More Efficient Routing Algorithm for Ad Hoc Network

ENSC 835: HIGH-PERFORMANCE NETWORKS

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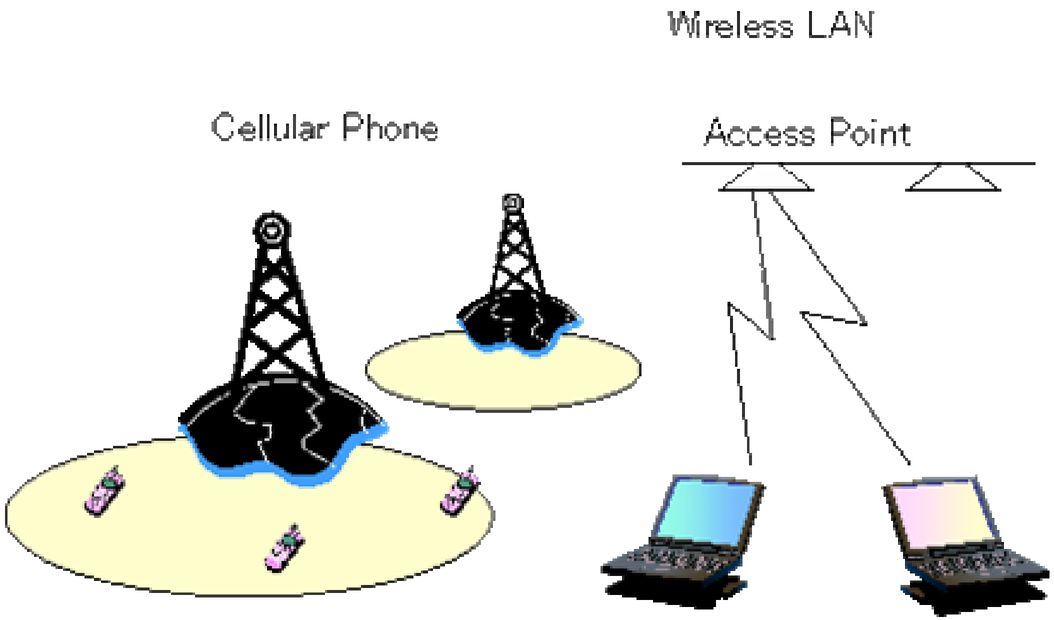
Outline

- Quick Overview of Ad hoc Networks
- AODV Routing Protocols
- Motivation
- Multipoint Relays Select techniques
- Implementation and Challenges
- NS2 Simulation Environment and Results
- Conclusion and Future Works

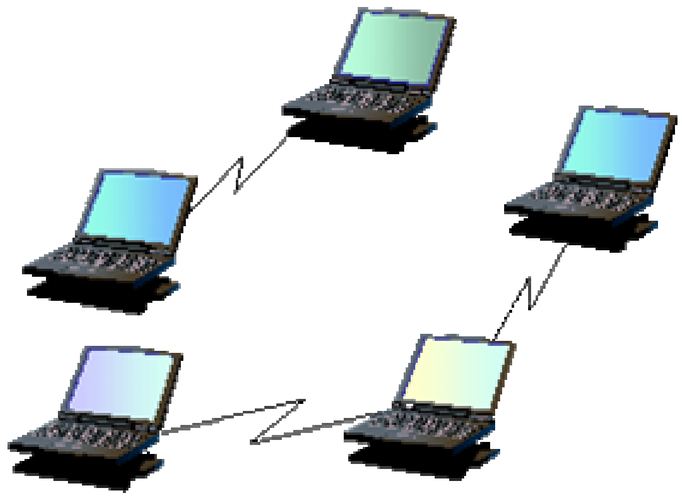
Wireless Ad Hoc Networks

Present Mobile Communication



Base station or access point recognizes terminal location and decides communication route.

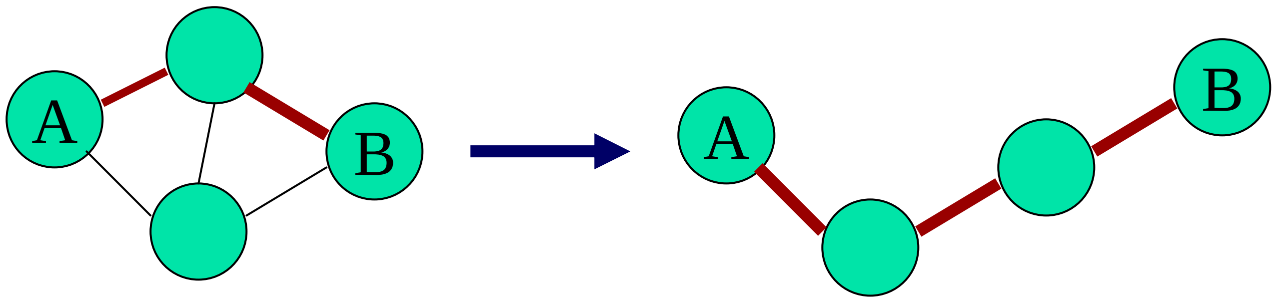
Wireless Ad Hoc Network



- No infrastructure (base station, access point)
  → Network anywhere
  (disaster stricken area, stadium)
- Key technologies
  - Routing algorithm
  - Adaptation to network topology change
  - Efficiency in frequency and power

Mobile Ad Hoc Networks (MANET)

