



Mobility and MANET

Intelligent Transportation Systems

Rolland Vida

MANET routing

- **Proactive routing**

- The routing table is continuously maintained
 - No matter if there is traffic or not
- Relatively stable networks
- DSDV – based on the Bellman-Ford algorithm

- **On demand, reactive routing**

- Builds a route only if needed, if a packet has to be sent to the destination
- The routes are temporary, are dismantled if not used
- AODV

- **Hybrid protocols**

- Combining the previous two

- **Position-based protocols**

- Makes use of geographical position information for routing



Constraints

- Delay
 - **Proactive** protocols provide lower delay, as routes are prepared in advance, and always up to date, ready to use
 - **Reactive** protocols provide large delay, as the route from A to B has to be found, when needed
- Overhead
 - **Proactive** protocols have a large overhead, too much signaling traffic to build and maintain the routes, even if no real data to send
 - **Reactive** protocols have lower overhead, useless routes are not maintained
- Each application will choose the best protocol
 - Low mobility -> **Proactive** protocols
 - High mobility -> **Reactive** protocols

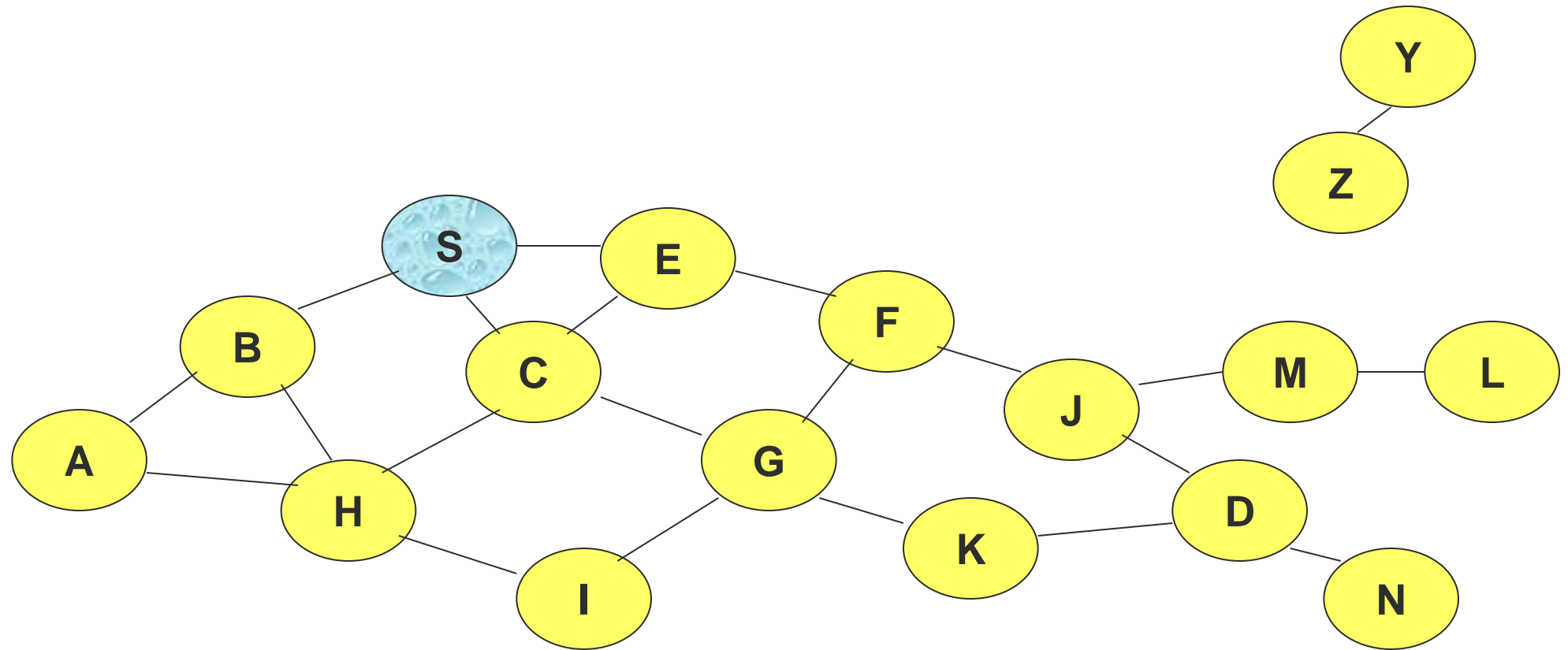
Ad Hoc On-Demand Distance Vector Routing (AODV)

- Reactive protocol
 - Maintains a routing table in each node, no need to store the route in the packet header
 - The route is built and maintained only if it is „active”

AODV

- To discover the route, the source broadcasts a **Route Request (RREQ)** message
- Those who receive it, rebroadcast it
- When a node rebroadcasts a Route Request message, it stores a **reverse path pointer** towards the node from where the request came
 - AODV symmetric (bi-directional) links
 - A small timer ensures that these records time out after a while
- If the RREQ arrives to the destination D, a **Route Reply (RREP)** message is sent back
- It will propagate along the path built from the reverse path pointers

