## Routing Fundamentals

***Packet routing*** is the overall, network-wide process of finding the most efficient path for forwarding the IP packet from source to destination through the use of network routing tables, protocols, and algorithms. The primary device that performs the packet routing process via path determination is the router. ***Path determination*** enables a router to compare the destination address to the available routes in its routing table and to select the best path.

### Types of routing

- ***Static route*** – This is a special route that is manually configured by a network administrator. This can be an effective method for networks with small and simple structures and reduce the effect of bandwidth and CPU resource consumption that occurs when other protocols are implemented.
- ***Dynamic route*** – This route uses routing protocols to talk to other routers and find out what networks they are attached to. Also, the information is responsive to changes in the network so that it is constantly being updated. Larger networks require the dynamic routing method because there are usually too many addresses and constant changes, which, if not acted on immediately, will result in loss of connectivity.

### Packet Forwarding

It is simply a passing or moving of information between interfaces (which can be from a host/router to the final destination/intermediate connecting device) according to the "directions".

- A ***routing table*** is actually a database that contains information about which router network interface or port to place information to send it to a particular network segment.

| *Mask* | *Network Address* | *Next Hop* | *Interface* |
|---|---|---|---|
| /26 | 180.70.65.192 | - | m2 |
| /25 | 180.70.65.128 | - | m0 |
| /24 | 201.4.22.0 | - | m3 |
| /22 | 201.4.16.0 | …. | m1 |
| Any | Any | 180.70.65.200 | m2 |

  - ***Destination and Mask*** – These are used in combination to identify the destination IP address to which the packet is finally delivered or the destination network segment where the destination host or router resides.
  - ***Protocol (Proto) field*** – As the name implies, it indicates the protocol through which routes learned.
  - ***Preference (Pre) field*** – It specifies the preference value that is associated with the protocol and is used to decide which protocol is applied to the routing table where two (2) protocols offer similar routes. The router selects the route with the highest preference (the smallest value) as the optimal route.
  - ***Cost value*** – It represents the metric that is used to distinguish when multiple routes to the same destination have the same preference, the route with the lowest cost is selected as the optimal route.
  - ***Flags field.*** This indicates the on/off switches that signify either presence or absence. Five (5) flags are defined namely:
    - ***U (up) flag***. This indicates that the router is up and running. If this flag is not present, it means that the router is down. The packet cannot be forwarded and is discarded.
    - ***G (gateway) flag***. This indicates that the destination is on another network. The packet is delivered to the next-hop router for delivery (indirect delivery). When this flag is missing, it means the destination is on this network (direct delivery).

- ***H (host-specific) flag***. This indicates that the entry in the network address field is a host-specific address. When it is missing, it means that the address is only the network address of the destination.
- ***D (added by redirection) flag***. This indicates that routing information for this destination has been added to the host routing table by a redirection message from ICMP.
- ***M (modified by redirection) flag***. This indicates that the routing information for this destination has been modified by a redirection message from ICMP.

- ***Next hop value*** – It indicates the IP address of the next network layer device or gateway that an IP packet passes through.
- ***Interface parameter*** – It indicates the outgoing interface through which an IP packet is forwarded.

**Packet Delivery**

It refers to the way a packet is handled by the underlying physical networks under the control of the network layer.

- ***Direct Delivery*** – This occurs when the IP node (either the sending node or an IP router) forwards a packet to the final destination on a directly attached network (shown in Figure 7.7).
- ***Indirect Delivery*** – This occurs when the IP node (Host (source) either a sending node or an IP router) forwards a packet to an intermediate node (an IP router) because the final destination is not on a directly attached network (shown in Figure 7.8).

**Routing Methods**

- ***Distance-vector routing protocols*** – In this type of routing, all the routers send their routing tables (or a portion of their tables) to only their neighboring routers. The routers then use the received information to determine whether any changes need to be made to their own routing table.
  - ***Routing Information Protocol (RIP)*** – This is a commonly used distance vector routing that uses hop count as its routing metric to determine the best route or shortest path a packet has to traverse from the source to a destination over a network. ***Hop count*** is the number of routers that a packet must go through until it reaches the destination network; it allows the data to be delivered at high speed in the shortest time.

| Features | RIP | |
|---|---|---|
| | **Version 1** | **Version 2** |
| Path selection | Hop based | |
| Routing | A classful distance vector routing protocol. No subnet mask information is transmitted with the routing updates | A classless distance vector routing protocol. Sends subnet mask with the routing updates. Support for discontinuous networks. |
| Transmission | Routing updates are broadcast; it uses broadcast destination address 255.255.255.255 to send periodic updates | Routing updates are multicast; it uses reserved multicast destination address 224.0.0.9 to send periodic updates |
| Administrative Distance | 120 | |
| Hop Count Limitation | 15 | |
| Authentication | No support for authentication of update messages | Supports both plain text and Message Digest 5 (MD5) authentication mechanism |
| | No support for variable-length subnet masking/ classless inter-domain routing (VLSM/CIDR) | Support for variable-length subnet masking/classless inter-domain routing (VLSM/CIDR) |
| Protocol | User Datagram Protocol (UDP) | |

  - ***Classless Inter-Domain Routing (CIDR)*** allows routers to group routes together to reduce the amount of routing information carried by the core routers.
  - ***Variable Length Subnet Masks (VLSM)*** helps optimize the available address space.

- ***Link-state routing protocol*** – In this type of routing, each of the routers sends the state of its own interfaces (its links) to all other routers (or to all routers in a part of the network, known as an area) (shown in Figure 7.10) only when there is a change to report. Each router uses the received information to recalculate the best path to each network and then saves this information in its routing table.
    - ***Open Shortest Path First (OSPF)*** – This is a link-state routing protocol developed by the Internet Engineering Task Force (IETF) in 1988 that is capable of quickly detecting topological changes within the autonomous system and establishing loop-free routes in a short period of time, with minimum additional communication overhead for negotiating topology changes between peering routers.

**References:**

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