CS 716: Introduction to communication networks

- 20th class; 14th Oct 2011

Instructor: Sridhar Iyer
IIT Bombay

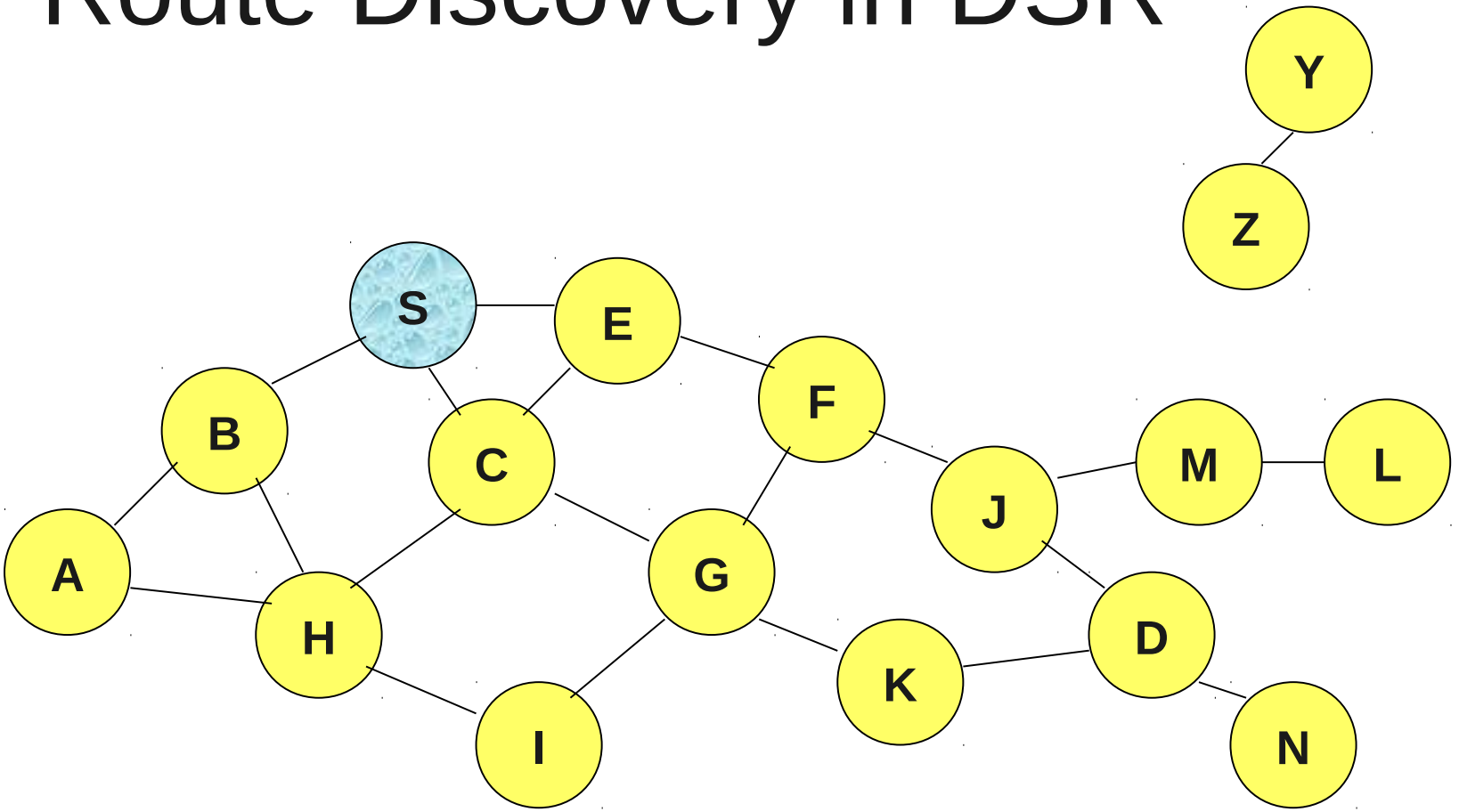
Routing methods

- Static routing: Default routes are specified at boot time
- Dynamic methods:
- Source-based: Specify route at source (DSR)
- Distance-vector routing: Set up next-hops to destinations looking at neighbors' routing tables (RIP)
- Link-state routing: Get map of network in terms of link states and calculate best route (but specify only the next-hop) (OSPF)

Dynamic Source Routing (DSR)

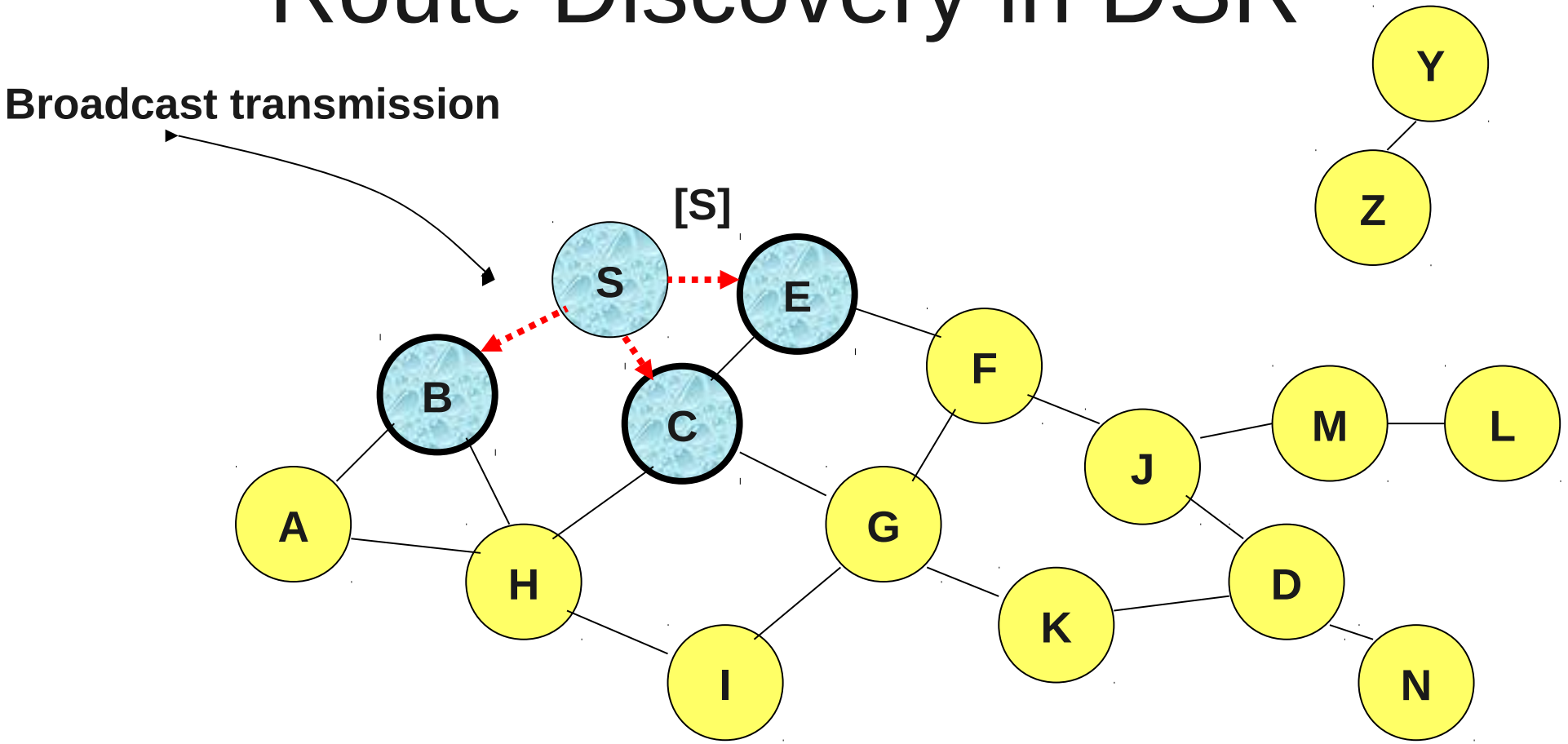
- Source S initiates a route discovery by flooding Route Request (RREQ)
  - Each node appends its own identifier when forwarding RREQ
- Destination D on receiving the first RREQ, sends a Route Reply (RREP)
  - RREP sent on route obtained by reversing the route appended in RREQ
  - RREP includes the route from S to D, on which RREQ was received by D
- S routes data using “source route” mechanism