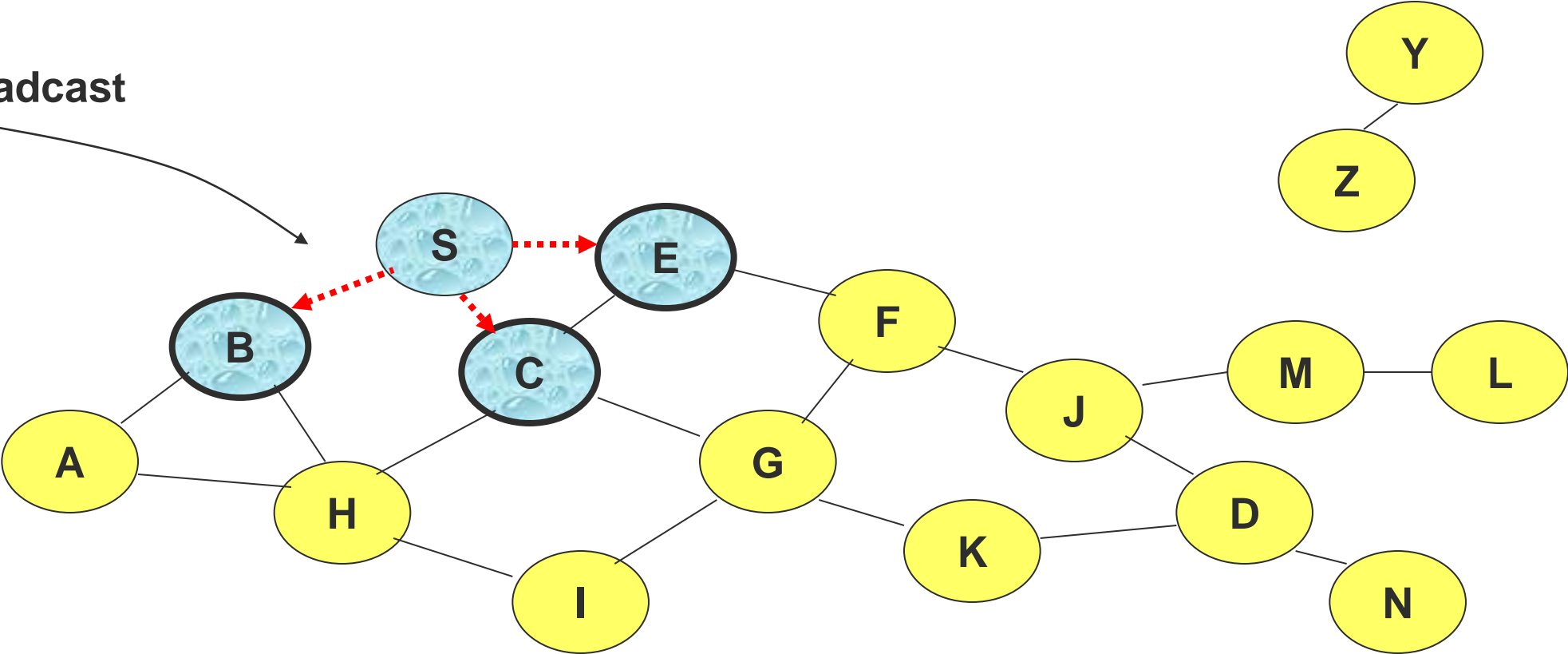
Route Request - AODV



Node that already received a RREQ for D initiated by S

Route Request - AODV

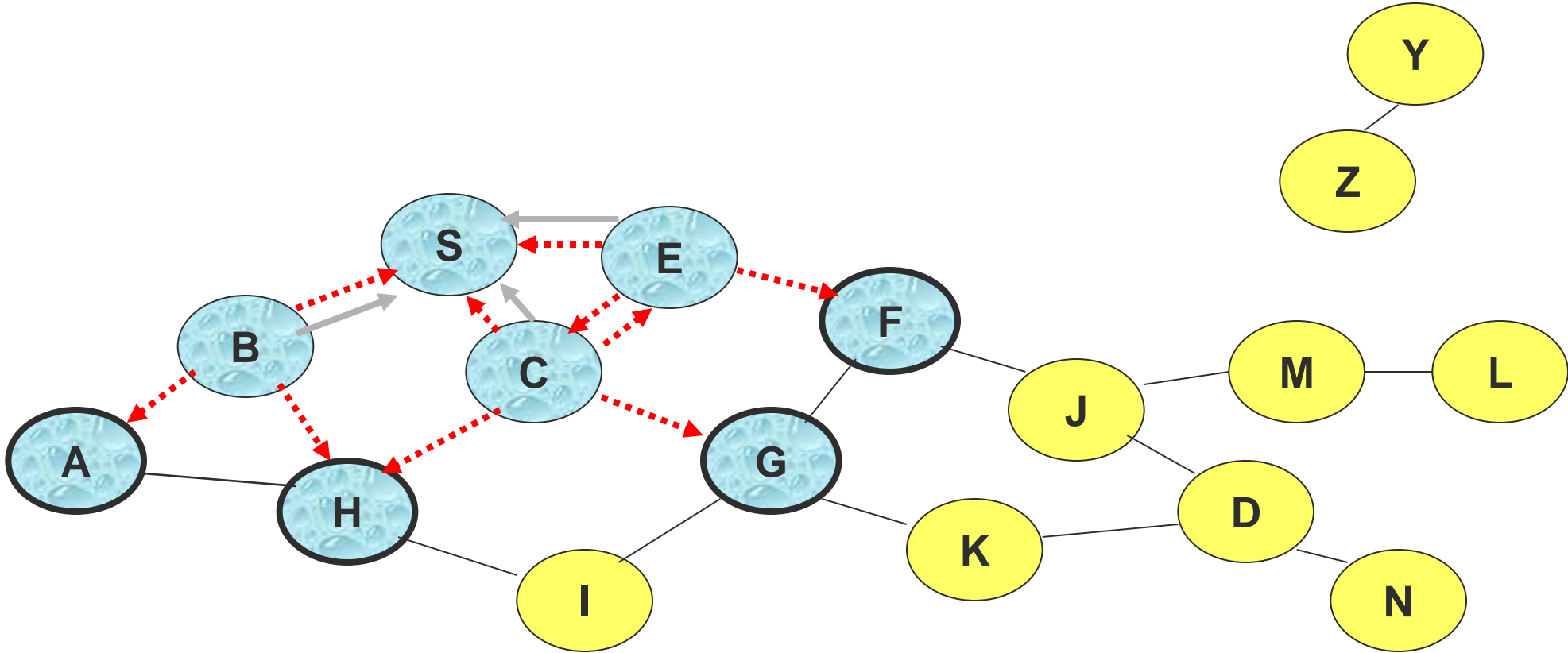
Broadcast



-----> RREQ

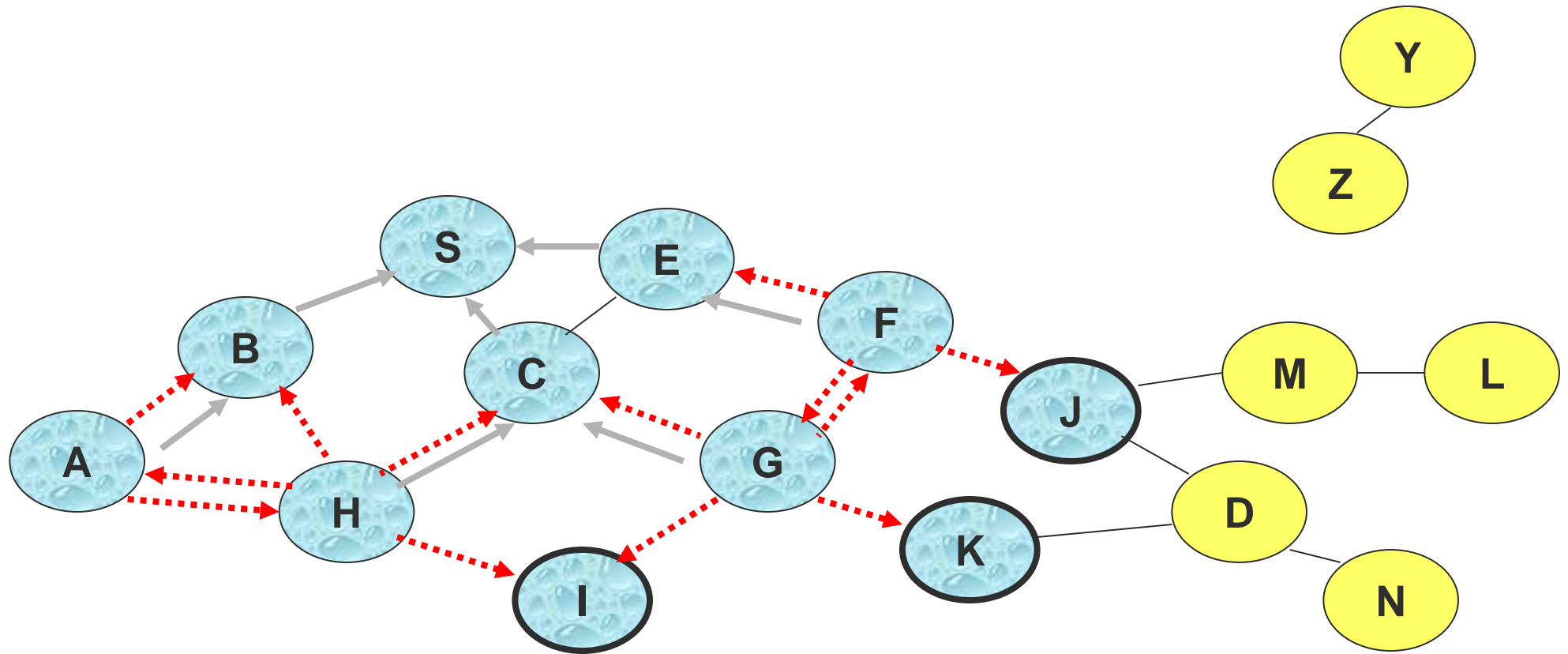


Route Requests - AODV



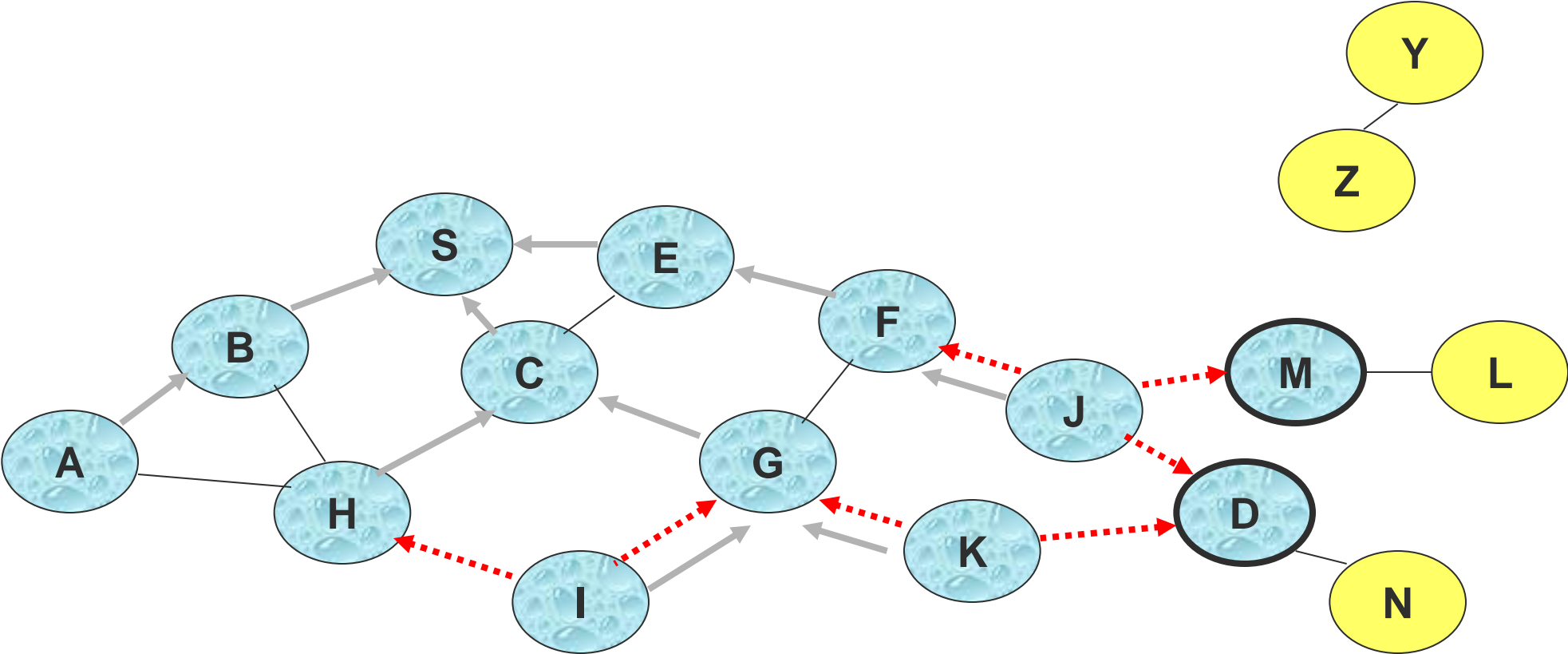
← Reverse Path pointer

Reverse Path - AODV

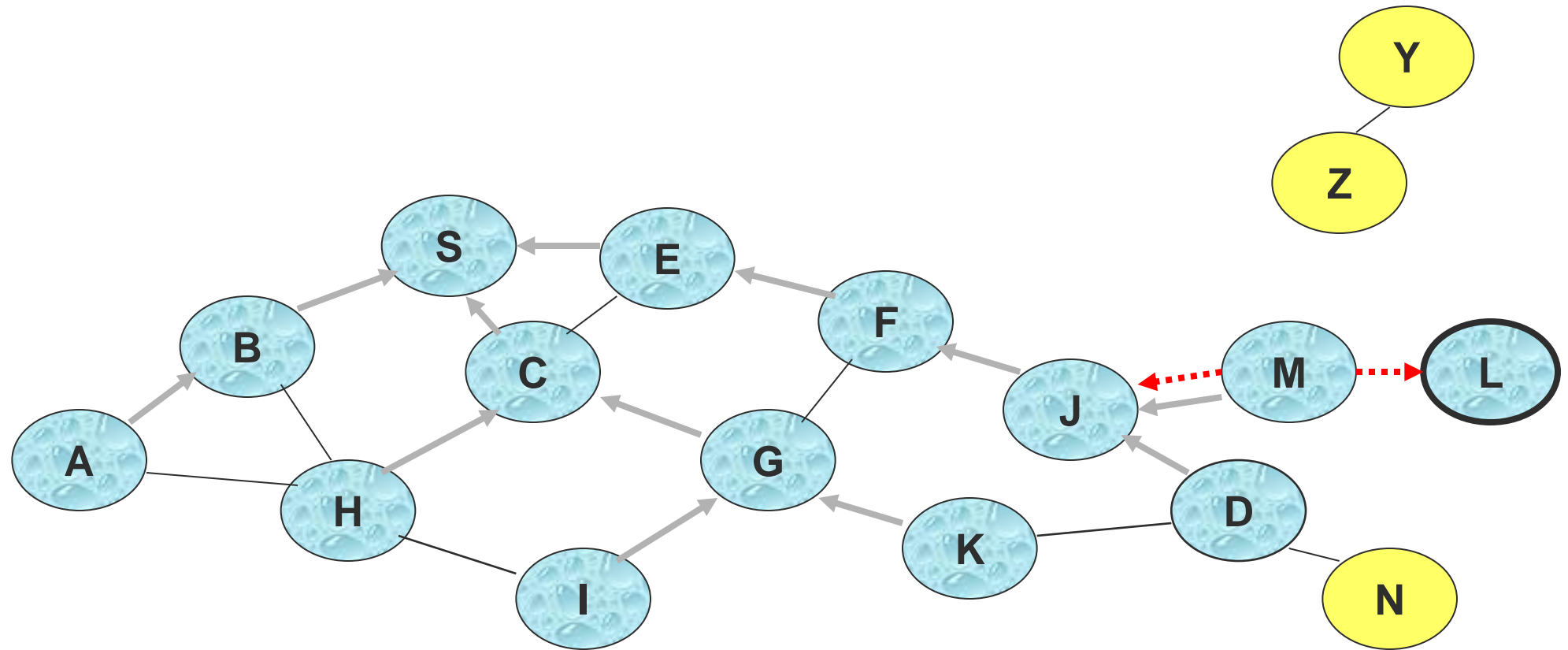


- C receives a RREQ from neighbors (G and H)
But does not rebroadcast it again

Reverse Path - AODV