- Host movement frequent
- Topology change frequent

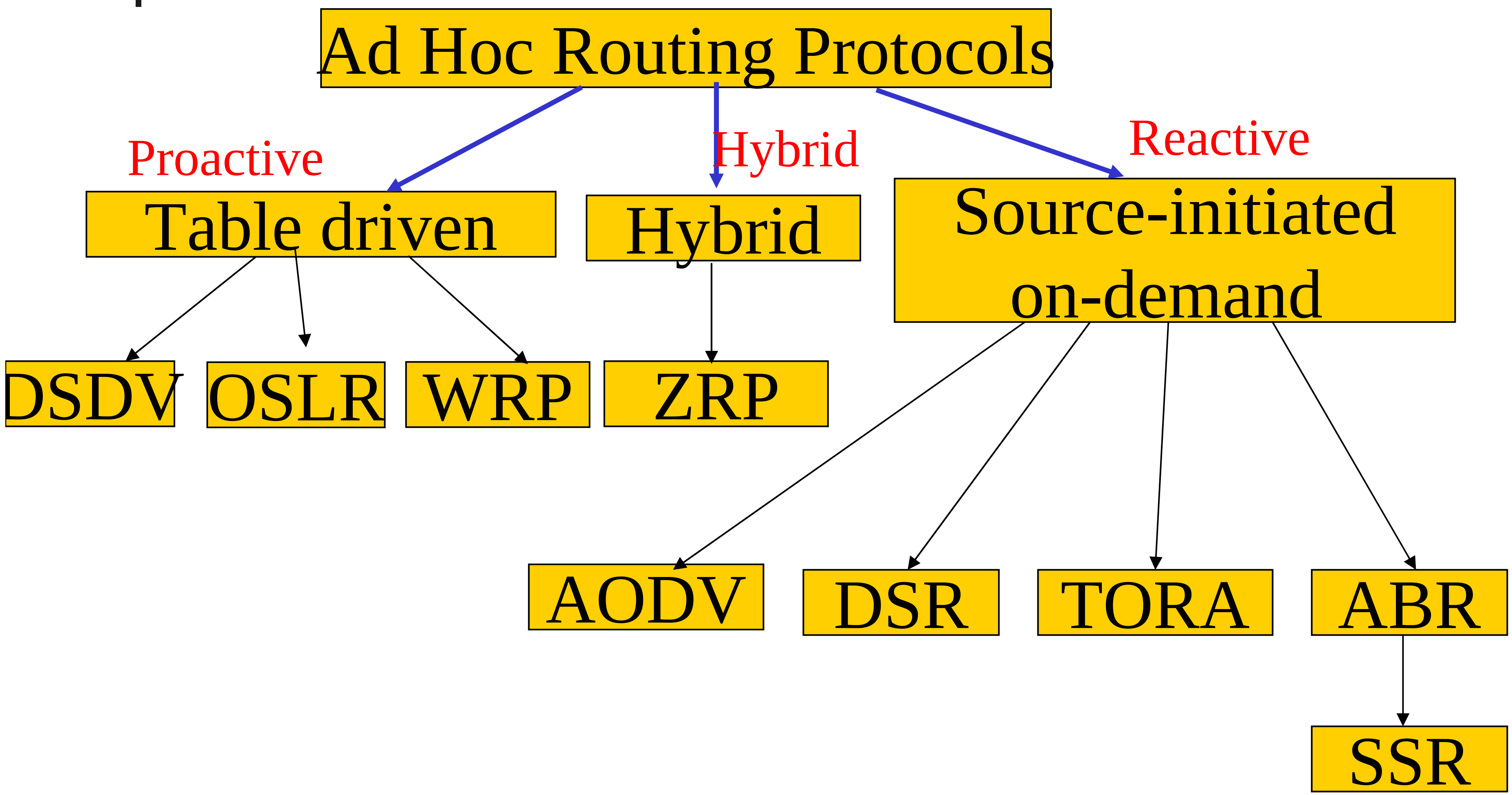


- No cellular infrastructure. Multi-hop wireless links may need to traverse multiple links to reach destination
- Data must be routed via intermediate nodes.

Unicast Routing Protocols

- Many protocols have been proposed
- Some specifically invented for MANET
- Others adapted from protocols for wired networks
- No single protocol works well in all environments
  - some attempts made to develop adaptive/hybrid protocols
- Standardization efforts in IETF
  - MANET, MobileIP working groups
  - **http://www.ietf.org**

Existing Ad Hoc Routing Protocols



Routing Protocols

- Proactive protocols
  - Traditional distributed shortest-path protocols
  - Maintain routes between every host pair at all times
  - Based on periodic updates; High routing overhead
  - Example: DSDV (destination sequenced distance vector)
- Reactive protocols
  - Determine route if and when needed
  - Source initiates route discovery
  - Example: DSR (dynamic source routing)
- Hybrid protocols
  - Adaptive; Combination of proactive and reactive
  - Example : ZRP (zone routing protocol)

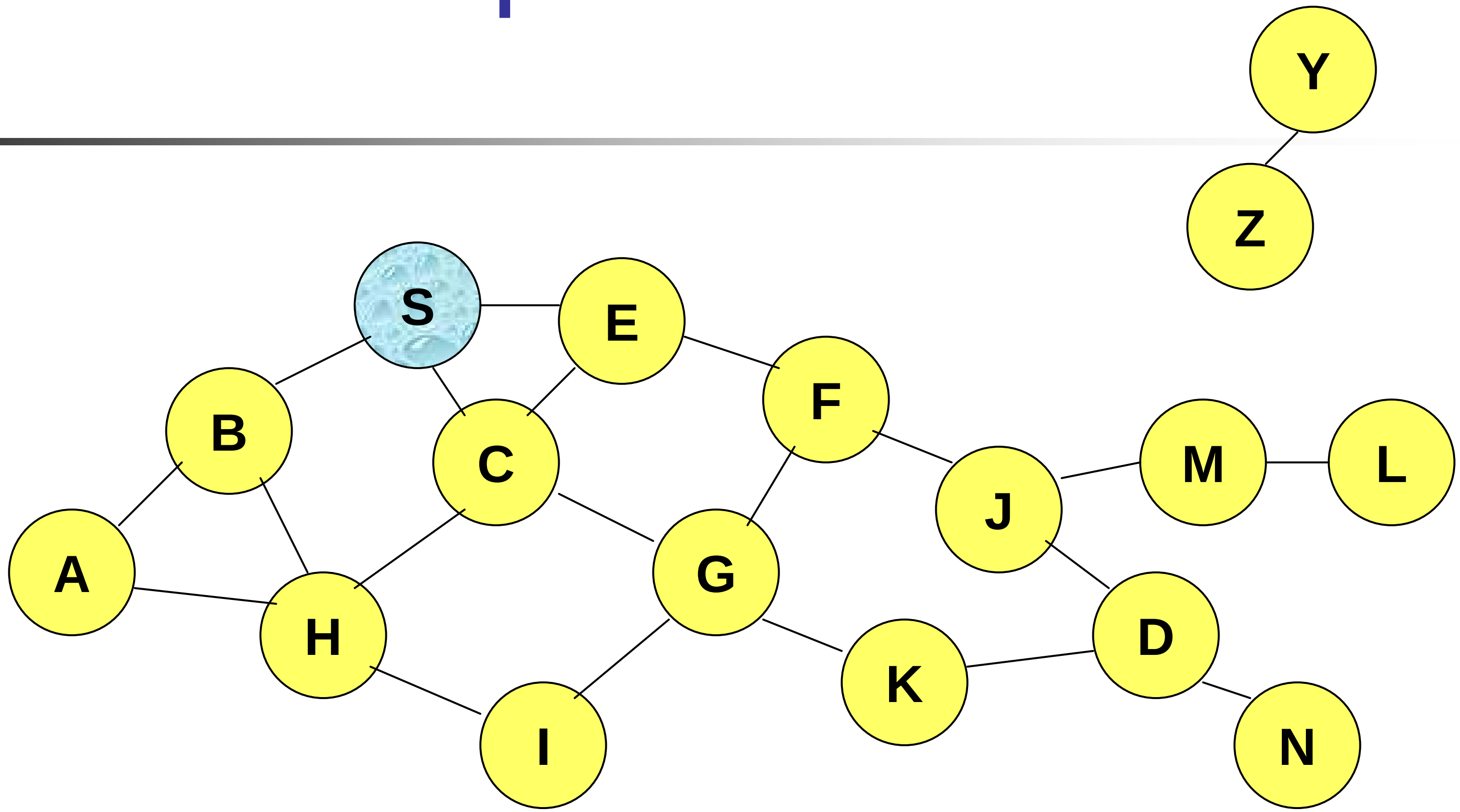
Protocol Trade-offs

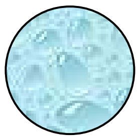
- Proactive protocols
  - Always maintain routes
  - Little or no delay for route determination
  - Consume bandwidth to keep routes up-to-date
  - Maintain routes which may never be used
- Reactive protocols
  - Lower overhead since routes are determined on demand
  - Significant delay in route determination
  - Employ flooding (global search)
  - Control traffic may be bursty
- Which approach achieves a better trade-off depends on the traffic and mobility patterns

Ad Hoc On-Demand Distance Vector Routing (AODV)

- Route Requests (RREQ) are flooded through entire network searching for destination
- When a node re-broadcasts a Route Request, it sets up a reverse path pointing towards the source
  - AODV assumes symmetric (bi-directional) links
- When the intended destination receives a Route Request, it replies by sending a Route Reply (RREP)
- Route Reply travels along the reverse path set-up when Route Request is forwarded

