University of BRISTOL

Advanced Networks

(EENGM4211)

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Best contact : Microsoft Team

Slides courtesy: Prof. Reza Nejabati and Slides from Ross's Book

Part 5:
Routing in Wireless Networks

ILOs

- Demonstrate the knowledge about different proactive and reactive wireless routing protocols
- Discuss the choice for different wireless routing protocols and their rationale
- Discuss the efficiency and applicability of different routing protocols in different wireless environments

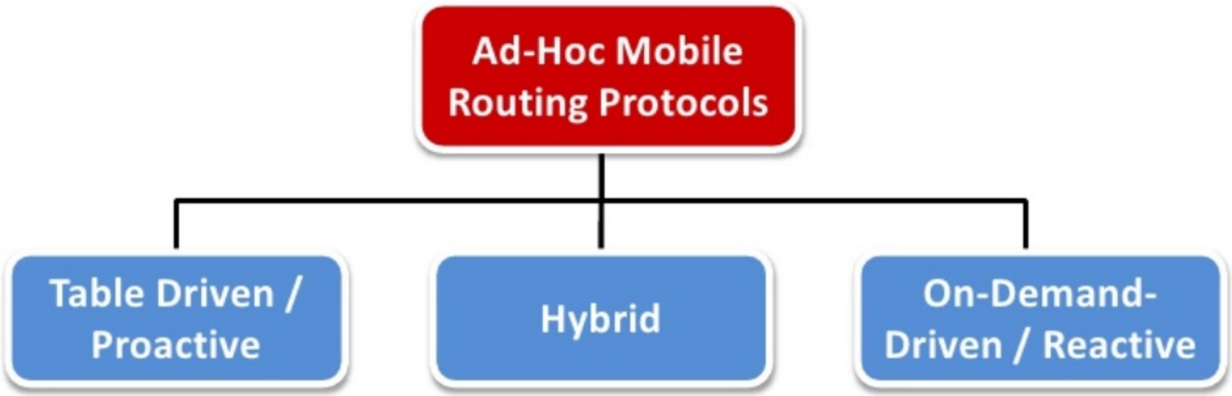
Ad-hoc Routing Protocols : Classification

- Proactive protocols
  - Determine routes independent of traffic demand
    - Similar to wired networks
  - Examples include variants based on traditional link-state and distance-vector routing protocols
  - Maintain routing tables to all destinations, updated periodically
  - Large overhead, low latency

- Reactive protocols
  - Establish and maintain routes only if needed, i.e. on-demand routing
  - Rely on route discovery and route maintenance
  - Low overhead, high latency

- Hybrid protocols
  - Why? Because neither of the above provides the solution

Ad-hoc Routing Protocols



- Dynamic Source Routing (Reactive)
- Ad-hoc On-Demand Distance Vector Routing (AODV) (Reactive)
- Optimized Link State Routing (OLSR) (Proactive)
- Destination-Sequenced Distance Vector (DSDV) (Proactive)
- ZRP = Zone Routing Protocol (Hybrid)

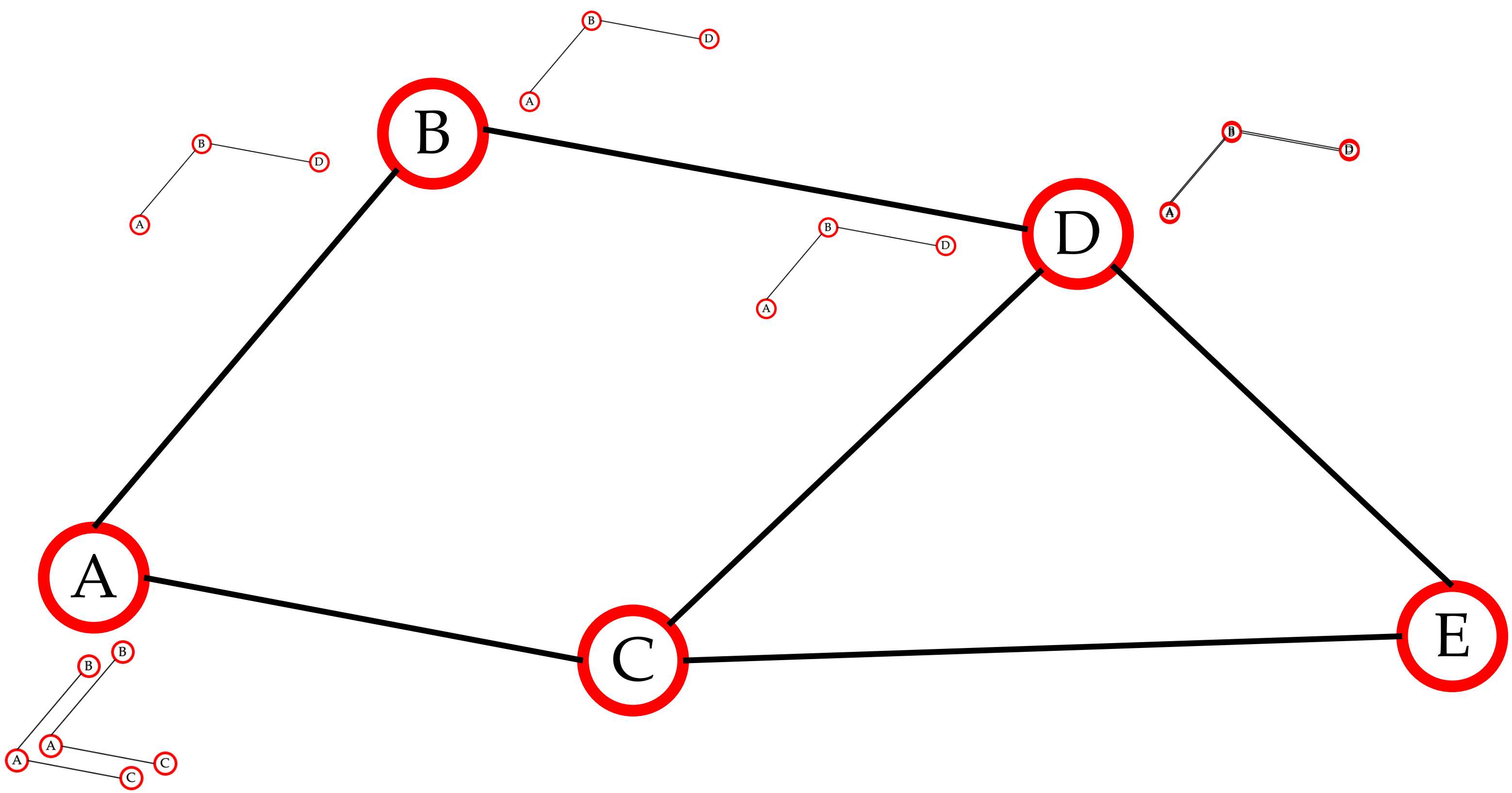
Outline & Topics

- Ad-hoc routing protocols
  - Proactive routing protocols
    - Link state routing
      - Optimized Link State Routing (OLSR) - OLSR
    - Distance vector routing
      - Destination-Sequenced Distance Vector - DSDV
  - Hybrid routing protocols
    - Cluster based - CEDAR
    - Zone routing - ZRP

