TCOM 515

Lecture 2

Lecture 2 Objectives

- Dynamic Routing
- Distance Vector Routing
- Link State Routing
- Interior vs. Exterior
- RIP - Routing Information Protocol

Routing Protocols

Routing algorithm must provide for:

- A way to pass network reachability info to other routers
- A way to receive network reachability info from other routers
- A way to determine optimal routes from the reachability info and put the best route into the routing table
- A way to react, advertise and work around network topology changes

Path Determination requires:

- Each network is connected to a router.
- Each router interface in the network must have an IP address of that network.

Routing Metrics

- Routing algorithms use metrics to determine the optimal route.
- Hop Count - the number of network devices in the path to the source
- Bandwidth - the higher the bandwidth, the lower the metric of the network.
- Load - metric based on the load of the links in the path, variable
- Delay - based on the amount of time the packet takes across a path
- Reliability - likelihood of link failure, variable or fixed, configurable or based on metrics
- Cost - configurable metric that allows network administrator to shift traffic as needed

Convergence

- Convergence is the process in which all route tables are brought to a state of consistency.
- Convergence time is how long it takes for all the information to be shared across the network and for all routers to calculate the best paths for each route.
- Convergence time dependencies:
  - Update mechanism
  - Size of topology table
  - Default timers of routing algorithm
  - Physical media type

- After each routing change, updates must propagate to all the routers before convergence occurs.
- Changes in routing caused by:
  - New routes added
  - Existing routes removed
  - Existing routes changed

Distance Vector Routing

- Most simple routing algorithm
- Known as Bellman-Ford algorithm
- Routes are advertised as vectors of distance, as a metric, and direction, next hop router.
- Distance Vector Protocols: RIP, IGRP, RIPv2
- Referred to as Routing by Rumor because of neighbor to neighbor passing of routing information.

DV Routing Characteristics

- Periodic Updates - routing updates are sent on regular intervals with default timers that can be configured
- Neighbors - network devices that share a common data link and have the routing protocol configured on the interfaces
- Broadcast Updates - routing updates are sent via broadcast for simplicity and to make sure all necessary devices receive the updates, uninterested devices drop the update packets
- Full routing Table Updates - most often routing updates include entire routing table for simplicity, neighbors can do with the information whatever it needs to

Split Horizon

- Reverse Route - a route pointing back to the router from which packets were received
- Split Horizon - technique for preventing reverse routes between two routers, for wasting resources and preventing routing loops
- Simple Split Horizon - when sending updates out an interface, do not send networks that were learned from an update that came in on the same interface
- Split Horizon with Poisoned Reverse - when sending updates out a particular interface, mark any networks that were learned from an update that was received on the interface as unreachable - Considered safer and stronger

DV Routing Protocol Options

- Define Infinity - to prevent routing updates from looping through a network endlessly, you can define “infinity” as a hop count, 16 is often used in distance vector routing protocols
- Triggered Updates - flash updates - update is sent by a topology or metric change immediately instead of waiting for regular update
- Holddown Timers - if a distance hop count increases, a holddown timer is set for 180 seconds for any new updates for that same route
- Asynchronous Updates - beneficial for routers sharing broadcast network preventing update packet collision - each router has own time or random time offset configured

Link State Routing Protocols

- Examples: OSPF, IS-IS
- Shortest Path First (SPF) or Distributed Database Protocols
- Based on Dijkstra's algorithm to determine shortest path
- All routers have same information, nothing is changed, all routers know all info about all other routers, making their own map of the network
- Routers do not change information in routing updates before passing them to other routers, only makes a copy of it for its database, increments the counter and passes it along.

Link State Functionality

- Each router establishes adjacency with each neighbor via a Hello mechanism.
- Each router sends LSAs, link state advertisements, to each neighbor. One LSA per router link, LSA includes link ID, link state, metric cost, neighbors connected to link. LSA is flooded to neighbors, which in turn floods it all its neighbors.
- Each routers stores copies of all LSAs received in a database. Databases should all be the same.
- Dijkstra algorithm is run for each destination to find optimal route, which is put into the route table.