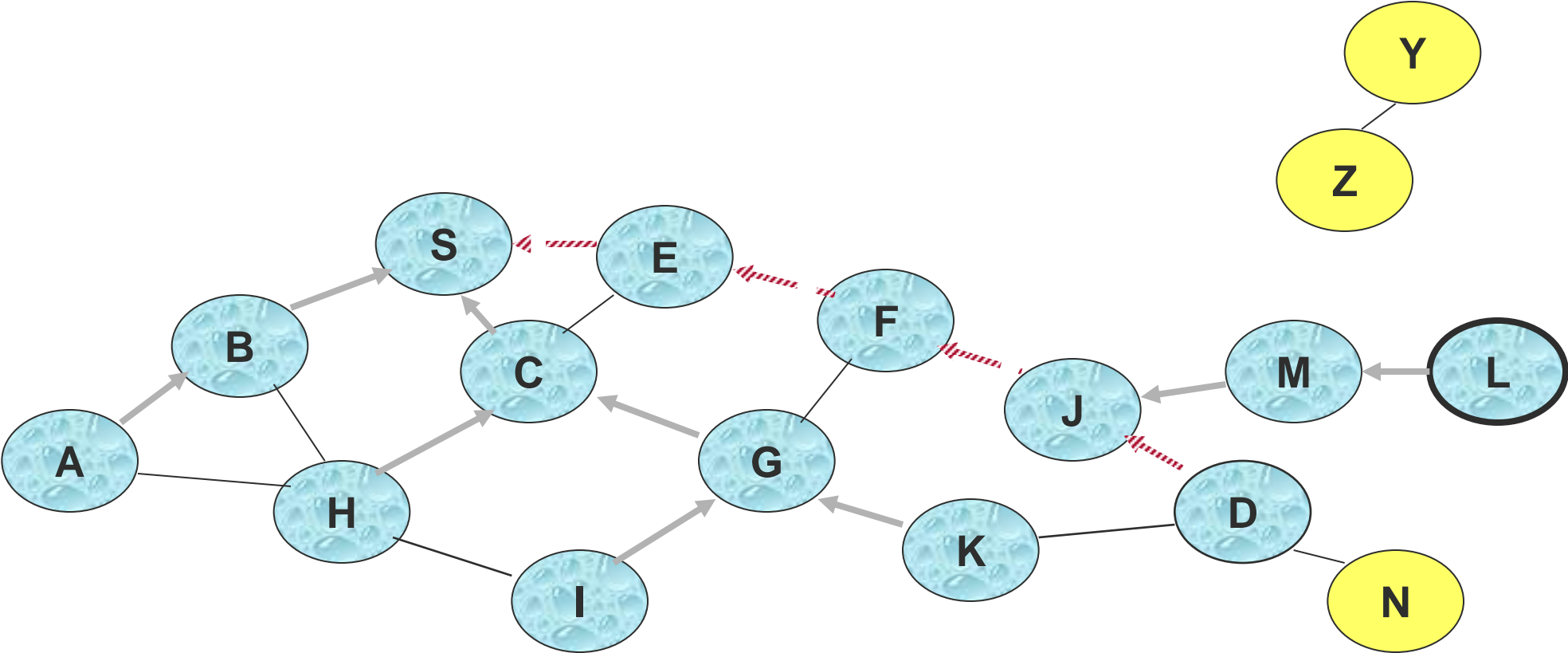


Reverse Path - AODV



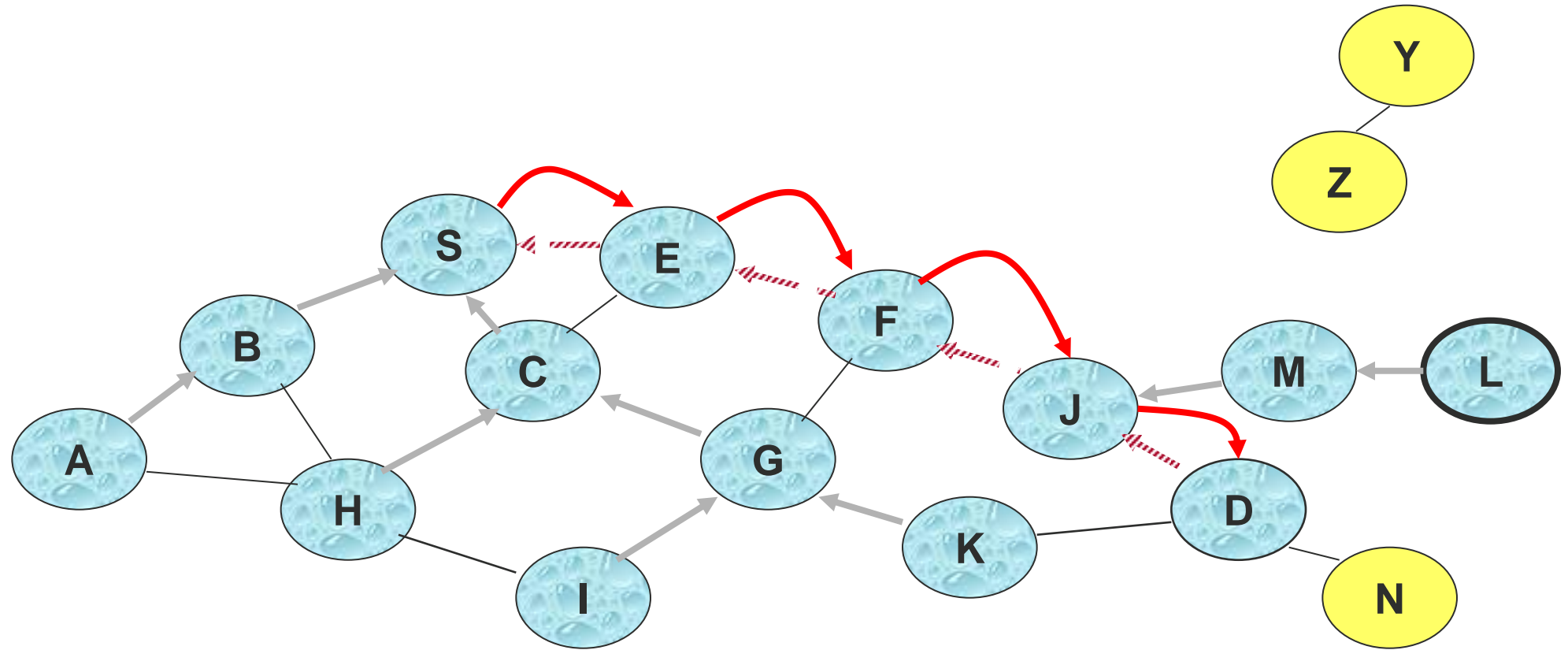
- node D does not forward anymore the RREQ message, as he is the destination

Route Reply - AODV



 Path of the RREP message

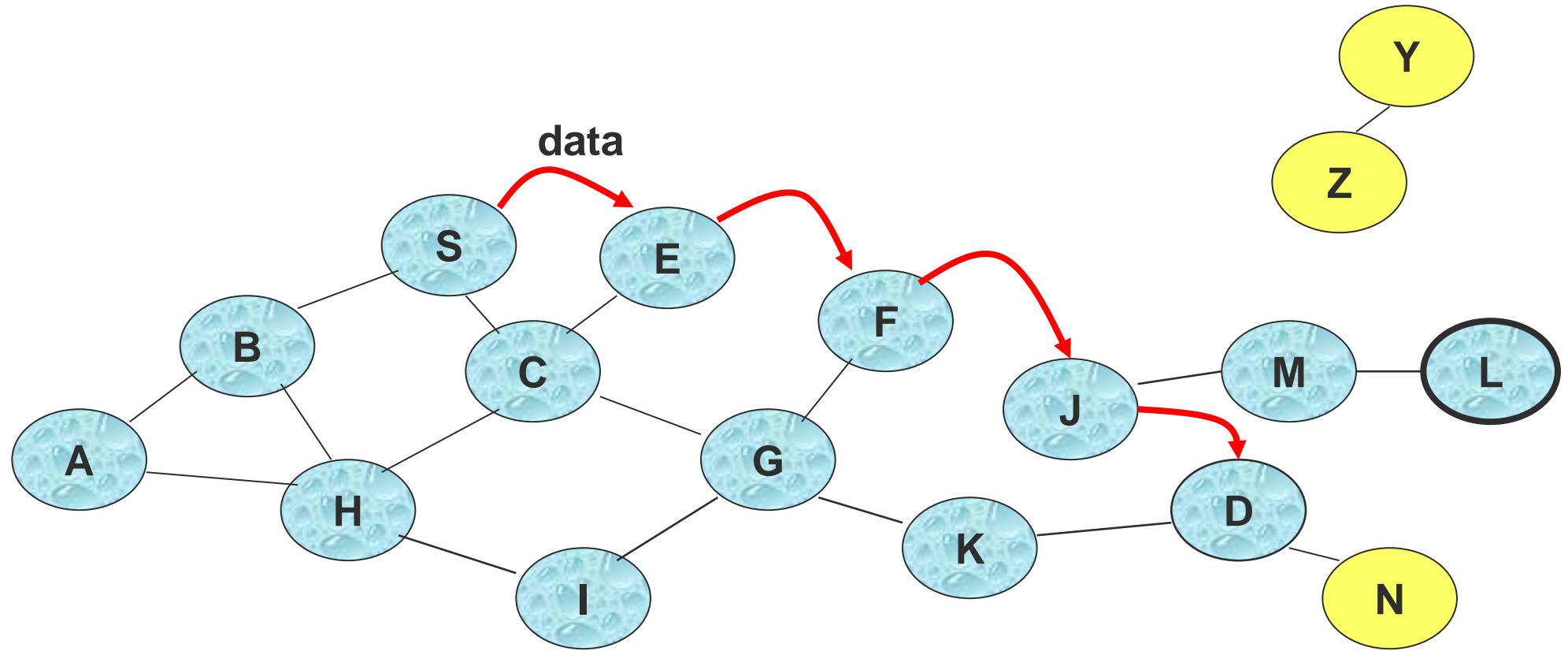
Forward Path - AODV



As the RREP message travels from D to S, forward path pointers are stored in the intermediate nodes

 Forward path pointer

Data sending - AODV



For sending the useful data, these forward path pointers are used

The path is not included in the header

Timers

- The **reverse path records** are deleted after a while from the routing tables
 - We should take into account the specificities of the wireless domain and the size of the network, leave time for the RREP message to propagate back before deleting the record

- The forward path pointer is deleted if it becomes inactive – no traffic
 - *active_route_timeout*
 - If no traffic, the record is deleted, even if the path is still valid

