Lecture 9
Distance-Vector
RIP and RIPv2

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Distance-Vector [repeat]

- Variations of Bellman-Ford algorithm.
- Each router starts by knowing:
  - Prefixes of its attached networks ("zero" distance).
  - Its next hop routers (how to find them?)
- Each router advertises only to its neighbors:
  - All prefixes it knows about.
  - Its distance from them.
- Each router learns:
  - All prefixes its neighbors know about.
  - Their distance from them.
- Each router figures out, for each destination prefix:
  - The "distance" (how far away it is).
  - The "vector" (the next hop router).
DV Computes the Shortest Path

- DV protocols are variants of the “distributed Bellman-Ford Shortest-Path algorithm”.
- “Routing by rumor”.
  - Each router believes what its neighbors tell it.
- In steady-state, each router has the “shortest” (smallest metric) path to the destination.

- Convergence time is (on the average) proportional to the diameter of the network.
- Any link change affects the entire network.
DV

A:0
B:1,B

B:0
A:1,A
E:1,E
C:1,C

C:0
B:1,B
D:1,D
G:1,G

F:0
E:1,E

E:0
F:1,F
B:1,B
D:1,B

D:0
E:1,E
C:1,C
G:1,G

G:0
C:1,C
D:1,D
DV

A: 0
B: 1, B
C: 2, B
E: 2, B

B: 0
A: 1, A
E: 1, E
C: 1, C
D: 2, C
G: 2, C
F: 2, E

C: 0
B: 1, B
D: 1, D
G: 1, G
A: 2, B
E: 2, B

F: 0
E: 1, E

E: 0
F: 1, F
B: 1, B
D: 1, D

D: 0
E: 1, E
C: 1, C
G: 1, G

G: 0
C: 1, C
D: 1, D
Counting to Infinity

- What happens when a link dies?

A: 0
B: 1, B
C: 2, B

A: 1, A
B: 0
C: 1, C

A: 2, B
B: 1, B
C: 0
Counting to Infinity

- What happens when a link dies?

A:0
B:1,B
C:2,B

A:1,A
B:0

A:2,B
B:1,B
C:0
Counting to Infinity

• What happens when a link dies?

A:0, B:1,B, C:2,B
A:1,A, B:0, C:3,A
A:2,B, B:1,B, C:0
Counting to Infinity

- What happens when a link dies?

```
A:0  A:1,A  A:2,B
B:1,B  B:0  B:1,B
C:4,B  C:3,A  C:0
```
Counting to Infinity

• What happens when a link dies?

And so on.
• Counting to infinity can take a long time.
• RIP defines infinity as 16.
• When infinity is reached, the route to C is declared dead.
Split Horizon

- To combat the effects of counting-to-infinity.
- Routers do not announce routes to the link from which they learned them.
Split Horizon

A

B

C

A:0
B:1,B
C:2,B

A:1,A
B:0
C:1,C

A:2,B
B:1,B
C:0
Split Horizon

• What happens when a link dies?
Split Horizon

• What happens when a link dies?

- Route to C expires after it hasn’t been refreshed for a while.
- This way we avoid counting to infinity.
Split Horizon with Poison Reverse

- Instead of suppressing routes, advertise them with infinite metric:

```
A:inf  A:1  B:0  C:1  C:inf  A:inf  A:2  B:inf  B:1  C:0
A  B  C  D
```
Split Horizon with Poison Reverse

- When the A-B link goes down, B believes C’s announcement:

![Diagram showing network topology and routing updates after A-B link failure]
Split Horizon with Poison Reverse

- Which he propagates (obviously as infinity)
Split Horizon with Poison Reverse

- Letting C know that A is now unreachable.

- SHwPR speeds protects against incorrect routes that may appear.
- Bad news is better than no news!
Split Horizon Does not Always Work
Split Horizon Does not Always Work
Split Horizon Does not Always Work

A: 0
B: 1,B
C: 2,B
D: 2,B

A: 1,A
B: 0
C: 1,C
D: 1,D

B: 1,B
C: 0
D: 1,D
A: 2,B

B: 1,B
D: 0
C: 1,C
A: 2,B
Split Horizon Does not Always Work

A:0

B:0
C:1,C
D:1,D

B:1,B
C:0
D:1,D
A:2,B

B:1,B
C:1,C
A:2,B
Split Horizon Does not Always Work
Split Horizon Does not Always Work
Triggered Updates

- (aka Flash Updates).
- If a metric changes (up or down), a router immediately propagates that change.
- Decreases convergence time.
- Regular updates still occur.
- Only include prefixes that actually triggered the update.

