

NSWI184 – Řízení počítačových sítí

Přednáška druhá

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RIP - Routing Information Protocol

- ▶ One of the oldest routing protocols
- ▶ Developed in the 1980s for small networks
- ▶ Simple and lightweight
- ▶ Distance Vector algorithm

RIP History

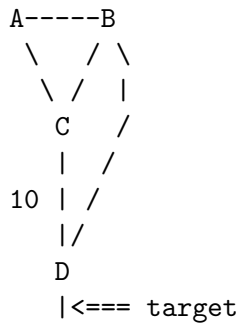
- ▶ RIPv1 (1988, RFC 1058)
- ▶ RIPv2 (1993, RFC 2453) - classless addressing, authentication
- ▶ RIPv6 (1997, RFC 2080) - IPv6

How RIP Works

Distance Vector Algorithm

- ▶ Each router maintains a routing table
- ▶ Initializes the table with local routes
- ▶ Periodically announces the entire table to neighbors
- ▶ Compare received routes with current ones, update when necessary
- ▶ Distributed Bellman-Ford algorithm

RIP Example



RIP Metric

Hop Count as Metric

- ▶ Small range of valid values
- ▶ Maximum metric: 15
- ▶ Metric 16 = unreachable
- ▶ Interface cost can be higher than 1

RIP Updates

- ▶ Entire routing table sent every 30 seconds
- ▶ ...or on request from a neighbor (initialization)
- ▶ Triggered updates upon topology changes
- ▶ Explicit announcement of unreachable routes
- ▶ Split horizon to prevent routing loops

RIP Update processing

For each received route

- ▶ Increment its metric by the interface cost
- ▶ Compare it with with current route for the same network
- ▶ If it is better than the current one, update the table
- ▶ If it is worse but from the same neighbor, also update the table
- ▶ When changed, mark for triggered updates
- ▶ Reset timeout timer for the route

Unreachable routes

- ▶ Generally, absent routes are not announced
- ▶ Unreachable route as a withdraw (state change)
- ▶ Absence of delimiters/reliability for full table update
- ▶ Explicitly announced for a while
- ▶ Then garbage-collected

RIP Timers

- ▶ Update time: 30 s (periodic updates)
- ▶ Triggered update time: 1-5 s (update on change)
- ▶ Timeout time: 180 s (route becomes unreachable)
- ▶ Garbage collection time: 240 s (unreachable route removed from table)
- ▶ A route can also become unreachable immediately based on link state

Counting to Infinity

Routers do not know if received routes are loops!

- ▶ Formation of loops due to the asynchronous nature of the protocol
- ▶ Propagation of old metrics concurrently with propagation of unreachability
- ▶ Routers 'deceive' each other regarding reachability
- ▶ Gradual increase of metric until maximum is reached
- ▶ Immediate switching to next-best route makes situation worse
- ▶ General problem of distance vector protocols

Loop Prevention

Mechanisms for Loop Prevention

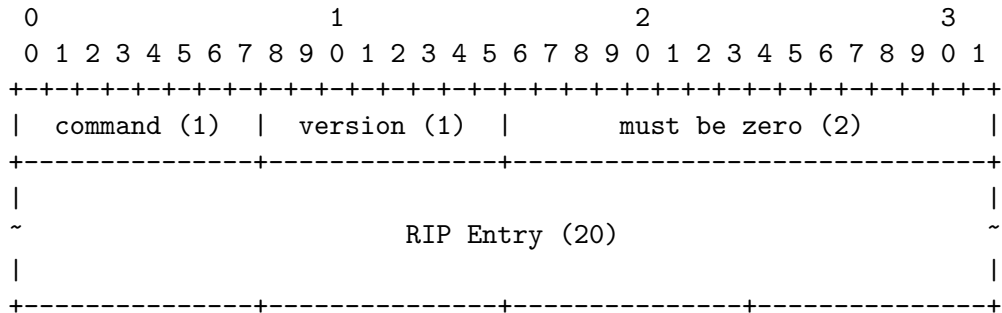
- ▶ Triggered updates: Reduce the time window for concurrency
- ▶ Split Horizon: Do not advertise routes back towards the source
- ▶ Split Horizon with Poisoned Reverse: Advertise as unreachable
- ▶ Hold-down time: Ignore updates after a route failure
- ▶ Low maximum metric: Limits the overall duration of 'counting to infinity'

Implementation Details

- ▶ Messages sent via UDP
- ▶ Ports 520 (RIPv2) and 521 (RIPng)
- ▶ 2 message types: request, response
- ▶ Sequence of blocks with a fixed structure
- ▶ Sent as both multicast and unicast

