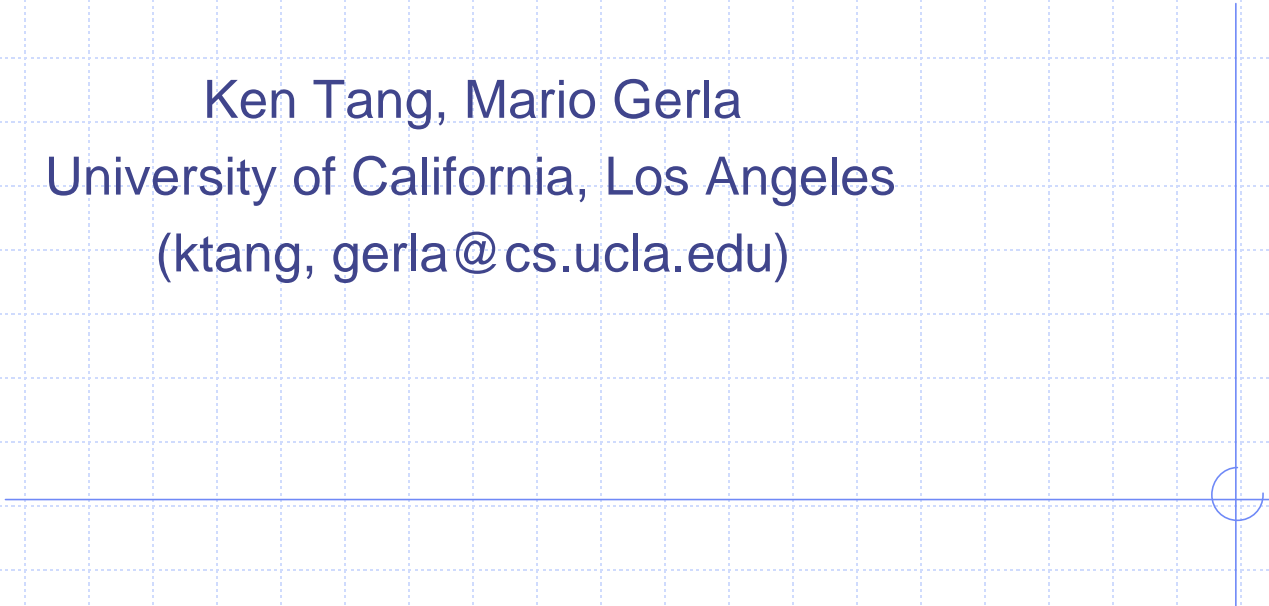# MAC Reliable Broadcast in Ad Hoc Networks

Ken Tang, Mario Gerla

University of California, Los Angeles
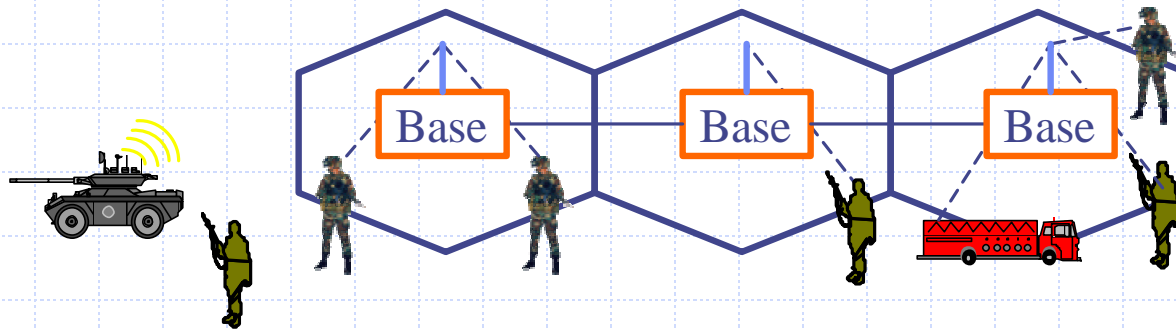
(ktang, gerla@cs.ucla.edu)

