TCP and MAC interplay in Wireless Ad Hoc Networks

- **K. Tang and M. Gerla, "Fair Sharing of MAC under TCP in Wireless Ad Hoc Networks," In Proceedings of IEEE MMT'99, Venice, Italy, Oct. 1999.**

Outline

- **Overview of CSMA, FAMA and IEEE 802.11.**
- **MAC performance with TCP.**
  - Variable Hop Length Experiments.
  - Hidden Terminal Experiments.
  - Ring Experiments.
  - Grid Experiments.
    - Static.
    - Mobility.

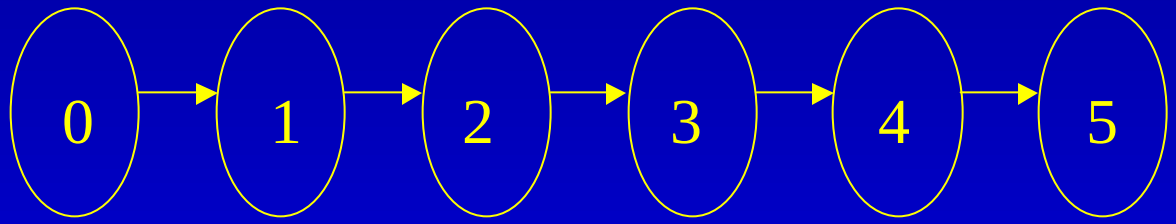
Simulation Using GloMoSim

- **Detailed model of the protocol stack.**
- **Allows investigation of TCP and MAC layer interactions.**
- **Capability to simulate large number of nodes.**
- **GloMoSim web page.**
  - http://pcl.cs.ucla.edu/projects/domains/glomosim.html

MAC Layer Protocols

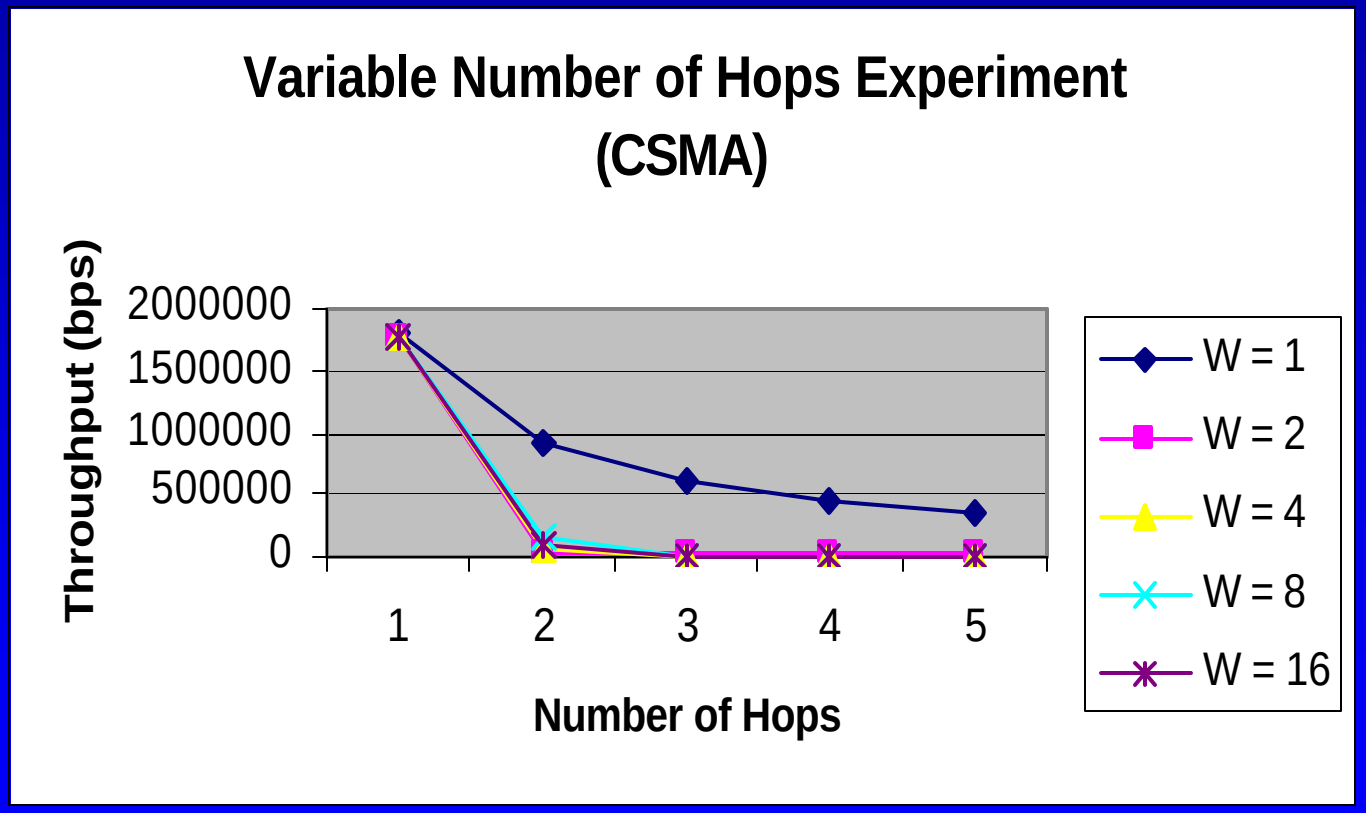
- **CSMA**
  - Requires carrier sensing before transmission.
  - If the channel is free, the packet is transmitted immediately.
  - Otherwise, it is rescheduled after a random timeout.
- **FAMA**
  - Builds on CSMA.
  - Uses the RTS (Request To Send) and CTS (Clear To Send) exchange to prepare the floor for data transmission.
- **802.11**
  - Uses carrier sensing and RTS/CTS, similar to FAMA.
  - Utilizes link-level ACKs.
  - Collision Avoidance scheme.

