Internet Routing Protocols

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Outline

- Internet Routers
- Routing Protocol
- Interior Gateway Protocol (IGP)
  - Distance- Vector Routing Protocol
    - Routing Information Protocol (RIP)
    - Interior Gateway Routing Protocol (IGRP)
  - Link- State Routing Protocol
    - Open Shortest Path First(OSPP)
    - Intermediate System to Intermediate System (IS-IS)
  - Hybrid Routing Protocol
    - Enhanced Interior Gateway Routing Protocol (EIGRP)
- Exterior Gateway Protocol (EXP)
  - Exterior Gateway Protocol
  - Border Gateway Protocol (BGP)

Internet Routers

- *Internet* routers are specialized computers that interconnect the network by switching communications from one line to another .
- When a computer communicates with another on the Internet, it addresses each *packet* with the other computer's *IP address* and then sends it to the closest Internet router.
- The router then uses a routing algorithm to send the packet across the Internet to the destination computer.

Routing Protocol

- It is used when the destination is not directly reachable. In this case, the host or gateway attempts to send the datagram to a gateway that is nearer the destination.
- The goal of a routing protocol is to supply the information that is needed to do routing

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Interior Gateway Protocol (IGP)

- Is a type of protocol used for exchanging routing information between routers within an autonomous system. In this type of networks speed and performance is the basic criteria.
- Interior Gateway Protocols can be devided into 2 groups.
  - Distance-Vector Routing Protocol
  - Link-State Protocol

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Distance –Vector Routing Protocol

- In these protocols, each router does not have information about the full network topology. It advertises its calculated distance value (DV) to other neighbouring routers and receives similar advertisements from them.
- Using these routing advertisements each router populates its routing table.
- In the next advertisement cycle, a router advertises updated information from its routing table. This process continues until the routing tables of each router converge to stable values.
- Distance-vector routing protocols use the Bellman–Ford algorithm.

Bellman–Ford Algorithm

- The **Bellman–Ford algorithm** is an algorithm that computes shortest paths from a single source vertex to all of the other vertices in a weighted diagraph.
- It is slower than Dijkstra's algorithm for the same problem, but more versatile, as it is capable of handling graphs in which some of the edge weights are negative numbers.

Distance –Vector Routing Protocol

Examples of Distance-Vector routing approaches.

- Routing Information Protocol (RIP)
- Interior Gateway Routing Protocol (IGRP)
- Enhanced Interior Gateway Routing Protocol(EIGRP) (Hybrid protocol)

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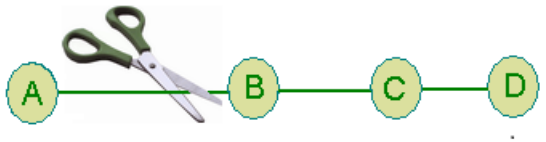
Routing Information Protocol (RIP)

- The **Routing Information Protocol** (**RIP**) employ the hop count as a routing metric.
- RIP uses User Datagram Protocol (UDP)
- Routing updates are broadcasted every 30 seconds
- RIP prevents routing loops by implementing limit on the number of hops allowed in a path. The maximum number of hops allowed for RIP is 15, which limits the size of networks that RIP can support.
- A hop count of 16 is considered an infinite distance and the route is considered unreachable.
- RIP implements the split horizon, route poisoning and hold down mechanisms to prevent incorrect routing information from being propagated.

Routing Information Protocol (RIP)



- Every node should advertise their routing table to each other.
- However according to **Split Horizon** rule, Node C does not advertise its route to A to Node B. Since node C routes to A via B. With this rule, when link between A to B goes down B can not find another route to A. This rule prevents the creation of loops and improves convergence time.