Overview

- Ad hoc network introduction

- Medium access control (MAC) protocol
    - Broadcast limitation

- Broadcast Medium Window (BMW) protocol
    - The broadcast medium window
    - Example

- Simulation results

- Conclusion

Ad Hoc Network Introduction

Standard base station cellular networks

Base   Base   Base

Instant infrastructure, multi-hop wireless ad hoc networks
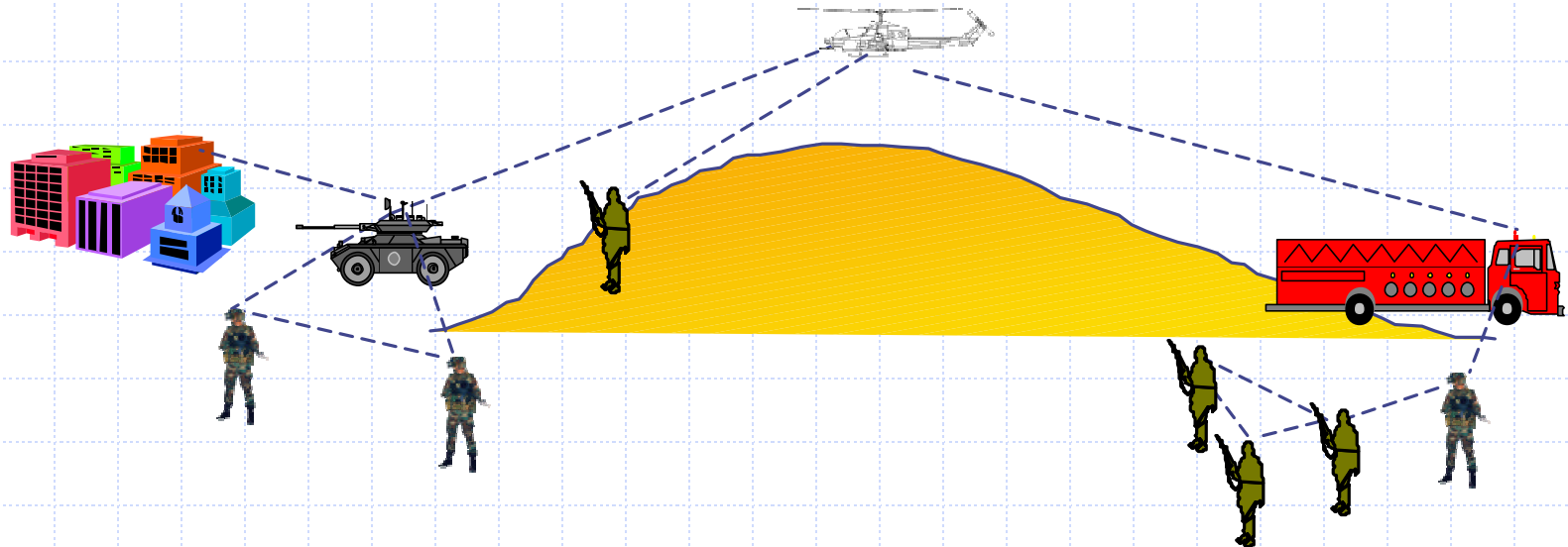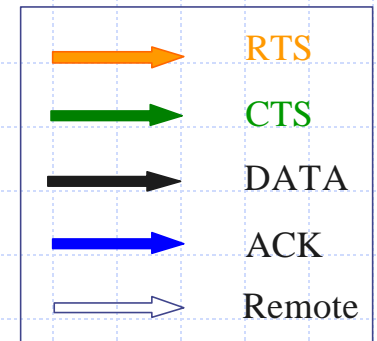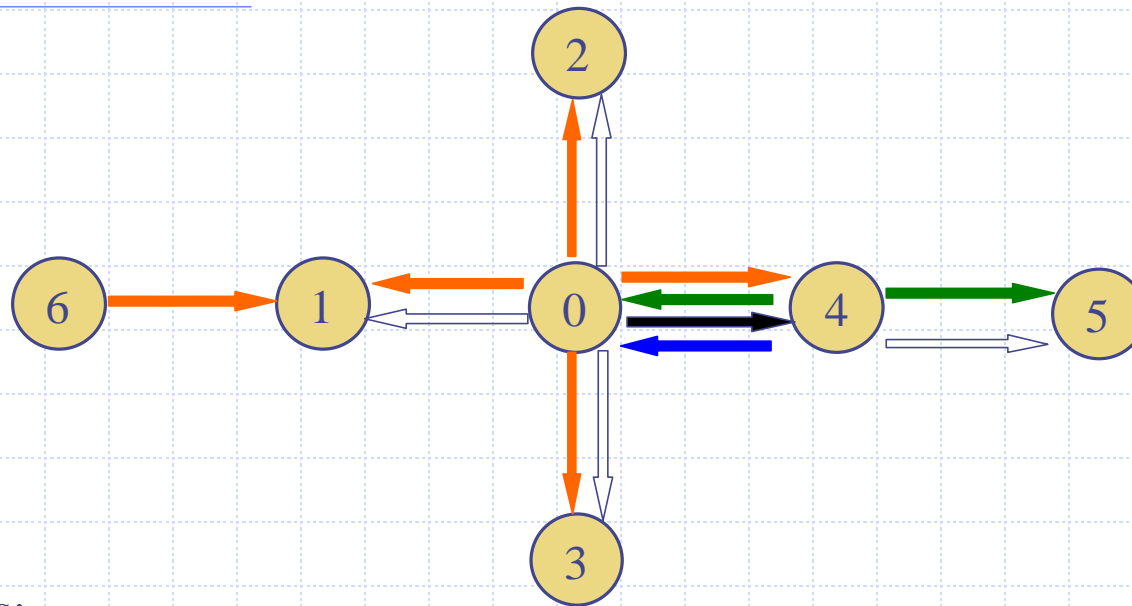
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An Example of Random Access Scheme (IEEE 802.11) – Unicast Mode