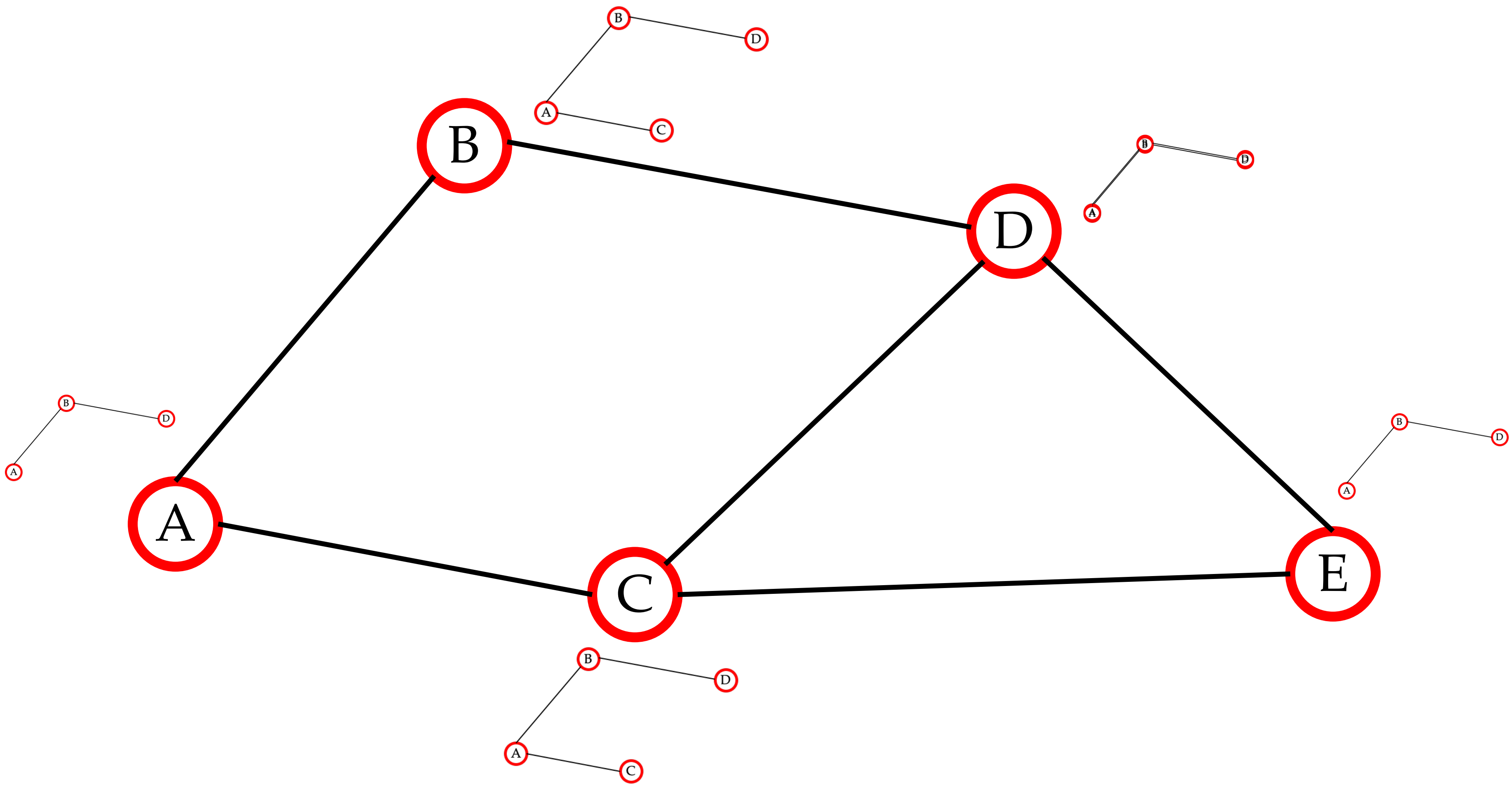
Ad-hoc routing protocols: Proactive routing

- Link State Routing protocols
  - Flooding principle
  - Nodes share information with neighbors only on link status (connectivity)
  - Every node constructs a *graph* of the network
  - Each node then independently calculates the next best logical *path* from it to every possible destination in the network (e.g., shortest path)

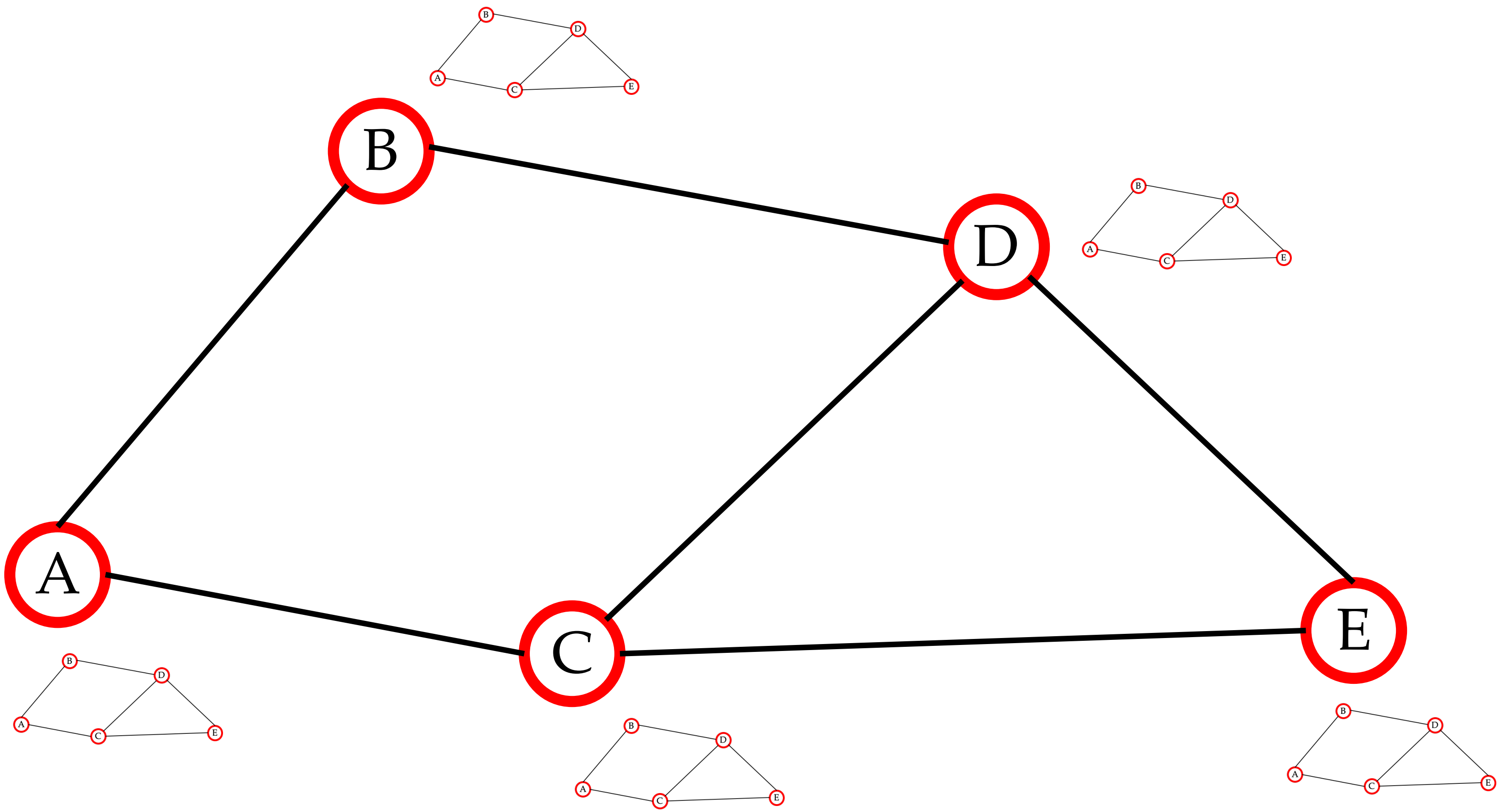
Ad-hoc routing protocols: LSR



Ad-hoc routing protocols: LSR



Ad-hoc routing protocols: LSR



Problem of LSR

- Unnecessary transmission of packets
- Flooding causes reception of multiple copies of same LS advertisement
- Adhoc networks refer to mobile devices with constrained power (battery)

Optimized Link State Routing (OLSR)

- Classical operation:
  - Each node floods status of its links
  - Each node forwards link state information received from its neighbour
  - Each node processes received link state reports to build and maintain routing tables

BUT:

