Routing Basics

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Layer 1, Layer 2, and Layer 3 are the layers that interests us for routing.

IPv4: 8.8.8.8 (32 Bytes)
IPv6: 16:16:16:16:16:16:16:16 (128 Bytes)

Classful vs Classless
Network a.b.c.d
Network 192.168.0.0 255.255.255.0

What is Routing?

Routing occurs when a router or some other layer 3 device makes a forwarding decision based on network address information. Routing is usually done when the destination is located on a different subnet. In IPv4, a host sends a frame by first looking at the CAM table to see if the destination is known and in the same subnet. If it is not there it will send the frame to its default gateway. From the router it looks in its routing table to see if it knows a route to the destination IP and chooses the best possible path. If there is then the router must determine the next-hop ip and the egress interface it must send it out off. Routing is all about picking the best path (lowest cost). There are two types of routing protocol - static and dynamic.

Routers work at layer 3 (and 2). Routers use layer 3 to determine the best possible route and if there is a match it uses a layer 2 MAC for the next-hop address and egress port. NOTE: IP will never change in the packet, only the MAC. A packet is encapsulated by a frame.

If there is NO ENTRY in the routing table that matches then the packets is DROPPED.

Split Horizon
A routing loop prevention mechanism that prevents routers from transmitting information that is received on a specific interface from going out of that same interface. Prevents update that is received on an interface from being forwarded out of the same interface.

Route Poisoning
A mechanism to prevent routing loops.

- RIP will advertise a hop count of 16 because its over the limit (0-15) which means this route is no good to other router

From where does the routing information originate?

In the routing table **(show ip route)** you can find:

- Directly connected (C)
- Static Routes (S)
- Dynamic (i.e. RIP, EIGRP, OSPF)

A router could know how to reach a network by simply having one of its interfaces directly connected to network. By a statically configured route; telling a router exactly how to reach a certain destination network. By a dynamic routing protocol (EIGRP, OSPF, RIP*) allowing routers configured with the same protocol to exchange route information and update thati nformation based on changing network conditions

If multiple paths to a destination exist, the router will look at the AD or Metric of each possible route. The lowest AD or Metric will win. AD is a measure of reliability and refers to the shortest distance. Metric is a measure of quality.

Directly connected	0
Static	1
EGRP Summary	5
EIGRP	90
OSPF	110

RIP	0 to 15
OSPF	0 to infinity
EIGRP	0 to infinity

RIP uses hop count
EIGRP uses a composite metric base (k-values)
OSPF cost base on cumulative bandwidth

How to determine a route
A router wants to select the best path to reach a destination. It looks for the best matching entry:

1. Longest bit match
2. Lowest AD
3. Lowest Metric
4. Load balancing**

**Load balancing occurs when the routes have the same AD and the same Metric.

What can you reach (routing)?

- **Understand how routing works (step by step and the requirements to route**
- **Where will this packet go and whether or not it will be dropped**
- **Question like from Quiz 1**

To be able to reach a destination the router must be capable of performing routing protocols. Without the ability to route packets (by looking up at a routing table, next-hop, egress, source/destination IP and MAC, etc.) it cannot send packets out. It needs source/destination MAC and source/destination IP.

Important: Both ends must have a route to each other for connectivity! Routes must be configured on both side!!!

IPv4: ARP
IPv6: neighbor discovery (ND).

Characteristics of routing Protocols

Salability: How easy it is to expand the network using the protocol

RIP	Not scalable because the admin has to input the routes manually and for each router
OSPF	Very Scalable. It uses areas to minimize the amount of entries in the routing table by dividing the network into areas
EIGRP	Scalable
Static	Depends. Not scalable, lots of work and lots of entries scalable if you use summary routes but this is not best practice.

Interoperability:
All routing protocols send packets to each other to communicate their routes. RIP advertises the routes it knows by saying the number of hop counts. OSPF sends LSA (type 1-5) and LSU to each other. EIGRP uses hello packets

OSPF	LSA (type 1-5) and LSU
EIGRP	Hello packets
RIP	

Speed of Convergence:

Convergence**:** A converged network describes the state of the network in which all routers have the same view on the network topology. Convergence is the normal and desired state of the network, and it is achieved when all routing information is exchanged between routers participating in the routing protocol. Any topology change in the network temporarily breaks the convergence until the change is propagated to all routers and best paths are recalculated.

To reduce convergence time (how long it takes to converge): convergence speed (routing protocol timers) or route summarization (reduce amount of info) - routers don't have to send updates whenever a subnet goes down within the summarized subnet, itll just drop the packet.