RIP Messages

- ▶ Request
- ▶ Response



RIPv2 Entries

0										1										2										3		3
0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
Address Family Identifier (2)										Route Tag (2)																						
+-----+-----+										+-----+-----+																						
										IP Address (4)																						
+-----+-----+										+-----+-----+																						
										Subnet Mask (4)																						
+-----+-----+										+-----+-----+																						
										Next Hop (4)																						
+-----+-----+										+-----+-----+																						
										Metric (4)																						
+-----+-----+										+-----+-----+																						

RIPng Entries

[illegible]

RIP Authentication

Securing RIP Messages

- ▶ Authentication via plaintext password
- ▶ MD5 authentication (RFC 2082)
- ▶ SHA-1 authentication (RFC 4822)
- ▶ Key management
- ▶ Sequence numbers

Advantages of RIP

- ▶ Simple to understand and implement
- ▶ Low CPU and memory requirements
- ▶ Minimal room for errors
- ▶ Illustrative distance vector protocol

Disadvantages of RIP

- ▶ Slow convergence
- ▶ Limited to 15 hops
- ▶ Inefficient use of links
- ▶ Lack of acknowledgement and flow control
- ▶ Counting-to-infinity problem

What is OSPF?

- ▶ **Open Shortest Path First (OSPF)**
- ▶ Link-state routing protocol
- ▶ Standardized by IETF
 - ▶ RFC 2328 (OSPFv2, IPv4)
 - ▶ RFC 5340 (OSPFv3, IPv6)
- ▶ Widely used in enterprise networks

Key Features of OSPF

- ▶ Link-state routing protocol
- ▶ Uses Dijkstra's shortest path algorithm
- ▶ Hierarchical design with areas
- ▶ 24-bit metric, 16-bit interface costs
- ▶ Supports authentication

RIP vs OSPF

Distance Vector (RIP):

- ▶ Maintains a routing table
- ▶ Shares routing table with neighbors
- ▶ Local view of the network
- ▶ Slower convergence
- ▶ Synchronized route propagation
- ▶ Potential for routing loops
- ▶ Simple

Link-State (OSPF):

- ▶ Maintains a topology database
- ▶ Shares network topology information
- ▶ Global view of the network
- ▶ Fast convergence
- ▶ Transient routing loops
- ▶ Complex

OSPF Overview

Tasks of an OSPF router:

- ▶ Discover neighbors (hello protocol)
- ▶ Establish and maintain *adjacencies* with them (neighbor state machine)
- ▶ Maintain a database of network topology information (link state database)
- ▶ Advertise local topology (link state advertisements)
- ▶ Exchange topology information (LSA flooding procedure)
- ▶ Calculate shortest paths (SPF algorithm)
- ▶ Identifier: Router ID

OSPF Areas - Overview

- ▶ Area
- ▶ Area 0: Backbone area, mandatory
- ▶ Other areas: Connected to the backbone
- ▶ Enables route summarization at area boundaries
- ▶ Reduces routing table size
- ▶ Limits LSA flooding
- ▶ Faster shortest path computation
- ▶ Identifier: Area ID

Types of OSPF Routers

- ▶ Internal router: All interfaces in the same area
- ▶ Backbone router: Interface in backbone area 0
- ▶ Area Border Router (ABR): Connects multiple areas
- ▶ AS Boundary Router (ASBR): Connects to external networks

Link State Database

Link State Database (LSDB)

- ▶ Contains all LSAs for the area
- ▶ Synchronized across all routers in the area
- ▶ Input for the SPF algorithm

Link State Advertisements (LSA)

- ▶ Information units in the Link State database
- ▶ Originated by a router and then flooded throughout the area
- ▶ Different types for different classes of information

Link State Advertisements

```

+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
|          LS age          |          Options          |          LS type          |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
|          Link State ID          |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
|          Advertising Router          |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
|          LS sequence number          |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
|          LS checksum          |          length          |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+

```

- ▶ LSAs identified by: Type, Link State ID, Advertising Router
- ▶ Age field (LS age) is used to discard outdated information
- ▶ Sequence number to determine which LSA is more recent
- ▶ Checksum for corruption detection

LSA Types

1. Router LSA: Router and its links
2. Network LSA: Information about a multi-access network
3. Net-summary LSA: Inter-area routes (from ABR)
4. Rt-summary LSA: Location of ASBR (from ABR)
5. External LSA: External routes
7. NSSA External LSA: External routes in NSSA areas
8. Link LSA: Exchange of information within a link (OSPFv3)
9. Intra-area prefix LSA: Information about link IP prefixes (OSPFv3)