Route Requests in AODV

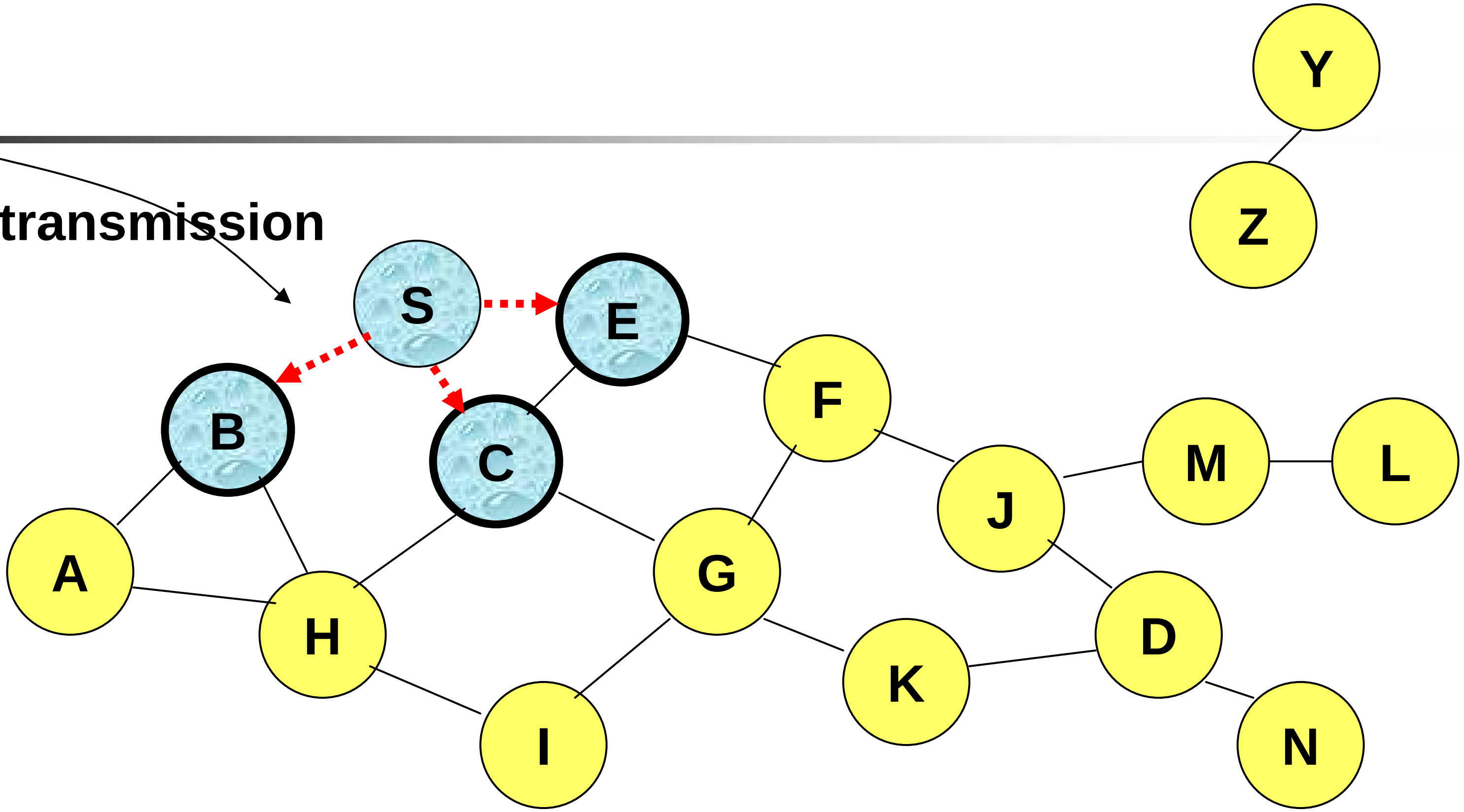




Represents a node that has received RREQ for D from S

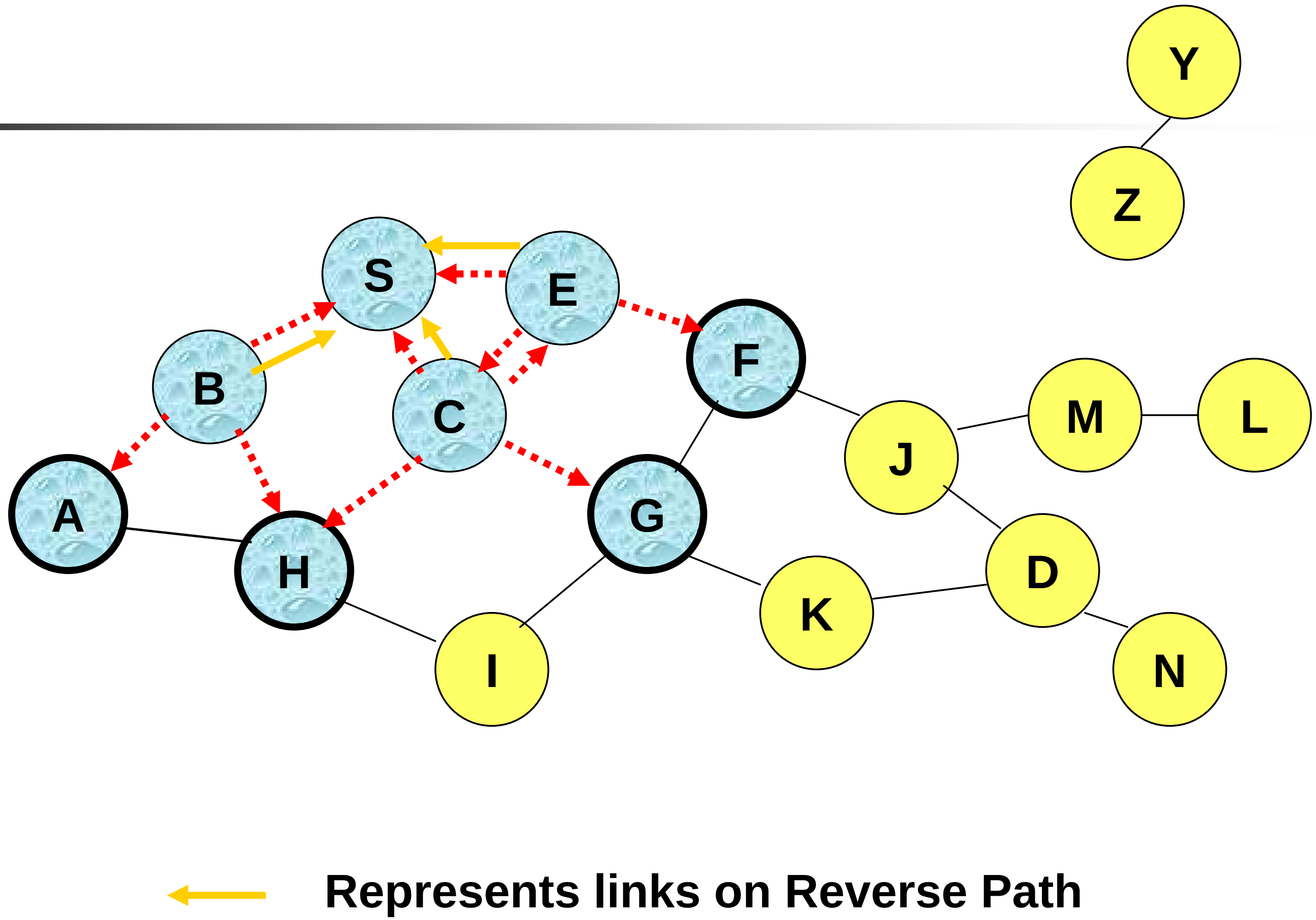
Route Requests in AODV

Broadcast transmission



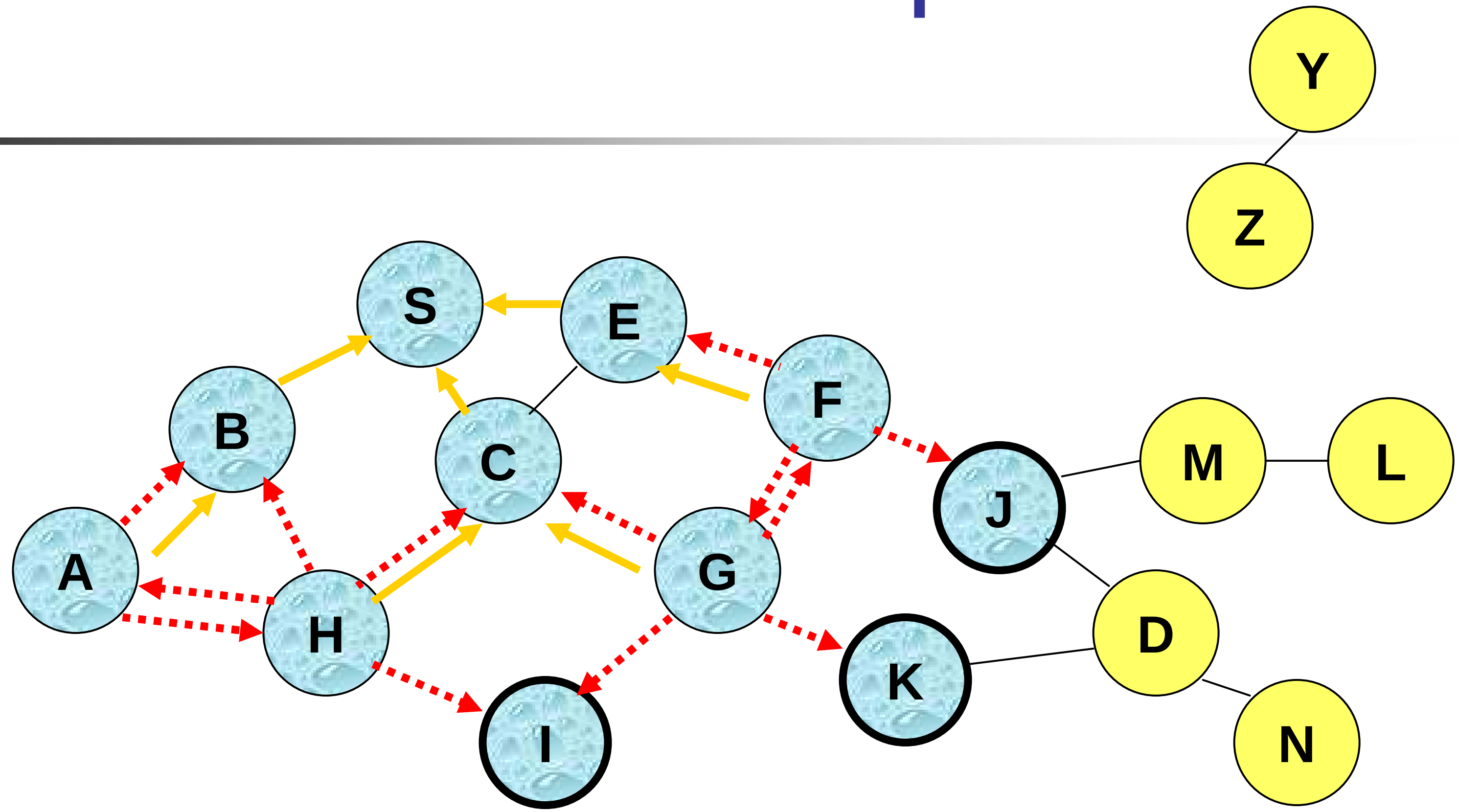
Represents transmission of RREQ

Route Requests in AODV



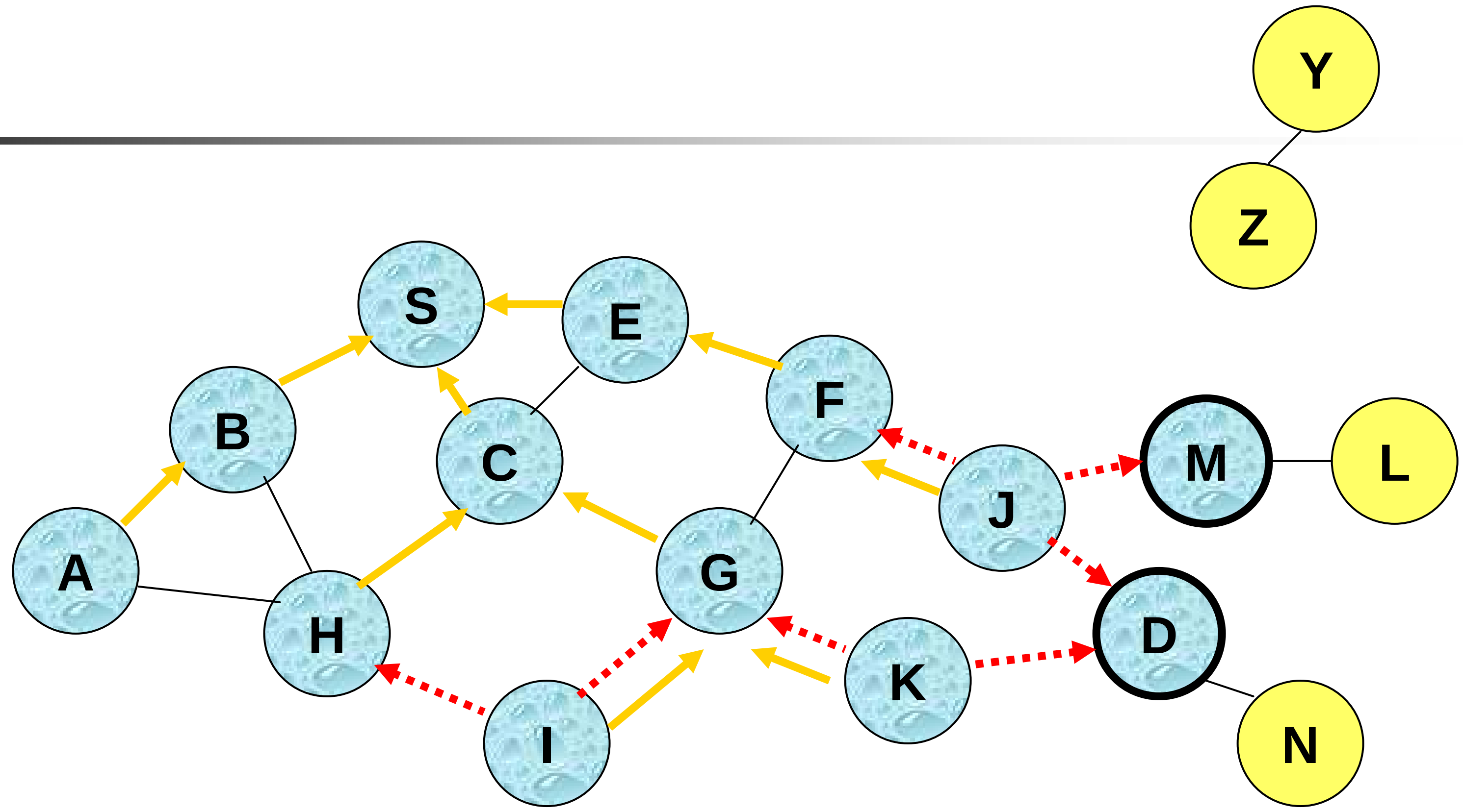
Represents links on Reverse Path

Reverse Path Setup in AODV

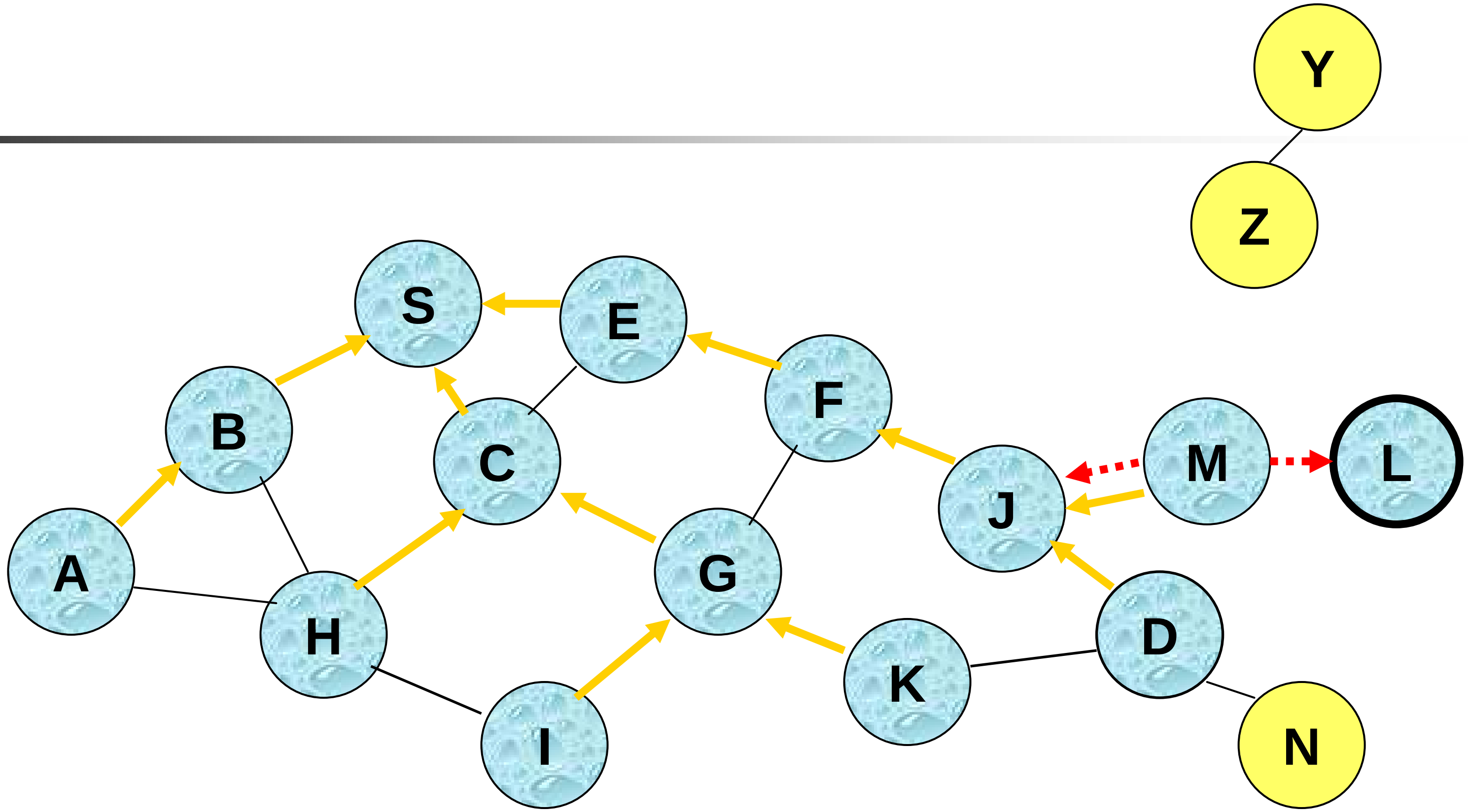