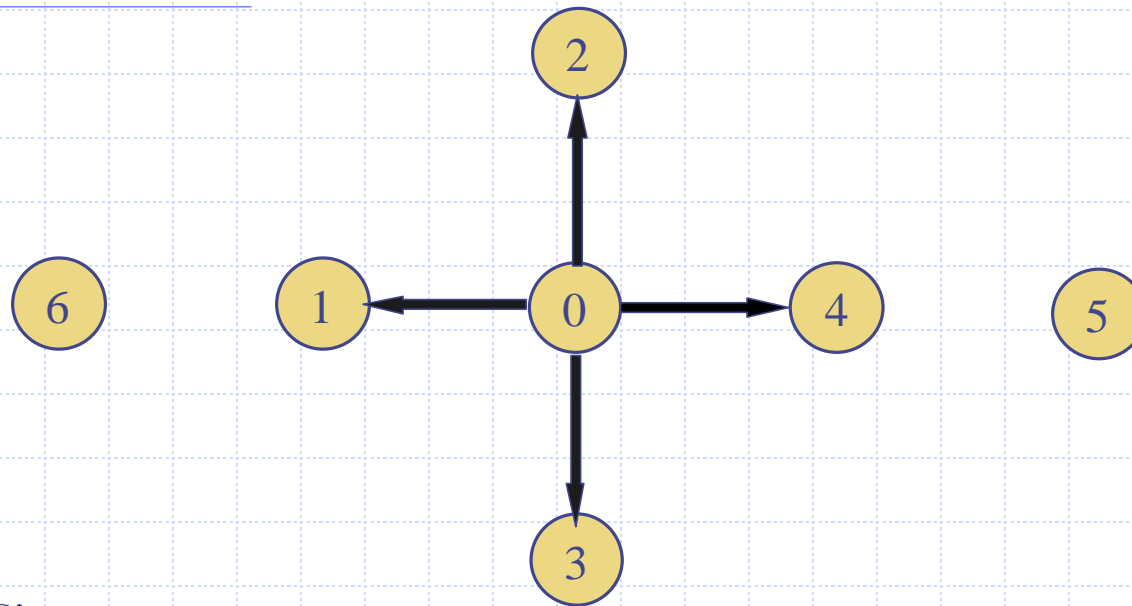|	
→	RTS
→	CTS
→	DATA
→	ACK
⇒	Remote

Steps:

