Introduction to Link State Protocols

Session RST-103
Agenda

- Overview of Link State Protocols
- Concepts in Link State Protocols
- The Dijkstra Algorithm
- IP Link State Protocols
- Choosing an IP Link State Protocol
Why Is It Called a Link State Protocol?

- Traditional distance vector protocols relay information regarding their relative distance to a destination
- Link State Protocols relay specific link characteristics and state information
- Only changes or updates are sent across the network
- Each router uses that information to build a routing table on its own
Link State Protocols

- Rely on the Dijkstra shortest path first (SPF) algorithm to calculate path tree
- Maintain a database of network information for a complete “picture” of the network
- Form adjacencies between neighboring devices and flood to exchange database information
- Utilize a hierarchal design to enable scalability
Advantages of a Link State Protocol

• Uses metrics (costs) to calculate path
• Typically displays faster convergence than distance vector routing protocols
• Typically more scalable due to hierarchical nature
Dijkstra Protocols

- IS-IS
- OSPF
- CLNS/DECnet phase 5
- NLSP
Common Concepts
Metrics

- **Metric** = path cost
- Numeric value that can be administrator assigned, or calculated using link characteristics information
- More flexible than hops used in DVRPs
Topology/Link State Database

- The LSDB contains information regarding all links and routers within a logical area.
- A router has a separate LS database for each area to which it belongs.
- All routers belonging to the same area have identical database.
- SPF calculation is performed separately for each area.
Adjacencies

- Routers participating in a Link State Protocol are uniquely identified throughout the network with a router ID (some form of address)
- Link state protocol routers “discover” their adjacent neighbors with some form of Hello protocol
- Once discovered neighbors form a relationship to exchange/synchronize LSDB information between them
Building the Database

- Hello packets discover neighbors
- Once neighbors are discovered, LSDB information is exchanged

Hello, I'm B
Hello, I'm A
Let's exchange information
OK
I know about these links...
I know about these links...
Logical Hierarchy

- Link State Protocols deploy a logical hierarchy in their design.
- Typically consists of two levels.
- Usually consists of the concept of a “backbone” level and another sub-level.
  - OSPF: Backbone area (area 0), regular areas
  - IS-IS: L2 areas, L1 areas
- Enables scalability by summarizing and abstracting, thereby reducing information from lower level areas into the higher level area.
Not Summarized: Specific Links

- Only summary LSA advertised out
- Link-state changes do not propagate
Summarized: Summary Links

- Only summary LSA advertised out
- Link-state changes do not propagate
Flooding

• Information that changes or is learned from a neighbor is “flooded” across a logical network area

• This is done to maintain consistency of the LSDB across all routers
Flooding
The Djikstra Algorithm
Dijkstra

Shortest Path First (SPF) Algorithm

- Dijkstra is a path finding algorithm
- Will find the shortest path from A to B given intermediate path and cost information
- One of many path finding algorithms: Dijkstra, best path, A*, etc
Dijkstra

Shortest Path First (SPF) Algorithm

- **Link state database**
  Created with link state packets (LSPs) from each router

- **TENT database**
  Tentative triples (ID, path cost, direction)
Dijkstra (SPF) Overview

- **PATH database**
  
  Best path triples
  (ID, path cost, direction)

- **Forwarding database**
  
  Aka the routing table
Dijkstra (SPF) Overview (Cont.)

- All routers exchange Link State Packets (LSPs)
- Each starts with itself as root
- Tent is built from LSPs
- Path is created by examining and comparing tent triples
- Once path is final the forwarding table is populated
Dijkstra Basics

- Router IDs are alphabetic
- Costs are numeric
- Lowest cost best
LSP Data

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<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
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</table>

Diagram:

- Nodes: A, B, C, D, E, F, G
- Connections:
  - A to B (4)
  - B to C (1)
  - C to D (4)
  - D to E (2)
  - E to A (4)
  - B to F (2)
  - F to G (2)
  - G to A (2)
Dijkstra Example—1/7

As an example start with B
A and C costs are tent
Dijkstra Example—2/7

- Now fill in C
- D, E are in tent
- BC is now in path
Dijkstra Example—3/7

- Now fill in C
- D,E are in tent
- BC is now in path
• Now fill in A
• G is in tent
• BA is now in path
Dijkstra Example—5/7

- CD is removed
- ED is placed in path
Dijkstra Example—6/7

- Now fill in F
- G is Tent
- GF does not provide better path
- EF is in path
Now fill in G
- FG is removed
- AG is in path
IP Link State Protocols
Terminology in IP LSPs

**OSPF**
- Host
- Router
- Link
- Packet
- Designated router (DR)
- Backup DR (BDR)
- Link-State Advertisement (LSA)
- Hello packet
- DataBase Description (DBD)

**ISIS**
- End System (ES)
- Intermediate System (IS)
- Circuit
- Protocol Data Unit (PDU)
- Designated IS (DIS)
- N/A (no BDIS is used)
- Link-State PDU (LSP)
- IIH PDU
- Complete sequence number PDU (CSNP)
### Terminology (Cont.)

**OSPF**
- Area
- Non-backbone area
- Backbone area
- Area Border Router (ABR)
- Autonomous System Boundary Router (ASBR)

**ISIS**
- Sub domain (area)
- Level-1 area
- Level-2 Sub domain (backbone)
- L1L2 router
- Any IS
Media Handling

**OSPF**

- Point-to-point
- Broadcast (LAN segments)
- Non-broadcast
- Point-to-multipoint

**OSPF**

- Point-to-point
- Broadcast
LSDB Management

**OSPF**

- OSPF counts up to MaxAge (60 minutes)
- It is not configurable
- Thus, every LSA needs to be refreshed every LSRefreshTime period (30 minutes)
- Refresh is a fixed constant

**ISIS**

- ISIS counts down to 0
- LSPs get flushed when age reaches 0
- LSPs are originated with a configurable non-zero value
- Thus refreshment interval is configurable (default is 15 minutes)
Choosing an IP Link
State Protocol
Choosing an IP LSP

- Both protocols are over 10 years old, using graph theory that’s at least 40 years old
- Both protocols are (even still) works in progress
- OSPF is more granular so you need to know the flooding behavior of different types of LSA’s
- ISIS can be simpler once you get over the NSAP addresses

* Dave Katz June 2000 NANO19
Choosing an IP LSP

• So which one is better?

  Depends on your comfort level and understanding

  Both scale equally well

  Do not implement them the same way

  Neither one will compensate for poor design