Link State Database

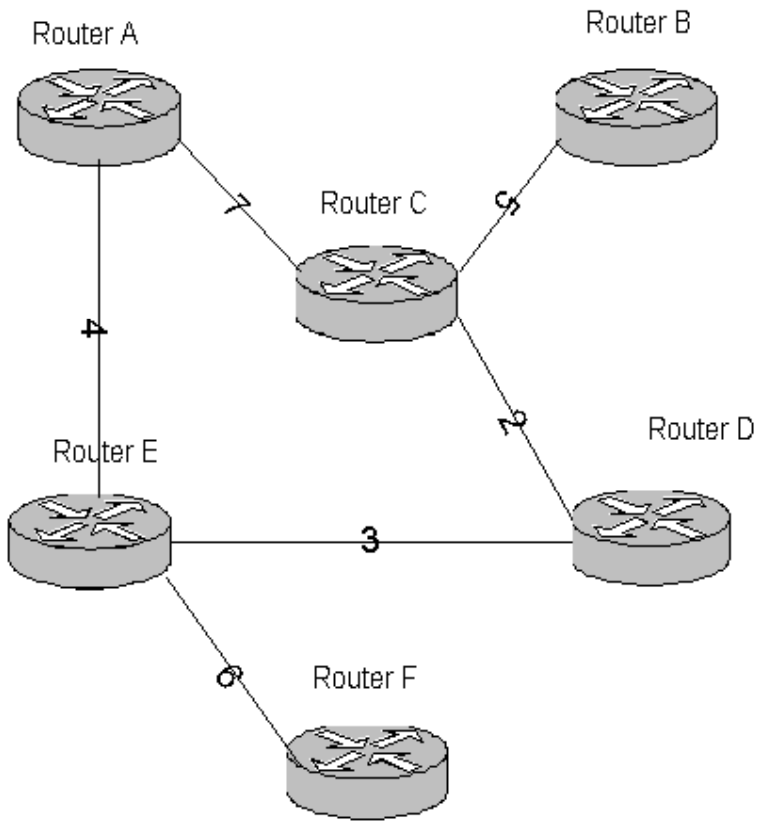
Link state advertisements information

- Router link information - router's adjacent neighbors with Router ID, Neighbor ID, and Cost.
- Stub network information - router's directly connected networks with no other neighbors with Router ID, Neighbor ID and Cost

Shortest Path First Algorithm

- Router initializes a tree with itself as root, with cost of zero.
- Cost to each neighbor is calculated and the best path is added as a node with the lowest cost.
- Each Router ID is added to the tree with the lowest cost path.
- Once the tree is complete, the routing table is updated.

Link State Example

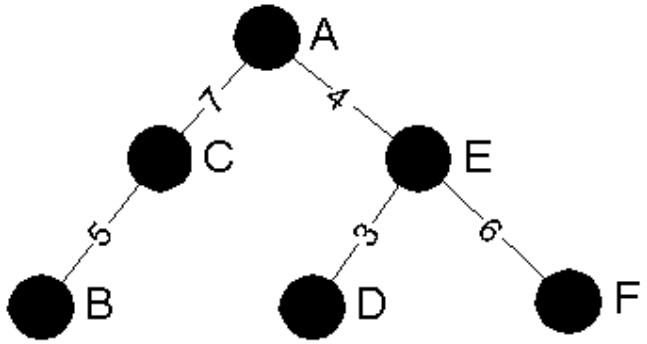


Link State Example

LS Database

Side 1	Side 2	Cost
A	C	7
A	E	4
B	C	5
C	A	7
C	B	5
C	D	2
D	C	2
D	E	3
E	A	4
E	D	3
E	F	6
F	E	6

Link State Example



Route Map from Router A Point of View

Destination	Next Hop	Cost
B	C	12
C	C	7
D	E	7
E	E	4
F	E	10

Link State Example 2

Route Map from Router E Point of View

Destination	Next Hop	Cost
A	A	4
B	D	10
C	D	5
D	D	3
F	F	6

Interior and Exterior Gateway Protocols

- Autonomous System (AS)- group of router under a common administrative domain.
- Interior gateway protocol (IGP)-used within a single AS.
  - OSPF, RIP, IS-IS, EIGRP
- Exterior gateway protocol (EGP)-used for communication between different AS
  - BGP
  - EGP

Routing Protocol Configuration

- Define the routing protocol and any area or AS information
- Define the networks that are to be advertised through the protocol
- Define the interfaces that are or are not to be advertised through
- Define any passwords to authenticate routing updates
- Define any costs or route filters to links or protocols
- Define any import or export to or from other routing protocols.