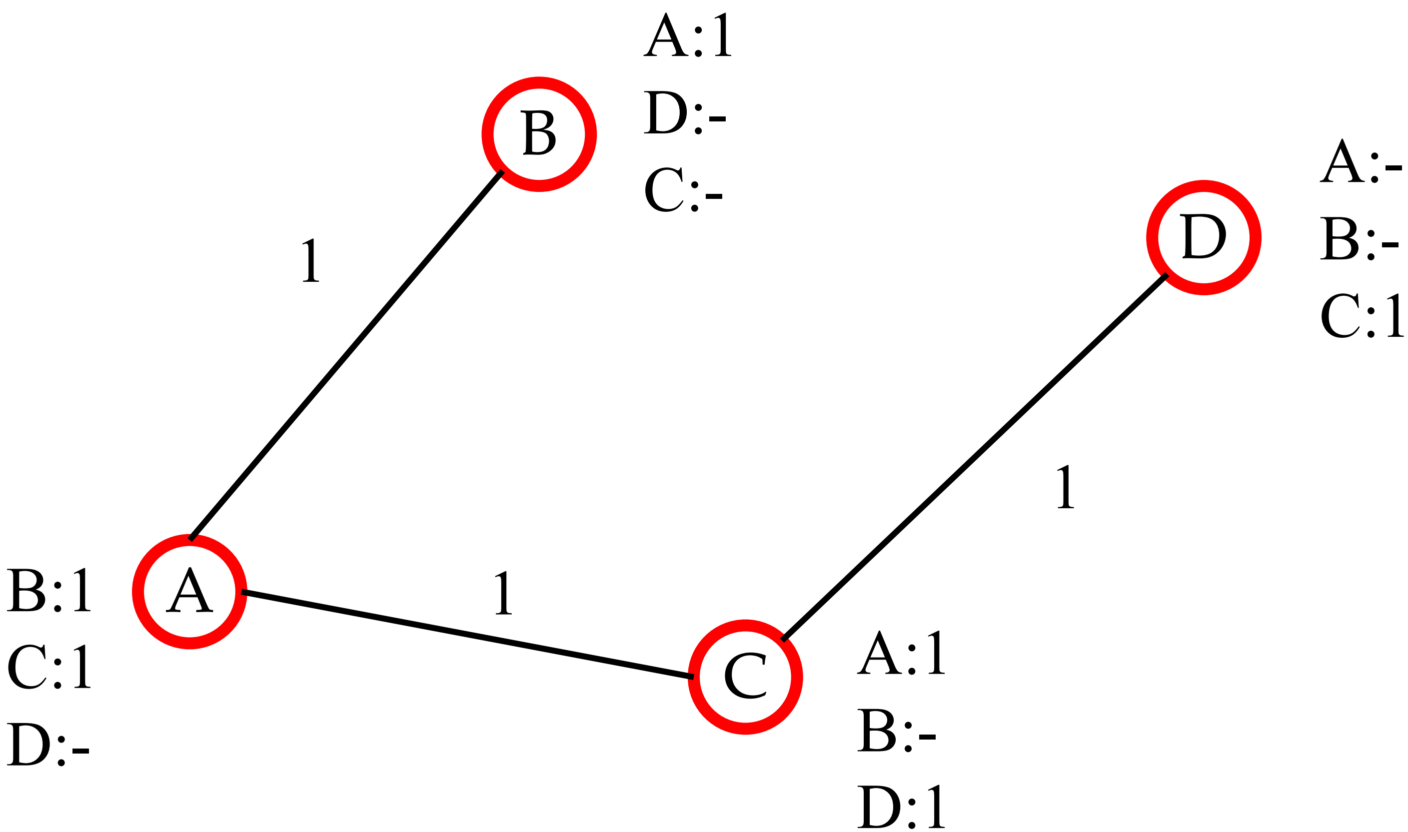
- Each node decides which neighbor can flood LS packet. These nodes are called MPR (Multi Point Relay)
- Use **Hello messages** to discovers 2-hop neighbor information and elect a set of *multipoint relays* (MPRs)
- Nodes select MPRs such that there exists a path to each of its 2-hop neighbors via a node selected as an MPR
- Only MPR can retransmit
- Each node periodically broadcasts a Hello message for the link sensing, neighbor detection and MPR selection processes

Ad-hoc routing protocols: Proactive routing - DV

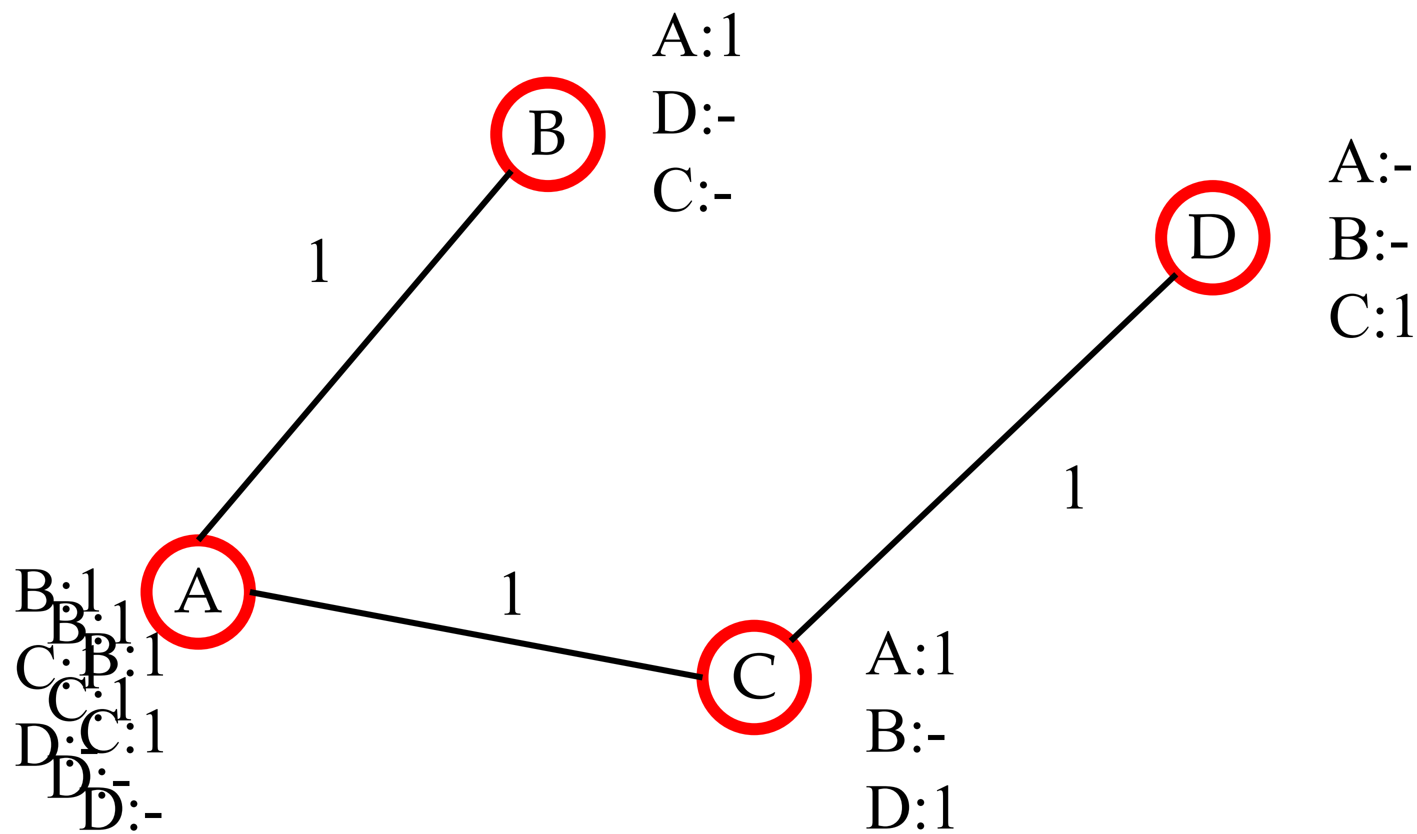
- Distance Vector
  - Each node maintains routing table with
    - Next hop towards destination
    - Metrics association with the path (distance)

  - Each node sends its routing table to neighbours
  - Proactive: create routing table entries for entire network

