**.
   (b) When routers receive packets, they look in their **Routing Table** to find the best route to forward that packet.
2. There are *two* main routing methods (methods that routers use to learn routes):
   (a) **Dynamic Routing**: Routers use Dynamic Routing Protocols (eg. `OSPF`) to share routing information with each other automatically and build their routing tables.
   (b) **Static Routing**: A network engineer/admin manually configures routes on the router.
3. A route tells the router: *To send a packet to* `Destination X` *, it should send the packet to* `Next Hop Y` .
   (a) Or, if the destination is directly connected to the router, send the packet directly to the **Destination**.
   (b) Or, if the destination is the router's own IP address, then **Receive the Packet for Yourself** (and don't forward).

Example Topology:
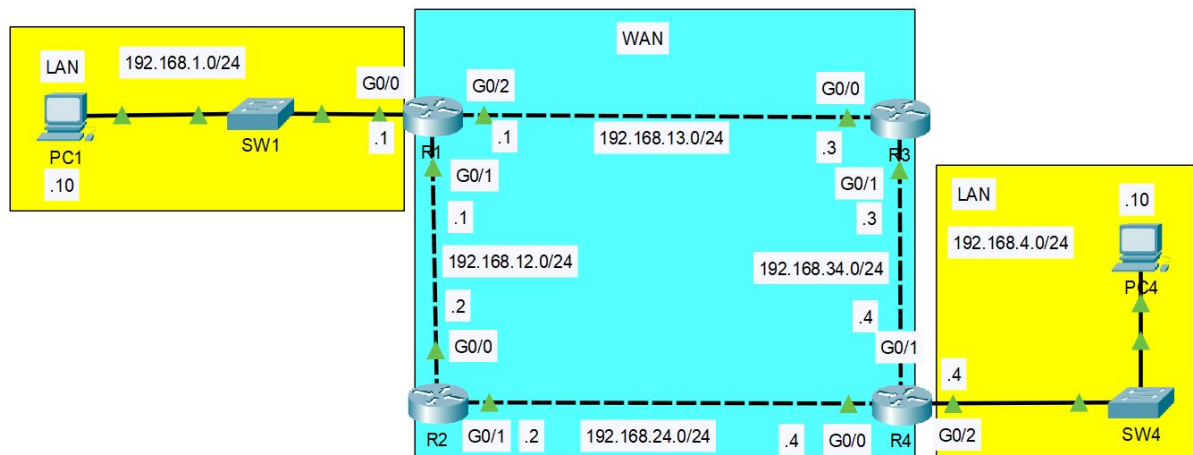
Pre-routing setup:

- Example:
  - R1> en
  - R1# conf t
  - R1(config)# interface g0/0
  - R1(config-if)# ip address 192.168.1.1 255.255.255.0
  - R1(config-if)# no shutdown
- Repeat for all PC, Routers & Interfaces.
  - **R1**:
    ```
    R1#show ip interface brief
    Interface            IP-Address      OK? Method Status                Protocol
    GigabitEthernet0/0   192.168.1.1     YES NVRAM  up                    up
    GigabitEthernet0/1   192.168.12.1    YES NVRAM  up                    up
    GigabitEthernet0/2   192.168.13.1    YES NVRAM  up                    up
    ```
  - **R2**:
    ```
    R2#show ip int br
    Interface            IP-Address      OK? Method Status                Protocol
    GigabitEthernet0/0   192.168.12.2    YES NVRAM  up                    up
    GigabitEthernet0/1   192.168.24.2    YES NVRAM  up                    up
    GigabitEthernet0/2   unassigned      YES NVRAM  administratively down down
    ```
  - **R3**:
    ```
    Interface            IP-Address      OK? Method Status                Protocol
    GigabitEthernet0/0   192.168.13.3    YES manual up                    up
    GigabitEthernet0/1   192.168.34.3    YES manual up                    up
    GigabitEthernet0/2   unassigned      YES unset  administratively down down
    ```
  - **R4**:
    ```
    R4#show ip int brief
    Interface            IP-Address      OK? Method Status                Protocol
    GigabitEthernet0/0   192.168.24.4    YES manual up                    up
    GigabitEthernet0/1   192.168.34.4    YES manual up                    up
    GigabitEthernet0/2   192.168.4.4     YES manual up                    up
    ```

View Routing Table (R1) using `show ip route` :

```
R1#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

      192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.1.0/24 is directly connected, GigabitEthernet0/0
L        192.168.1.1/32 is directly connected, GigabitEthernet0/0
      192.168.12.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.12.0/24 is directly connected, GigabitEthernet0/1
L        192.168.12.1/32 is directly connected, GigabitEthernet0/1
      192.168.13.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.13.0/24 is directly connected, GigabitEthernet0/2
L        192.168.13.1/32 is directly connected, GigabitEthernet0/2
```

Dissecting routing table (R1):

1. **Codes**:

```
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 are
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route
```

The **Codes** section is the legend for the table which lists the different protocols which routers can use to learn routes.

2. **Routes**:

We automatically get **2 Routes** without even configuring anything.