- Node C receives RREQ from G and H, but does not forward it again, because node C has already forwarded RREQ once

Reverse Path Setup in AODV

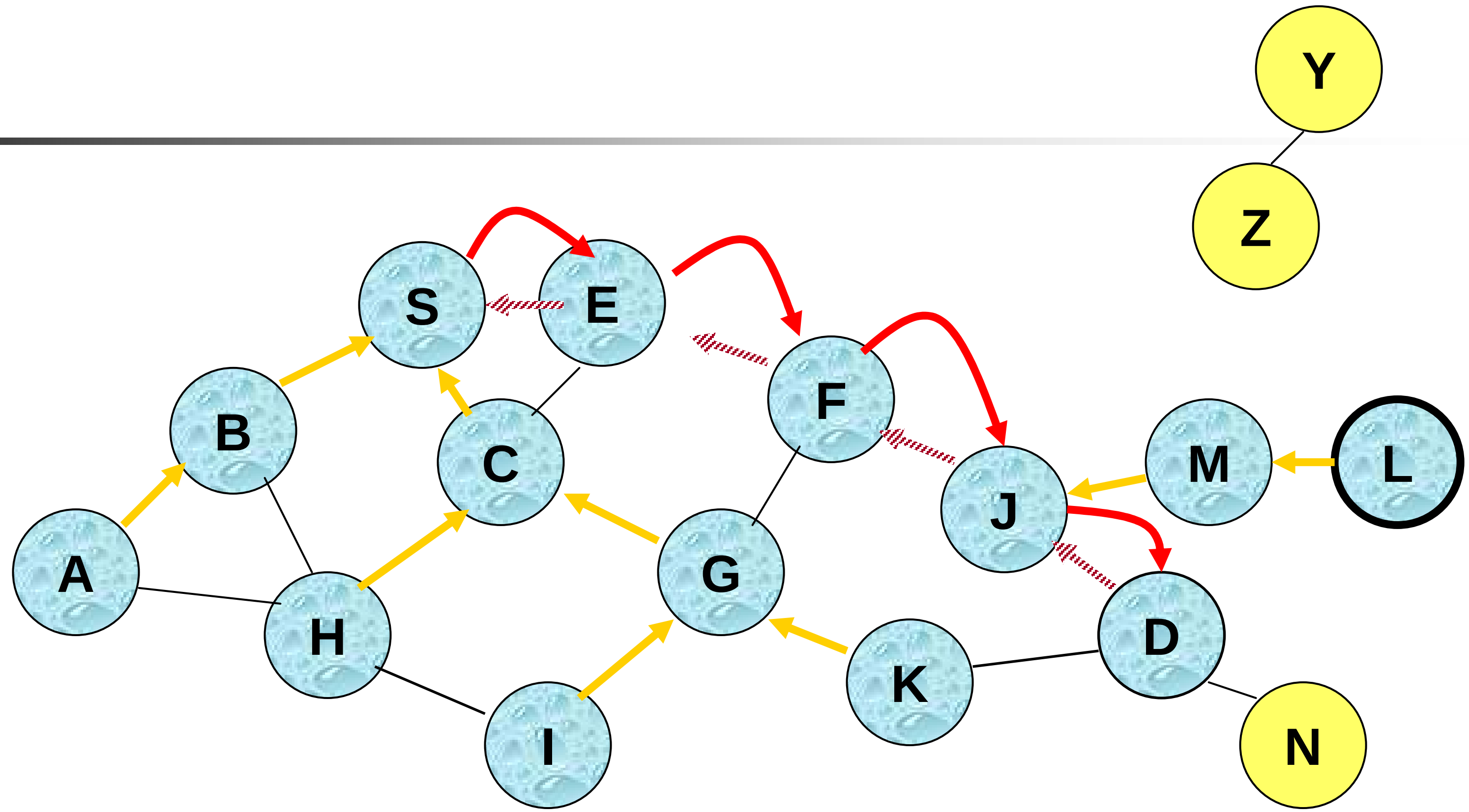


Reverse Path Setup in AODV

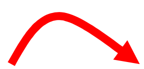


- **Node D does not forward RREQ, because node D is the intended target of the RREQ**

Forward Path Setup in AODV



Forward links are setup when RREP travels along the reverse path

