Link State Routing Algorithm

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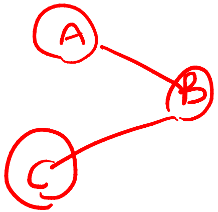
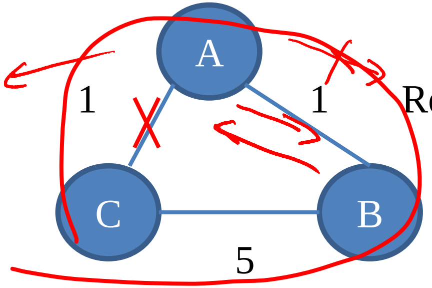
Idea

- Two Phases
- Phase 1: Reliable flooding
  - Initial State: Each node knows the cost to its neighbors
  - Final State: Each node knows the entire graph (network topology)
- Phase 2: Route calculation
  - Each node uses Dijkstra's algorithm on the graph to calculate optimal routes to all nodes

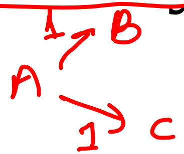
Reliable Flooding

- Each node sends its link-state (neighborhood information) to all nodes in the topology reliably

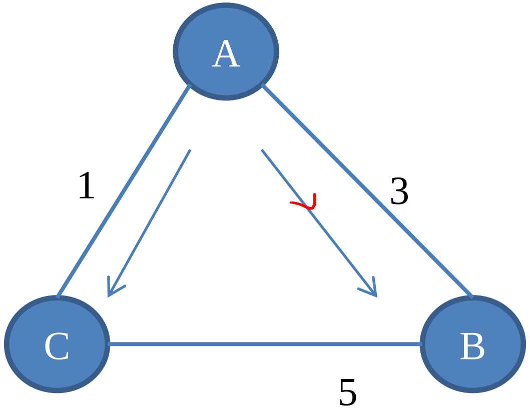


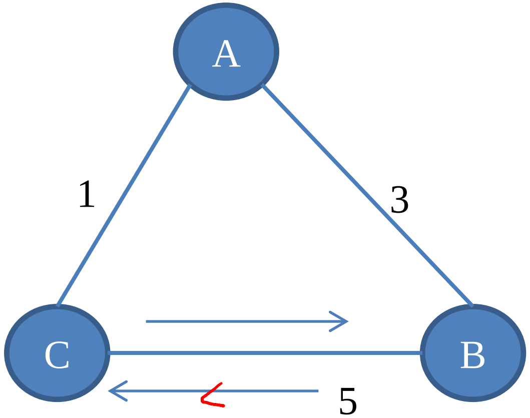


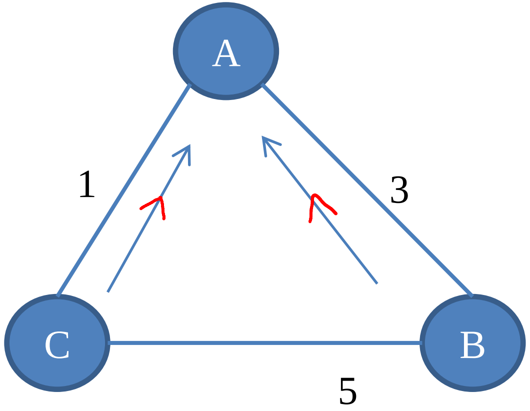
Reliability



Flooding

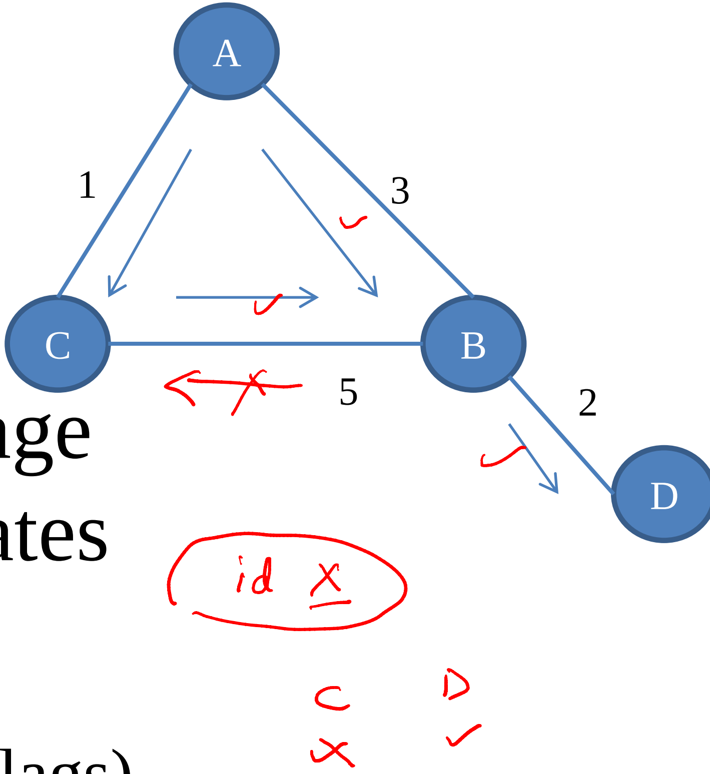






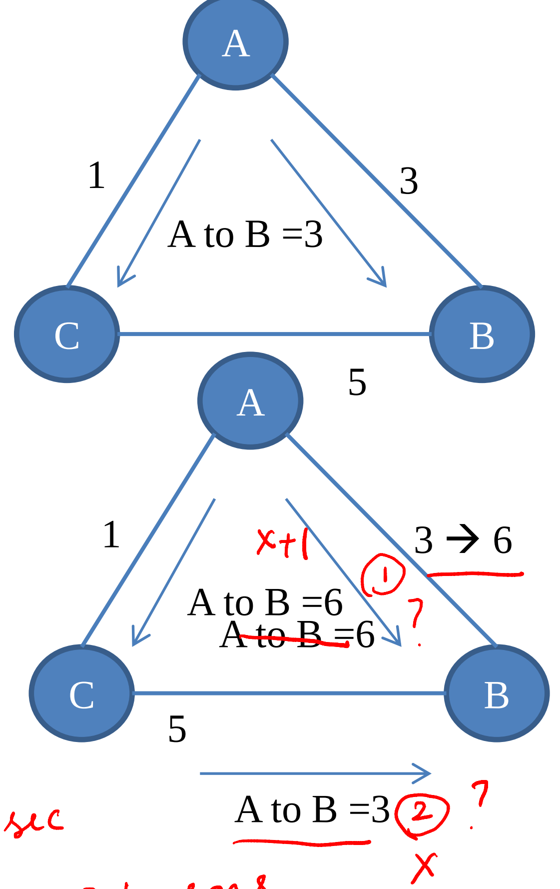
Features and Solutions

- Reliability: Employ a reliable protocol to transfer information between neighbors
- Avoid loops and minimize message exchange: Need to detect duplicates
  - Packets need unique 'ids'
  - For a given id, maintain state (Send flags) to determine on which interface to send



- New information should precede older information
  - Use sequence no (also uniquely identifies a packet)
  - At a node, increment sequence no for each new message flooded
- What about sequence number wrap around?
  - Use a very large sequence number space (e.g. 32 bits)

1 every sec



2^{32} sec

→ 136 years

- Corruption of sequence number?
  - Use checksums
  - Each entry stored at node is 'aged'
- What if a router crashed and came back up? What sequence number should it use?
  - Start with sequence no 0, if heard 'your own' packet, increment sequence number (within) and use
  - Packets are associated with TTL, discard packets when TTL hits zero → removes old information

5 4 A lifetime