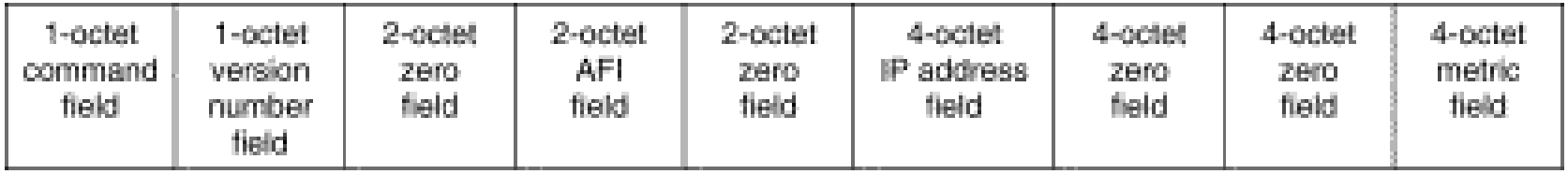
RIP
Routing Information Protocol

- Version 1 - RFC 1058, 1388
- Version 2 - RFC 1721, 1722, 1723, 1724, 2453
- Designed for small networks with same speed links
- Uses UDP port 520
- Request and Response messages - requests update and responds with update
- Broadcasts request out every RIP configured interface on start up of routing protocol.
- Upon receipt of response message, routes are checked in current routing table, if absent, routes are added, if existing, route only updated if it has a lower hop count

RIP v1 & v2

- Metric of hop count only allowable of 1-15. At 16, destination is considered unreachable, to prevent routing loops. This limits the depth of a network to run RIP.
- Update timer - Router sends gratuitous Response message out each interface every 30 seconds with full routing table.
- Expiration timer - initialized to 180 seconds for a new route and reset upon update of that route. If timer expires, hop count set to 16, unreachable, but still advertised.
- Flush timer - set to 240 seconds upon initialization, once expired, route is removed from routing table and no longer advertise.
- Holddown timer - Cisco only - set for 180 seconds when updated route has a higher hop count than previous advertisement.

RIP v1



- Command specifies Request = 1 or Response - 2
- Version Ripv1 = 1
- AFI - Address-Family Identifier - specifies protocol, IP = 2
- IP address of destination route
- Metric - hop count to destination
- Up to 25 routes - AFI, IP and Metric combinations
- Request message my specify full table or identified routes.
- Administrative distance of 120 for RIP routes
- Classful routing - only has routes for and routes packets with classful routing information - Class A, B & C. - More in book

RIP Version 2 Changes

- Classless routing and subnet masks in routing updates
- Routing update authentication - simple text and MD5
- Next-hop addresses for each route
- External route tags
- Multicast route updates, instead of broadcast
- Same procedures, timers & functions of v1

RIPv2 Packet

1-octet command field	1-octet version number field	2-octet unused field	2-octet AFI field	2-octet route tag field	4-octet network address field	4-octet subnet mask field	4-octet next hop field	4-octet metric field

- Command specifies Request = 1 or Response - 2
- Version Ripv2 = 2
- AFI - Address-Family Identifier - specifies protocol, IP = 2
- Route Tag - mark external or redistributed routes into RIP
- Network - IP address of destination route
- Subnet Mask - allows for classless routing
- Metric - hop count to destination
- Up to 25 routes - AFI, IP and Metric combinations
- Maximum datagram size 512 octets
- Authentication by password in update

RIP v1 & v2 Interoperability

Interfaces can be configured for:

- RIP-1 - only RIPv1 messages
- RIP-1 Compatibility - RIPv2 broadcasts instead of multicast to allow RIPv1 to receive them (both)
- RIP-2 - RIPv2 multicast updates are sent to 224.0.0.9
- None - no updates