- It’s obvious.
- But RIP didn’t do it this way initially.
- Bad information can also propagate very quickly.
Holddown Timers

• If a route metric increases, no new updates for that route are accepted until the holddown timer expires.
• Too short - ineffective.
• Too long - increases convergence time.
Asynchronous Updates

• Left unattended, DV routers on a broadcast network synchronize themselves.

• Increased collisions (even with Ethernet CD and exponential backoff).

• Add jitter to each update period (~15%).
RIP (v1)

- Simplest of the DV protocols currently in use.
- Traces its ancestry to the PUP GWINFO and XNS RIP.
  - Apple RTMP and IPX RIP also trace their ancestry to XNS RIP.
- 4.2BSD (1983) implements RIP in routed(8).
- RFC 1058 written in 1988!

- UDP-based, Port 520, broadcast.
- Classful.
- Request and response messages.
- Metric is hop-count.
- Infinity is 16.
RIP (v1) Cont’d

- On startup, broadcast request on all interfaces.
- When a request is received, a response is sent.
  - Response contains entire routing table.
- A response is also gratuitously sent every 30s (jittered).
  - Contains full routing table minus entries suppressed by SHwPR.
- Routes are invalidated (set to 16) after 6 update periods.
- Routes are flushed after another 4 update periods.

- Triggered updates do not reset the update timer.
  - TU cannot be re-triggered for 1-5 seconds.
RIP (v1) Cont’d

- When a response is received:
  - If the route is not in the table, it is inserted.
  - If the route has the same metric, exp timer is reset.
  - If the route has a lower metric than what is in the table, it replaces it.
  - If the route has a higher metric AND update came from same router:
    - Marked as unreachable for holddown period.
    - If adv persists beyond holddown period, route is installed.
### RIP (v1) Message Format

<table>
<thead>
<tr>
<th>Command</th>
<th>Version (1)</th>
<th>Reserved (0)</th>
<th>AF (2)</th>
<th>Reserved (0)</th>
<th>IP Address</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Reserved (0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Reserved (0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Reserved (0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Metric</td>
</tr>
</tbody>
</table>

*Up to 25 route entries*
RIPv2

- Incremental improvement to RIP.
- RFC2453.
- Packets are multicast to 224.0.0.9.
- Additional features:
  - Authentication.
  - Classless.
  - Route tags.
  - Router IP address.
## RIPv2 Message Format

<table>
<thead>
<tr>
<th>Command</th>
<th>Version (2)</th>
<th>Reserved (0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AF (2)</td>
<td></td>
<td>Route tag</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IP Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netmask</td>
</tr>
<tr>
<td>Next Hop</td>
</tr>
<tr>
<td>Metric</td>
</tr>
</tbody>
</table>

*Up to 25 route entries*
RIPv2 Authentication

<table>
<thead>
<tr>
<th>Command</th>
<th>Version (2)</th>
<th>Reserved (0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FFFF</td>
<td></td>
<td>Auth type</td>
</tr>
<tr>
<td></td>
<td>Auth Data (bytes 0-3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Auth Data (bytes 4-7)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Auth Data (bytes 8-11)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Auth Data (bytes 12-15)</td>
<td></td>
</tr>
</tbody>
</table>

- Default auth is just a password (useless).
- Cisco uses an MD5 hash that includes a password (somewhat better).
- Up to 24 route entries follow.
Other DV protocols

- Cisco IGRP and EIGRP.
  - (Enhanced) Interior Gateway Routing Protocol.
  - Proprietary.
  - Flexible (complex!) metric definition.
  - Have areas/autonomous systems.
- Read Doyle and cisco documentation for details.
- BGP is a “path-vector” protocol.
  - We’ll examine it in excruciating detail.
- Older, defunct protocols.
  - EGP/Hello.