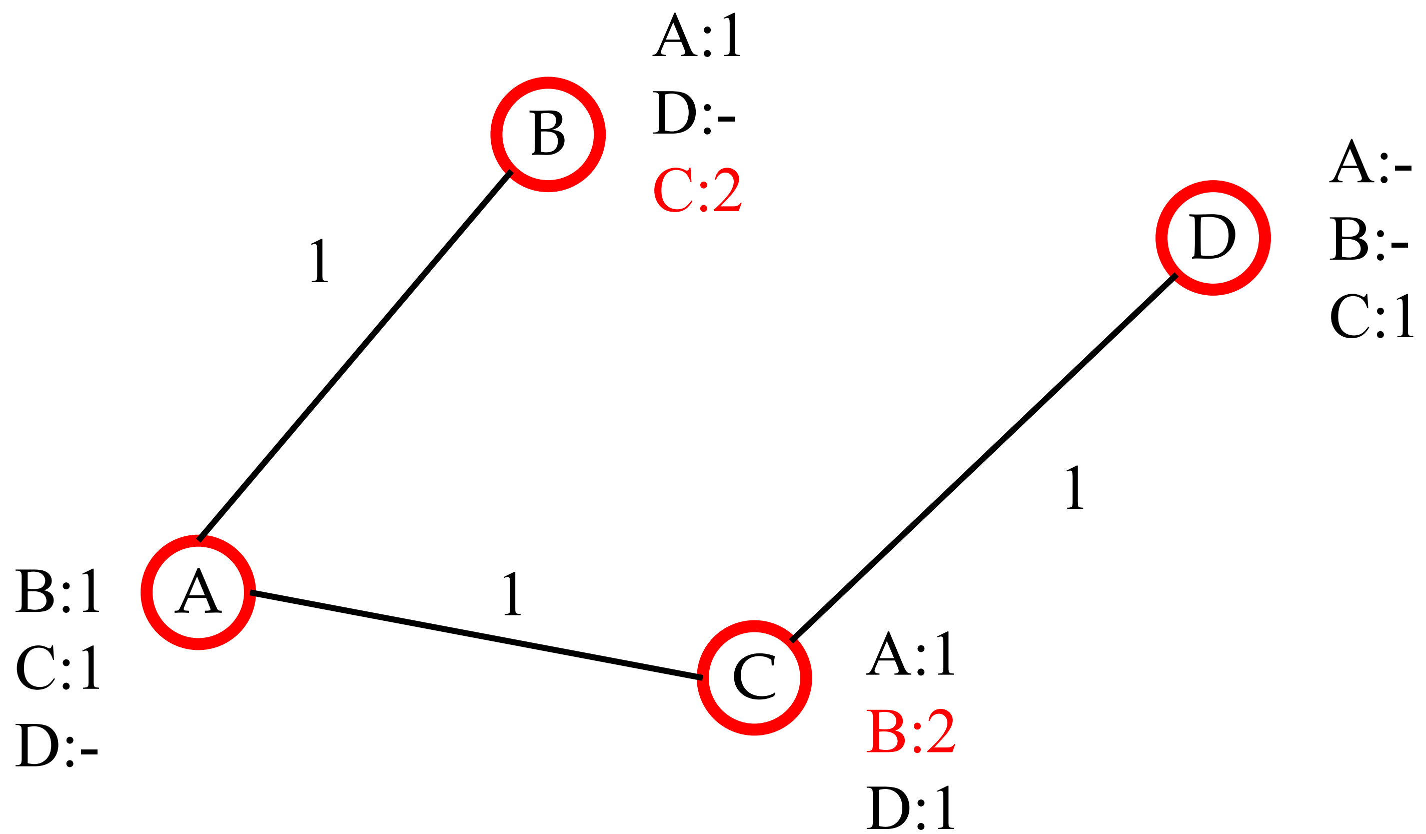
Ad-hoc routing protocols: Proactive routing - DV