 **Represents a link on the forward path**

Motivations

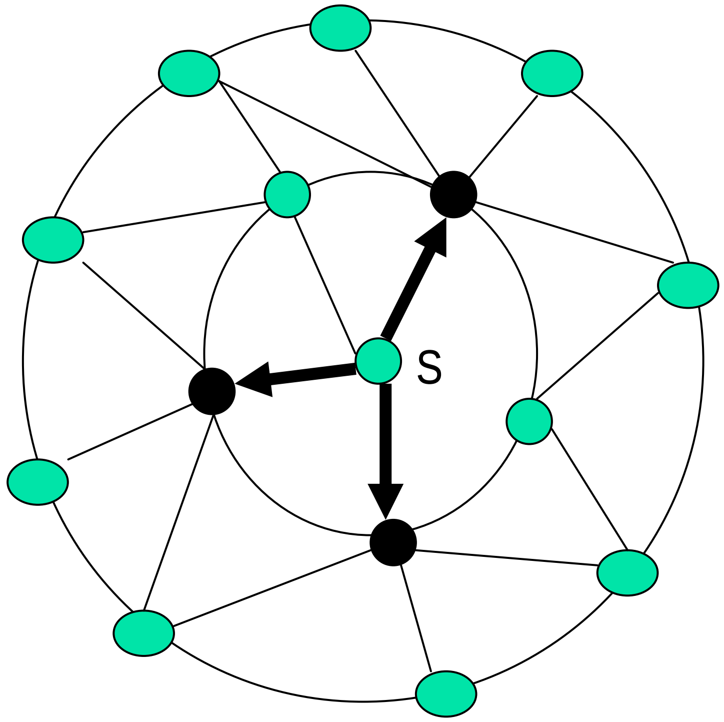
- The Lack of Scalability of AODV:
  - As the number of source-destination pairs increases
    - Major control overhead of AODV is caused by “Route Query” flood packets
    - Routing overhead is proportional to the number of route queries
  - As the given traffic becomes heavy
    - Heavy routing overhead causes significant effective throughput degradation