Routing Information Protocol (RIP)

- When a router detects that one of its connected routes has failed, the router will poison the route by assigning an infinite metric to it and advertising it to neighbors. It is called **route poisoning**.
- If a router advertises a poisoned route to its neighbors, its neighbors break the rule of split horizon and send back to the originator the same poisoned route, called a **split horizon routing with poison reverse**.
- This situation gives network enough time(default 180 second for RIP) to propagate the poisoned node and ensures that no routing loop occurs while propagation . It is called **hold-down** mechanism

Routing Information Protocol (RIP)

- RIP defines two types of messages.
  - Request Message: When a RIP router comes online, it sends a broadcast Request Message.
  - Response Message: All the neighbouring routers which receive the Request message respond back with the Response Message containing their Routing table

Routing Information Protocol Version 1 (RIPv1)

- The original specification of RIP defined in RFC 1058
- It was was published in 1988.
- Uses classful routing protocol.
- Does not carry subnet information.
- Does not allow different-sized subnets inside of the same network class.
- No suport for router authentication that makes RIP unguarded for various attacks.

Routing Information Protocol Version 2 (RIPv2)

- RIP version 2 (RIPv2) was developed in 1993[4] and last standardized in 1998 as RFC 2453
- Ability to carry subnet information is included, thus supporting Classless Inter-Domain Routing (CIDR).
- The hob count limit is still 15 to maintain compatibility with RIPv1.
- MD5 authentication is introduced.
- Route tags function that allows a distinction between routes learned from the RIP protocol and routes learned from other protocols, is added.

Routing Information Protocol Next Generation (RIPng)

- RIPng defined in RFC 2080
- Support for IPv6 networking
- The hob count limit is still 15 to maintain compatibility with RIPv1.
- It uses IPsec for authentication and RIPng does not support update authentication of RIPv1.
- RIPv2 encodes the next-hop into each route entry, RIPng requires specific encoding of the next hop for a set of route entries.

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Interior Gateway Routing Protocol (IGRP)

- IGRP is developed by Cisco
- IGRP was created in part to overcome the limitations of RIP (maximum hop count of only 15, and a single routing metric).
- IGRP supports multiple metrics for each route, including bandwidth, delay, load, and reliability
- The maximum configurable hop count of IGRP-routed packets is 255 (default 100)
- Routing updates are broadcast every 90 seconds.
- IGRP is considered a classful routing protocol. Because the protocol has no field for a subnet mask

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Enhanced Interior Gateway Routing Protocol (EIGRP)

- It was designed by Cisco Systems as a proprietary protocol, available only on Cisco routers.
- It was published with informational status as RFC 7868 in 2016.
- EIGRP only sends incremental updates
- EIGRP supports classless IPv4 addresses which IGRP does not.
- It uses MD5 and SHA-2 authentication between two routers.

Enhanced Interior Gateway Routing Protocol (EIGRP)

- In addition to the routing table, EIGRP uses the following tables to store information.
  - Neighbor Table: It keeps a record of the IP addresses of routers that have a direct physical connection with this router. Indirectly connected routers are not stored in this table.
  - Topology Table: It stores routes that it has learned from neighbor routing tables and metrices for each of the listed EIGRP routes, the feasible successor.

Enhanced Interior Gateway Routing Protocol (EIGRP)

- When a router is connected to another router in EIGRP network, information is exchanged between the two routers and a relationship is formed known as an adjacency. Once it happens, only the changes are sent.
- EIGRP does not send its routing table periodically but it checks routing changes to neighboring routers periodically.
- EIGRP can considered as a hybrid protocol because it is sends link state updates when link states change.

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Link State Protocol

- In Link State Protocol every routers knows all the information about other routers and the traffic in the network.
- When a router starts to run it send a Hello packet to all routes to get their ip adresses. Every routers which takes this packet replies it with their ip adresses.
- Routers send the echo packets to the network and all other routers reply it with an another echo packet to calculate delay time throughout this traffic.
- Routers broadcast their information to all routers and meanwhile they get the other routers information.
- Router choose the best route between two nodes with the Dijkstra Shortest Path Algorithm.