Ad-hoc routing protocols: Proactive routing - DV

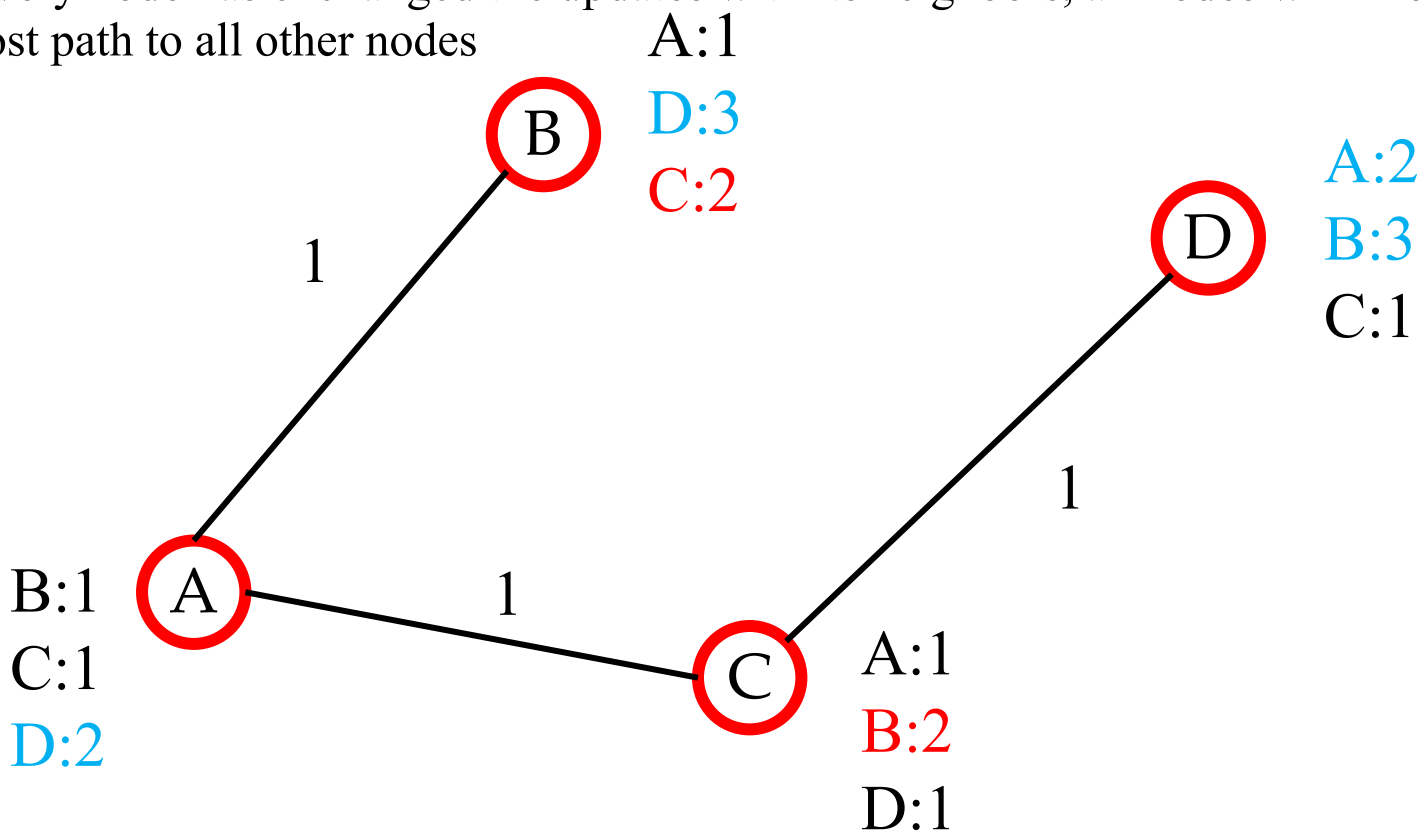


Ad-hoc routing protocols: Proactive routing - DV



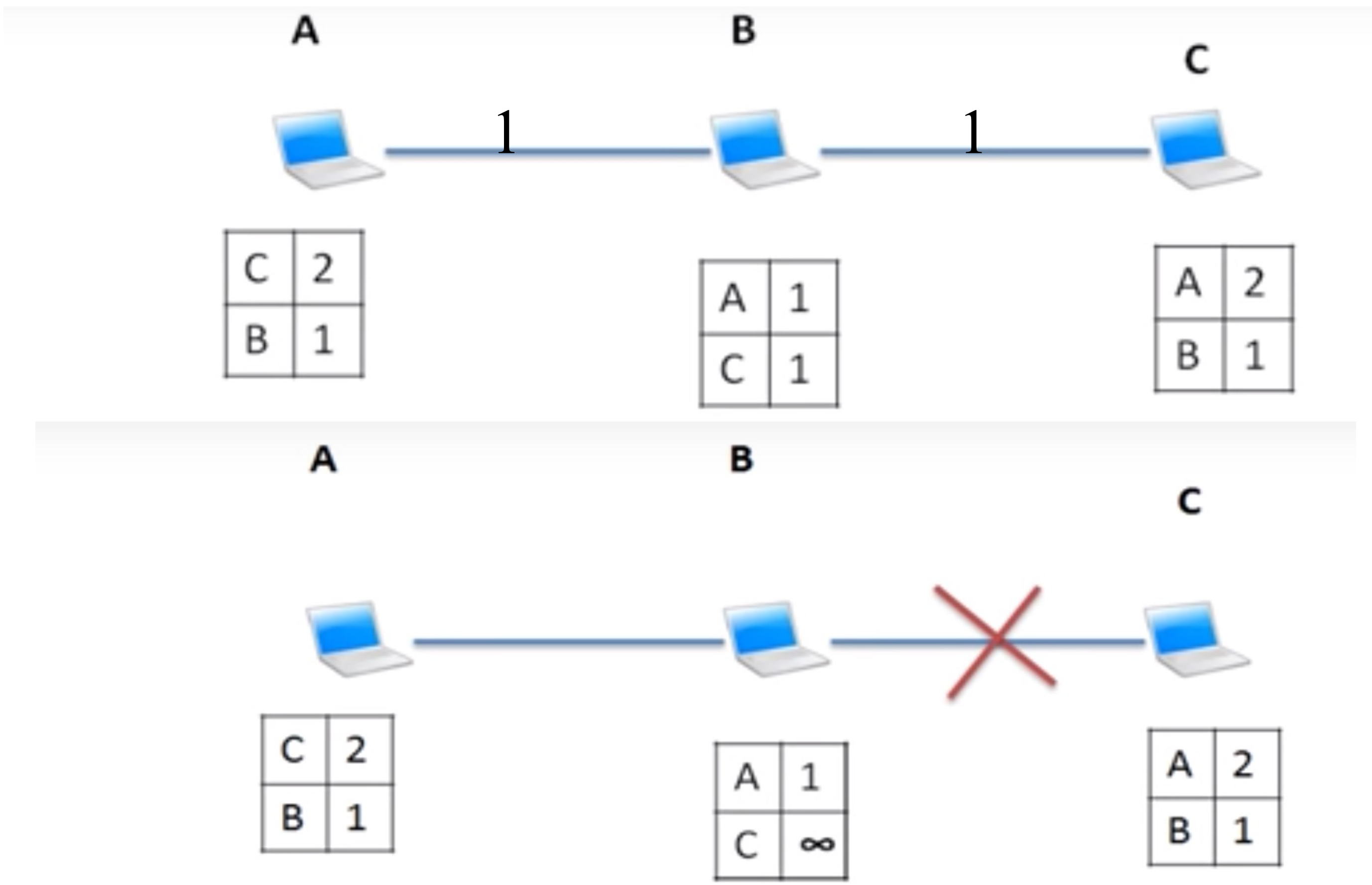
Ad-hoc routing protocols: Proactive routing - DV

- Every node sends a message to its directly connected neighbors with its personal list of distance
- After every node has exchanged the updates with its neighbors, all nodes will know the least-cost path to all other nodes



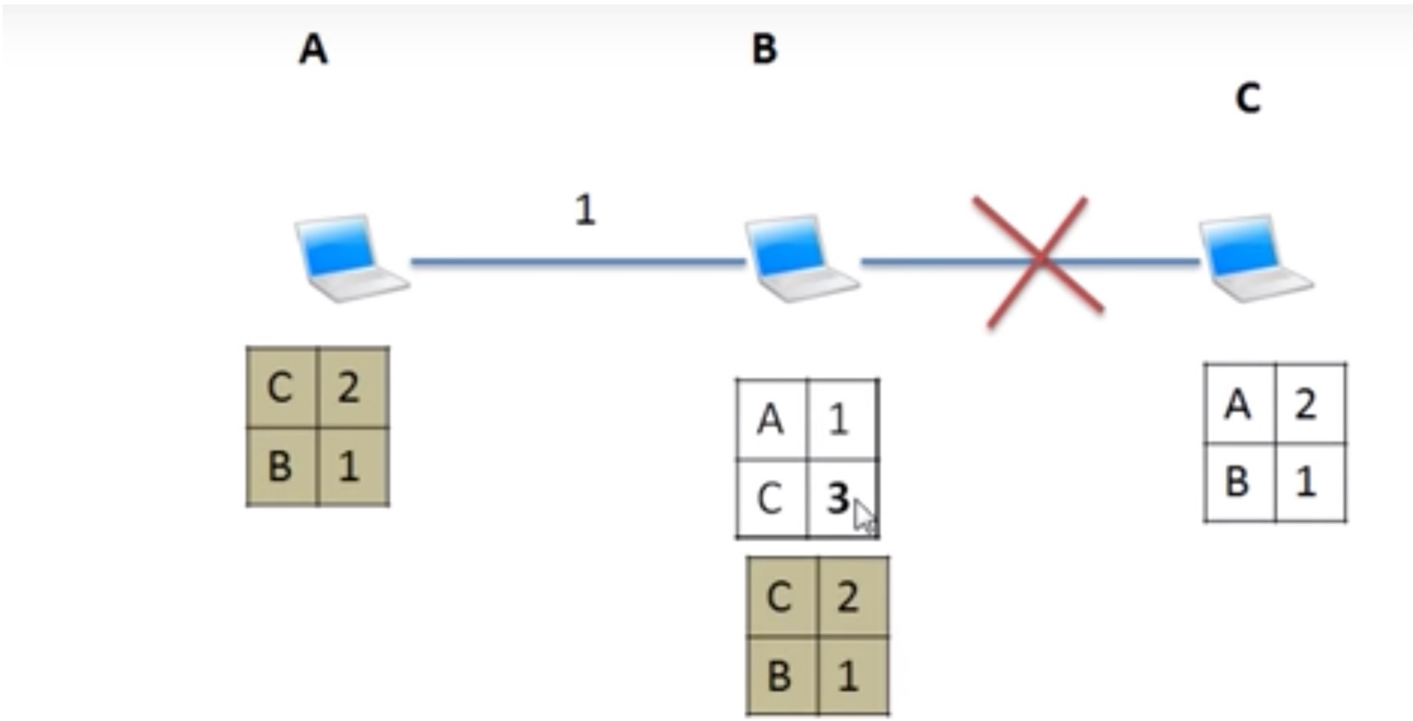
Ad-hoc routing protocols: Proactive routing - DV

- The problem: potential for loops



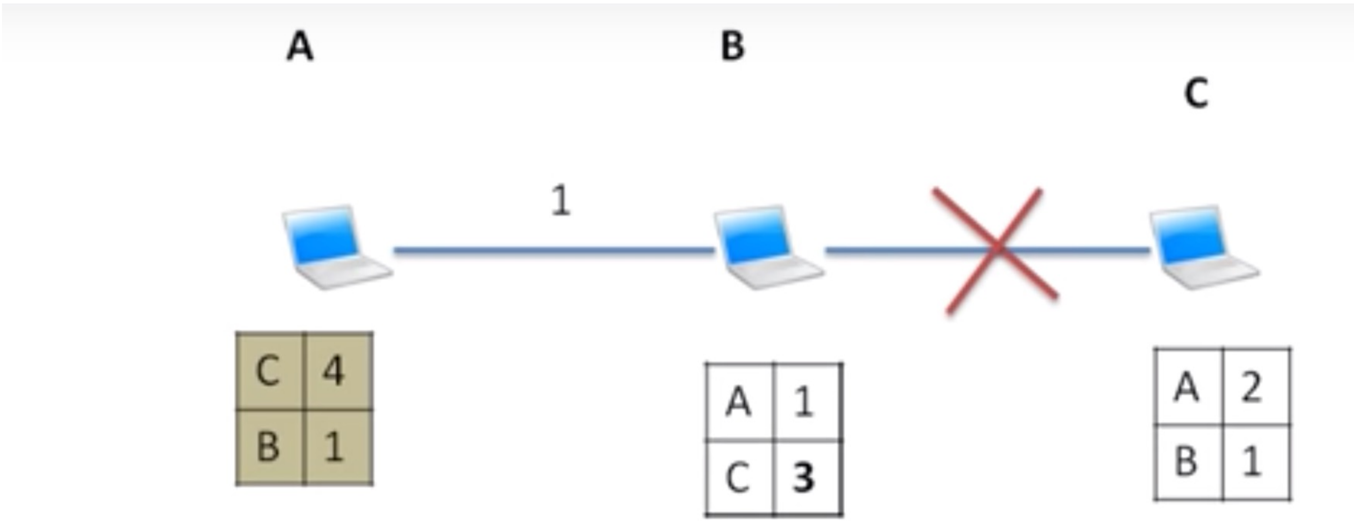
Ad-hoc routing protocols: Proactive routing - DV

