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DYNAMIC ROUTING P1

Routers: Fwd packets using info in r-table: Can be learned: statically | dynamically: Since late 1980's

RIP	**Routing Information Protocol** ○ 1 of 1st: RIPv1: 1988: Some algorithms in it: ARPANET: 1969 ○ Updated for network growth: **RIPv2**: Doesn't scale well
Time	Larger networks: 2 advanced r-protocols made: • **OSPF: Open Shortest Path First** • **IS-IS: Intermediate System-to-Intermediate System** Cisco developed these to scale w/larger networks: • **IGRP: Interior Gateway Routing Protocol** • **EIGRP: Enhanced IGRP** Need to connect different internetworks/provide routing between them • **BGP: Border Gateway Protocol**: ISPs

To support IPv6: Newer vers of protocols made
Protocols used to facilitate exchange of r-info between routers
Routing protocol: Set of processes/alg/msgs used to exchange r-info/populate r-table w/best paths

Purpose: Dynamic

1. Remote network discovery
2. Maintain up-to-date r-info
3. Choosing best path to destination networks
4. Finding new best paths if current no longer available

Components: Dynamic

Data structures	Uses tables/databases: Info in RAM
Messages	Used to: • Discover neighbor routers • Exchange r-info • Learn/maintain accurate info about network
Algorithm	**Algorithm:** Finite list of steps used to accomplish a task • Facilitates routing info/best path determination

Role: Allows routers to dynamically share info about remote networks: Adds info to own r-tables: Determine best path
Benefits: Routers exchange r-info when topology changes: Auto learn: Find alternate paths if link failure
Compared to static: Less overhead: More resources [CPU/network/link BW]: Both static/dynamic can be used

Static: Dynamic has advantages over static: Still used today: Typically combo of both

Primary uses	○ Ease of r-table maintenance: Smaller networks [not expected to scale] ○ Routing to/from stub network (1 default route out/no knowledge of remote networks) ○ Accessing single default route ▪ Represents path to any network not specific match w/other route in r-table

Advantages/Disadvantages of static routing:

Advantages	○ Easy to implement [small network] ○ Secure: No advertisements ○ Route to destination always same ○ No routing alg/updates: Less CPU/RAM/resources

Disadvantages	▪ Only simple topologies/special purposes Example: Default static route ○ Config complexity increases w/network size ○ Manual intervention: To re-route traffic ○ Time consumption ○ Link fails? Static can't re-route traffic

Advantages/Disadvantages of dynamic routing:

Advantages	○ Good for multiple routers ○ Independent of network size ○ Auto adapts topology to re-route traffic
Disadvantages	○ Complexity in implementation: Additional commands ○ Less secure: Updates ○ Depends on current topology ○ More resources: CPU/RAM/Link BW

Dynamic Operation

1. R-sends/receives msgs on its ints
2. R-shares msgs/info w/other routers using same protocol
3. R-exchange info to learn about remote networks
4. When notes topology change: R-protocol advertises change to other routers

Cold Start	Power up: No info on topology: Only info of saved config in NVRAM After boot: Applies saved config: If config good: Discovers connected networks
Network Discovery	After boot: R-table updated w/directly connected networks/ints If config'd: Router begins exchanging updates to learn routes R-sends update packet out all ints enabled: Contains info in table • Also receives/processes updates from other connected routers • Receiving update: Checks for new info: Networks not listed added **Full knowledge/converge don't take place until another exchange of r-info in table**
Exchanging Info	Exchanges next round of updates: Each checks updates for new info **Split Horizon**: A routing loop prevention technique implemented by r-protocols • Prevents info from being sent out same int was received • After convergence: Can use info w/in table to determine best path
Convergence	Converges: When all routers have complete/accurate info about entire network **Convergence time:** Time it takes routers to share info/calc best paths/update tables • Collaborative/independent • Share info w/each other: Independently calc impacts on their routes • B/C they develop an agreement w/new topology independently: Said to converge

Convergence properties: Speed of propagation of r-info **|** Calc of optimal paths
Speed of propagation: Amt of time it takes routers w/in network to fwd r-info
Protocols can be rated on speed to convergence: Faster = better
Older protocols: RIP slow to converge **| Modern protocols:** EIGRP/OSPF: Converge more quickly
Classifying Routing Protocols: Different groups according to characteristics

Purpose	**IGP**: Interior Gateway Protocol or **EGP**: Exterior Gateway Protocol
Operation	Distance vector | link-state protocol | path-vector protocol
Behavior	Classful | Classless

IPv4 r-protocols classifications

RIPv1 [legacy]	IGP | Distance vector | Classful
IGRP [legacy]	IGP | Distance vector | Classful | Cisco
RIPv2	IGP | Distance vector | Classless
EIGRP	IGP | Distance vector | Classless | Cisco
OSPF	IGP | Link-state | Classless

