Lab Course „RouterLab“

Open Shortest Path First (OSPF)
Miscellaneous

- Don't set enable passwords on Cisco router
- ...

...
OSPF (Open Shortest Path First)

- “Open”: specification publicly available
  - RFC 1247, RFC 2328
  - Working group formed in 1988
  - Goals:
    - Large, heterogeneous internetworks
- Uses the Link State algorithm
  - Topology map at each node
  - Route computation using Dijkstra’s algorithm
- Hierarchy
OSPFv2: Tasks (to be filled in)

- Neighbor discovery and maintenance
  - „Hello“ Protocol
- Link state database
  - kept at each router
  - stores topological information
  - needs to be synchronized with neighbors
- Calculation of routing table
  - Dijkstra
**OSPFv2: Components**

- Hello Protocol: “Who is my neighbor?”
- Database Synch: “What info am I missing?”
  - after establishing OSPF neighborhood
- Reliable flooding algo: “How do I distribute info?”
  - after something has changed (link failure, cost changes)
- Route computation
  - Based on link state database
  - Using Dijkstra’s algorithm
OSPF Packets

- IP Protocol #89
- Directly to neighbors using Multicast address ⇒ TTL 1
- Five packet types
  - Hello
  - Database Description
  - Link State Request
  - Link State Update
  - Link State Acknowledgement
Neighbor Discovery and Maintenance

- **Hello Protocol**
  - Ensures that neighbors can send packets to and receive packets from the other side: bi-directional communication
  - Ensures that neighbors agree on parameters (HelloInterval and RouterDeadInterval)

- **How**
  - Hello packet to fixed well-known multicast address
  - Periodic Hellos
Link State Database

- Based on link-state technology
  - Local view of topology in a database

- Database
  - Consists of Link State Advertisements (LSA)
  - LSA: data unit describing local state of a network/router → **different LSA types**!
  - Must kept synchronized to react to routing failures
Database synchronization

- Central aspect:
  all routers need to have identical databases!

- 2 types of synchronization
  - Initial synchronization
    - After hello
  - Continuous synchronization
    - Flooding
Initial Synchronization

- Explicit transfer of the database upon establishment of neighborship
- Once bi-directional communication exists
- Send all LS **header** from database to neighbor
  - OSPF database description packets (DD pkt)
  - Flood all future LSA’s
Initial Synchronization (2.)

- Database description (DD) exchange
  - Only one DD at a time
  - Wait for Ack
- Control of DD exchange
  - Determine which LSA’s are missing in own DB
  - Request those via link state request packets
  - Neighbor sends these in link state update packets
- Result:
  - Fully adjacent OSPF neighbors
Database Synchronization - Example

10.1.1.4

OSPF Hello

OSPF Hello: I heard 10.1.1.6

Database Description: Sequence = x

DD: Sequence = x, 5 LSA Headers =
(router-LSA, 10.1.1.1, 0x80000004),
..........

DD: Sequence = x+1, 1 LSA Header =
(router-LSA, 10.1.1.1, 0x80000004)
...

DD: Sequence = x+1

10.1.1.6
Reliable Flooding

- E.g., after something changes
  - link failure
  - OSPF cost change for a link

- Robustness
  - LSA refreshes every 30 minutes
  - LSAs have checksums
  - LSAs are aged
  - LSAs cannot be send at arbitrary rate: there are timers
Calculation of routing table

- Link state database is a directed graph with costs for each link
- Use Dijkstra to compute paths from source to all destinations
- More info on Dijkstra: Check the web ...
Network Types

- So far only point-to-point
- Many other technologies
  - Point-to-point
  - Broadcast
  - ...

Hierarchical OSPF
Hierarchical OSPF

- **Two-level hierarchy**: local area and backbone.
  - Link-state advertisements do not leave respective areas.
  - Nodes in each area have detailed area topology; they only know direction (shortest path) to networks in other areas.

- **Area Border routers**: “summarize” distances to networks in the area and advertise them to other Area Border routers.

- **Backbone routers**: run an OSPF routing algorithm limited to the backbone.

- **Boundary routers**: connect to other ASs.
Areas

- An AS (or Routing Domain) is divided into areas.
- Group of routers
- “Close” to each other.
- Reduce the extend of LSA flooding
- Intra-area traffic
- Inter-area traffic
- External traffic: injected from a different AS
- OSPF requires a backbone area (Area 0)
  - Routing between areas only via backbone area
  - Strict area hierarchy (no loops allowed)
OSPF: Summary

- Neighbors
  - Discovery: Multicast group
  - Maintenance: Hello protocol

- Database
  - Granularity: Link state advertisements (LSA)
  - Synchronization: Initial synchronization
    Reliable flooding

- Routing table
  - Calculation: Local shortest path calculation
Lab Course „RouterLab“

Worksheet 3: Questions
Quagga (Question 1)

- „Software router“ for various platforms
- Supports many routing protocols
- Collection of several daemons
  - zebra: „communication“ with kernel and integration of all daemons
  - ripd: RIP support
  - ospfd: OSPF support
  - ...
- User interface shell: VTY
- Apart from that: Similar configuration as on previous work sheets
  - if you wish you can reuse existing dumps
Work sheet 3

- Question 2
  - basic OSPF setup
  - reachability over multiple hops

- Question 3
  - Link-State Database
  - Database Synchronization
Question 4

- Link state database is a directed graph with costs for each link

- Dijkstra’s SPF algorithms
  - Add all routers to shortest-path-tree
  - Add all neighbors to candidate list
  - Add routers with the smallest cost to tree
  - Add neighbors of this router to candidate list
    - If not yet on it
    - If cost smaller
  - Continue until candidate list empty

- “Run the algorithm by hand“!
Question 5

· OSPF costs
· OSPF hierarchy, areas
· intra- and interarea paths