Route Discovery in DSR



Represents a node that has received RREQ for D from S

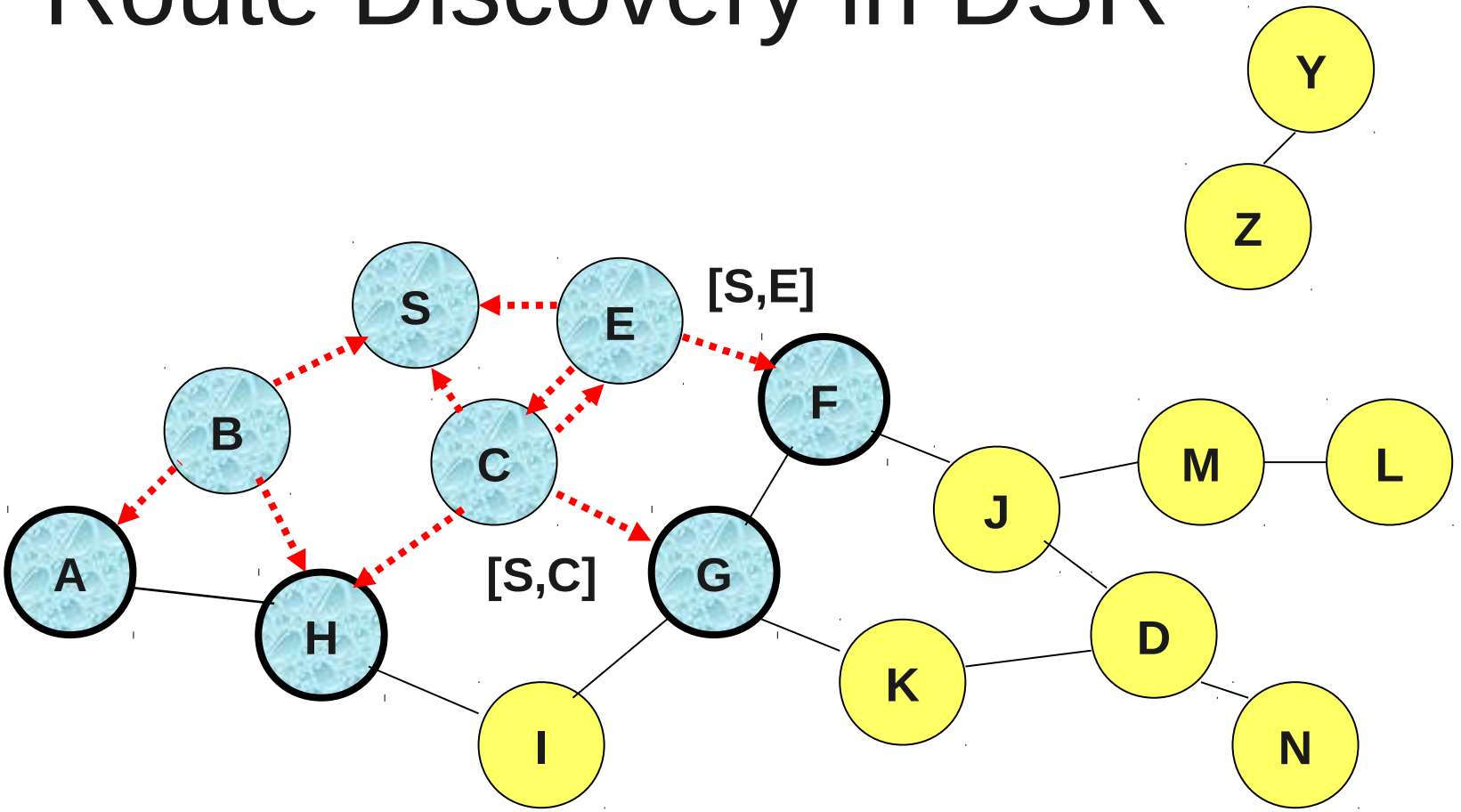
Route Discovery in DSR



Represents transmission of RREQ

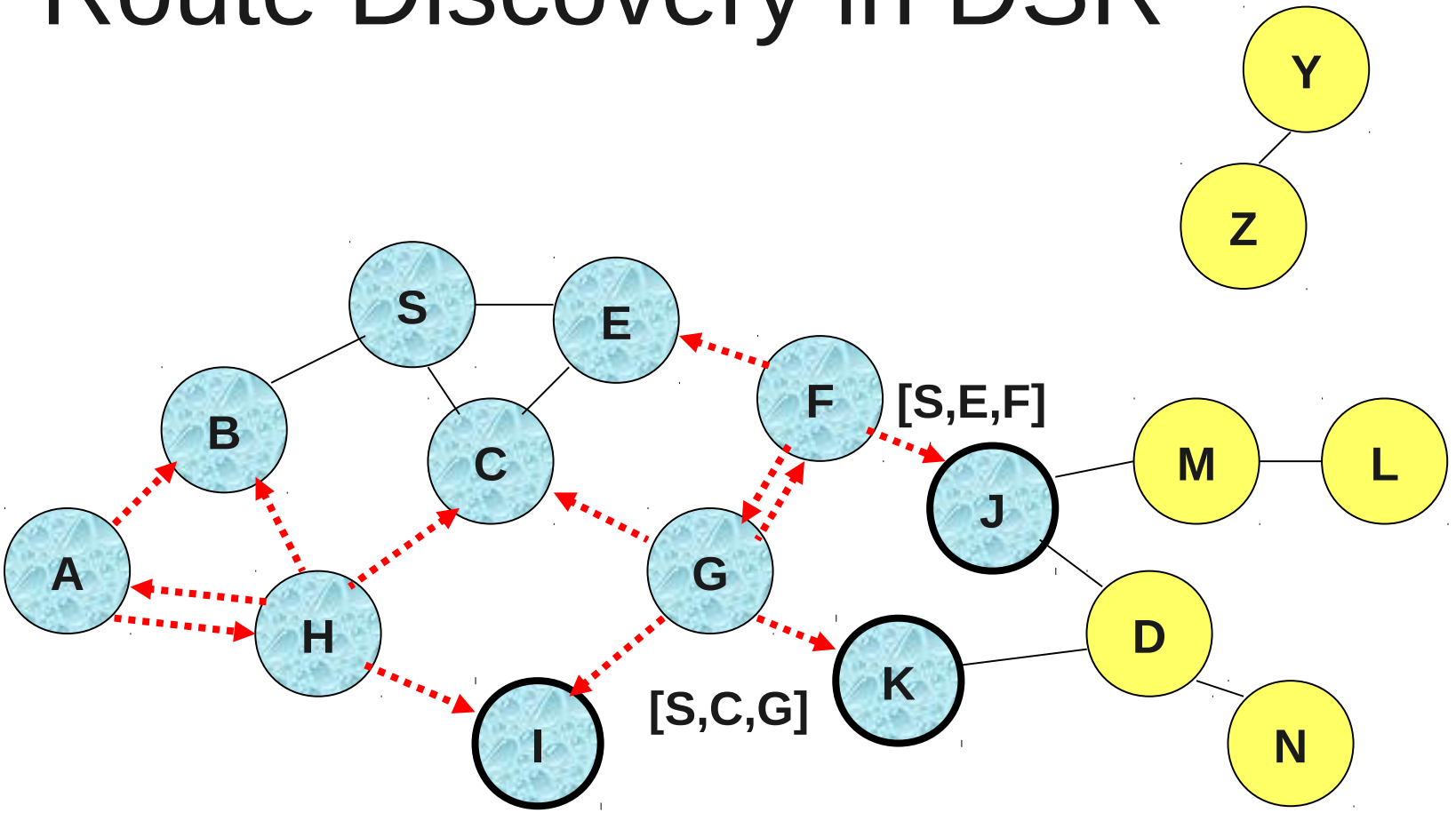