128 128 curr. state
10 sec
really long time
→ old cleaned out
→ older
seq + 1

Putting it all together

- What message to send? Link-state packet (LSP)
- What to do when you receive an LSP? Action at a node
- When to send LSPs? Updates

Link State Packet

graph

- The id of node sending the packet
- The link-state of the node: neighborhood information (list of neighbors and cost to each)
- Sequence number
- Time-To-Live (TTL)

Action at a node

- Suppose a node X receives an LSP generated by node Y (Y need not be X's neighbor)
- Did I (i.e. X) hear from Y before?
  - No: Store the link-state information. Start an ageing timer.
  - Yes: Compare sequence number of this packet (Seq_new) with stored information (Seq_old).
    - If Seq_new > Seq_old, overwrite old link-state information, refresh ageing timer, forward to 'required' neighbors
    - If Seq_old >= Seq_new, discard received packet → outdated info

Updates

- Flooding leads to lot of traffic
  - Avoid to the extent possible
- Triggered updates
  - A node floods the network whenever its link-state information changes
- Periodic updates
  - Need not be sent often, use long timers (order of hours)

Route Calculation

- Once a node has a LSP packet from every node, it has complete graph information
- Use Dijkstra's algorithm to calculate shortest paths to nodes

Points to Note

- No problem of looping since each node has global information
  - Transient loops still possible
- Fast convergence
- But, scaling problems due to:
  - Flooding, computation, amount of information storage required at each node

    areas
  - Can reduce overhead by setting period update timer to hours

Break

OSPF

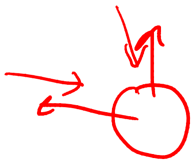
OSPF

Routing domain

- Very widely used interior gateway protocol
- Operates at the network layer
  - Encapsulated within IP datagrams with protocol number of 89 (demux key)

