Chapter 13

Routing Protocols (RIP, OSPF, BGP)

- INTERIOR AND EXTERIOR ROUTING
- RIP
- OSPF
- BGP
Introduction

- Packets may pass through several networks on their way to destination
- Each network carries a price tag, or a “metric”
- The metric of a network may be:
  - constant (i.e. each network costs one hop)
  - Service type-dependent (the cost of the network depends on what service the packet needs: e.g. throughput, delay, .. etc.)
  - Policy-dependent: a policy defines what paths should, or should not, be followed.
- The router uses a “routing table” to determine the path
  - Static vs. Dynamic routing tables.
13.1 Interior & Exterior Routing

**Autonomous system:**
a group of networks and routers under authority of a single administrator
Popular routing protocols

- Interior
  - RIP
  - OSPF
- Exterior
  - BGP
13.2 RIP: Routing Information Protocol

- **Distance Vector Routing**
  - Share the most you know about the entire autonomous system
  - Share with all your direct neighbors, and them only
  - Share periodically, e.g. every 30 seconds

<table>
<thead>
<tr>
<th>Destination</th>
<th>Hop Count</th>
<th>Next Hop</th>
<th>Other Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>163.5.0.0</td>
<td>7</td>
<td>172.6.23.4</td>
<td></td>
</tr>
<tr>
<td>197.5.13.0</td>
<td>5</td>
<td>176.3.6.17</td>
<td></td>
</tr>
<tr>
<td>189.45.0.0</td>
<td>4</td>
<td>200.5.1.6</td>
<td></td>
</tr>
</tbody>
</table>
**RIP Updating Algorithm**

Receive: a response RIP message

1. Add one to the hop count for each advertised destination
2. Repeat for each advertised destination
   - If (destination is not in my routing table)
     - Add the destination to my table
   - Else If (next-hop field is the same)
     - Replace existing entry with the new advertised one
   - Else if (advertised hop-count –after incrementing- is smaller)
     - Replace existing entry with the new advertised one
Example of updating a routing table

Receive: a response RIP message
1. Add one to the hop count for each advertised destination
2. Repeat for each advertised destination
   - If (destination is not in my routing table)
     - Add the destination to my table
   - Else If (next-hop field is the same)
     - Replace existing entry with the new advertised one
   - Else if (advertised hop-count –after incrementing- is smaller)
     - Replace existing entry with the new advertised one

<table>
<thead>
<tr>
<th>Old routing table</th>
<th>RIP message from C</th>
<th>RIP message from C after increment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net1 7 A</td>
<td>Net2 4</td>
<td>Net2 5</td>
</tr>
<tr>
<td>Net2 2 C</td>
<td>Net3 8</td>
<td>Net3 9</td>
</tr>
<tr>
<td>Net6 8 F</td>
<td>Net6 4</td>
<td>Net6 5</td>
</tr>
<tr>
<td>Net8 4 E</td>
<td>Net8 3</td>
<td>Net8 4</td>
</tr>
<tr>
<td>Net9 4 F</td>
<td>Net9 5</td>
<td>Net9 6</td>
</tr>
</tbody>
</table>

New routing table

| Net1 7 A          | Net1 7 A          |
| Net2 5 C          | Net2 5 C          |
| Net3 9 C          | Net3 9 C          |
| Net6 5 C          | Net6 5 C          |
| Net8 4 E          | Net8 4 E          |
| Net9 4 F          | Net9 4 F          |

Net1: No news, do not change
Net2: Same next hop, replace
Net3: A new router, add
Net6: Different next hop, new hop count smaller, replace
Net8: Different next hop, new hop count the same, do not change
Net9: Different next hop, new hop count larger, do not change
Initial routing tables in a small autonomous system

- Configuration File
  - Directly attached networks
  - Hop-count = 1
Final routing tables for the previous autonomous system

- RIP messages are exchanged
- Routing tables are updated
RIP message format

1: Request
2: Response

1 or 2

Address Family Identifier
2: TCP/IP family

Command | Version | Reserved
---------|---------|---------
Family   | All 0s  |
Network address
All 0s
All 0s
Distance

Hops from advertising router to dest. network

up to 25 AFI's

12 Bytes

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RIP Request Messages

- Sent by a router when booted, or when an entry times-out
- May request updates for ALL networks, or specific one(s)

RIP Response Messages

- Solicited responding to a previous request
- Unsolicited (sent periodically to all neighbors)
Example 1

What is the periodic response sent by router R1? Assume R1 knows about the whole autonomous system.

RIP message

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Reserved</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1</td>
<td>All 0s</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>144.2.7.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All 0s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>144.2.9.0</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>All 0s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>144.2.12.0</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>All 0s</td>
</tr>
</tbody>
</table>
RIP Timers

- **Periodic Timer** (25 < random < 35): controls advertising of update messages. There ONE such timer.

- **Expiration Timers**: governs route validity. Reset upon receipt of an update. If it ever expires, destination is considered unreachable. Yet, entry is not removed from table, it continues to be advertised with hop count = 16 (i.e. infinity).

- **Garbage Collection Timers**: Reset to 120sec when a route is invalidated. If it expires, the route entry is completely removed from routing table.
Example 2

A routing table has 20 entries. It does not receive information about five routes for 200 seconds. How many timers are running at this time?

Solution

The timers are listed below:

- Periodic timer: 1
- Expiration timer: 20 - 5 = 15
- Garbage collection timer: 5
RIP Problems: 1) Slow convergence

- Network topology changes propagate slowly (avg. 15 sec per hop)
- Solution: Limit the diameter of an autonomous system to 15 hops.

Total hop count should be less than 16
RIP Problems: 2) Instability

- Net1 is disconnected from Router A
- Router A updates its hop count to 16
- Router A waits for 30 seconds before sending its advertisement
- Router B advertises Net1 (with hop-count =2) to A before A has a chance to advertise that Net1 is disconnected
- A is fooled and sets its Hop-count to 2+1=3
Remedies for RIP Instability

- **Triggered Update:**
  - Send an immediate update (with hop count = 16) whenever a network becomes unreachable, otherwise send periodic updates.

- **Split Horizons:**
  - Never sent same information back to the interface it came from
Remedies for RIP Instability: Poison reverse

- A variation of Split Horizon.
### RIP-v2 Format: Same length as in RIP-v1

<table>
<thead>
<tr>
<th>Command</th>
<th>Version</th>
<th>Reserved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family</td>
<td></td>
<td>Route tag</td>
</tr>
<tr>
<td>Network address</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subnet mask</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Next-hop address</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- RIP version 2 supports CIDR.
- RIP messages are encapsulated in a UDP datagram.
- RIP uses the services of UDP on well-known port 520.
Authentication

- Protect against unauthorized advertisement
- First entry (with family type = FFFF) is used for authentication

<table>
<thead>
<tr>
<th>Command</th>
<th>Version</th>
<th>Reserved</th>
</tr>
</thead>
<tbody>
<tr>
<td>FFFF</td>
<td></td>
<td>Authentication type</td>
</tr>
</tbody>
</table>

- Authentication data
  16 bytes

- Three additional entries