In OSPFv3, the type includes information about scope

LSA Scope

- ▶ Global (External LSA)
- ▶ Per-area
- ▶ Per-link (Link LSA)

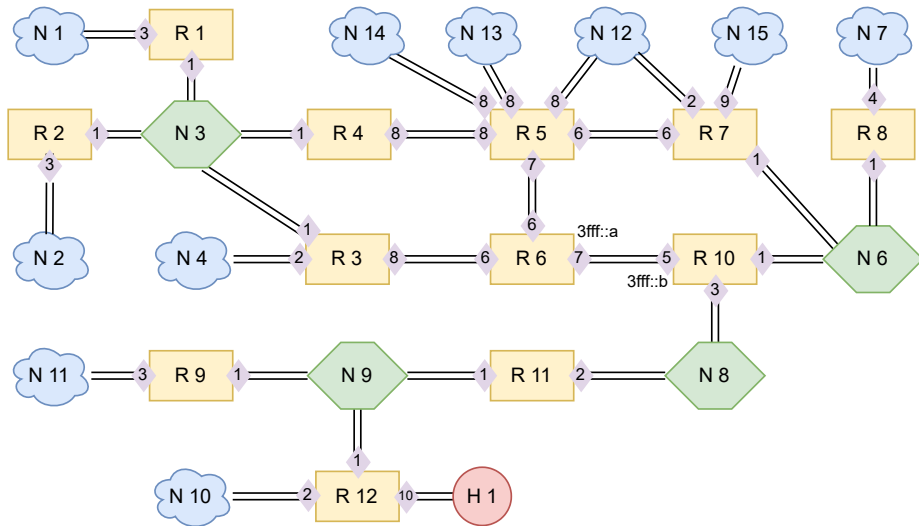
Router and Network LSA

- ▶ Router LSA contains a list of links and their metrics
- ▶ Links reference adjacent LSAs
- ▶ Network LSA contains a list of attached routers (Router IDs)

4 link types:

1. PtP link to a router
2. Link to a multi-access network
3. Stub network
4. (Virtual link)

Topology Example

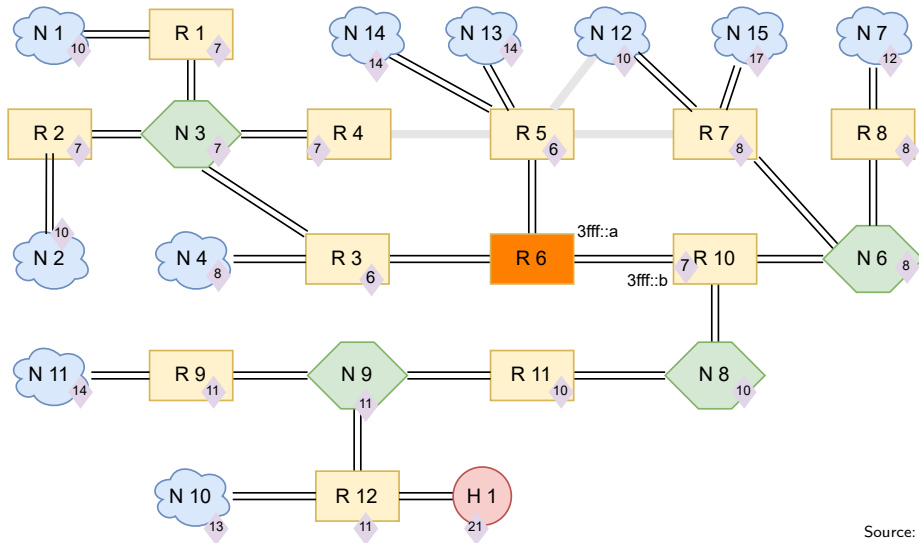


Source: RFC 2328

SPF Algorithm (Dijkstra)

- ▶ Mark all Router/Network LSAs as unreachable
- ▶ Place the router as the root of the SPF tree
- ▶ Mark its LSA as reachable at distance 0
- ▶ Iteratively process the nearest reachable LSAs
- ▶ Update distances of referenced LSAs
- ▶ Back-check whether the referenced LSA points back to the LSA being processed
- ▶ Gradually build the complete SPF tree, distances and paths to all destinations
- ▶ Build the routing table with the best paths
- ▶ Repeat after every topology change

Topology Example after SPF Calculation



Source: RFC 2328