Proposed Modification

- Reduce routing overhead of AODV using Efficient Flooding (Selective Flooding)
- What's efficient flooding?
  - Only a subset of nodes (dominating nodes) forwards a Route Query flood packet
  - In contrast, in blind flooding all nodes relay each packet at most once
- How to choose dominant nodes?
  - Multipoint Relay Sets (MPRs)

Multipoint Relay (MPR)

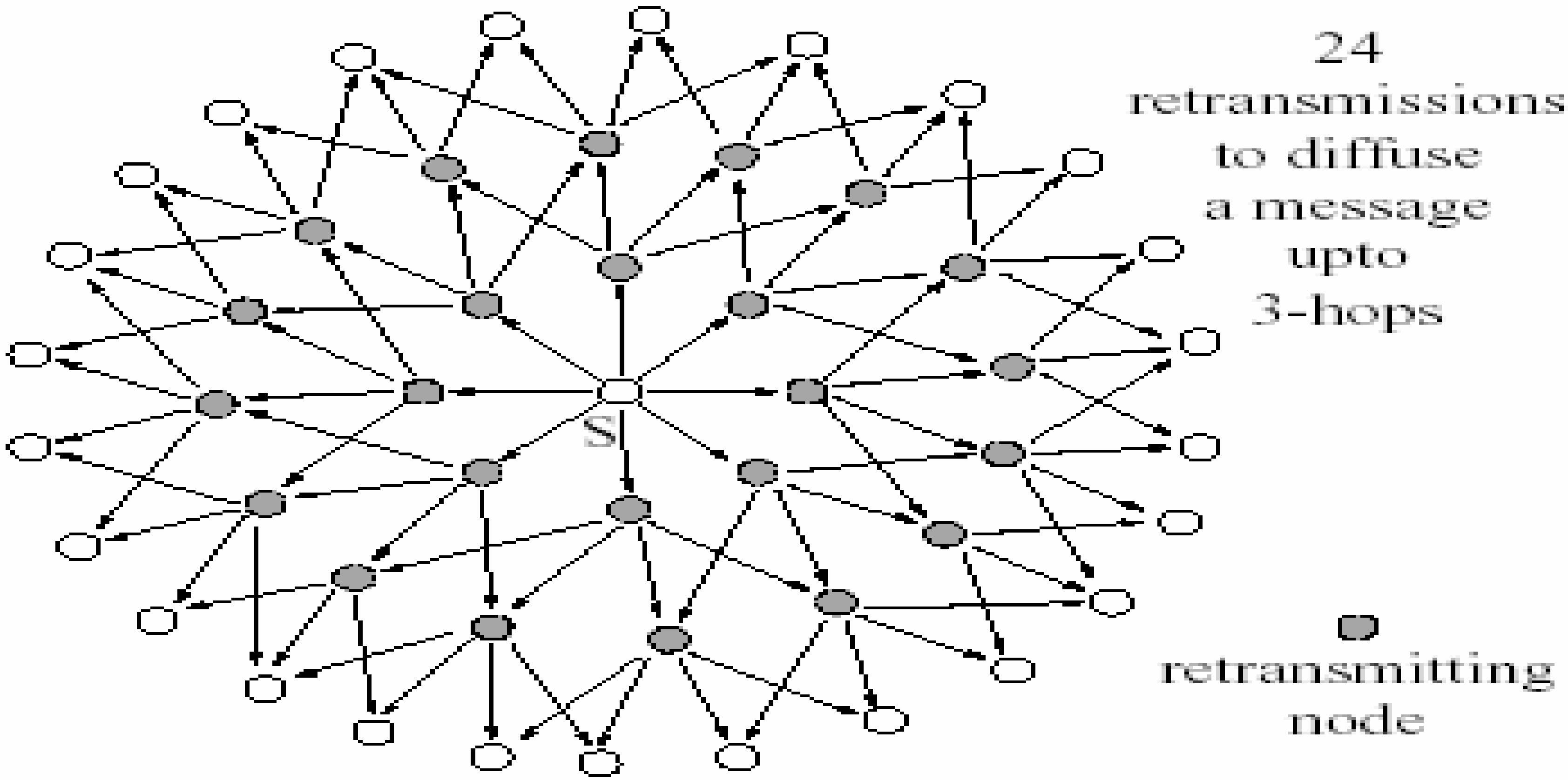
- The Concept of MPR is to reduce the number of duplicated retransmissions while forwarding a broadcast packet
- Multipoint relay set (MPRs): subset of a node's 1-hop neighbors, such that each of its 2-hop neighbors is a 1-hop neighbor of a node in the MPR set



Multipoint Relay

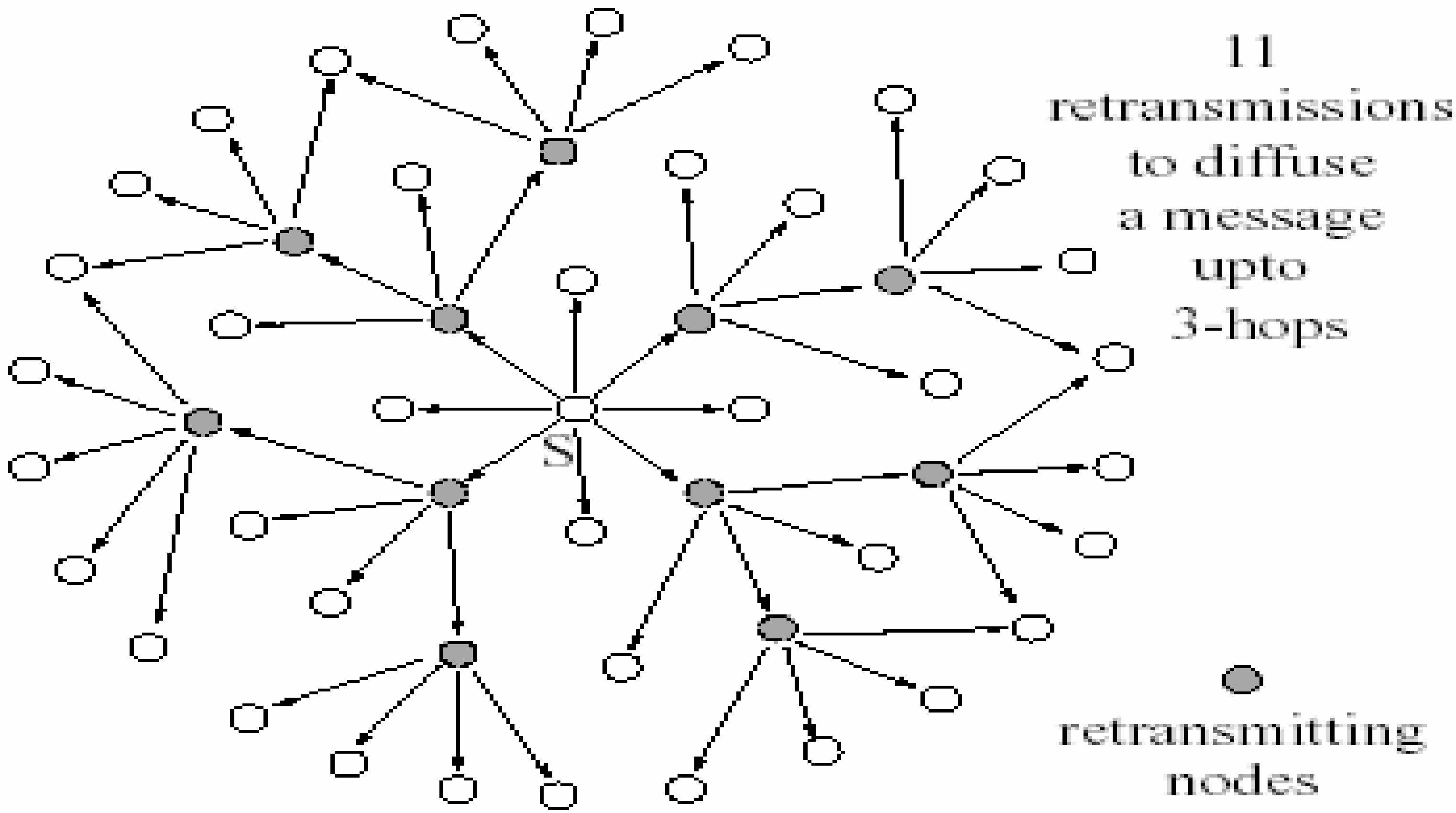
- A node selects its Multipoint relays with two rules:
  - Any 2-hop neighbors must be covered by at least one multipoint relay
  - Try to minimize the multipoint relay set
- Note that each node independently determines its own MPR set (no global “network MPR set”)
- A node forward a flooding packet with the following rules:
  - The packet has not yet been received.
  - The node is multipoint relay of last emitter