- `L` : **Local** route, a route to the **Actual IP Address configured on the interface** (With a `/32` netmask).

```
R1#show ip int brief
Interface                IP-Address
GigabitEthernet0/0       192.168.1.1
GigabitEthernet0/1       192.168.12.1
GigabitEthernet0/2       192.168.13.1
L        192.168.1.1/32 is directly connected, GigabitEthernet0/0
      192.168.12.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.12.0/24 is directly connected, GigabitEthernet0/1
L        192.168.12.1/32 is directly connected, GigabitEthernet0/1
      192.168.13.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.13.0/24 is directly connected, GigabitEthernet0/2
L        192.168.13.1/32 is directly connected, GigabitEthernet0/2
```

- **C** : **Connected** route, a route to the **Network ID the interface is connected to** (with the actual netmask configured on the interface.)
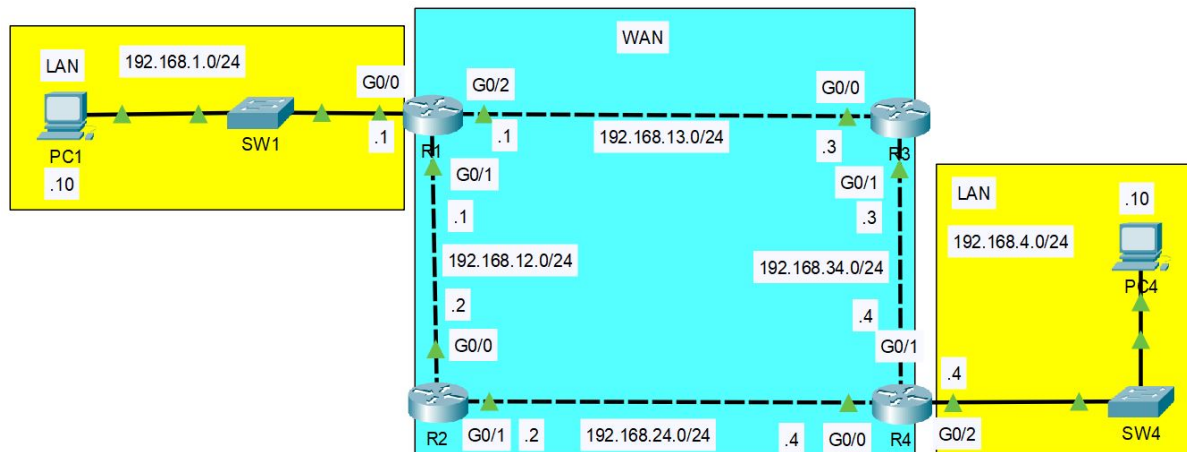


```
      192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.1.0/24 is directly connected, GigabitEthernet0/0
L        192.168.1.1/32 is directly connected, GigabitEthernet0/0
      192.168.12.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.12.0/24 is directly connected, GigabitEthernet0/1
L        192.168.12.1/32 is directly connected, GigabitEthernet0/1
      192.168.13.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.13.0/24 is directly connected, GigabitEthernet0/2
L        192.168.13.1/32 is directly connected, GigabitEthernet0/2
```

Connected vs. Local Routes:
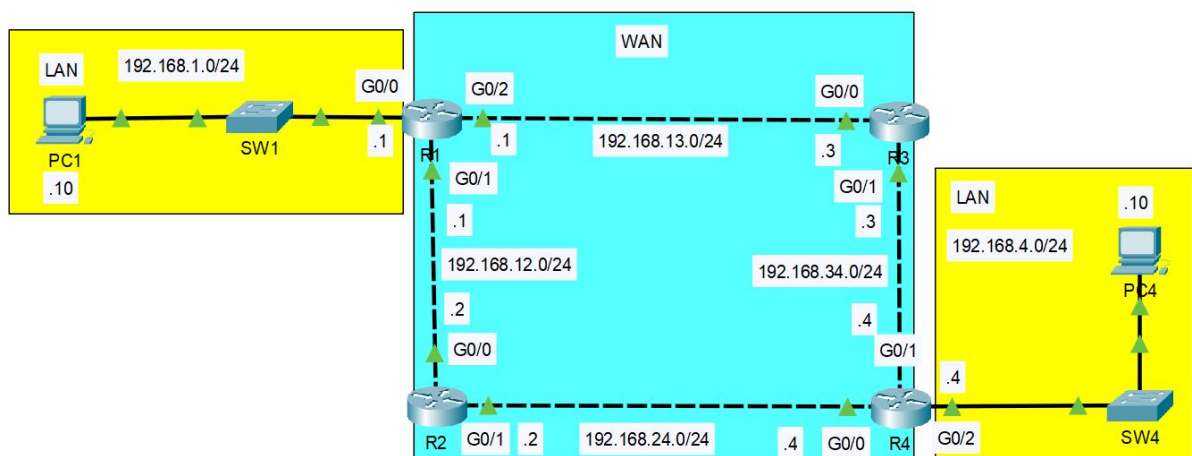
- A **Connected Route** is a route to the network the *interface* is connected to:
  - **G0/2** of **R1**: 192.168.1. `1` /24
  - **Network Address**: 192.168.1. `0` /24
  - It provides a route to **all hosts in that network**:
    * 192.168.1. `3`
    * 192.168.1. `135`
    * 192.168.1. `254` etc.