Dijkstra Algorithm

- With Dijkstra algorithm router creates a network graph utilizing recieved information from other routers.
- This graph consist of routers and their links.
- Every link called with a number named “weight of link”.
- This number represents traffic and delay time.
- Routers run this algorithm to choose the appropriate route according to networks criteria.

Link State Protocol

- Examples of Link State Protocol

-Open Shortest Path First (OSPF)

- Intermediate System to Intermediate System (IS-IS)

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Open Shortest Path First(OSPP)

- It gathers link state information from available routers and constructs a topology map of the network.
- OSPF detects changes in the topology, such as link failures, and converges on a new loop-free routing structure within seconds. It computes the shortest-path tree for each route using a method based on Dijkstra's algorithm.

Open Shortest Path First(OSPF)

- A OSPF router construct a route table to get the shortest path to all other routers.
- It defines itself as a root router.
- Cost factors can be distance of a router,data throughput of a link, or link availability and reliability. This provides a dynamic process of traffic load balancing between routes of equal cost.

Open Shortest Path First(OSPF)

- A OSPF encapsulates its data directly in IP packets with protocol number 89, does not use UDP or TCP protocols.
- OSPF implements its own transport layer error detection and correction functions.
- A OSPF version 1 and 2 rely on RFC2328 standarts for IPv4 networks. For IPv6 networks OSPF version 3 defined in RFC 5340
- OSPF uses multicast addressing for distributing route information within a broadcast domain.

Open Shortest Path First(OSPF)

- Protocol Messages of OSPF
  - Hello Message: It allows a router to discover other adjacent routers on its local links and networks. During operation, routers send hello messages to their neighbors at regular intervals (the *hello interval*). If a router stops receiving hello messages from a neighbor, after a set period (the *dead interval*) the router will assume the neighbor has gone down.
  - Database Description message: It contains descriptions of the topology of the autonomous system or area. It conveys the contents of the link-state database (LSDB) for the area from one router to another.

Open Shortest Path First(OSPF)

- Protocol Messages of OSPF
  - Link State Request Message: These messages are used by one router to request updated information about a portion of the link-state database from another router. The message specifies exactly which requesting device wants more current information about which link(s).
  - Link State Update Message: It contains only the updated information about the links on the link-state database. They are sent in response to a Link State Request message, and also broadcast or multicast by routers on a regular basis.
  - Link State Acknowledgment Message: It provides reliability to the link-state exchange process, by explicitly acknowledging receipt of a Link State Update message.

Open Shortest Path First(OSPF)

- An OSPF network is divided into *areas* that are logical groupings of hosts and networks to reduce the routing traffic between parts of an autonomous system.
  - Backbone area: It forms the core of an OSPF network. All other areas are connected to it, and inter-area routing happens via routers connected to the backbone area and to their own associated areas.
  - Stub area: It is an area which does not receive route advertisements external to the autonomous system and routing from within the area is based entirely on a default route.
  - Not-so-stubby area: It is a type of stub area that can import autonomous system external routes and send them to other areas, but still cannot receive AS-external routes from other areas.
  - Totally stubby area: This area does not allow *summary* routes in addition to not having *external* routes, that is, *inter-area* (IA) routes are not summarized into totally stubby areas. The only way for traffic to get routed outside of the area is a default route which is the only Type-3 LSA advertised into the area.

Open Shortest Path First(OSPF)

- OSPF defines the following overlapping categories of routers
  - Internal router (IR): An internal router has all its interfaces belonging to the same area.
  - Area border router (ABR): It connects one or more areas to the main backbone network. It is considered a member of all areas it is connected.
  - Backbone router (BR): It has an interface to the backbone area. Backbone routers may also be area routers.
  - Autonomous system boundary router (ASBR): It is a router that is connected by using more than one routing protocol and that exchanges routing information with routers autonomous systems. It is also run an exterior routing protocol.