[X,Y] Represents list of identifiers appended to RREQ

Route Discovery in DSR



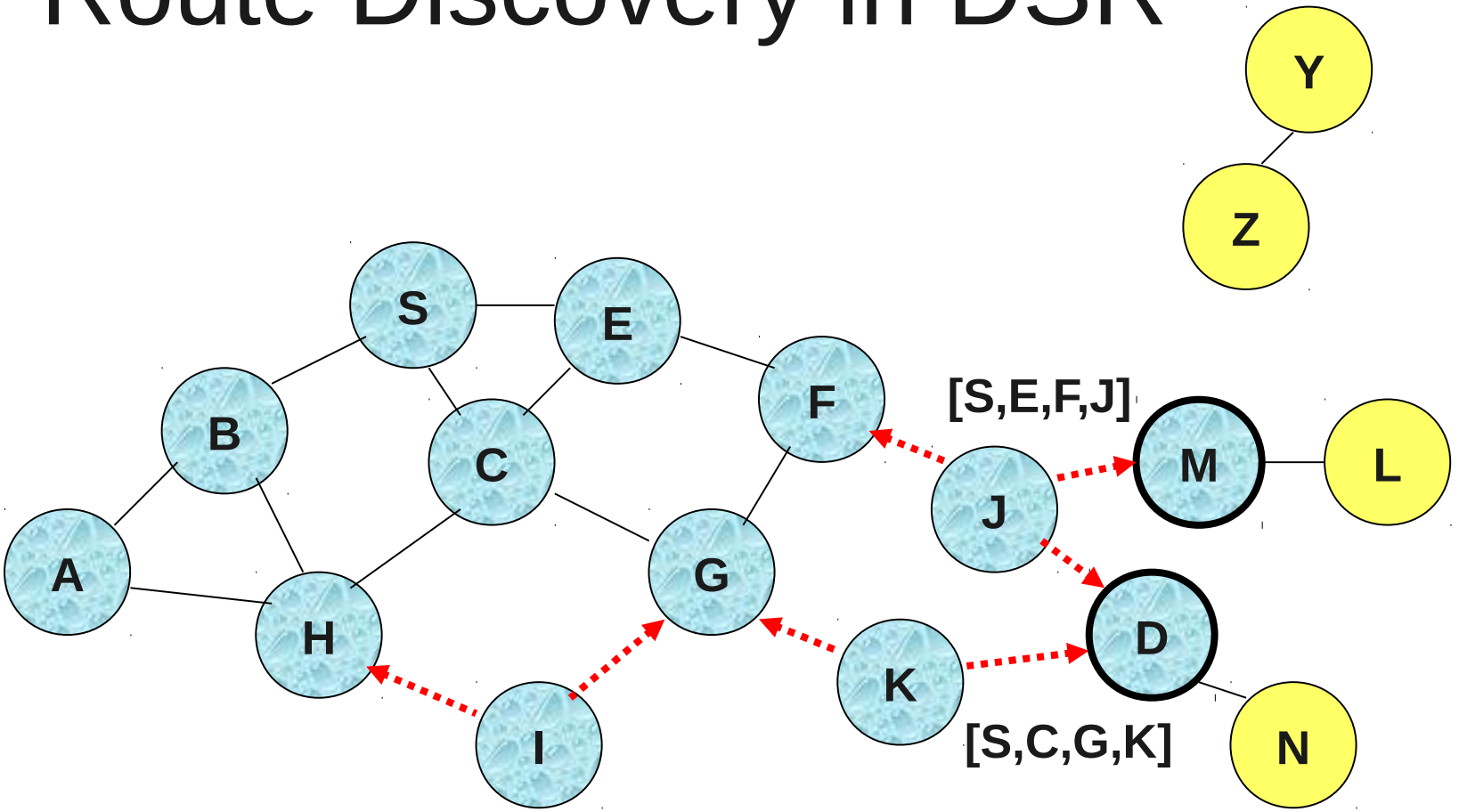
- **Node H receives packet RREQ from two neighbors:**
  potential for collision