Variable Hop Length Experiments Configuration

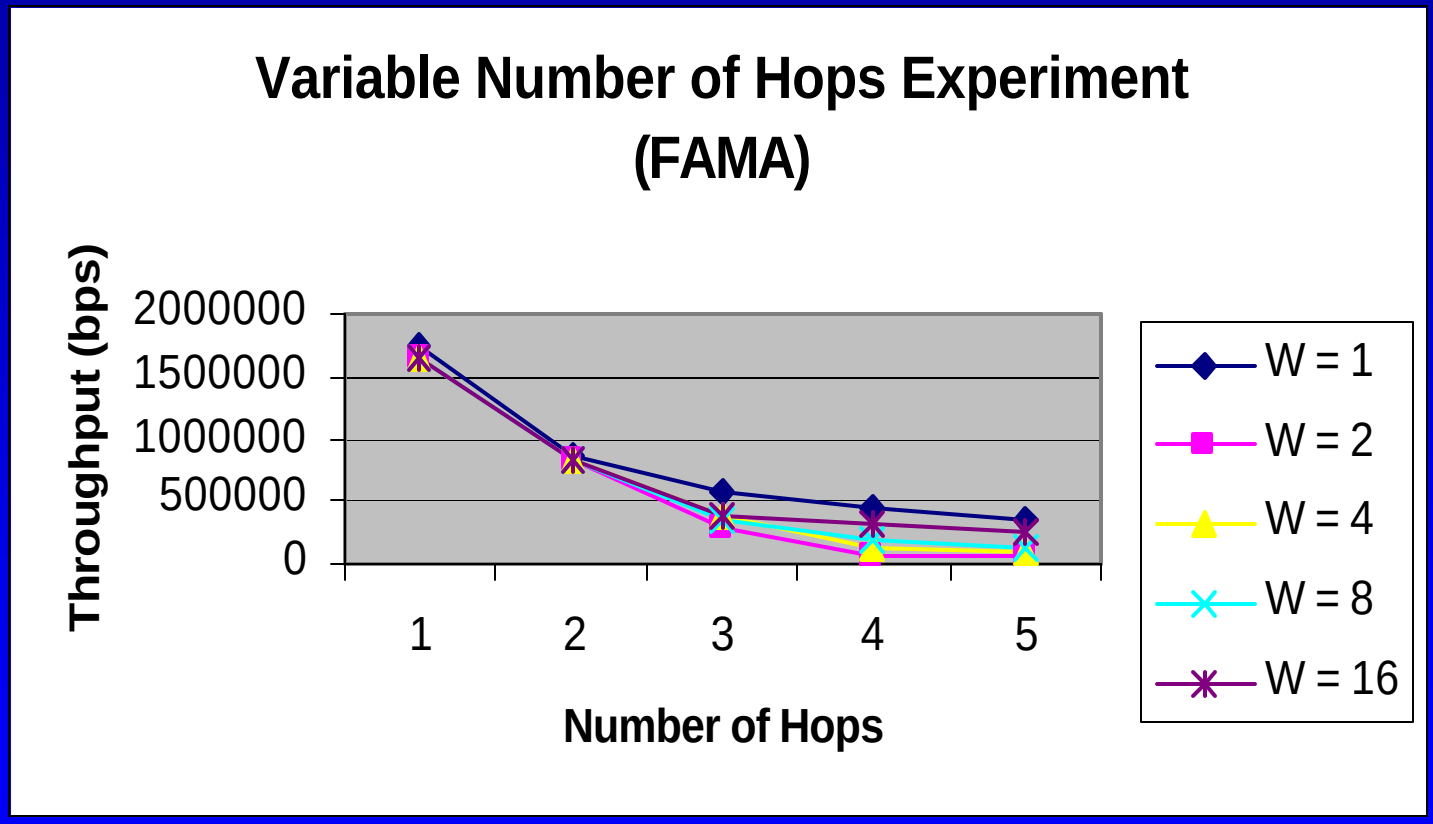


- **Each node is 10 meters apart from its neighbors.**
- **Each node has a radio power range of 10 meters.**
- **2Mbps channel bandwidth.**
- **FTP traffic.**
- **TCP window size varies from 1 to 16 packet size.**