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Intermediate System to Intermediate System (IS-IS)

- IS-IS is a link-state routing protocol, operating by reliably flooding link state information throughout a network of routers.
- Each IS-IS router independently builds a database of the network's topology, aggregating the flooded network information.
- IS-IS uses Dijkstra's algorithm for computing the best path through the network.

Intermediate System to Intermediate System (IS-IS)

- The IS-IS protocol was developed by Digital Equipment Corporation as part of Decnet Phase V.
- It was standardized by the ISO in 1992 as ISO 10589 for communication between network devices which are termed Intermediate Systems. The purpose of IS-IS was to make possible the routing of datagrams using the ISO-developed OSI protocol stack called CLNS.

Intermediate System to Intermediate System (IS-IS)

- IS-IS was developed at roughly the same time that the Internet Engineering Task Force IETF was developing a similar protocol called OSPF.
- IS-IS was later extended to support routing of *datagrams* in the Internet Protocol (IP), the Network Layer protocol of the global Internet. This version of the IS-IS *routing* protocol was then called *Integrated IS-IS* (RFC 1195)

Intermediate System to Intermediate System (IS-IS)

- IS-IS can support variable length subnet masks and authentication of routing updates.
- It can use multicast to discover neighboring routers using hello packets.
- While OSPF build its layer 3 protocol that runs on top of IP, IS-IS is an OSI Layer 2 protocol

Intermediate System to Intermediate System (IS-IS)

- Is-Is neworks divided into types of areas.
  - Level 1 (intra-area); Routing information is exchanged between Level 1 routers and other Level 1 routers of the same area.
  - Level 2 (inter area); Routers can only form relationships and exchange information with other Level 2 routers.
  - Level 1-2 (both); Routers exchange information with both levels and are used to connect the inter area routers with the intra area routers.
- IS-IS does not need backbone area as OSPF

Intermediate System to Intermediate System (IS-IS)

- IS-IS is a use of type-length-value (TLV) data allows engineers to implement support for new techniques without redesigning the protocol.
- IS-IS can support more routers in an area than OSPF with given the same set of resources.

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Exterior Gateway Protocol (EXP)

- An **exterior gateway protocol** is a routing protocol used to exchange routing information between autonomous systems.
- It includes two types of protocol.
  - Exterior Gateway Protocol (EGP)
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Exterior Gateway Protocol (EXP)

- EGP was developed by Bolt, Beranek and Newman in the early 1980s.
- It was first described in RFC 827 and formally specified in RFC 904 (1984).
- During the early days of the Internet, EGP version 3 (EGP3) was used to interconnect autonomous systems.
- Currently, BGP version 4 is the accepted standard for Internet routing and has essentially replaced the more limited EGP3.

Border Gateway Protocol (BGP)

- It is a standardized exterior gateway protocol designed to exchange routing and reachability information among autonomous systems (AS) on the Internet.
- The protocol is often classified as a path vector protocol but is sometimes also classed as a distance-vector routing protocol.
- It makes routing decisions based on paths, network policies, or rule-sets configured by a network administrator.
- Most of Internet Service Provider use BGP.

Border Gateway Protocol (BGP)

- BGP4 is the current version of BGP and it relys on RFC 4271 standarts.
- Is supports Classless Inter-Domain Routing and use of route aggregation to decrease the size of routing tables.
- It uses TCP port 179 to send 19 bytes keep alive messages in every 60 seconds.
- It provides security by MD5 algorithm.
- BGP counts the autonomous sytems passed to define routes.