IS-IS	IGP | Link-state | Classless
BGP	EGP| Path-vector | Classless

RIPv1/IGRP: Legacy: Only used in older networks

- Evolved into classless r-protocols: RIPv2/EIGRP: Link-state r-protocols are classless

IGP/EGP R-Protocols
AS: Autonomous system: AKA routing domain: Collection of routers under a common administration [company/org]
Internet based on AS: 2 types of protocols required:

- **IGP: Interior Gateway Protocols**
    1. **Intra-AS routing:** Used for routing w/in an AS
    2. Companies/orgs/ISP's use an IGP on their internal networks
    3. IGPs include: RIP/EIGRP/OSPF/IS-IS
- **EGP: Exterior Gateway Protocols**
    1. **Inter-AS routing:** Used for routing between AS
    2. ISP's/large companies may interconnect using an EGP
    3. BGP: Border Gateway Protocol: Only viable EGP: R-protocol of Internet

Multihomed: Connects to 2 different service providers
Distance Vector R-Protocols
Distance = *How far?* | **Vector** = *Which direction?*
Routes advertised by 2 characteristics:

Distance	ID's how far it is to destination network • Based on a metric: Hop count/cost/BW/delay/etc…
Vector	The direction of next-hop router or exit int to reach the destination

- Router using distance vector: No knowledge of entire path to destination network
- Only info known about remote network: Distance/metric to reach it and which path/int to use to get there
- Don't have actual maps of network topology

4 distance vector IPv4 IGPs:

RIPv1	1st gen legacy	**RIPv2**	Simple distance vector
IGRP	1st gen Cisco (replaced by EIGRP)	**EIGRP**	Advanced version of distance vector

Link-State R-Protocols: Contrast to distance vector

- Can create topology of network by gathering info from other routers
- A complete map of network topology: Uses link-state info to create map/select best path
- Don't use periodic updates
- After network converged: Link-state update is only sent when there a change in topology

Best in situations where: Design = hierarchical/Fast convergence = crucial
2 link-state IPv4 IGPs:

OSPF	Standards based	**IS-IS**	Provider networks

Classful/Classless Routing Protocols

Classful	▪ NO subnet mask info in r-updates □ Only RIPv1/IGRP classful: All other IPv4/IPv6 are classless □ **Can't provide VLSMs:** Variable-Length Subnet Masks/**CIDR:** Classless Interdomain Routing ▪ Create problems in discontiguous networks ▪ Modern networks no longer use: Subnet can't be determined by 1st octet **Discontiguous network:** Subnets from same classful major network address are separated by diff classful address
Classless	○ Subnet mask info in r-updates ▪ IPv4 r-protocols: RIPv2/EIGRP/OSPF/IS-IS ○ Support VLSM/CIDR

		○ IPv6 r-protocols are classless: Only applies to IPv4 ○ All IPv6 r-protocols classless: Include prefix-length w/IPv6 address

Protocol Characteristics

Speed of Convergence	How quickly routers in topology share info/reach state of knowledge • R-loops can occur when inconsistent tables are not updated
Scalability	How large network can be based on protocol • Larger = More scalable protocol needs to be
Classful or Classless	Don't include subnet mask | Can't support VLSM • Classless support VLSM/better route summarization
Resource Usage	**Includes:** • Requirements of protocol [RAM/CPU/link BW] • Higher resource reqs: More HW needed to support it
Implementation/ Maintenance	Level of knowledge required

Metric: Measurable value assigned to different routes based on usefulness
Distance Vector Technologies: Share updates between neighbors
Neighbors: Routers that share a link **|** Config'd to use same protocol

- Router is only aware of addresses of own ints: Remote addresses it can reach through neighbors
- Using distance vectors mean routers aren't aware of network topology

Some distance vectors send periodic updates:
RIP: Periodic update: All neighbors: Every 30 seconds

- Even if topology hasn't changed: Reaches neighbors through broadcast: 255.255.255.255 all IPv4

Broadcasting periodic updates consumes BW/CPU usage: Every device has to process msg

- RIPv2/EIGRP: Multicast so only neighbors that need updates get them
- EIGRP: Can also send unicast: Only sends an update when needed: Not periodic

Distance Vector Algorithm: Core of distance vectors: Used to calc best paths/send info to neighbors

1. Send/receive r-info
2. Calc best paths/installing routes in table
3. Detecting/reacting to topology changes

Diff protocols use diff alg to: Install routes in table/send updates to neighbors/make path decisions

RIP	○ **Bellman-Ford** alg ○ Based on 2 alg developed in 1958/1956: Richard Bellman | Lester Ford Jr.
IGRP/EIGRP	○ **Diffusing Update Algorithm (DUAL)** ○ Dr. J.J. Garcia-Luna-Aceves at SRI International