Route Discovery in DSR



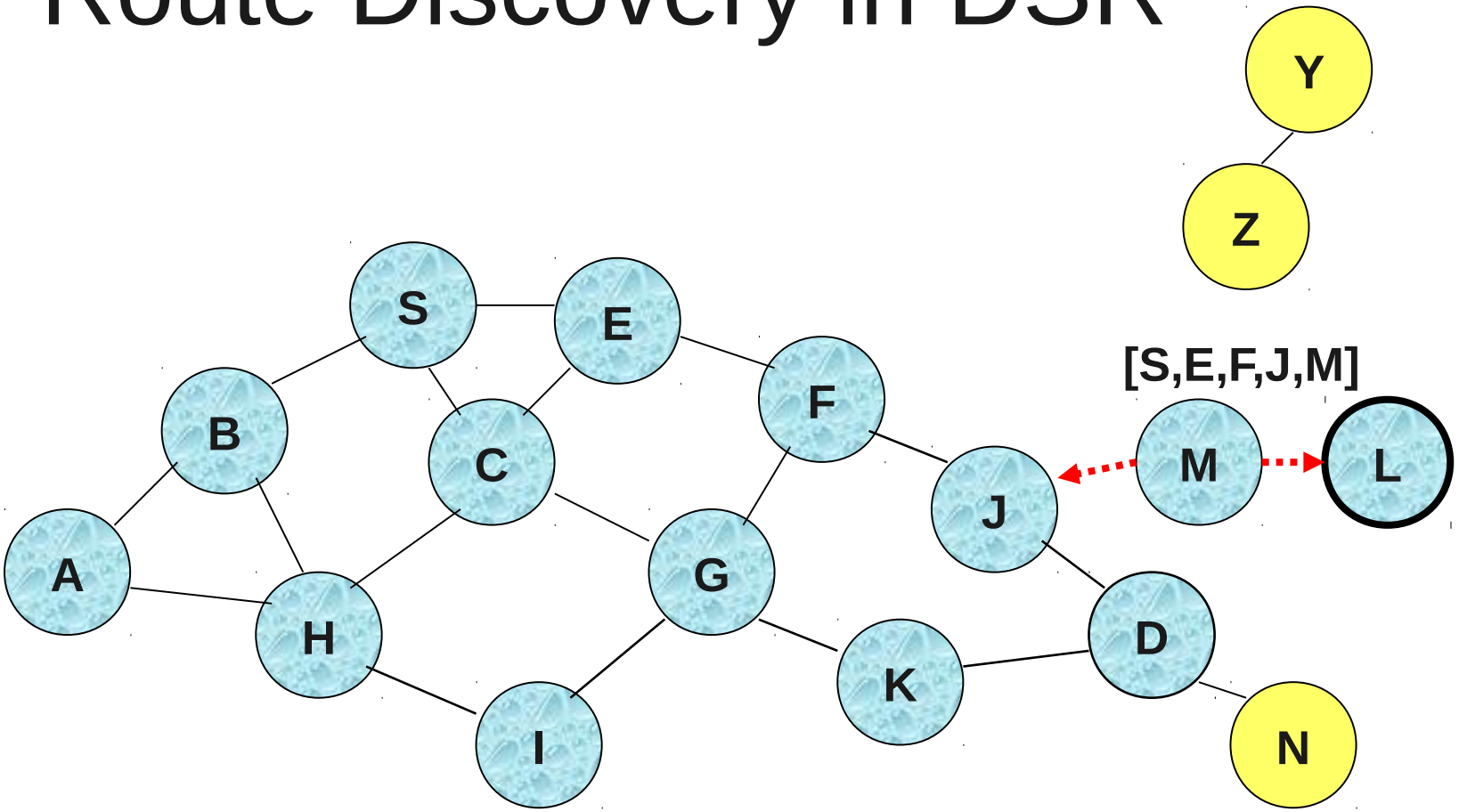
- **Node C receives RREQ from G and H, but does not forward it again, because node C has already forwarded RREQ once**

Route Discovery in DSR



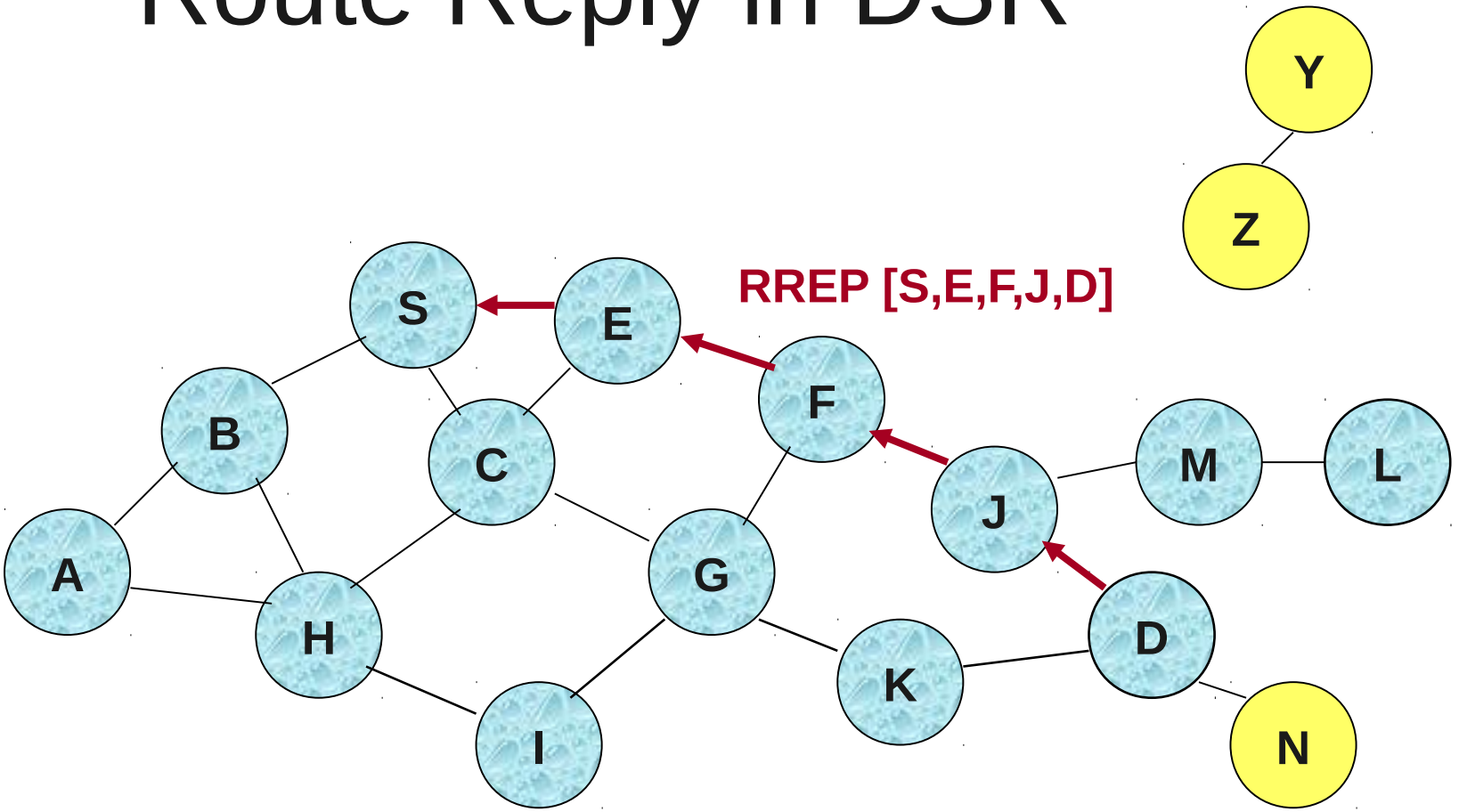
- **Nodes J and K both broadcast RREQ to node D**
- **Since nodes J and K are hidden from each other, their transmissions may collide**