- The problem



Ad-hoc routing protocols: Proactive routing - DV

- The problem: Count to infinity problem



Ad-hoc routing protocols: Proactive routing

- DSDV = Destination-Sequenced Distance Vector
- Each node maintains routing table with
  - Next hop towards destination
  - Metrics association with the path
  - Destination sequence number created
    - Used to avoid loops
- Each node sends its routing table to neighbours
  - Each forwarding is sent with an incrementing sequence number
  - Routing table entries, when updated, record this sequence number

In DSDV routing table entry include
<destination, next hop, distance, sequence number>

OLSR vs DSDV

Distance vector protocols

- are simpler to configure and require little management,
- are susceptible to routing loops and converge slower than link state routing protocols.
- use more bandwidth because they send complete routing table
- link state protocols sends specific updates only when topology changes occur

Link state routing protocols

- converge much faster than distance vector routing protocols
- send updates using multicast addresses and use triggered routing updates
- require more router CPU and memory usage than distance-vector routing protocols
- can be harder to configure

Hybrid Protocols

Pro-Active Routing Protocols	Reactive Routing Protocols
In Advance	On Demand
Route Immediately available	Route delayed availability
Route might be stale	Route less likely to be stale

Hybrid protocols objective:

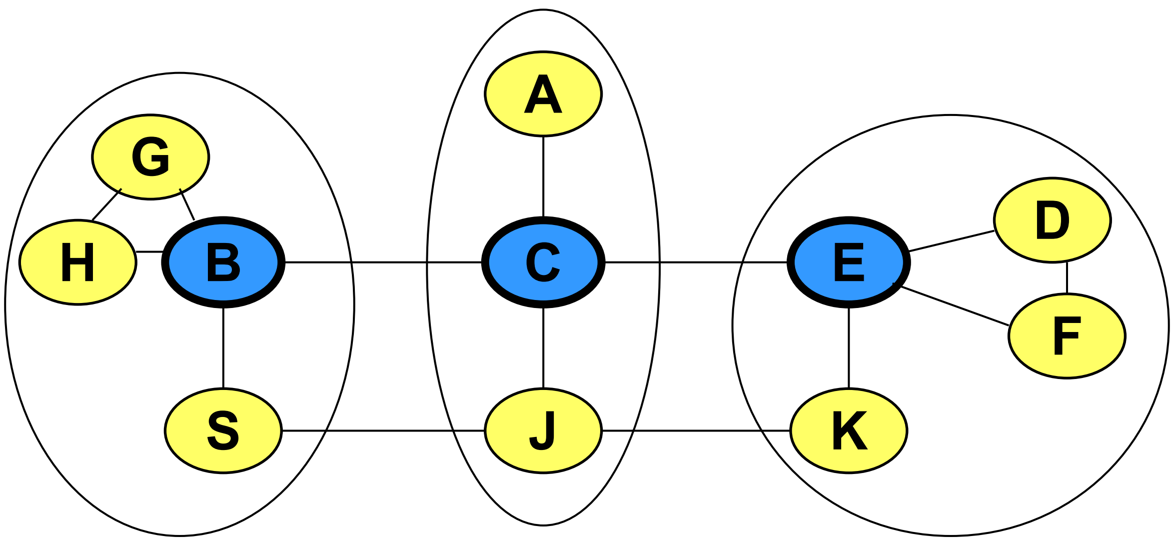
Best of both worlds

Ad-hoc routing protocols: Cluster-based (1/4)

- Asymmetric node roles
  - All nodes remain router and hosts
  - Some take additional management roles
- The network is partitioned in groups of nodes (clusters)
- A node is selected for each cluster (leader/dominator)
- Schemes differ in:
  - How the clusters are defined
  - The leader election process
  - Functionality performed by the cluster head
- Example: CEDAR

Ad-hoc routing protocols: CEDAR (2/4)

- CEDAR = Core-Extraction Distributed Ad Hoc routing
- Hierarchical scheme : not all nodes are equal!
  - A subset of nodes is identified as the core (leader/dominator)
  - Core nodes are selected so that every other node is adjacent to at least one core node
  - Core nodes maintain routing information with non-core nodes by periodic control message exchange
  - Routing table to other core nodes is also maintained



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Ad-hoc routing protocols: CEDAR (3/4)

- Link state propagation
  - A function of the link status (stable / unstable) and the link bandwidth
  - Link state is maintained among core nodes
  - Each core node knows the state of the local links and stable routes to adjacent core nodes (usually <=3 hopes)
- Route Discovery
  - Originator node notifies its (dominator) core node
  - Dominator (core) node finds route to dominator (core) node of destination
  - Core nodes in between dominators of source and destination build route information between source and destination

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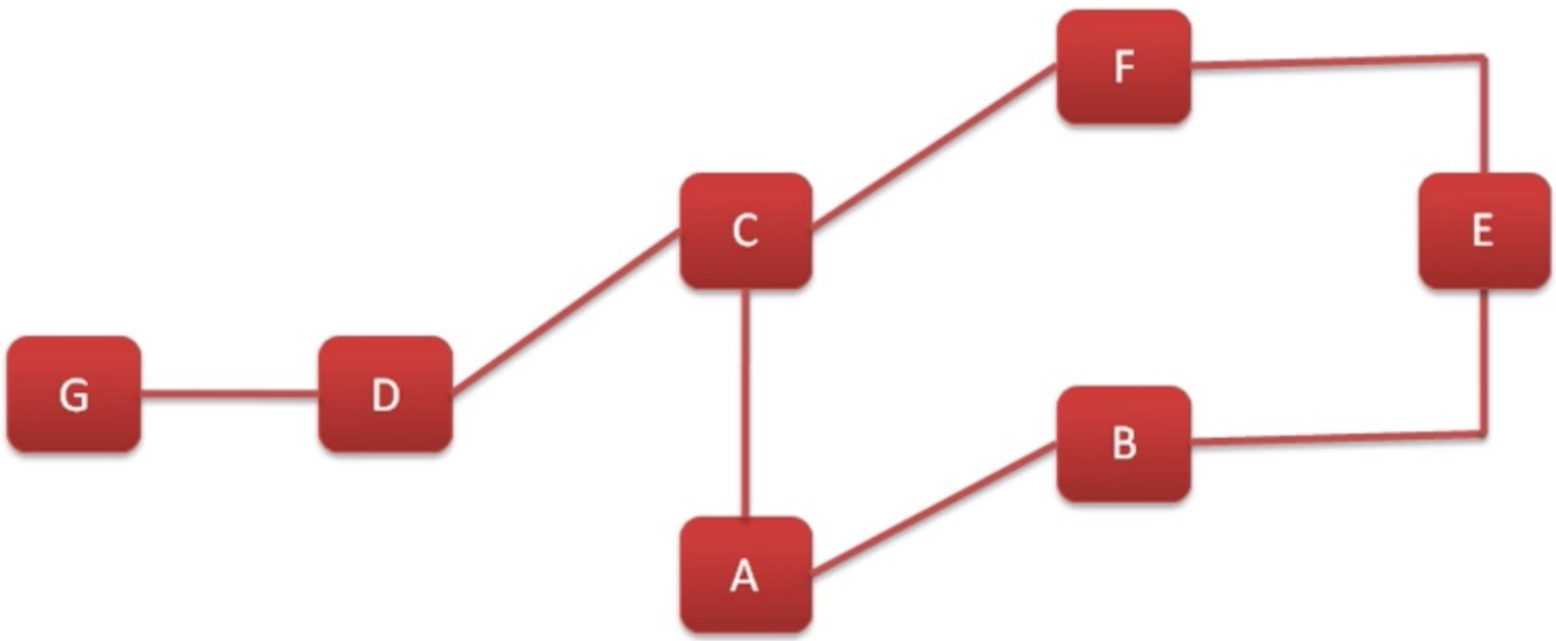
Ad-hoc routing protocols : CEDAR (4/4)

- **Advantages**
  - Routing information management function performed by a relatively small number of nodes ➔ possibly better performance
  - Introduces link state propagation as a function of its quality (including stability) – new!
- **Against**
  - Core nodes require more resources (need to handle additional traffic for management of the overall routing information)
  - Role election algorithms are required – how to choose/elect core nodes in a self-organised system?