OSPF	Very fast. The network is divided into areas which creates smaller networks, and not every router needs to know about all the routes that are known to the enterprise. The areas are connected through a backbone - area 0. The advantage of having the areas is to reduce the amount of routing entries in the routing table. Routers have different roles (Internal, ABR, ASBR, DR) in OSPF. In OSPF, Routers (internal routers) only need to know about their own area and its networks (50 Max). If a route goes down, only the internal routers need to reconverge and update its routing table. The areas are connected through the ABR router which uses summary routes between. Since it uses summary routes, it doesn't have to send LSU because it doesn't affect the route from the routing table. So only the affected area will have to reconverge. Which is a lot faster than having to update every routers routing table. If the enterprise has thousands of networks, the routing table would be ridiculous and if a change were to occur every router would have to send packets which generates a

	lot of traffic which consumes a lot of bandwidth. LSA are sent every 30 minutes or seconds?
EIGRP	Very fast. EIGRP creates a topology based on a route's advertised distance and reported distance. In a redundant network, a router will become a successor and another router can become a feasible successor. The speed of convergence is very fast if both these roles are present in a EIGRP network. Basically a feasible is a backup route that a packet can take to reach its destination. The routers already know about it and if a route is to go down, the backup router will automatically come up without having to recalculate all the metric (AD/RD). Hellos are sent every 180 seconds, if a router doesn't receive a hello packet from a router after a specific amount of time the link is deemed down and reconvergence occurs (FS).
RIP	RIP just advertises routes it knows, it doesn't build a topology like in OSPF or EIGRP

Capability to perform summarization:
Route summarization: distance vector protocols support route summarization configuration on each outbound interface, link-state protocols support summarization only at area boundaries
Hierarchical addressing, structured address assignment, and route summarization improve the overall scalability regardless of routing protocol type.

OSPF	Uses areas for scalability which allows summarization to be implemented on the area border. This is like having stub networks where other networks don't have to worry about the internal networks. They only need to know about the reachability from the ABR routers.
EIGRP	EIGRP supports summarization for stub network (passive interface) to reduce traffic and optimize resource and information exchange. This also comes with a looping prevention mechanism by creating null routes for non existing routes. However with auto-summary enabled, this creates classful IP address. Can be problematic so its best to turn it off.
RIP	Can do route summarization. The efficiency depends on how well the network is design. To preserve IP space the networks should be contiguous.

Network traffic Type

Unicast	Traffic between a sender and a receiver (source to destination) One to one context. Source address can only be unicast.
Multicast	Identifies a group of interfaces (destinations) across different devices. Traffic is sent to multiple destinations using a multi cast address which is different for each protocols. (Look at the table) NOTE: IPV6 uses this to send packets to everyone (equivalent to IPv4 broadcast)
Anycast	Multiple interfaces across the network will have the same IP and configs set. The router sending it will proceed in finding the shortest path first. The packet will only be sent to the nearest one and only sends it out to the one.
Broadcast	Sends it to every device in the subnet. 255.255.255.255. Note IPv6 doesnt use broadcast.

IPv4 Multicast Address	Description
224.1.1.5	Used by OSPFv2: All OSPF Routers
224.1.1.6	Used by OSPFv2: All Designated Routers
224.1.1.9	Used by RIPv2
224.1.1.10	Used by EIGRP
IPv6 Multicast Address	**Description**
FF02::5	Used by OSPFv3: All OSPF Routers
FF02::6	Used by OSPFv3: All Designated Routers
FF02::9	Used by RIPng
FF02::A	Used by EIGRP for IPv6

Network Architecture Type (Routing)

Point-to-Point Network:
A network that connects a single pair of routers. A packet that is sent from one end to the other and is only received by one recipient on the other end of the link.

- A serial connection is a point to point

Advantage	Secure in terms of only 2 devices is on the line meaning there cant be a man in the middle if the network was only a peer-to-peer and nothing else
Challenge	No redundancy meaning if the line goes down the network goes down. Unless the network is large and other routing protocol is configured to have redundancy. With other Point to point or routing protocol.

Broadcast Network:
A network that can connect many routers along with the capability to address a single message to all of the attached routers

- Ethernet is an example
    - OSPF - Multi-Access network for DR so reduce LSA/LSU traffic

Advantage	Easy to implement and doesn't present any difficulties in implementing routing protocols. Used in OSPF
Challenge	If all the routers are connected via a switch it is prone to attacks because anyone can connect to the network if security is weak if connected to a switch.

Non-Broadcast Multi-Access Network:
A Ethernet network that can support multiple routers but cannot send broadcast traffic. The sender must create individual copies of the packets and send them to each devices using a unicast address. This being said, the devices must have a routing protocol that tell it where to send it (Destination MAC and IP is required)

- Frame Relay
- ATM

Advantage	Does not waste network resource by flooding the network with broadcast packets
Challenge	Routing protocols need to be adapted through configuration in how they perform neighbor discovery. Because theres no broadcast packets the routers will not be able to send broadcast packets to discover other devices nor about their routing information and routing tables. Distance vector protocols need additional configs, which also changes the default behaviour of how long routing info is exchange between neighbors.

TCP/IP Fundamentals

Asymmetric routing: This is when a packet goes through 1 path towards a destination and comes back through a different path when it comes back. This occurs when there's multiple

paths (redundancy)
MTU is to configure the maximum size of a packet for the data. This creates packet segmentation. This can influence network congestion because it will send smaller packets and or packets. And the path contains more than one type of packets in converged networks