Route Discovery in DSR



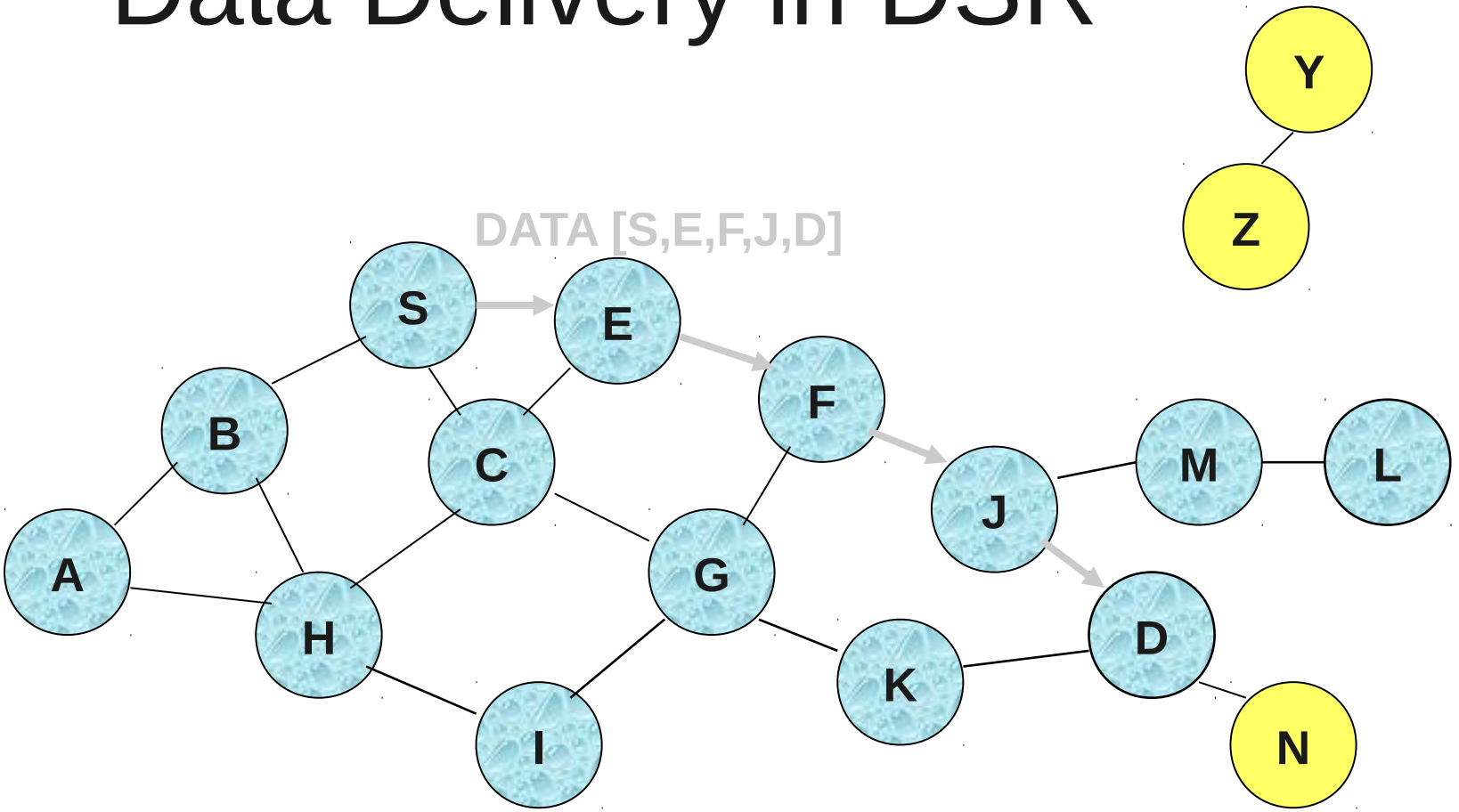
- **Node D does not forward RREQ, because node D is the intended target of the route discovery**