IP 89 → OSPF

- OSPF implements reliability itself via checksum and in-built ACKs



all IP prefixes @ cost 0

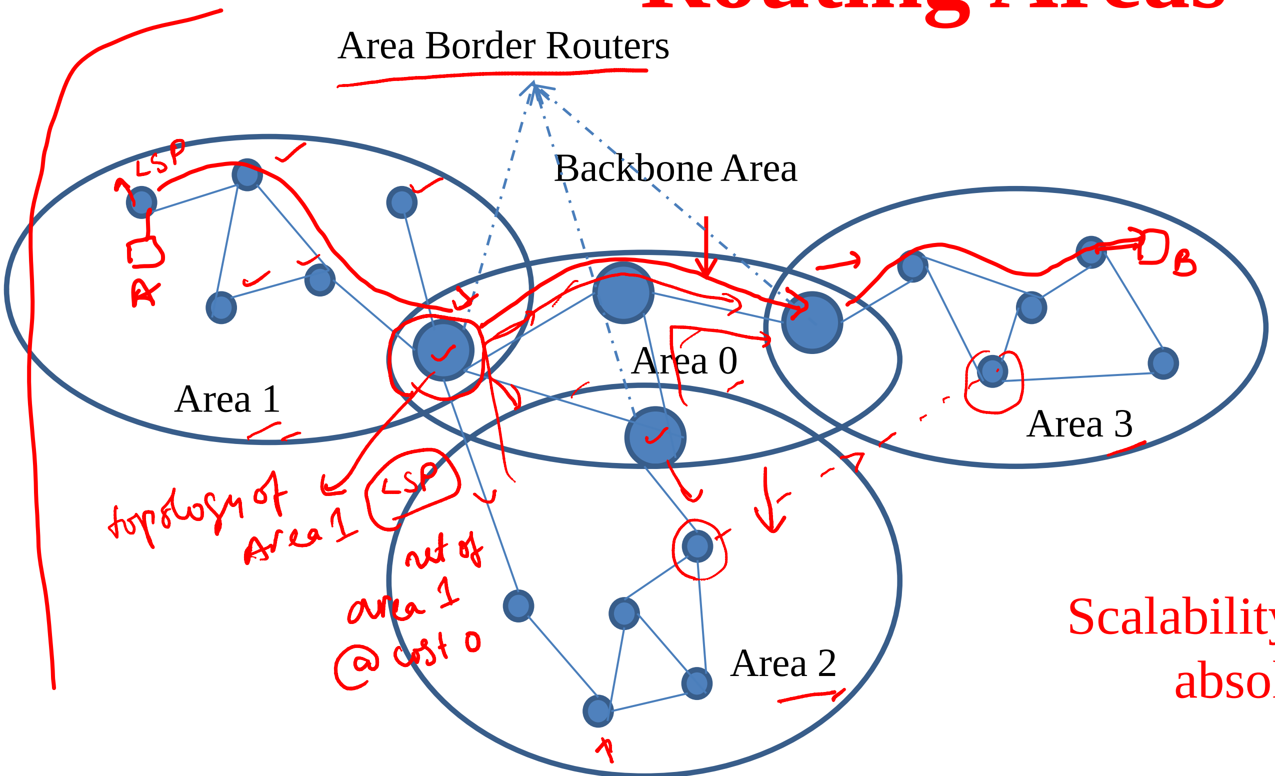
- Has many features

equal cost paths

areas

  - Supports authentication; Additional hierarchy; Load balancing

Routing Areas



→ IP datagram

Path of a packet:

1. Source network to backbone area
2. Cross the backbone area
3. Backbone area to destination network

Scalability more important than absolute shortest path

- Link state advt. of a non-area border router don't leave area
- Area border routers summarize area advertisements and advertise it to other areas

OSPF Common Header Format

Version No (=2)	Type	Packet Length (including header)
Router ID → IPaddress		
Area ID		
Checksum		Authentication Type
Authentication		
Message Body		

Type Value	Message Type
1	Hello
2	Database Description
3	Link State Request
4	Link State Update
5	Link State Acknowledgment

Authentication Type Value	Authentication Type
0	No Authentication
1	Simple Password Authentication
2	Cryptographic Authentication

OSPF Link State Update Packet

Number of Link State Advertisements
Link State Advertisement #1
. . .
Link State Advertisement #N

Link State Advertisement Header

<table>
<tr><td>LS Age</td><td>Options</td><td colspan="2">LS Type → Router
→ network</td></tr>
<tr><td colspan="4">Link State ID</td></tr>
<tr><td colspan="4">Advertising Router</td></tr>
<tr><td colspan="4">LS Sequence Number</td></tr>
<tr><td colspan="2">LS checksum</td><td colspan="2">Length</td></tr>
<tr><td colspan="4">LSA Body</td></tr>
</table>

Distance Vector vs Link State Algorithm

- DV: Each node talks only with directly connected neighbors but tells everything it has learned
  - Loops, slow convergence
- Link State: Each node talks to all nodes, but only state of directly connected node
  - Fast convergence but scalability concerns

Summary

- Link State routing: Another approach based on reliable flooding
- Provides fast convergence, but can pose scalability problems
- OSPF: a popular standard based on link state routing (RIP and OSPF fall under the category of interior gateway protocols)
- Ahead: Inter-domain routing (exterior gateway protocol)