- **Variable number of hops (single connection).**
  - i.e., FTP connection 0-1, 0-2, 0-3, 0-4, 0-5 (one at a time).

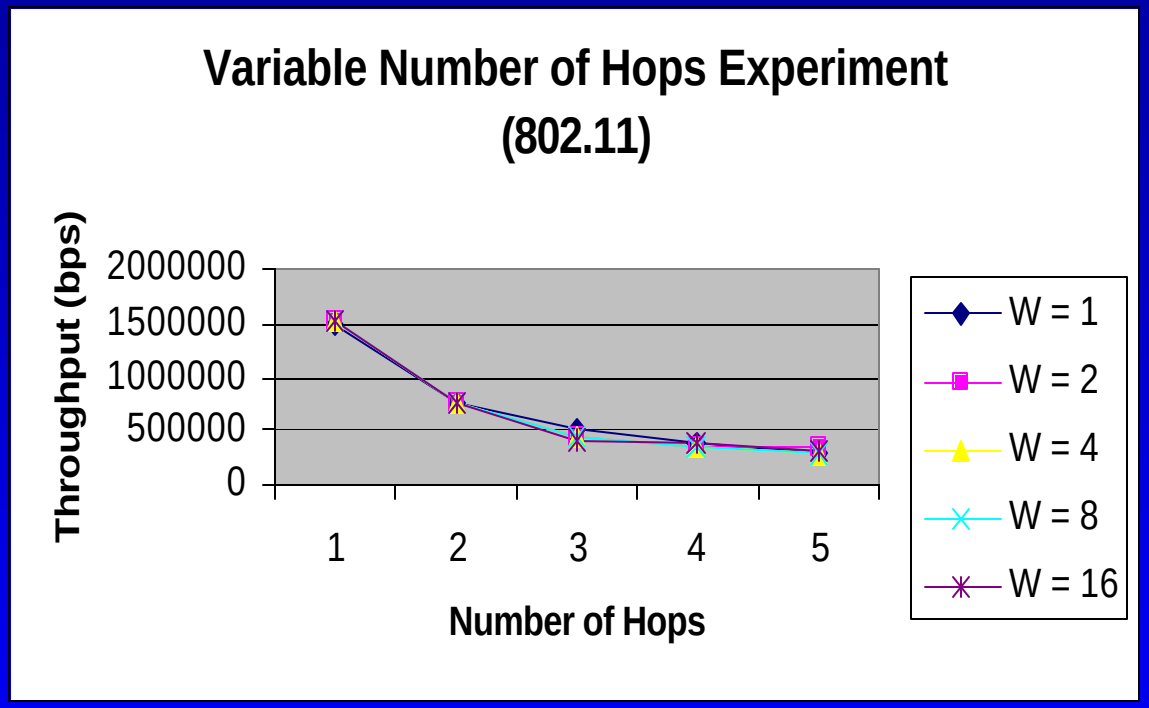
Variable Hop Length Experiments Results



Variable Hop Length Experiments Results (Cont'd)

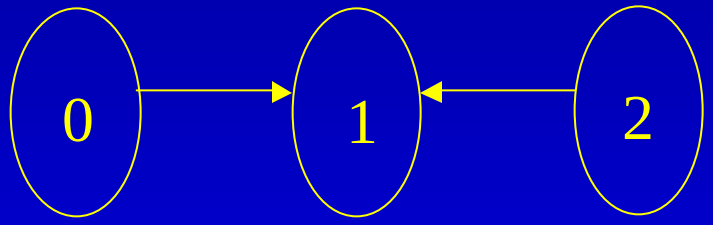


Variable Hop Length Experiments Results (Cont'd)