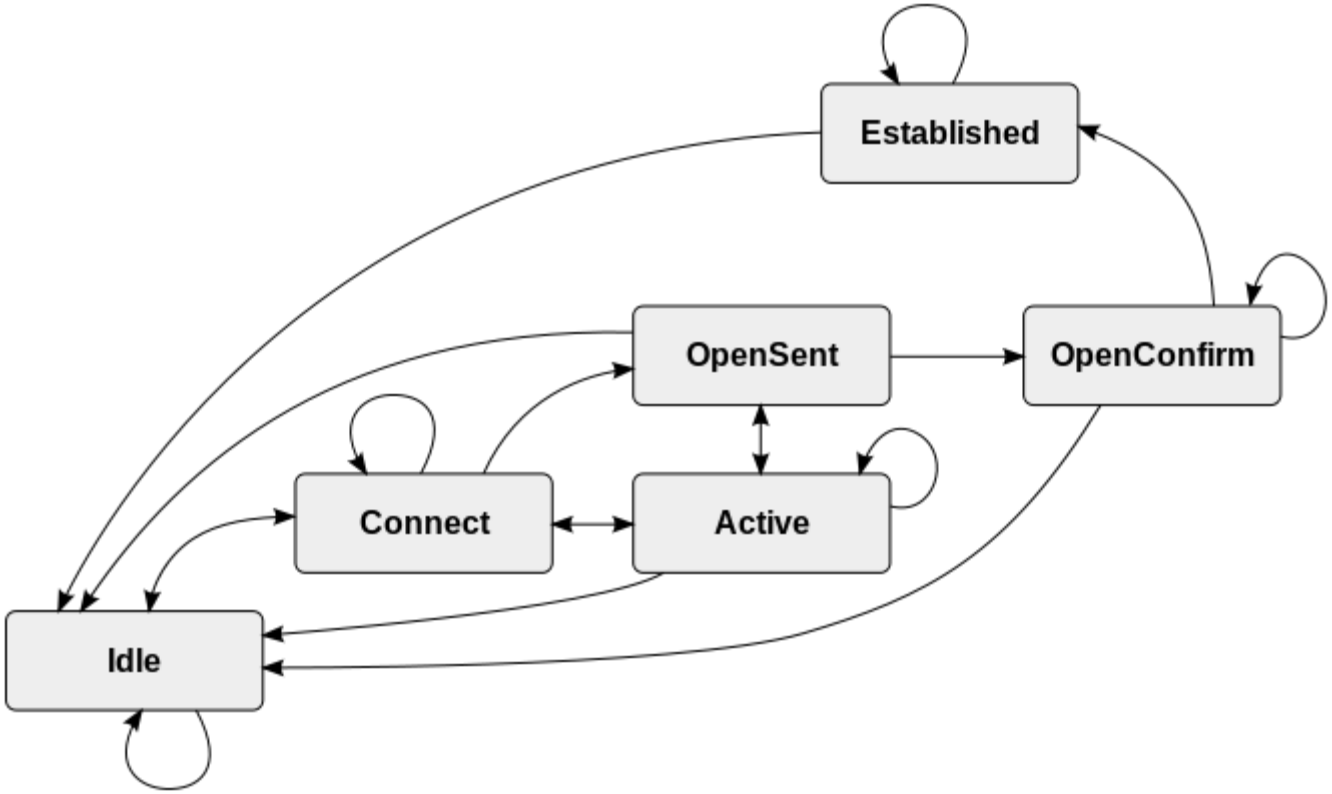
Border Gateway Protocol (BGP)

- Only updated parts are sent .
- Autonomous system number added to update message to prevent that message comes back to the same AS and creates loop.
- BGP has 3 types of tables:
  - Neighbour table: It stores neighbour routers.
  - BGP table: It stores update messages.
  - IP Routing table: It stores the best routes in the BGP table.

Border Gateway Protocol (BGP)

- In order to make decisions in its operations with peers, a BGP peer uses a simple finite state machine (FSM) that consists of six states: Idle; Connect; Active; OpenSent; OpenConfirm; and Established.
- BGP has 5 types of messages. Open; Update; Notification; Keep Alive; Route-Refresh;

Border Gateway Protocol (BGP)



Thank You

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