A. Collision avoidance

B. Node 0 transmits RTS to node 4

C. Node 4 transmits CTS and node 6 attempts an RTS

D. Node 0 transmits DATA

E. Node 4 transmits ACK

MAC Broadcast Limitation

- Reliable unicast
  - RTS/CTS to acquire the channel
  - ACK to make sure data is received
- What about broadcast?
  - Send data and pray!

An Example of Random Access Scheme (IEEE 802.11) – Broadcast Mode

```
                    (2)
                     ↑
                     |
(6)        (1) ←─── (0) ───→ (4)        (5)
                     |
                     ↓
                    (3)
```

┌─────────────────────────────┐
│ ──────►   DATA   │
└─────────────────────────────┘

Steps:

A. Collision avoidance
B. Node 0 transmits DATA

Overview

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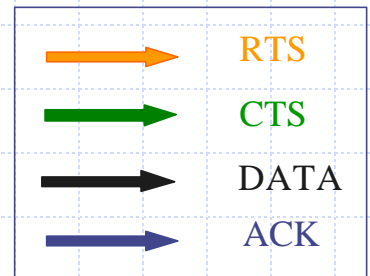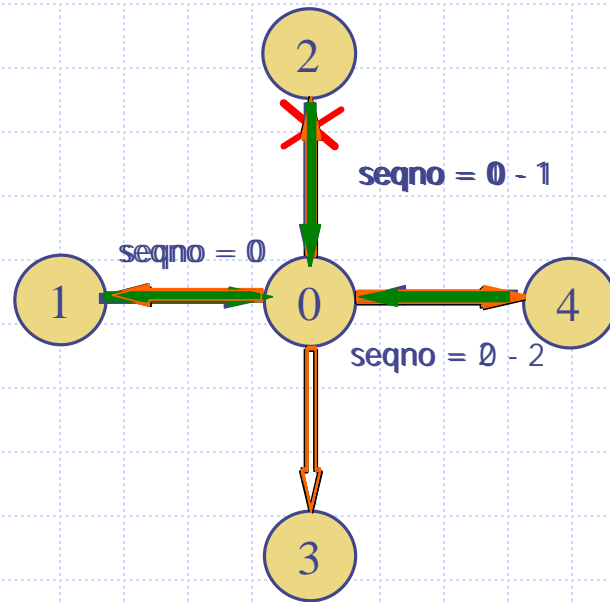 - Example
- Simulation results
- Conclusion

Broadcast Medium Window (BMW)

- Ad hoc multicast routing protocols rely on MAC broadcast to achieve multicasting

- Typical ad hoc MAC layer protocols (e.g., IEEE 802.11) are very "lossy" in the broadcast mode

- We propose a novel scheme, Broadcast Medium Window (BMW) to provide robust (but not 100% reliable) MAC broadcasting

The Broadcast Medium Window

- Conventional window protocol (e.g., TCP) transmits packets in sequence to a single destination
- The "broadcast window" protocol transmits packets by increasing sequence numbers to ALL neighbors
- The window protocol "visits" each neighbor in Round Robin order to retransmit packets which the node missed in the broadcast transmission

# Broadcast Medium Window (BMW) Protocol Example

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Simulation Results

- GloMoSim/QualNet network simulator
  - (http://www.scalable-networks.com)
- Application
  - CBR (512B)
- Transport
  - UDP multicast traffic
- Routing
  - ODMRP
- MAC
  - 802.11
  - BMW
- Channel
  - 2Mbps
  - free-space