Multipoint Relay



Diffusion of broadcast message using pure flooding

Multipoint Relay



Diffusion of broadcast message using multipoint relays

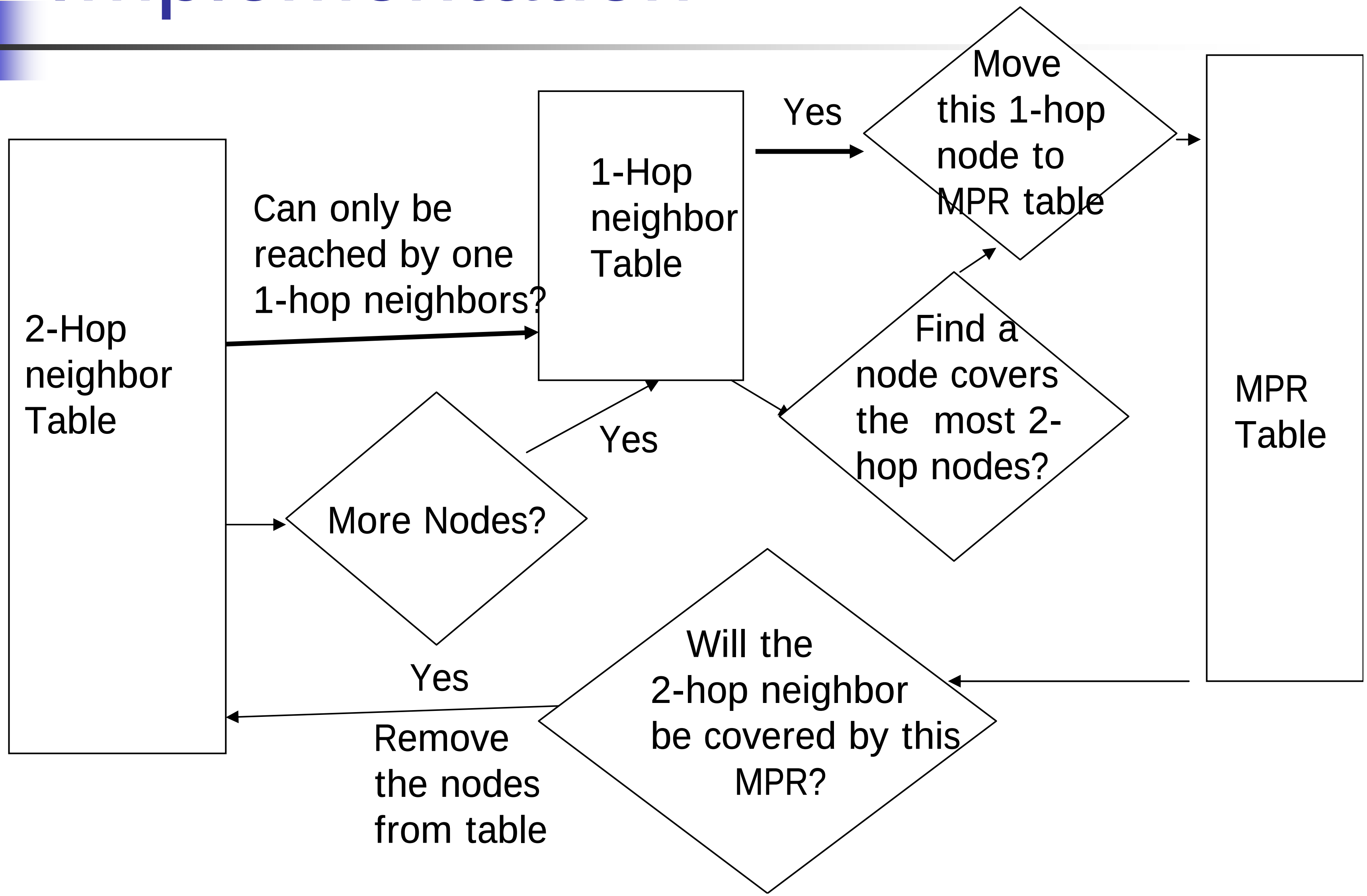
Implementation

The algorithm for calculating the multipoint relay table is shown bellow:

1. Find all 2-hop neighbors that can only be reached by one 1-hop neighbor. Assign those 1-hop neighbors as MPRs.
2. Determine the resultant cover set (i.e., the set of 2- hop neighbors that will receive the packet from the current MPR set).
3. From the remaining 1-hop neighbors not yet in the MPR set, find the one that would cover the most 2-hop neighbors not in the cover set.
4. Repeat from step 2 until all 2-hop neighbors are covered.