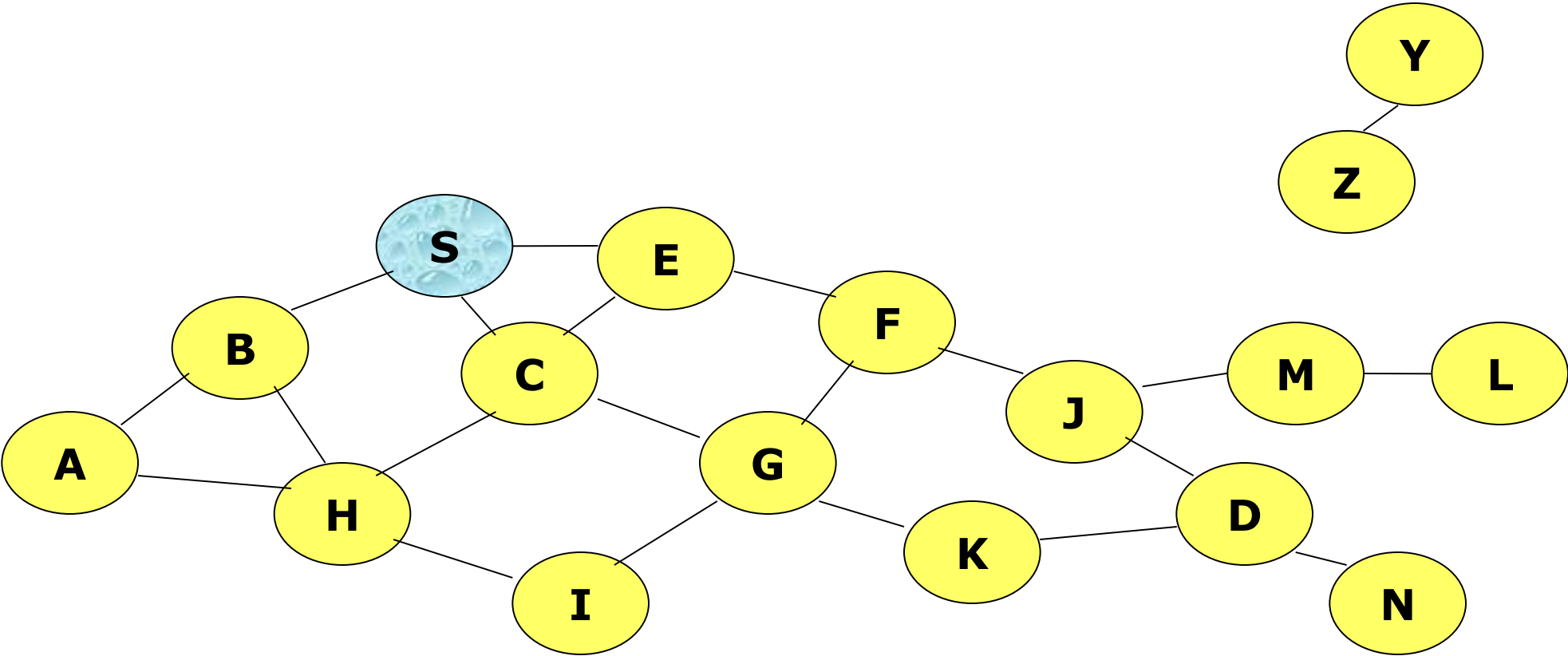
Optimization: Expanding Ring Search

- Searching an expanding territory
- The RREQ messages are first sent out with a small Time-to-Live (TTL) value
 - After each hop the TTL value is decreased
 - If 0, the message is dropped
 - Used in many protocols that are based on flooding
- If no Route Reply until a timer expires, the value of the TTL is increased
 - After a few steps the search will cover the entire topology

Dynamic Source Routing (DSR)

- If the source **S** wants to send something to destination **D**, it initiates route discovery
- **S** floods the network with Route Request (**RREQ**) messages
- Each intermediate node adds his ID to the RREQ before forwarding it