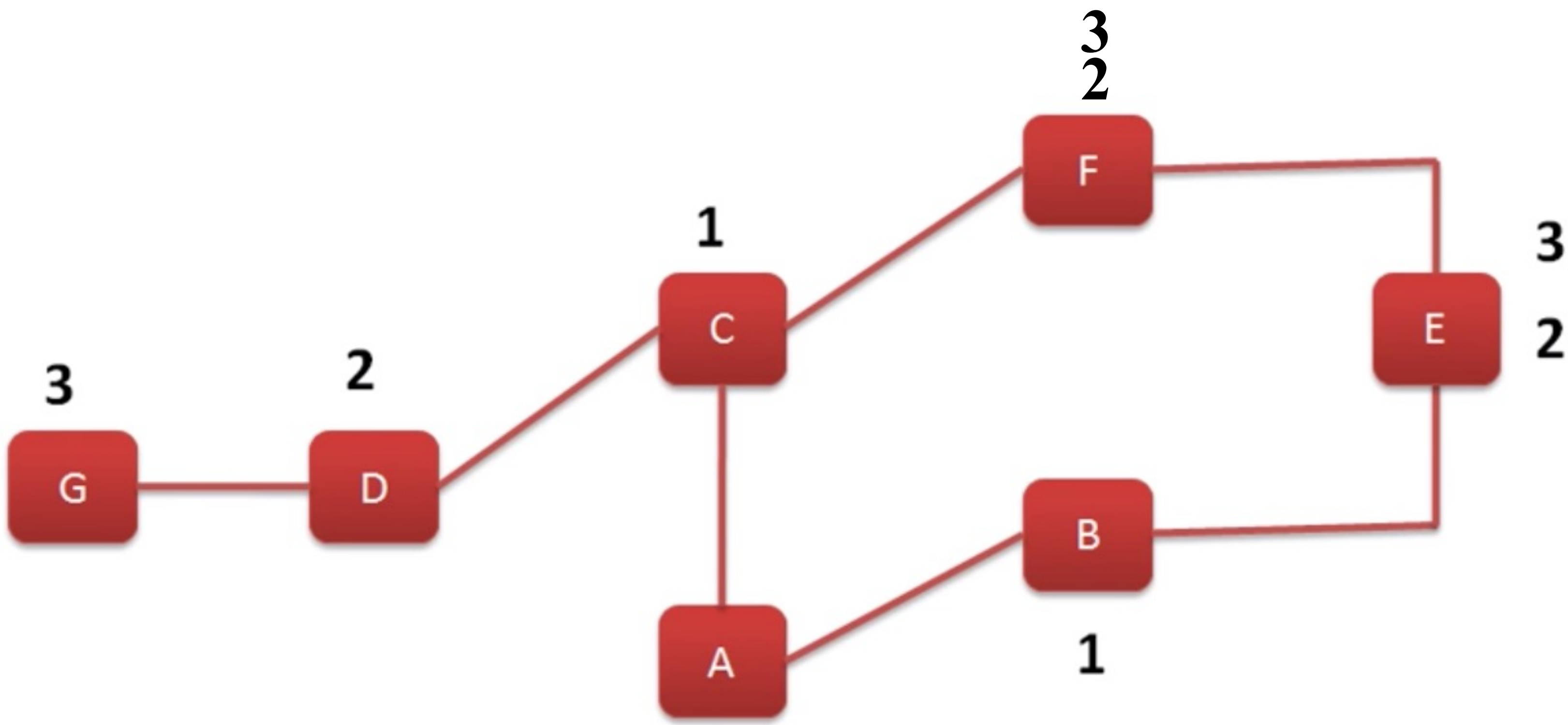
Hybrid Protocols: ZRP

- ZRP = Zone Routing Protocol
- Combines:
  - Proactive protocol : routing information maintained independently of the traffic characteristics
  - Reactive protocols: route is build only when there is data to be sent
- Basic principle:
  - All nodes within radius (hop distance) d from a node X are said to be in the routing zone of node X
  - All nodes at exactly distance d are considered peripheral nodes
- Intra-zone routing is done proactively
- Inter-zone routing is done reactively (similar to DSR)