Route Reply in DSR



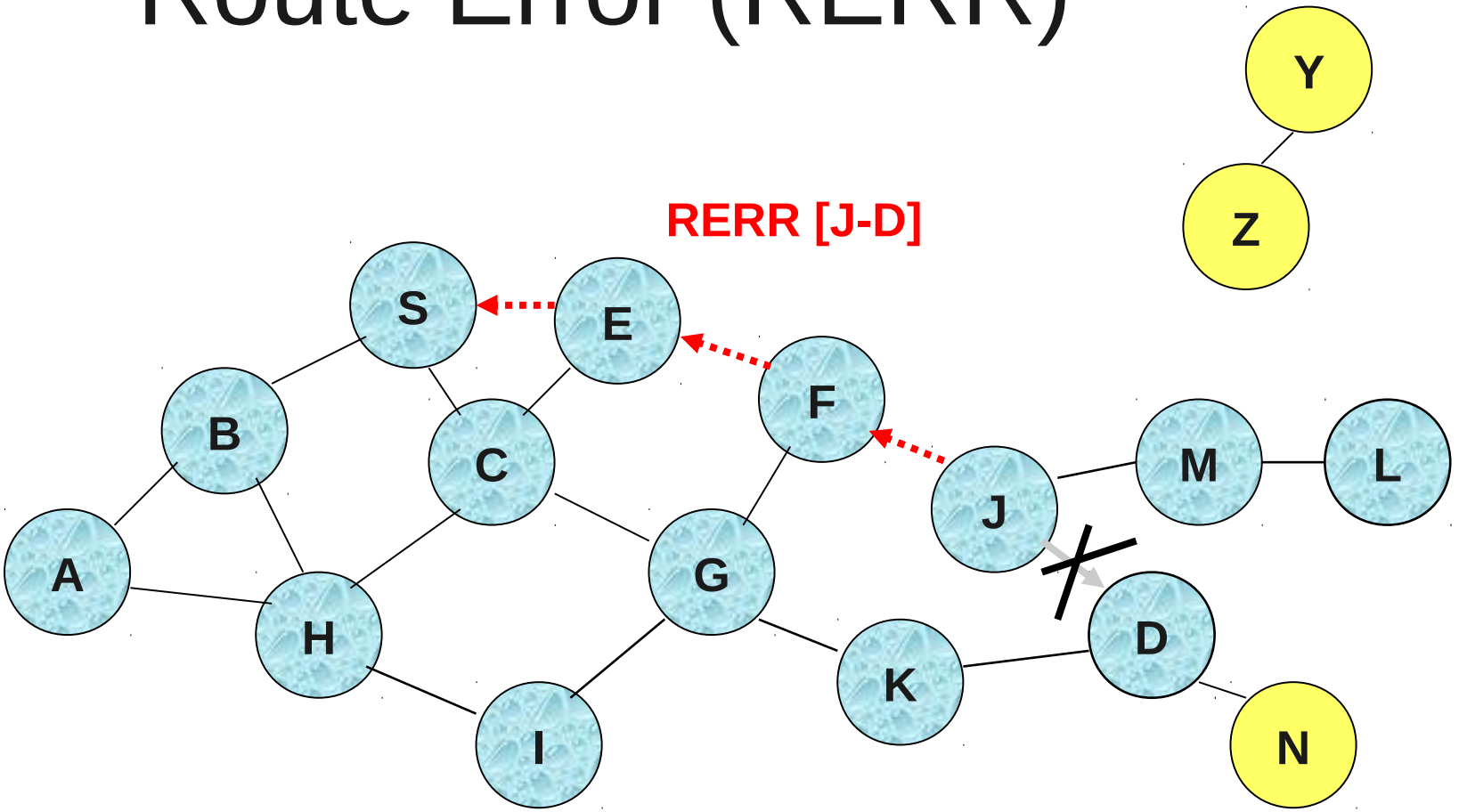
← **Represents RREP control message**

Data Delivery in DSR



Packet header size grows with route length

Route Error (RERR)



J sends a route error to S along route J-F-E-S when its attempt to forward the data packet S (with route SEFJD) on J-D fails

DSR: Route caching

- Each node caches a new route it learns by *any means*
- When node S finds route [S,E,F,J,D] to node D, node S also learns route [S,E,F] to node F
- When node K receives Route Request [S,C,G] destined for node, node K learns route [K,G,C,S] to node S

Route caching

- When node F forwards Route Reply RREP [S,E,F,J,D], node F learns route [F,J,D] to node D
- When node E forwards Data [S,E,F,J,D] it learns route [E,F,J,D] to node D
- A node may also overhear Data to learn routes

Route caching

- Uses:
  - Finding alternate routes in case original route breaks
  - Route reply from intermediate nodes
- Problems:
  - Cached routes may become invalid over time and due to host mobility
  - Stale caches can adversely affect performance

DSR: Advantages

- Routes maintained only between nodes who need to communicate
  - reduces overhead of route maintenance
- Route caching can further reduce route discovery overhead
  - A single route discovery may yield many routes to the destination, due to intermediate nodes replying from local caches

DSR: Disadvantages

- Packet header size grows with route length due to source routing
- Flood of route requests may potentially reach all nodes in the network
- An intermediate node may send Route Reply using a stale cached route, thus polluting other caches

Ad Hoc On-Demand Distance Vector Routing (AODV)

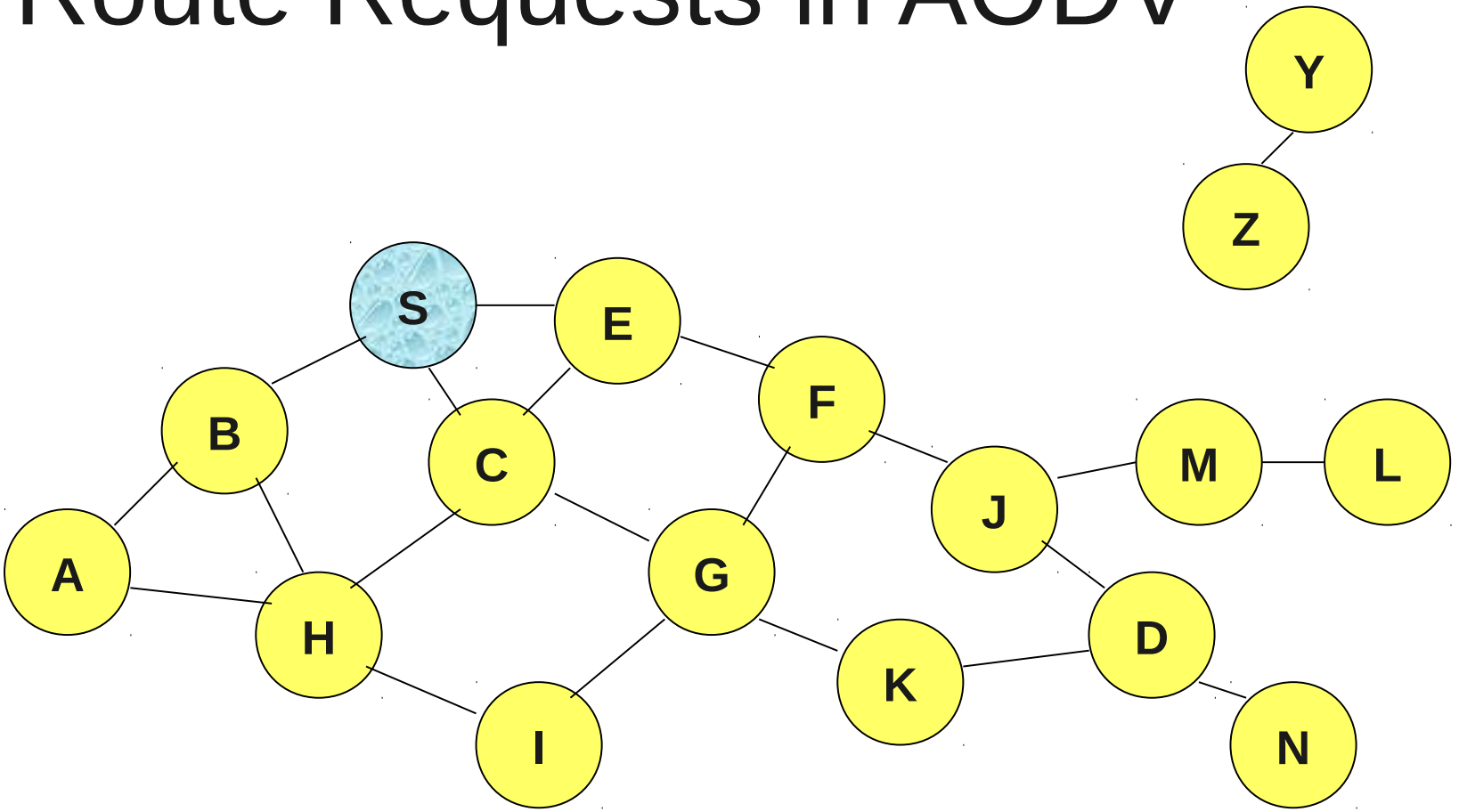
- DSR includes source routes in packet headers
- Resulting large headers can sometimes degrade performance
  - particularly when data contents of a packet are small