# On-Demand Multicast Routing Protocol (ODMRP)
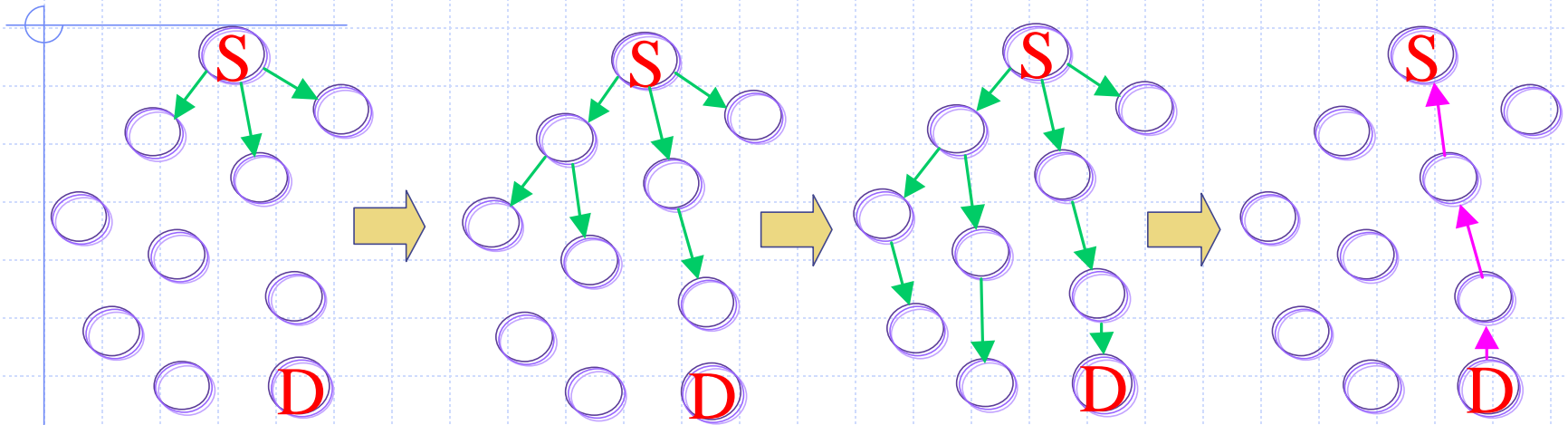
- Sources build routes on demand by flooding
  - Sources flood JOIN QUERY to multicast receivers
  - Multicast receivers respond with JOIN REPLY to sources

Traffic Rate Experiment
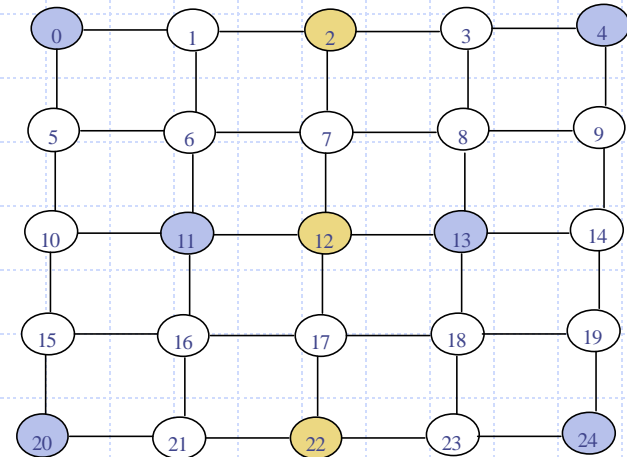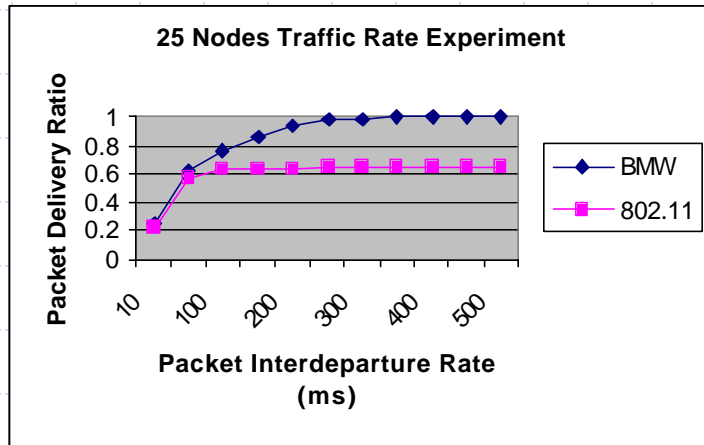
- 25 nodes in grid topology, 3 sources and 6 members
- BMW outperforms 802.11
- Under high rate, BMW and 802.11 are comparable
  - BMW reverts to 802.11 unreliable broadcast