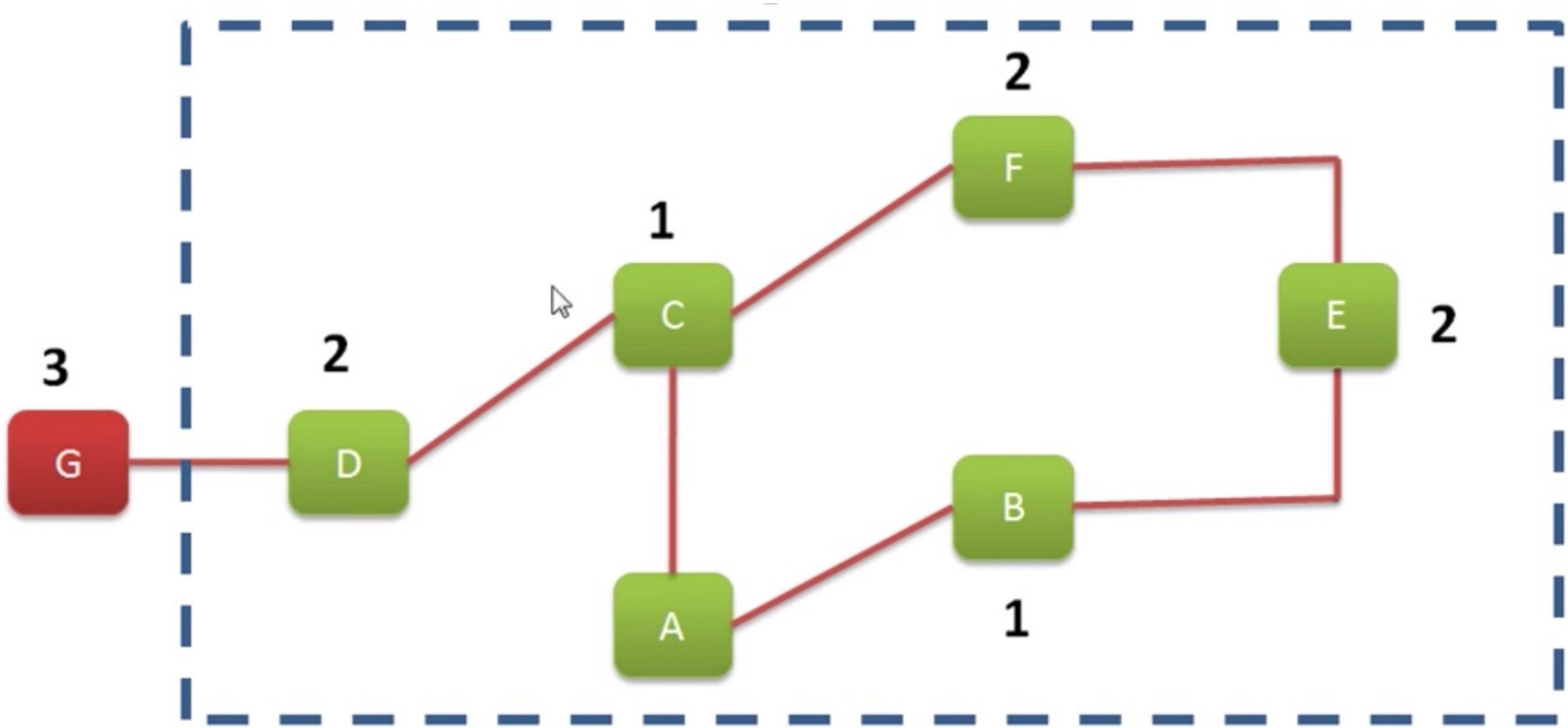
Hybrid Protocols: ZRP



Hybrid Protocols: ZRP

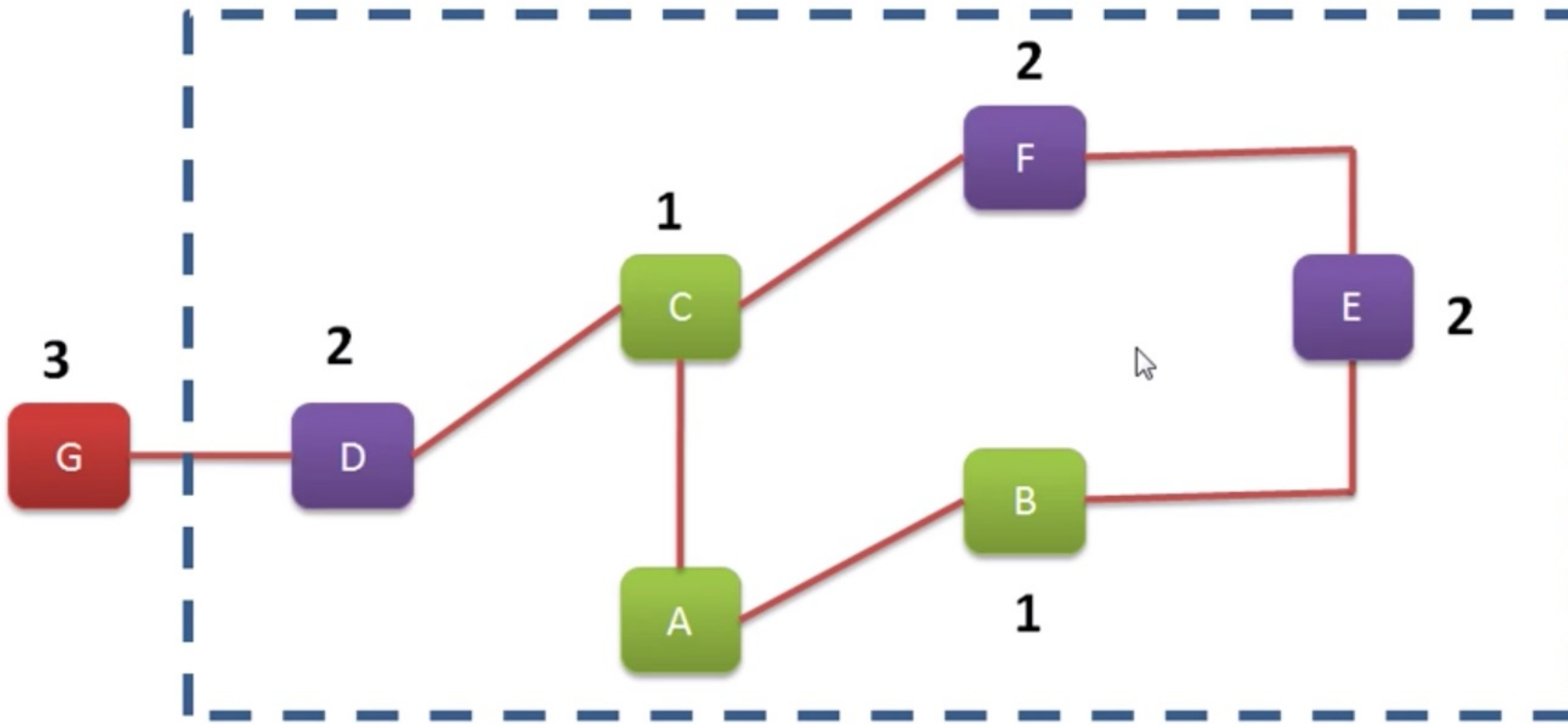


Hybrid Protocols: ZRP



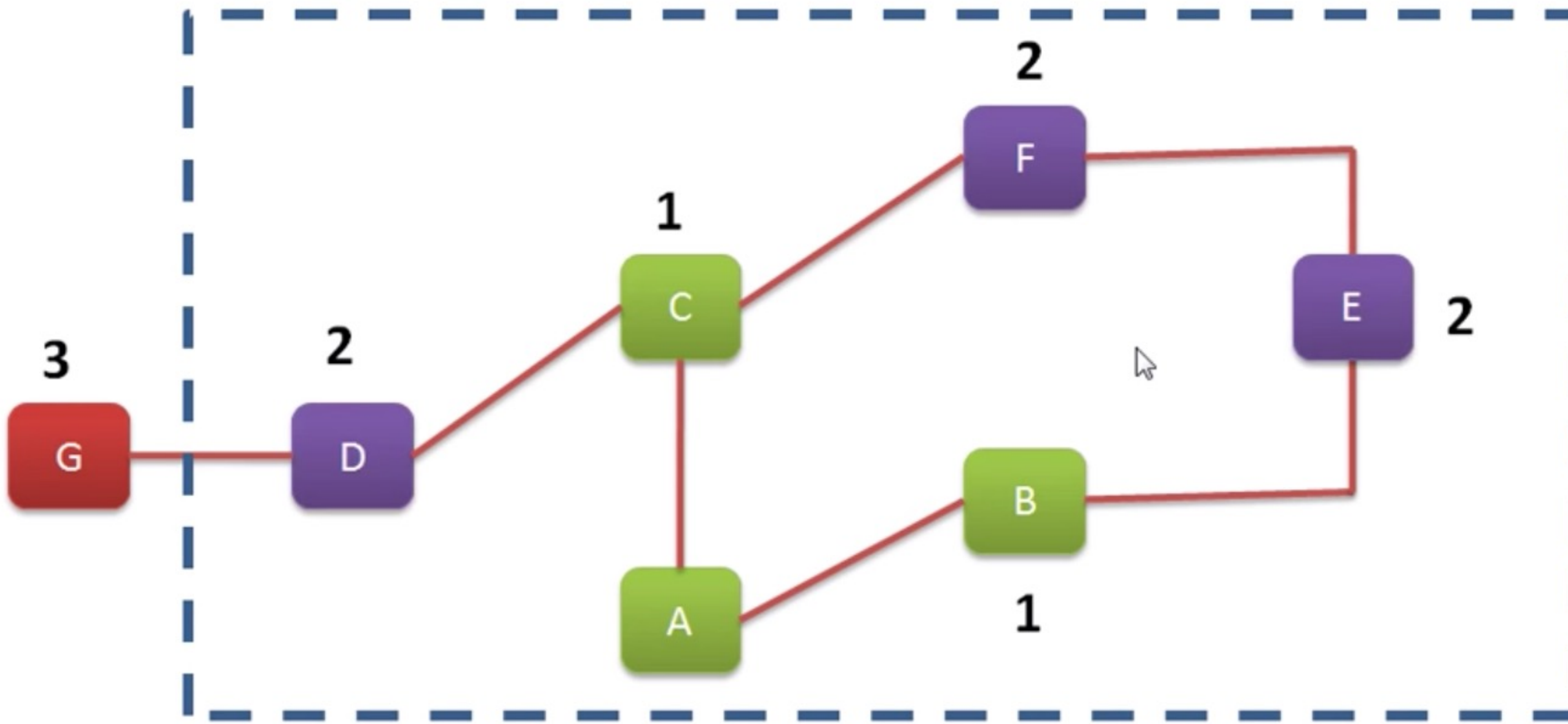
Routing zone with radius 2

Hybrid Protocols: ZRP



Peripheral nodes are nodes with minimum distance equal to zone radius
Node D,F and E are peripheral nodes

Hybrid Protocols: ZRP



IARP - Intra zone routing protocol: proactive routing protocols used
IERP – Interzone routing protocol: Reactive routing protocols used

Hybrid Protocols: ZRP

- For routes beyond the local zone, route discovery happens reactively
- The source node sends a route request to the border nodes of its zone, containing its own address, the destination address and a unique sequence number.
- Each border node checks its local zone for the destination. If the destination is not a member of this local zone, the border node adds its own address to the route request packet and forwards the packet to its own border nodes.
- If the destination is a member of the local zone, it sends a route reply on the reverse path back to the source.
- The source node uses the path saved in the route reply packet to send data packets to the destination.

Summary

- Difference between routing in wired and wireless scenarios
- How are the routing protocols optimized for wireless scenarios?
- Reactive and proactive protocols
- Which protocol fits in which scenario?
- Hybrid routing protocols (the best of both)
- Selection of cluster heads

End of Session

Any questions?