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- **R1** knows:
  * *"If I need to send a packet to any host in the `192.168.1.0/24` network, I should send it out using the **G0/2 Interface***"
    · 192.168.1.`87` = Within that network, send packet out of **G0/2**
    · 192.168.`2`.1 = **Not Within the same Network**, Send out via a different interface or drop the packet.
- A **Local Route** is a route to the *exact* IP address configured on the interface.
  - A `/32` netmask is used to specify the exact IP address of the interface.
  - **R1** knows:
    * *"If I receive a packet destined to this IP address, the message **is for me***"

Route Selection:
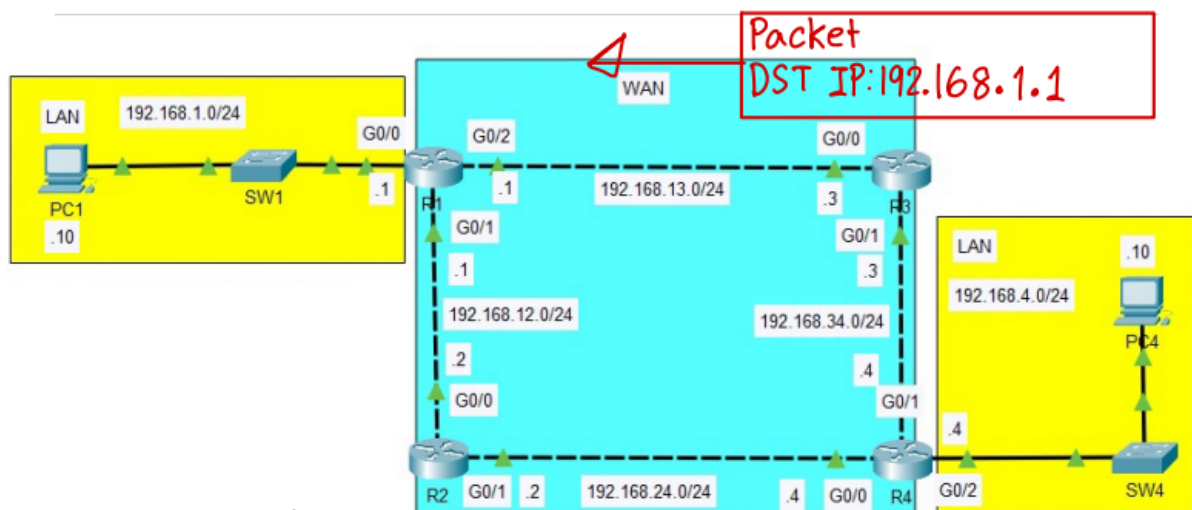

```
       192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C          192.168.1.0/24 is directly connected, GigabitEthernet0/0
L          192.168.1.1/32 is directly connected, GigabitEthernet0/0
```

Imagine a packet with **Destination**: `192.168.1.1` coming from **G0/0 R3**.

- The packet is matched by two routes:
  - `C` route: `192.168.0/24` for the network IP.
  - `L` route: `192.168.1.1/32` for the R1's G0/0 IP.
- Which route will R1 use?
  - It will choose the **MOST SPECIFIC** Matching Route.
    * The route to `192.168.1.0/24` includes **256** different IP addresses (`192.168.1.1` to `192.168.1.255`)
    * The route to `192.168.1.1/32` includes **1** IP address (only `192.168.1.1`)

- We can see that `192.168.1.1/32` route is the most specific.
- Thus, the route **R1** uses is `L` `192.168.1.1/32` .

Misc.

```
      192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.1.0/24 is directly connected, GigabitEthernet0/0
L        192.168.1.1/32 is directly connected, GigabitEthernet0/0
      192.168.12.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.12.0/24 is directly connected, GigabitEthernet0/1
L        192.168.12.1/32 is directly connected, GigabitEthernet0/1
      192.168.13.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.13.0/24 is directly connected, GigabitEthernet0/2
L        192.168.13.1/32 is directly connected, GigabitEthernet0/2
```

These three lines are not routes, they mean:

1. `192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks`
   (a) In the routing table, there are **Two Routes** to subnets that fit within the `192.168.1.0/24` class C network, with **two different netmasks** (`24` and `32`)
2. `192.168.12.0/24 is variably subnetted, 2 subnets, 2 masks`
   (a) In the routing table, there are **Two Routes** to subnets that fit within the `192.168.12.0/24` class C network, with **two different netmasks** (`24` and `32`)
3. `192.168.13.0/24 is variably subnetted, 2 subnets, 2 masks`
   (a) In the routing table, there are **Two Routes** to subnets that fit within the `192.168.13.0/24` class C network, with **two different netmasks** (`24` and `32`)

We will cover **Subnetting** later, for now just know that these three lines are not routes.

Route Selection (Practice):

Summary