(MPR): Multipoint Relay

Implementation



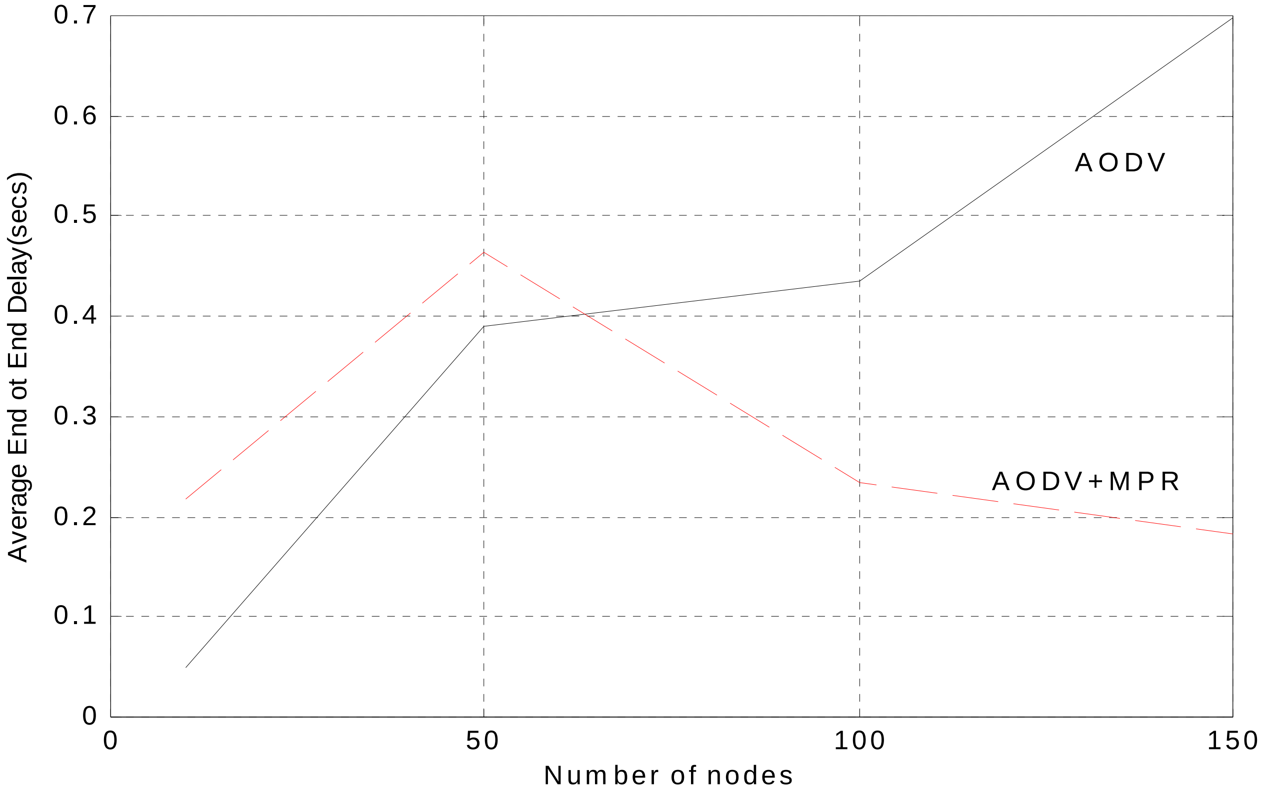
Challenges

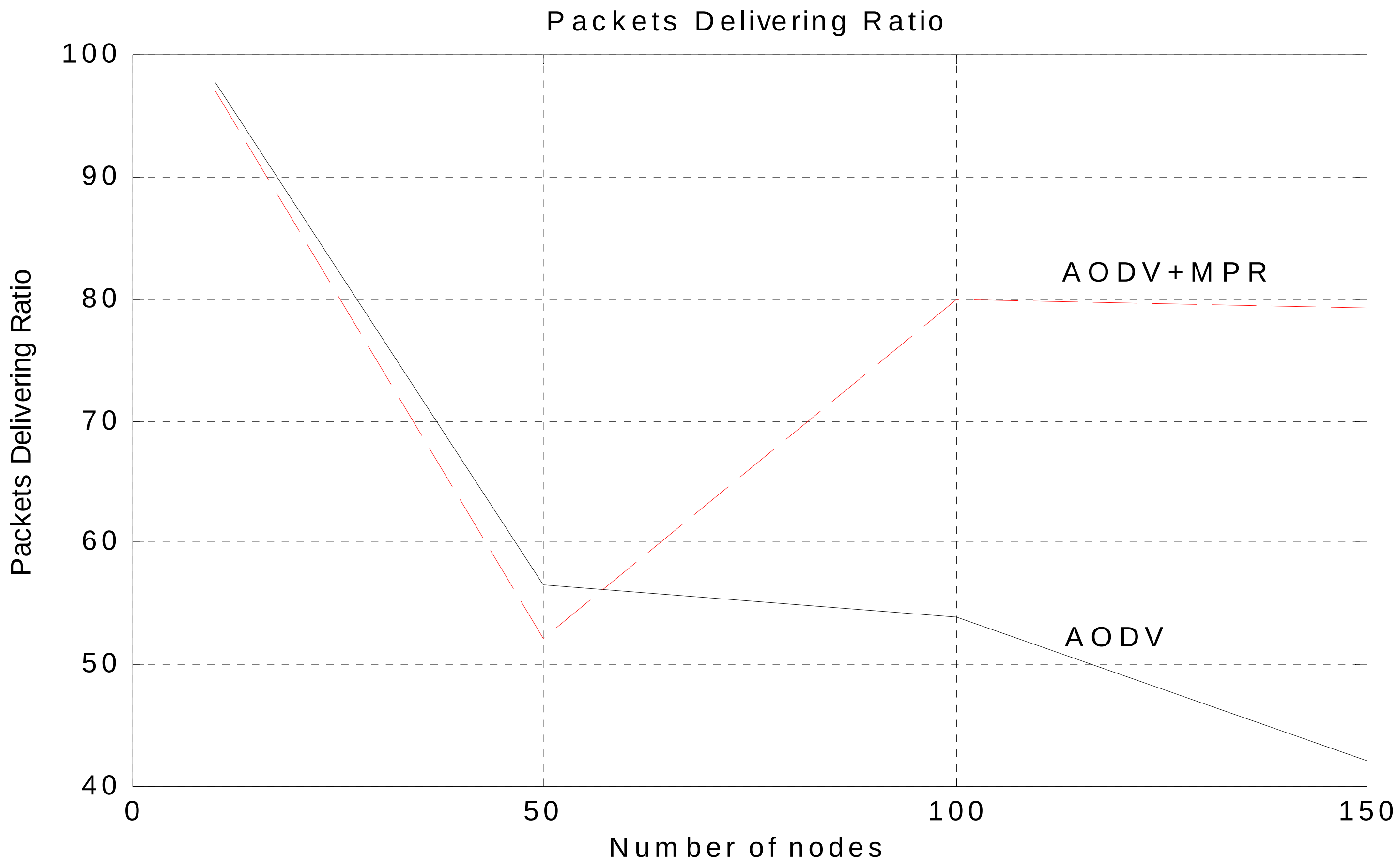
- Because of the nature of Ad Hoc network, nodes are moving constantly. We have to keep updating each node’s movement and their neighbors.
- Each node must have the 1-hop and 2-hop neighbor information at any given time.
- This information can only be obtained by exchanging message periodically

NS2 Simulation Environment

- Simulator: NS2-2.26
- Operating System: Linux
- Network Area: 900 * 900 meters
- Number of nodes simulated: 10, 50, 100,150
- Max. pause time: 10s
- Max. speed: 20m/s

Results


0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
Average End ot End Delay(secs)
Number of nodes
AODV
AODV+MPR



Packets Delivering Ratio
100
90
80
70
60
50
40
0
50
100
150
Number of nodes
Packets Delivering Ratio
AODV+MPR
AODV

Conclusion

- Our simulations show the MPR technique improves AODV protocol significantly by reducing the overhead and delay in dense node networks
- With this technique, AODV can achieve better package delivery ratio

MPR: Multipoint Relay

AODV: Ad Hoc On-Demand Distance Vector Routing

Future Works

- The AODV protocol can be further optimized by applying other techniques such as probability based methods or location based methods

References

1. Yoav Sasson, David Cavin, André Schiper. Probabilistic Broadcast for Flooding in Wireless Mobile Ad hoc Networks. *IEEE Wireless Communications and Networking Conference (WCNC) - March 2003*
2. Zygmunt J. Haas, Joseph Y. Halpern, and Li Li. Gossip-based ad hoc routing.In *IEEE INFOCOM*, Jun 2002. Sze-Yao Ni, Yu-Chee Tseng, Yuh-Shyan Chen, and Jang-Ping Sheu.
3. The broadcast storm problem in a mobile ad hoc network. In *Proceedings of the Fifth Annual ACM/IEEE International Conference on Mobile Computing and Networking*, pages 151–162, Aug 1999.
4. T. Clausen, P. Jacquet, A. Laouiti, P. Muhlethaler, a. Qayyum et L. Viennot. Optimized Link State Routing Protocol, IEEE INMIC Pakistan 2001.
5. Charles E. Perkins, Elizabeth M. Belding-Royer, and Samir Das. "Ad Hoc On Demand Distance Vector (AODV) Routing." *IETF Internet draft*, draft-ietf-manet-aodv-12.txt, November 2002 (Work in Progress).

Thank you!

Any Questions And Comments?