Internet Standard Intra-domain Routing Protocols

• Distance Vector-type
  – Routing Information Protocol (RIP), RFC 1058, 2453

• Link-State-type
  – Open Shortest Path First (OSPF), RFC 2328
  – Intermediate System-to-Intermediate System (IS-IS), an OSI protocol supported by most routers

• Note well: destinations are networks
  – Remember: IP's only job is to get the packet to a router attached to the same network as the destination
  – That network does the rest of the job
Routing Information Protocol (RIP)

• Version 1, RFC 1058 (1988)
  – Derived from Xerox PARC protocols
  – Implemented in Berkeley Unix
    • RFC written long after the protocol was in production use
  – Used mainly on small broadcast networks

  – Support for classless addressing (subnet masks)
  – Next-hop router ID advertised with destination
    • Prevents 2-hop loops
  – Rudimentary Authentication
    • Plain-text passwords (!)
    • RFC 2082 added MD5 Keyed-hash authentication
RIP Version 2 Header

<table>
<thead>
<tr>
<th>Command</th>
<th>Version</th>
<th>Unused</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0xFFFF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Authentication Type</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Authentication (16 bytes)</td>
</tr>
<tr>
<td>Address Family Identifier</td>
<td>Route Tag</td>
<td></td>
</tr>
<tr>
<td>Destination Address</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subnet Mask</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Next Hop</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metric</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Address Family Identifier</td>
<td>Route Tag</td>
<td></td>
</tr>
<tr>
<td>Destination Address</td>
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<td></td>
</tr>
</tbody>
</table>

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Open Shortest Path First Protocol

  - RFC 2328: 244 pages
- Widely deployed in the Internet
- Link-state protocol
  - Each router builds a link-state database (graph model)
  - Each router runs Dijkstra's "Shortest Path First" algorithm to determine routes
OSPF Features

- **HELLO Protocol**: neighbor discovery and maintenance
- Reliable flooding: Flooded messages retransmitted until acknowledged
- Two-level routing hierarchy (Optional)
  - **Area**: group of networks treated as one node
  - Hides details of topology from other parts of network
  - Shrinks LS databases
- Explicit support for importing routes from outside the domain
- Miscellaneous
  - Load-sharing across equal-cost routes
  - All protocol exchanges are authenticated
  - Support for "virtual links"
  - Runs over UDP
    - Alternatives: directly over link, directly over IP
OSPF LSA Types

• Router LSAs
  - Contains one "link descriptor" for each active interface connected to a router
  - Sent by every router, flooded throughout the area

• Network LSAs
  - For broadcast networks with 2 or more routers attached
  - Sent by net’s designated router, flooded throughout area

• Summary LSAs
  - Summarize destinations outside an area (but inside the AS)
  - Sent by area border routers, flooded throughout the area

• AS-external LSAs
  - Describe destinations outside the AS
  - Information imported from Inter-domain routing protocol
## OSPF Packet Format

<table>
<thead>
<tr>
<th>Version</th>
<th>Type</th>
<th>Length</th>
<th>Sender ID</th>
<th>Area ID</th>
<th>Checksum</th>
<th>Auth Type</th>
<th>Authentication Info</th>
</tr>
</thead>
</table>

- One of:
  - 1 = HELLO
  - 2 = DB Descr.
  - 3 = LS Request
  - 4 = LS Update
  - 5 = LS Ack

The packet format includes a 24-byte common header.
Every Router has a 32-bit ID, unique in its AS. Typically this is its lowest IP address.
OSPF Packet Format

<table>
<thead>
<tr>
<th>Version</th>
<th>Type</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Sender ID
- Area ID
- Checksum
- Auth Type
- Authentication Info

24-byte common header

32-bit ID of the Area this packet belongs to

Type-specific Information
OSPF Packet Format

<table>
<thead>
<tr>
<th>Version</th>
<th>Type</th>
<th>Length</th>
</tr>
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<tbody>
<tr>
<td>Sender ID</td>
<td>Area ID</td>
<td></td>
</tr>
<tr>
<td>Checksum</td>
<td>Auth Type</td>
<td></td>
</tr>
<tr>
<td>Authentication Info</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type-specific Information</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Internet Checksum, covers all but Auth. Info

24-byte common header
OSPF Packet Format

Version | Type | Length
--- | --- | ---
Sender ID | | |
Area ID | | |
Checksum | Auth Type | |
Authentication Info | | |
Type-specific Information | | |

24-byte common header

Tells how to interpret Auth. Info, one of:
0=null
1=passwd
2=keyed hash
**OSPF Hello Protocol**

**Purpose**
- Detect routers joining the network
- Detect failure of links or neighbor routers
- Ensures bidirectional communication
  - Only bidirectional links can be advertised!

**Function** (Different for point-to-point, broadcast)
- Each router sends a *Hello* packet to the "all OSPF routers" multicast address every *HelloInterval* secs on all of its attached interfaces
- Hello Packet contains list of all routers from which sender has received Hello packets recently
- A state machine is maintained for each i/f, which keeps track of which neighbors are up, down, in transition, etc.
### Link-State Announcement Format

<table>
<thead>
<tr>
<th># LSAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>LS Age</td>
</tr>
<tr>
<td>Options</td>
</tr>
<tr>
<td>Type</td>
</tr>
<tr>
<td>Link State ID (sender's ID)</td>
</tr>
<tr>
<td>Advertising Router</td>
</tr>
<tr>
<td>Sequence Number</td>
</tr>
<tr>
<td>LS Checksum</td>
</tr>
<tr>
<td>Length</td>
</tr>
<tr>
<td>(stuff)</td>
</tr>
<tr>
<td># links</td>
</tr>
<tr>
<td>Link ID</td>
</tr>
<tr>
<td>Link Data</td>
</tr>
<tr>
<td>Link Type</td>
</tr>
<tr>
<td># TOS</td>
</tr>
<tr>
<td>Metric</td>
</tr>
</tbody>
</table>

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