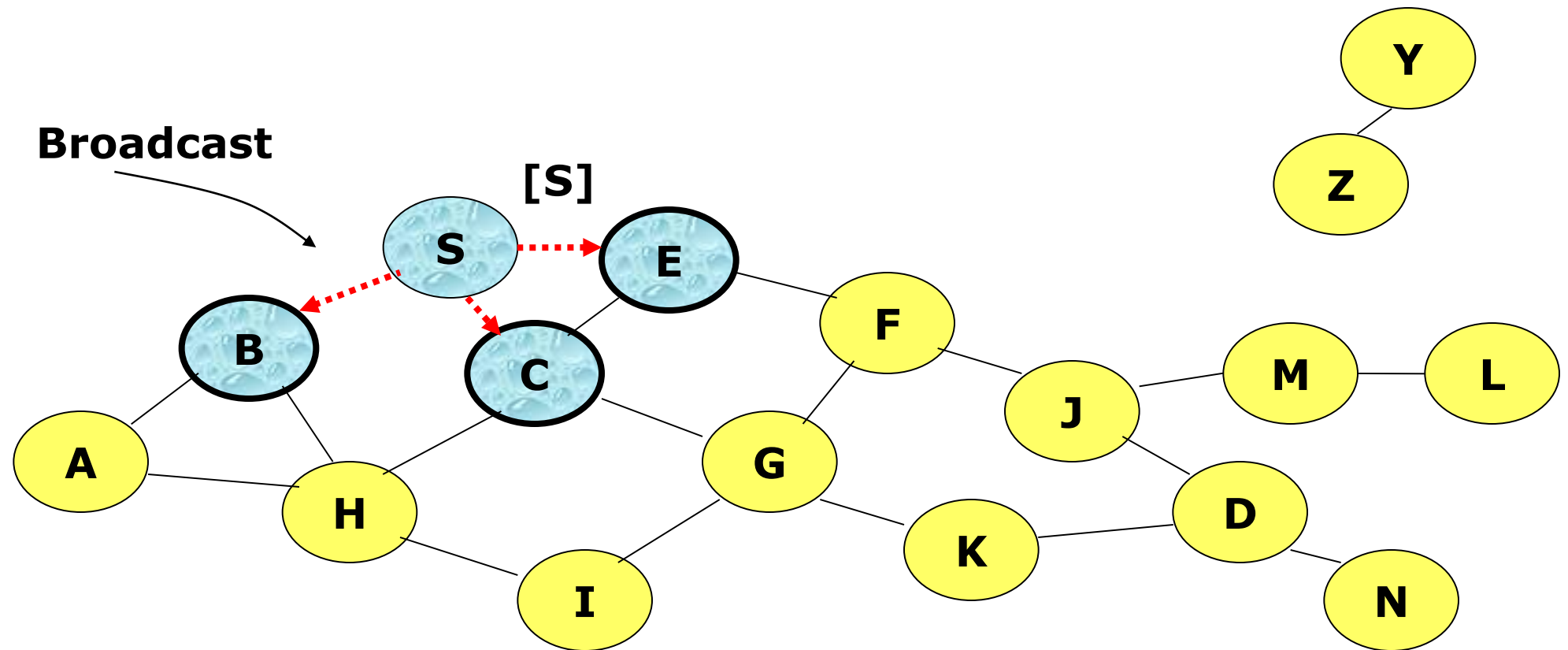
DSR Route Discovery



Nodes that already received the RREQ from S, regarding D



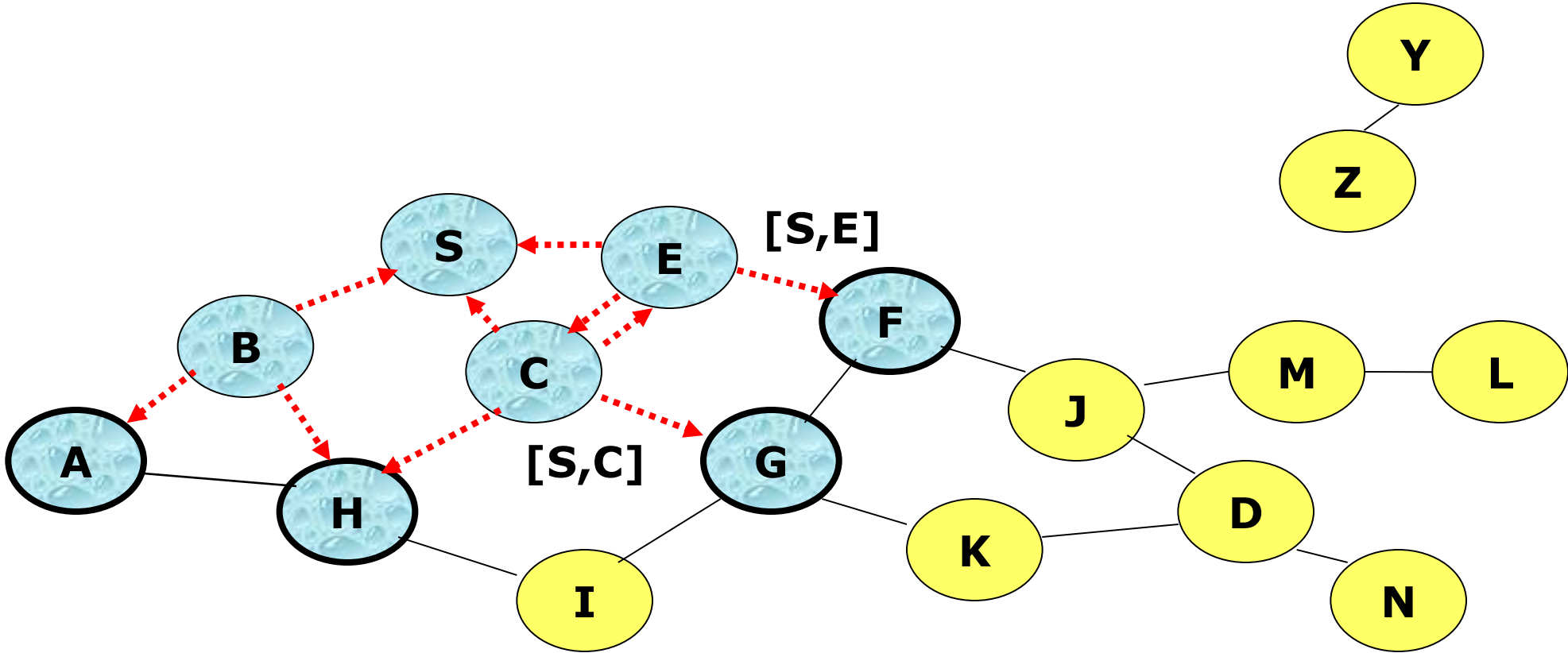
DSR Route Discovery



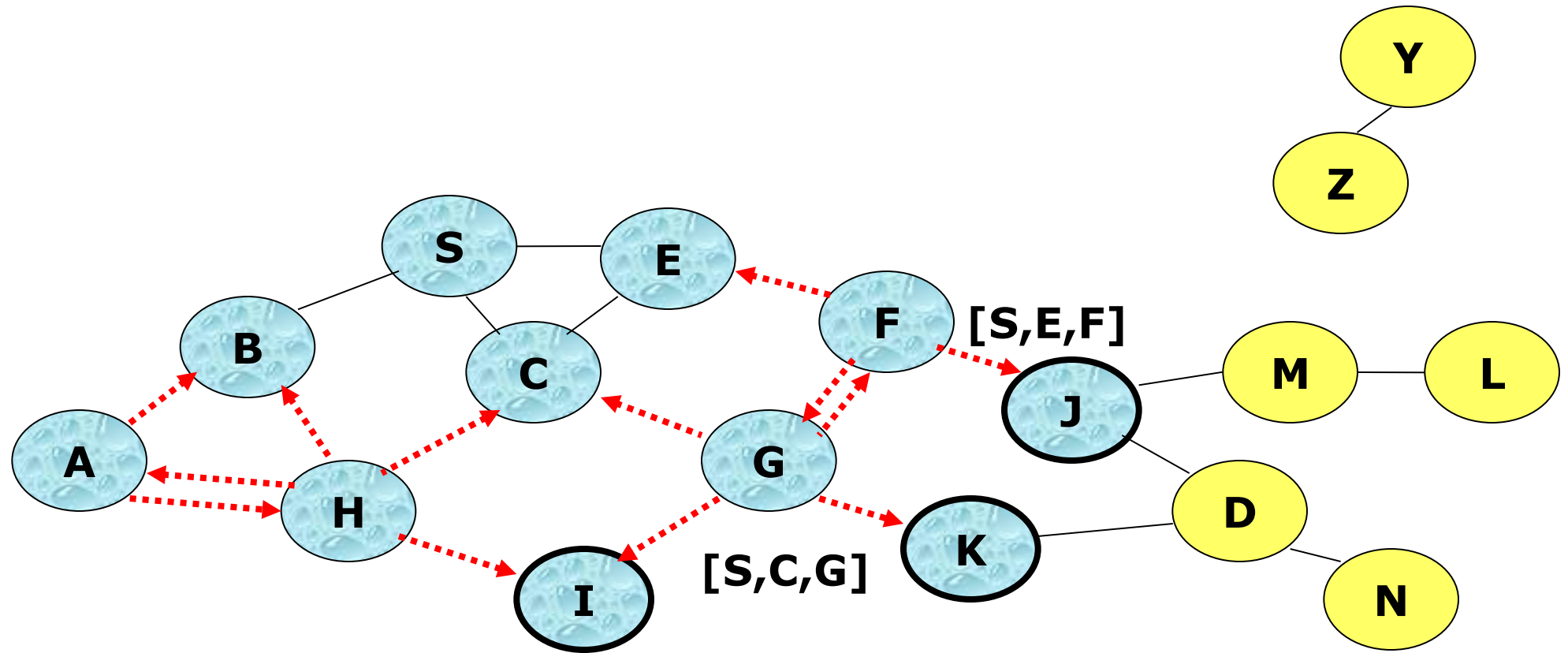
RREQ

[X, ...] intermediate nodes already added to the path

DSR Route Discovery

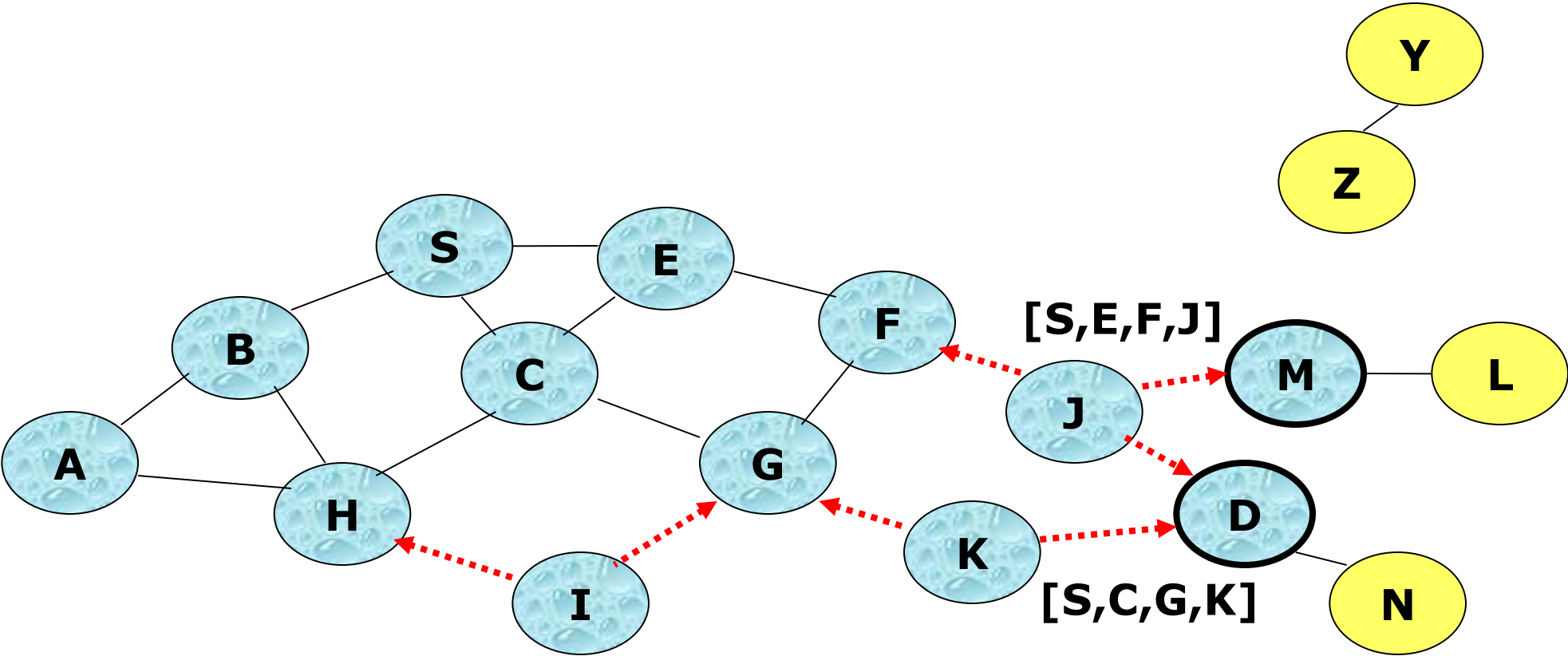


DSR Route Discovery

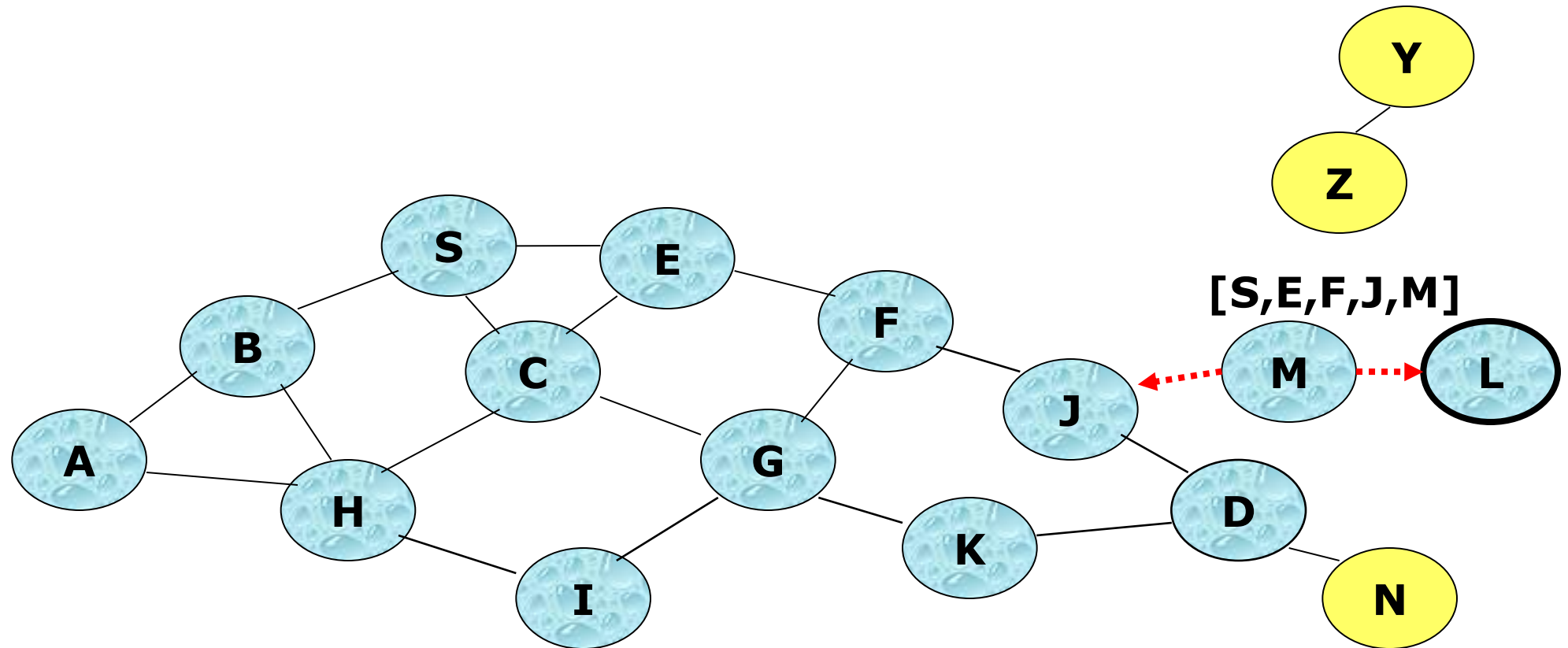


