

CSE 123b Communications Software

Spring 2003

Lecture 7: Link State Routing

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Last class

- Routing: how to get packets to their destination
 - **Forwarding**: local calculation to decide next hop for each packet
 - **Routing**: global calculation to ensure that forwarding decisions ultimately take packets to the right place
- Intra-domain routing protocols
 - Also called Interior Gateway Protocols (IGP)
 - Distance Vector
 - » Local exchange of global topology information
 - » In steady-state converges to correct solution
 - » Problems during failures: count-to-infinity

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2

This class

- Finish Intra-domain routing
 - **Link-state protocols**

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3

Link State routing

- Same goal as DV, but a different approach
- Two phases
 - **Reliable flooding**
 - » Tell **all** routers what you know about your **local** topology
 - **Path calculation** (Dijkstra's algorithm)
 - » Each router computes best path over **complete** network
- Motivation
 - Using DV, routers only have local information, making it difficult to decide what to do when there are changes
 - With LS, faster convergence and better stability (hopefully)
 - But... more complex

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4

Reliable flooding

- Goal: tell everyone what you know about local topology
- Periodically send **link state packets** (LSPs) on **all** links
 - LSP contains [node, neighbors, costs]
- If node X receives an LSP from node Y over link Q
 - Save it in local link state database
 - Forward LSP on all links **except** Q
- Use explicit ACKs and retransmits to make flooding reliable
- Each LSP will travel **exactly once** over each link

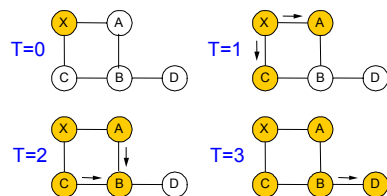
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5

Flooding example

- LSP generated by X at T=0
- Nodes become orange as they receive it



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6

Dijkstra's Shortest Path Tree (SPT) algorithm

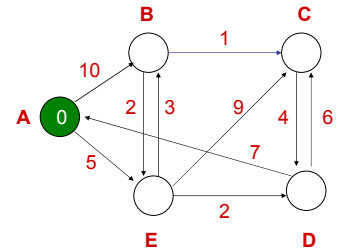
- Graph algorithm for single-source shortest path tree

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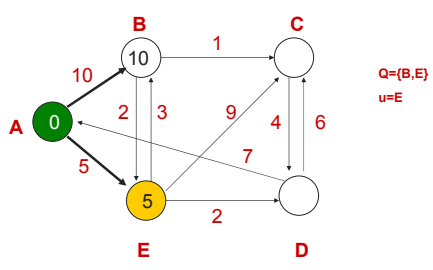
S ← {}
Q ← <all nodes keyed by distance>
While Q != {}
    u ← extract-min(Q)
    S ← S plus {u}
    for each node v adjacent to u
        "relax" the cost of v
    
```

← u is done

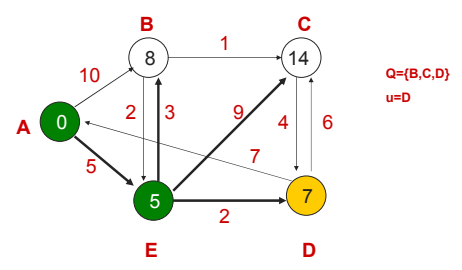
Dijkstra Example – Step 1



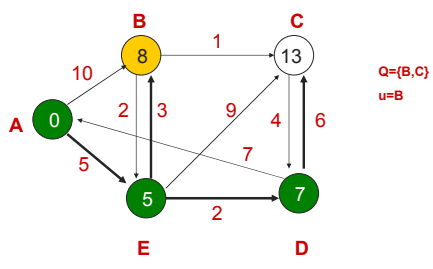
Example – Step 2



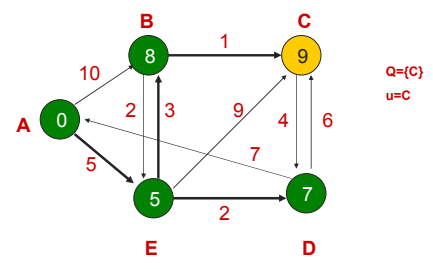
Example – Step 3



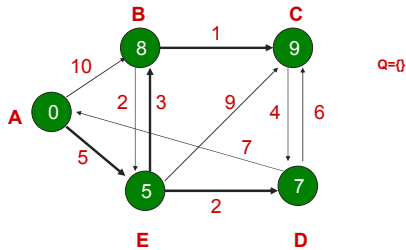
Example – Step 4



Example – Step 5



Example – Done



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13

Reliable flooding challenges

- When link/router fails need to remove old data...how?
 - LSPs carry sequence numbers to distinguish new from old
 - Only accept (and forward) the "newest" LSP seen from a node
 - Send a new LSP with cost infinity to signal a link down
- What happens when a router fails and restarts?
 - What sequence # should it use? Don't want data ignored
- Aging
 - » Put a TTL in the LSP, periodically decremented by each router
 - » When TTL = 0, purge the LSP and flood the LSP with TTL 0 to tell everyone else to do the same
 - » If router waits for LSP to age out can use any sequence number
- Alternative: when receiving an "old" LSP from a node, tell the node what the current sequence # is rather than simply dropping the LSP

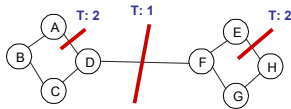
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14

More challenges

- What happens if the network is partitioned and heals?
 - Different LS databases must be synchronized
 - Use version #s on each LSP (incremented for each update)
 - Compare version #s when a link comes back up and request out of date LSPs



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15

Link State evaluation

- Strengths
 - Loop free as long as LSDB's are consistent
 - » Can have transient routing loops
 - Messages are small (esp compared to DV)
 - Converges quickly (esp compared to DV)
- Weaknesses
 - Must flood data across entire network (scalability?)
 - Must maintain state for entire topology

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16

Link State in practice

- OSPF (Open Shortest Path First) and IS-IS
 - Most widely used intra-domain routing protocol
 - Run by almost all ISPs and many large organizations
- Basic link state algorithm plus many features:
 - Authentication of routing messages
 - Extra hierarchy: Partition into **routing areas**
 - Load balancing: Multiple equal cost routes

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17

For next time...

- Inter-domain routing
- Read 4.3-4.3.3

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18

Flooding

- Each router maintains link state database and periodically sends link state packets (LSPs) to neighbor
 - LSPs contain [router, neighbors, costs]
- Each router forwards LSPs not already in its database on all ports except where received
 - Each LSP will travel over the same link at most once in each direction
- Flooding is fast, and can be made reliable with acknowledgments