Sources Experiment

Sources Experiment — chart showing Packet Delivery Ratio vs Number of Sources for BMW and 802.11
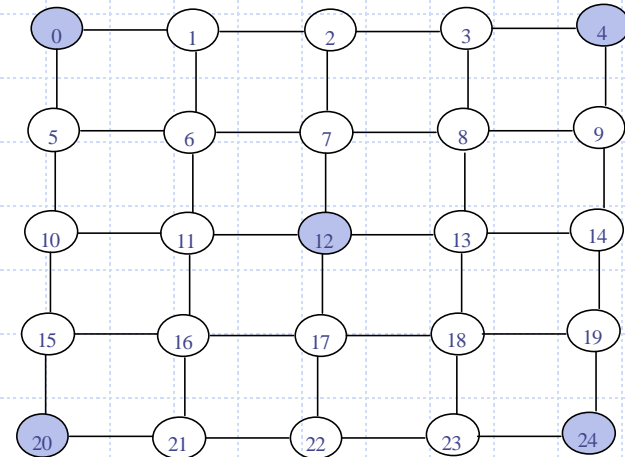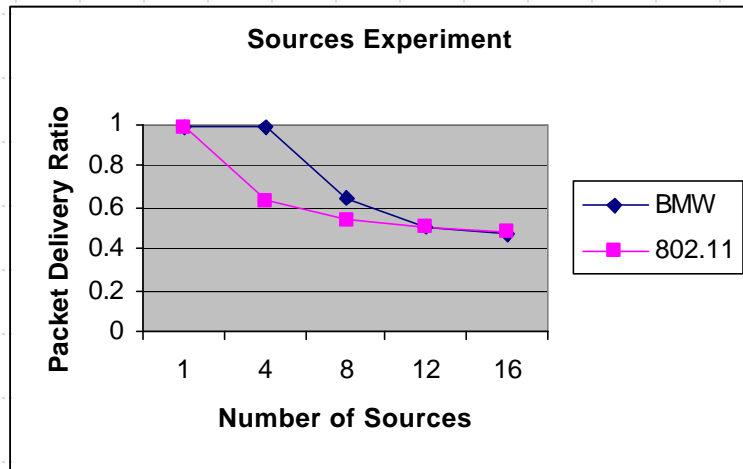

- 5 members, 2 packets per second, vary number of sources
- BMW improves upon 802.11 with moderate number of sources
- Under large number of senders, performances are comparable
  - Large number of senders also implies high network load
  - BMW reverts to 802.11 again