- AODV attempts to improve on DSR by maintaining routing tables at the nodes, so that data packets do not have to contain routes

AODV

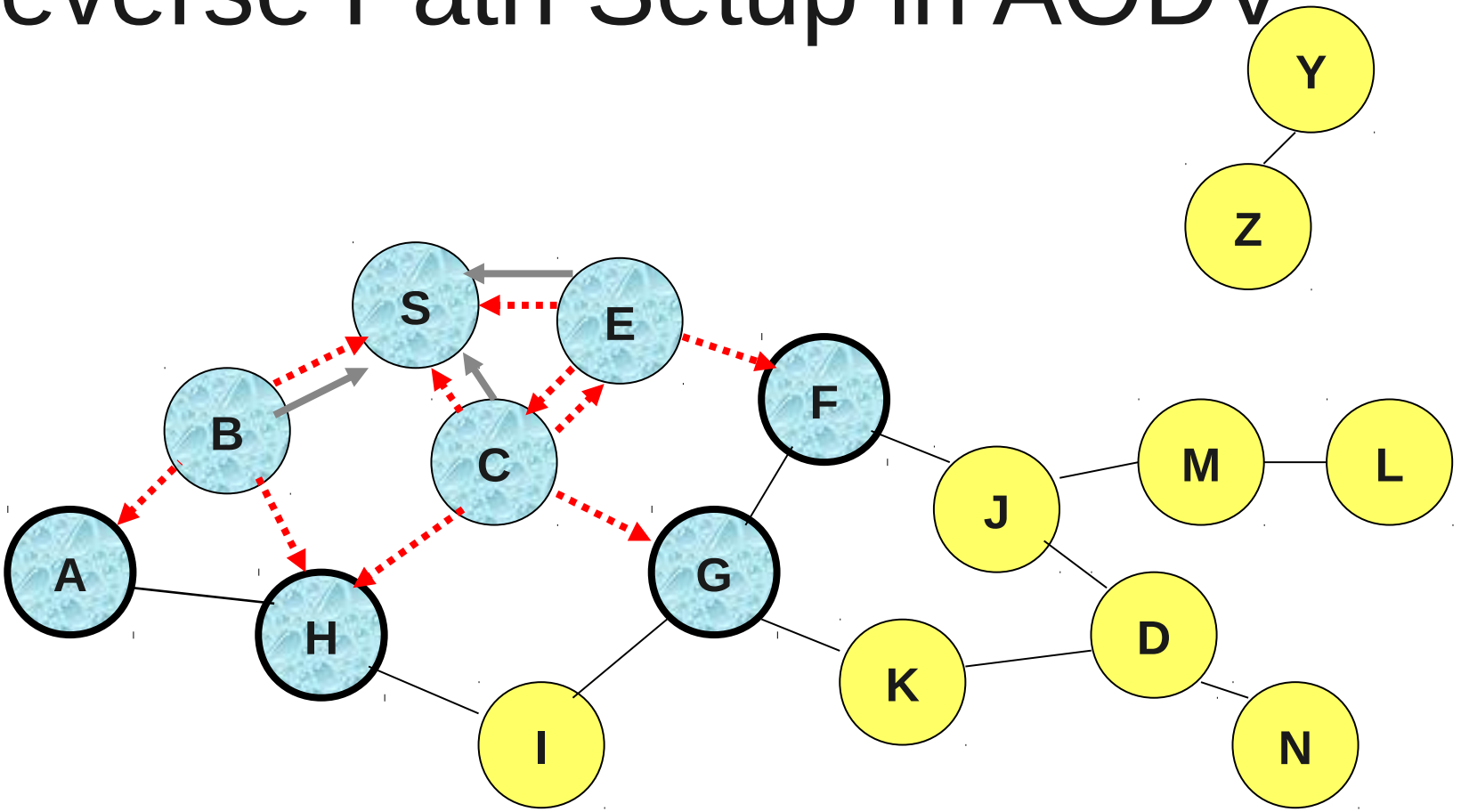
- Route Requests (RREQ) are forwarded in a manner similar to DSR
- When a node re-broadcasts a Route Request, it sets up a reverse path pointing towards the source
- Route Reply (RREP) travels along the reverse path set-up when Route Request is forwarded

Route Requests in AODV



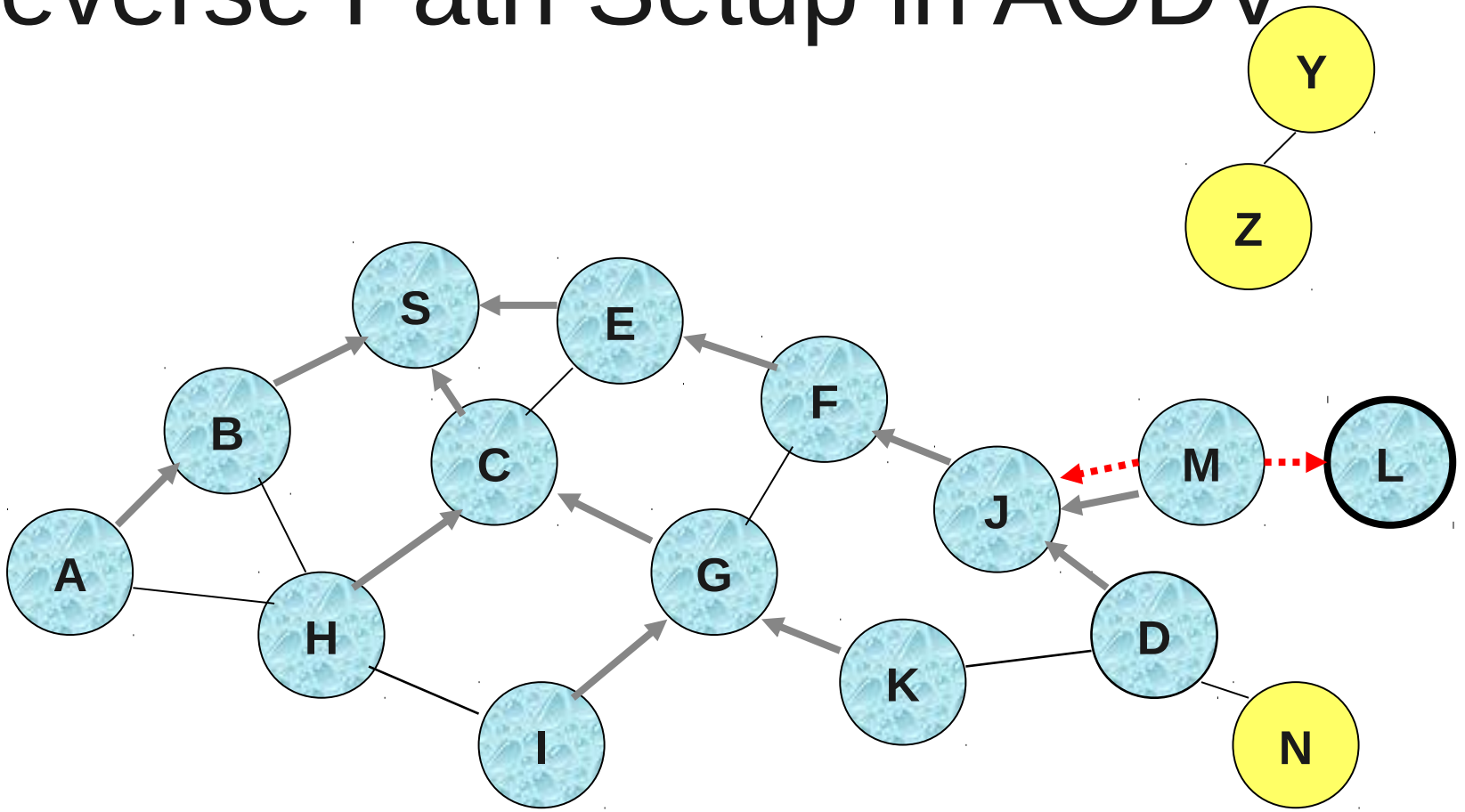
Represents a node that has received RREQ for D from S