**Restricting the flooding (like in AODV):
C receives the RREQ again from G and H, but does not forward it again**

DSR Route Discovery



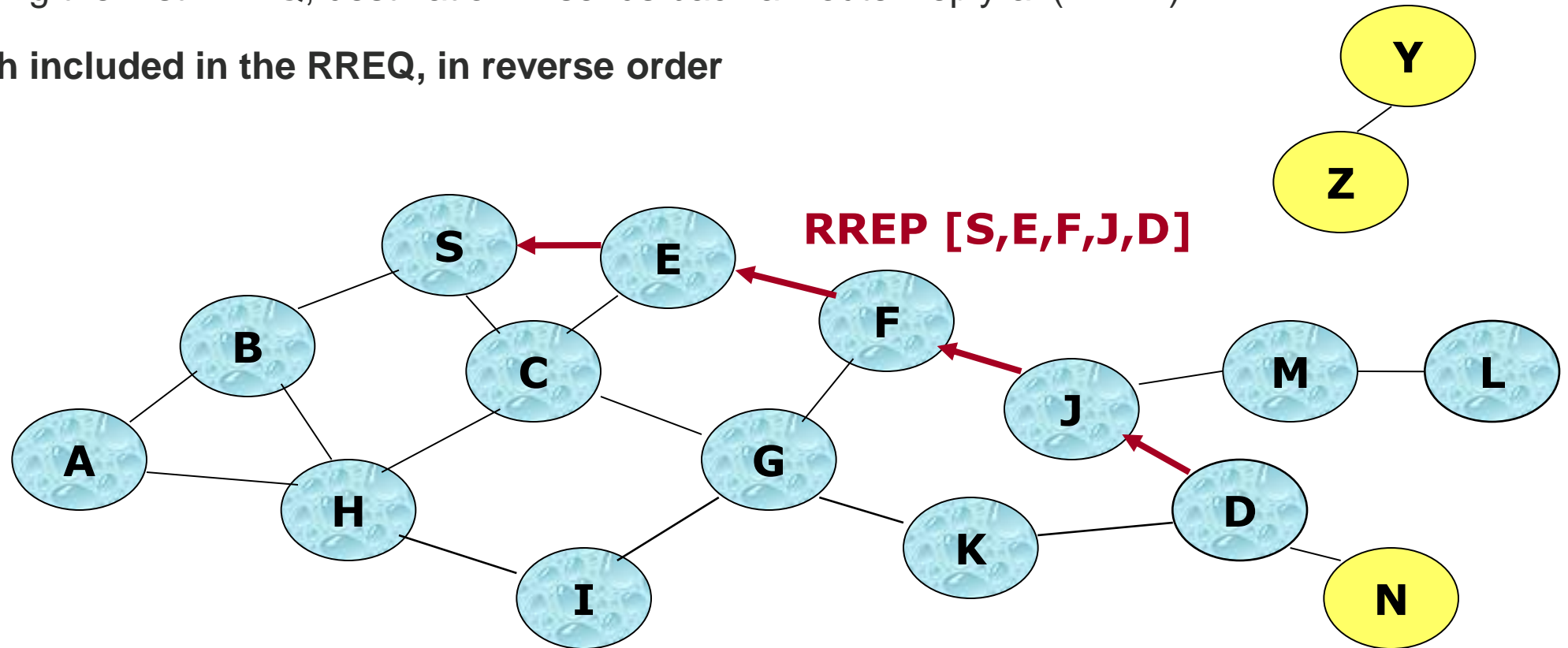
DSR Route Discovery



D stops the broadcast of RREQ, as it is the destination

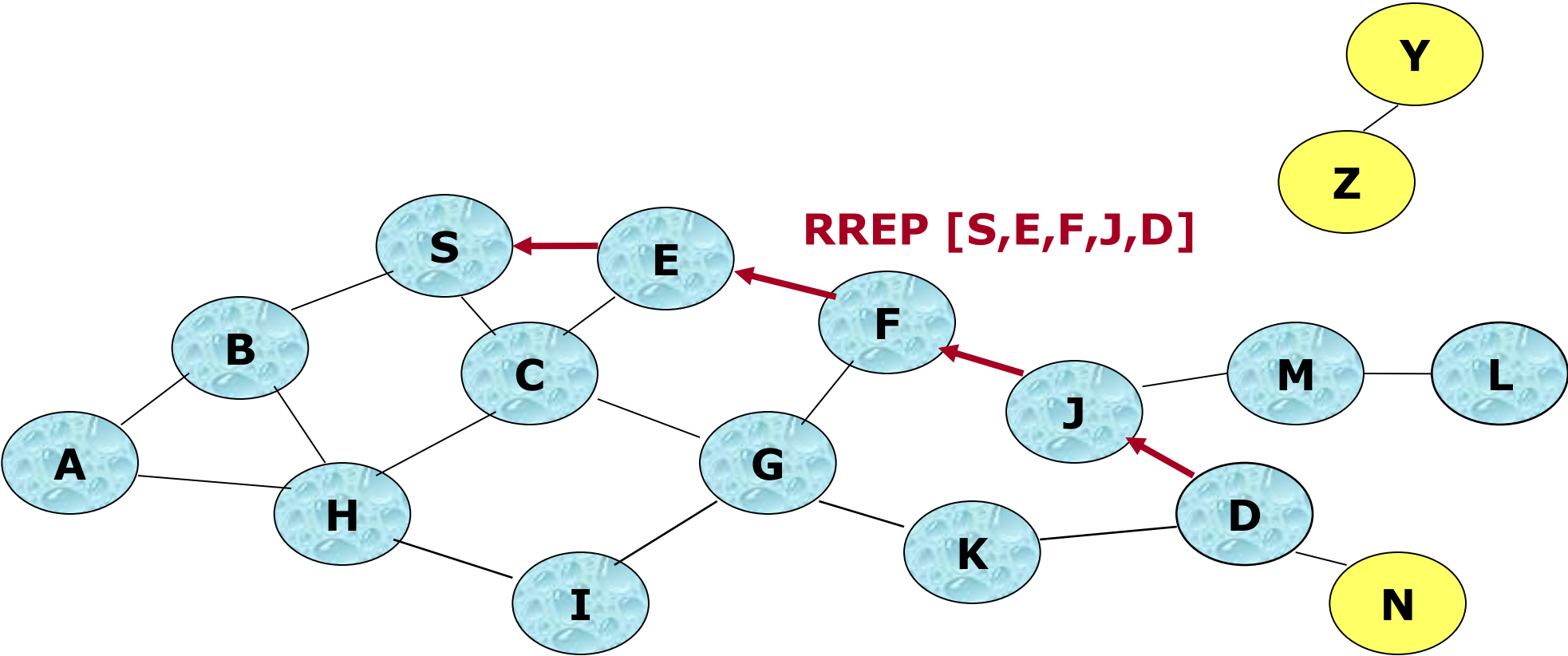
DSR Route Discovery

- After receiving the first RREQ, destination D sends back a Route Reply-al (RREP)
- On the path included in the RREQ, in reverse order