Members Experiment
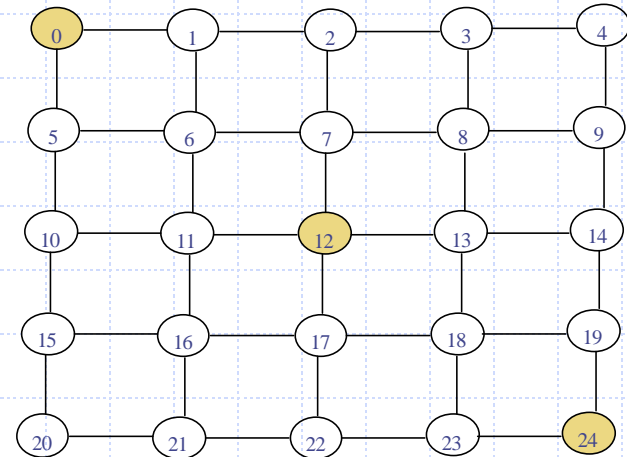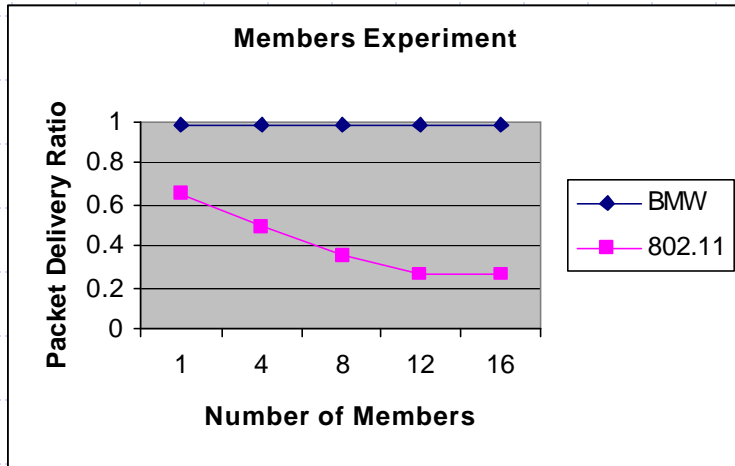
- 3 sources, 2 packets per second, vary number of members
- BMW achieves 100% reliability
- 802.11 gradually degrades as the number of members increases

Uniform Experiment

Uniform Experiment — chart of Packet Interdeparture Rate (50MS–500MS) vs BMW and 802.11
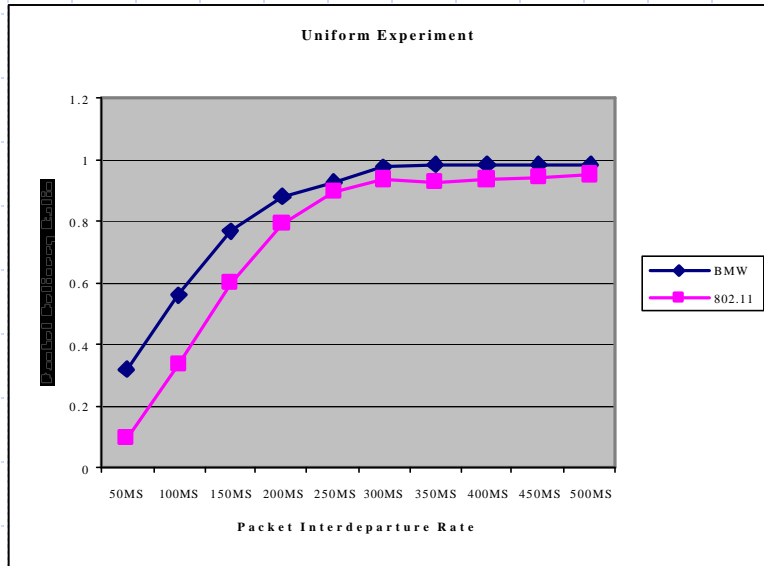
- More realistic ad hoc scenario
- 25 nodes placed in 1000m x 1000m
- Randomly select 5 sources and 5 members
- Vary traffic rate
- BMW consistently outperforms 802.11

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Conclusion

- Free-space model is very conservative
  - BMW benefit more from detailed channel model
- Drawback of BMW
  - Increase latency as neighbors and packet loss increase
  - Solution
    - Reduce transmit power -> reduce power consumption
- Port BMW concept directly into ODMRP
  - More efficient due to knowledge of forwarding group members