Reverse Path Setup in AODV



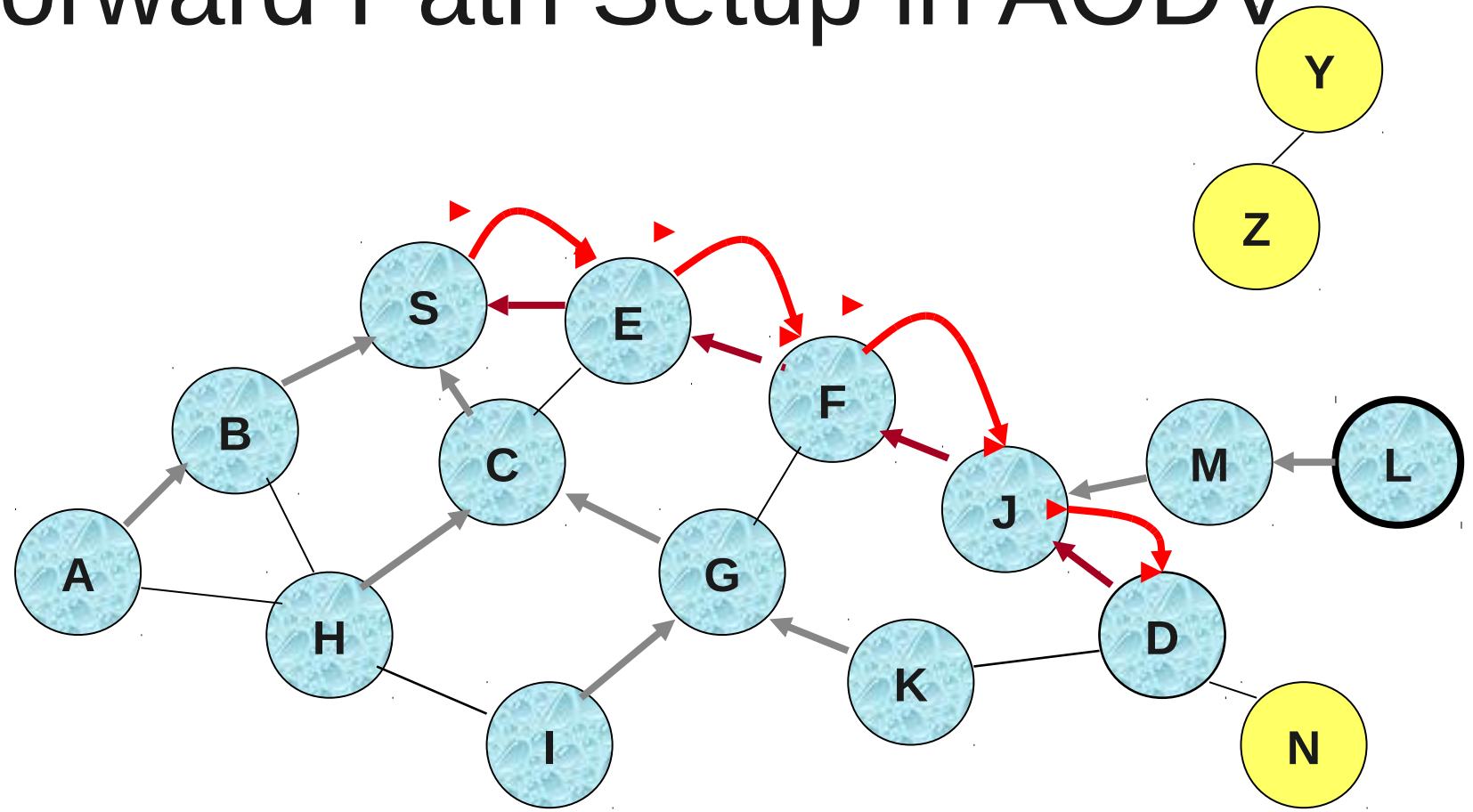
Represents links on Reverse Path

Reverse Path Setup in AODV



- **Node D does not forward RREQ, because node D is the intended target of the RREQ**

Forward Path Setup in AODV



Forward links are setup when RREP travels along the reverse path

Represents a link on the forward path

Route Request and Route Reply

- Route Request (RREQ) includes the last known sequence number for the destination
- An intermediate node may also send a Route Reply (RREP) provided that it knows a more recent path than the one previously known to sender
- Intermediate nodes that forward the RREP, also record the next hop to destination

AODV: Timeouts

- Neighboring nodes periodically exchange hello message

- A routing table entry maintaining a reverse path is purged after a timeout interval
- A routing table entry maintaining a forward path is purged if *not used* for a *active_route_timeout* interval

AODV: Link failure

- Absence of hello message is used as an indication of link failure
- When the next hop link in a routing table entry breaks, all active neighbors are informed

- Link failures are propagated by means of Route Error (RERR) messages, which also update destination sequence numbers

AODV: Expanding ring search

- Route Requests are initially sent with small Time-to-Live (TTL) field, to limit their propagation
  - DSR also includes a similar optimization

- If no Route Reply is received, then larger TTL tried

AODV: Summary

- Routes need not be included in packet headers
- Nodes maintain routing tables containing entries only for routes that are in active use
- At most one next-hop per destination maintained at each node
- Sequence numbers are used to avoid old/broken routes and prevent routing loops