← RREP

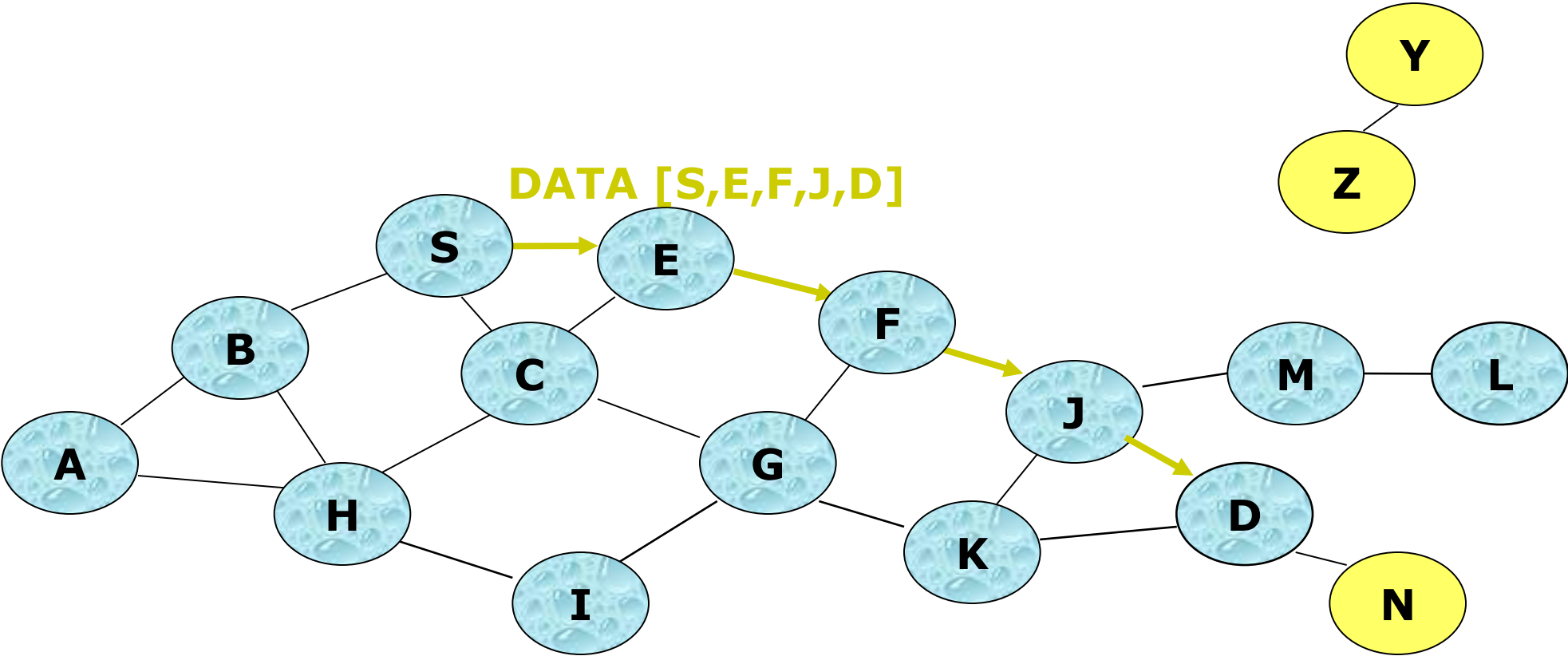
DSR Route Reply



← RREP routing message



Data Delivery in DSR



The header increases with the path length



Position-based routing

- Eliminate some drawbacks of the topology-based routing algorithms
- The source makes use of some **localization service**, and finds out the geographical position of the destination.
- If we know the position of the destination, there is no need to build and maintain routes in advance
 - Instead of building the routes, we need a **forwarding strategy**
 - At each node, we select the next hop based on the position of the destination and the position of the neighbors

Localization service

- **Localization service**
 - Helps a node to determine its position
 - In an ad hoc network a localization server is not always available
- The localization service can be provided by one or several nodes:
 - „some/all to some/all”
 - „Chicken-egg” problem: but how do we know the position of the localization server?
- If a source does not know the position of the destination, makes use of such a localization service
 - In case of a cellular (mobile) network, localization is centralized, and at cell level
 - It cannot be applied in ad hoc systems

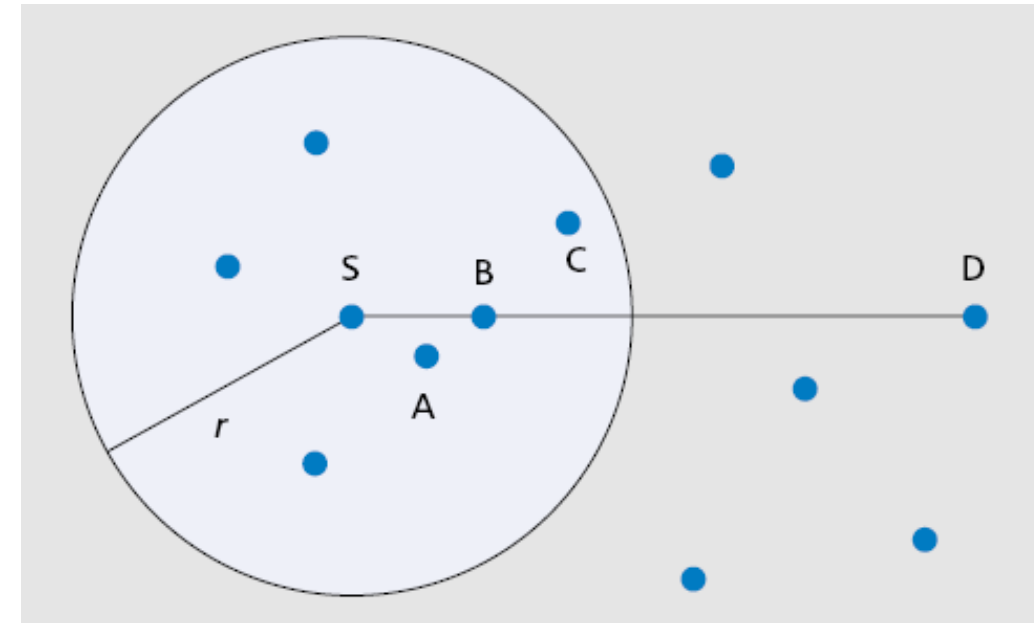
Forwarding strategies

- The forwarding decision of an intermediate node:
 - Based on the position information of the destination, embedded in the packet
 - Based on the position of one-hop neighbors
- Positions of the neighbors: known from periodic Hello messages

- Forwarding strategies:
 - Greedy forwarding
 - E.g. MFR, NFP, compass routing
 - Restricted directional flooding
 - E.g., LAR, DREAM
 - Hierarchic solutions

Greedy forwarding

- Which strategy should be used to select the next hop?
- **Most forward within r (MFR)**
 - Choose the node that is closest to the destination **D** (Node **C** in the figure)
 - The number of hops is minimized
 - Good strategy if the radio power cannot be changed
- **Nearest with forward progress (NFP)** (node **A**)
 - If the radio power can be adapted
 - Decreases the probability of collisions
- **Compass routing** (node **B**)
 - The smallest angle compared to the SD line
- **Random** choice of a neighbor in the good direction
 - No precise position information needed about neighbors
 - Lower overhead



Greedy forwarding

- Problems:
 - **S** might be closer to the destination **D** than any other node
 - Forwarding might arrive to a local maximum, where there is no way forward
 - **Recovery** mode:
 - If the greedy forwarding stops, we switch to recovery mode
 - If a neighbor can be found again, we switch back to the greedy mode