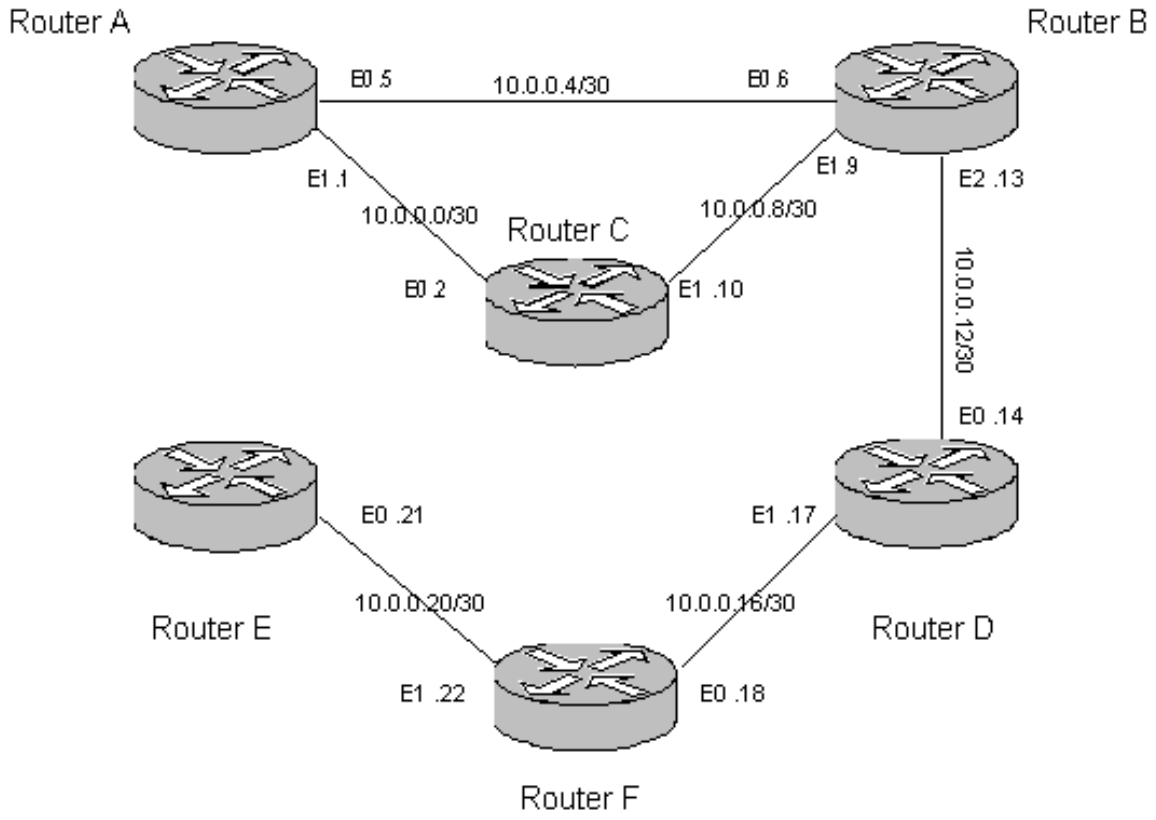
VLSM
Variable Length Subnet Mask

- RIPv2 first classless routing protocol
- Must always carry subnet mask in addition to IP address for any route in updates between routers
- The ability to breakdown and aggregate up any IP subnet beyond the definitions of classful subnets of A, B, C, D & E.
- Please refer to:
  www.3com.com/other/pdfs/infra/corpinfo/en_US/501302.pdf

RIP Operations

1. On start-up, RIP broadcast Request message out each RIP enabled interface.
2. From then on, it listens for Request and Response messages from others.
3. Neighbor routers respond to initial Request with full routing table in Response Message(s) - 25 routes per Response packet.
4. On receipt of Response message,
   - If route entry is new, it is added to routing table with address of advertising router.
   - If the route entry is not new and the hop count is the same, the timer is updated.
   - If the route entry is not new and the hop count is lower, the new next hop information is entered.
   - If the route entry if not new and the hop count is greater, the route is marked as Hold down.
5. Routers continue to send gratuitous Response message(s) out each RIP enable interface every 30 seconds

RIP Example


Router A
Router B
E0 .5
10.0.0.4/30
E0 .6
E1 .1
E1 .9
E2 .13
10.0.0.0/30
Router C
10.0.0.8/30
E0 .2
E1 .10
10.0.0.12/30
E0 .14
E0 .21
E1 .17
10.0.0.20/30
10.0.0.16/30
Router E
Router D
E1 .22
E0 .18
Router F

RIP Example

Given the initial routing table for Router D below, complete the routing table with RIP routes assuming RIP v2 is enabled on all interfaces to send and receive.

C 10.0.0.12/30 E0

C 10.0.0.16/30 E1

RIP Example

C 10.0.0.12/30	E0
C 10.0.0.16/30	E1
R 10.0.0.0/30	via 10.0.0.13, E0
R 10.0.0.4/30	via 10.0.0.13, E0
R 10.0.0.8/30	via 10.0.0.13, E0
R 10.0.0.20/30	via 10.0.0.18, E1

Summary

- Dynamic Routing
- Distance Vector
- Link State
- RIP Version 1
- RIP Version 2
- Reading Assignment: chapters 4,5, and 6 (Skip RIPng)