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Communication Systems

Link State Routing

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  - Prof. Dr. Gerhard Schneider
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Dynamic IP Routing

- Started with distance vector routing last lecture
- Example protocol: RIP
- Rather old, newer version RIP II
  - Read on “split horizon” and “poison reverse”
- Limitations:
  - Unsuitable for large networks:
  - Interrupts routers frequently, slowing them down
  - More distant networks reachable via 15++ hops are ignored

RIP – Problems

- UDP is unreliable, RIP is very insecure
- Only one metric - RIP doesn’t consider bandwidth
- RIP converges very slowly (minutes)
  - The potential range for other metrics as bandwidth, throughput, delay, and reliability can be large
  - The value for INFINITY should be large; but this can result in slow convergence of RIP due to count-to-infinity problem
- Distance vector was used within ARPANET until 1979 and much longer within LANs

Link State Routing

- Two problems caused demise of distance vector routing within LANs and its protocols:
  - Does not scale
  - Convergence of algorithm often took too long (even with split horizon or similar hacks)
  - Line bandwidth was not taken into account – no problem in the beginning with just all lines having 56kbit/s (or in LANs with just only 10Mbit/s Ethernet)
- Therefore a completely new concept “link state routing” was introduced

Link state – Topology Dissemination

- In distance vector the path or cost to destination is partially determined by its neighbors
- With link state every router gets information on complete topology of a given network
  - All routers use same algorithm – so they will compute the same paths (avoiding loops)
- Two components
  - Topology dissemination and shortest path algorithm
- Topology dissemination should establish a consistent link state database in each router
- Once established each router computes shortest paths to all destinations from itself as origin

Routing Protocols

- The idea behind this algorithm can be stated as five parts:
  - Each router must discover its neighbors and learn their network addresses
  - ... measure the delay or cost to each of its neighbors
  - ... construct a packet telling all it has just learned
  - ... send this packet to all other routers
  - ... compute the shortest path to every other router
- So the complete topology and all the possible delays are measured
- Information is distributed to every router

Routing Protocols

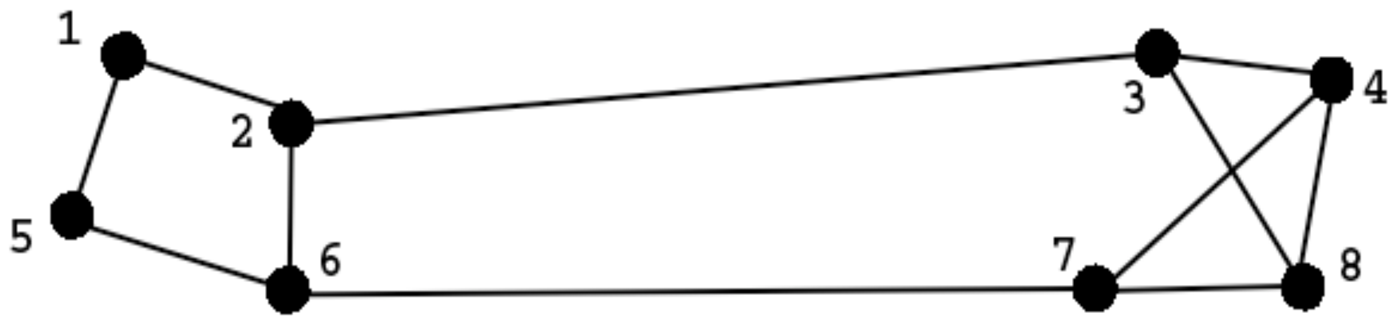
- During boot procedure of a router it has to learn its neighbors first
- This is done by sending a special discovery packet (HELLO) on every point-to-point line
- The router on the other end should send a response packet telling who it is
- Router names must be unique, so if one router hears of routes to a router N it should know that the same machine is meant
- Point-to-point connections are normal within WAN, but within LAN more than one router may be present
- An artificial router is introduced presenting the LAN, so every router has point-to-point connections again

Link State – Measuring Line Costs

- Each router should know (or an estimate of it) of the delay to each of its neighbors
- Direct way to getting this information is via a special ECHO packet that other routers should send back immediately – round trip time divided by two gives an estimate (or for better approx. send several packets and compute the average)
- Question is if the load of a line should be taken into account
  - Load is interfering with the delay
  - But it could lead to problems in special scenarios

Routing Protocols – General Considerations

- If you have a routing scenario as shown in the picture (examples are typical over sea connections or similar ...)
- Two parts of the net are connected through the lines 2 – 3 and 6 -7
- If most traffic is using 6 – 7 the line is heavily loaded as a result (and the delay increased)
- If delay is taken into account, 2 – 3 is the shortest path instead of 6 - 7



Routing Protocols – Pitfalls

- In the next round a new computation would find 6 – 7 as shortest path again
- As an result the routing tables may oscillate wildly, leading to erratic routing and many difficulties finding errors
- If load is ignored then the aggregated bandwidth of the two lines is not used optimally
- If traffic is spread over the two lines bandwidth may be better utilized but routing may be suboptimal

Routing Protocols – Theory

- After collecting needed information the router should build a packet containing all data
- The packet starts with identity of sender, followed by a sequence number, age and a list of neighbors
- For each neighbor the delay to it is given
- Building the packets is relatively easy, the hard part is when to distribute them
- This may be done in regular intervals or when a significant change occurs (line going down or up, changing properties)

Routing Protocols – Theory

- How to distribute packets reliably?
- As packets are distributed and installed, the router getting the first ones will use it and change it routes
- Consequently different routers may have a different view of the topology, which may lead to inconsistencies, loops, unreachable machines, ...
- Fundamental idea is to use flooding (described last lecture) for distribution of those packets
- Therefore a sequence number is included

Routing Protocols – Theory

- Routers keep track of all pairs (source router, sequence number) they see
- When a new packet arrives it is checked against the packets already seen – if new it is forwarded to all lines except the one it came from (duplicates are discarded)
- If packet with lower sequence number arrives it is rejected as obsolete (already seen)
- Some problems may occur
  - Wrapping around of sequence number counter
  - Corrupted packets with wrong numbers which confuse the algorithm

Link State

- Once a router has accumulated a full set of state packets it can construct the entire graph
- Every link is presented (even twice – for each direction!)
- Now Dijkstras algorithm can be used on every router for computing the shortest paths to every destination
- For a subnet of N routers with K neighbors the memory required to store is proportional to K*N (and the computing power required is growing too)
- For larger networks hierarchical routing is introduced

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