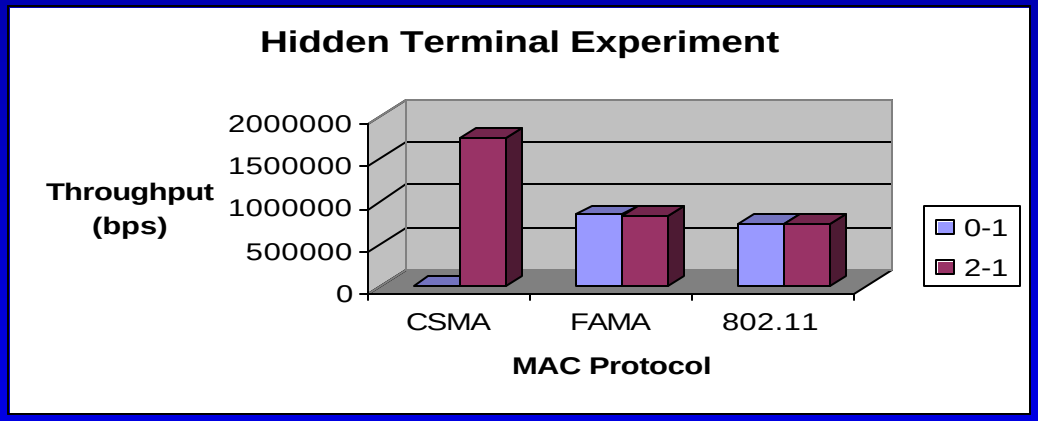
- **CSMA and FAMA degrades with window size > 1 pkt.**
  - Collisions between TCP data and ACKs.
- **802.11 performs the same no matter the window size.**
  - Link-level ACKs combat collisions.

Hidden Terminal Experiments Configuration



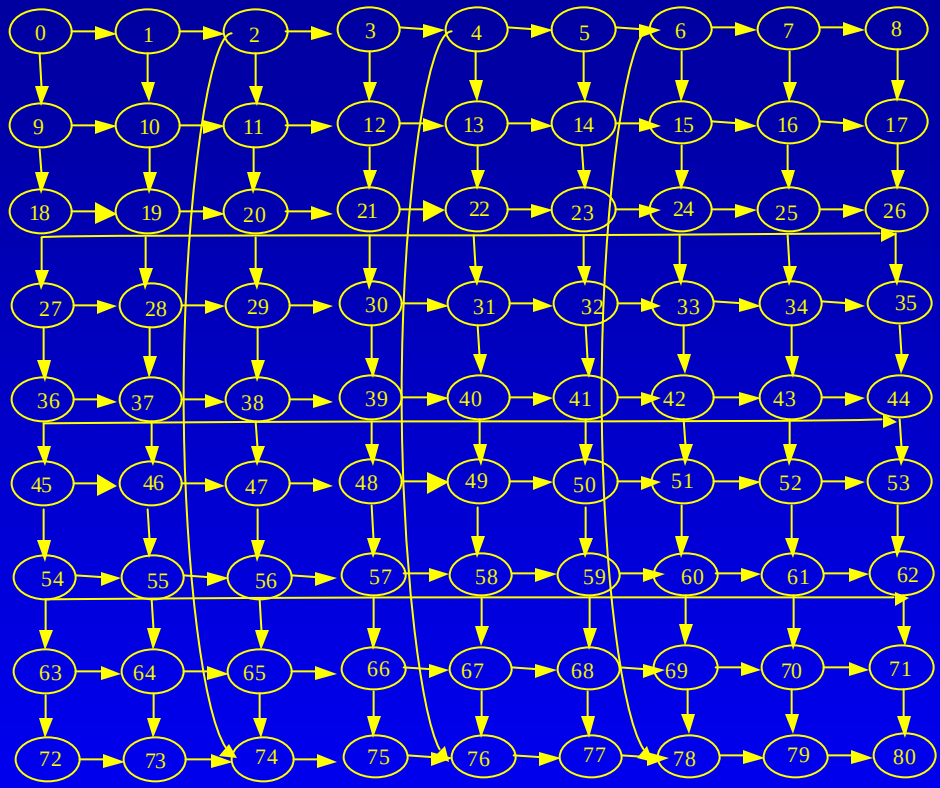
- FTP traffic
- Connections from node 0 to node 1 and from node 2 to node 1.
- Node 0 and node 2 cannot hear each other.

Hidden Terminal Experiments Results



- CSMA suffers from hidden terminal.
- FAMA and 802.11 performs well due to RTS/CTS exchange.

Grid Experiment Configuration

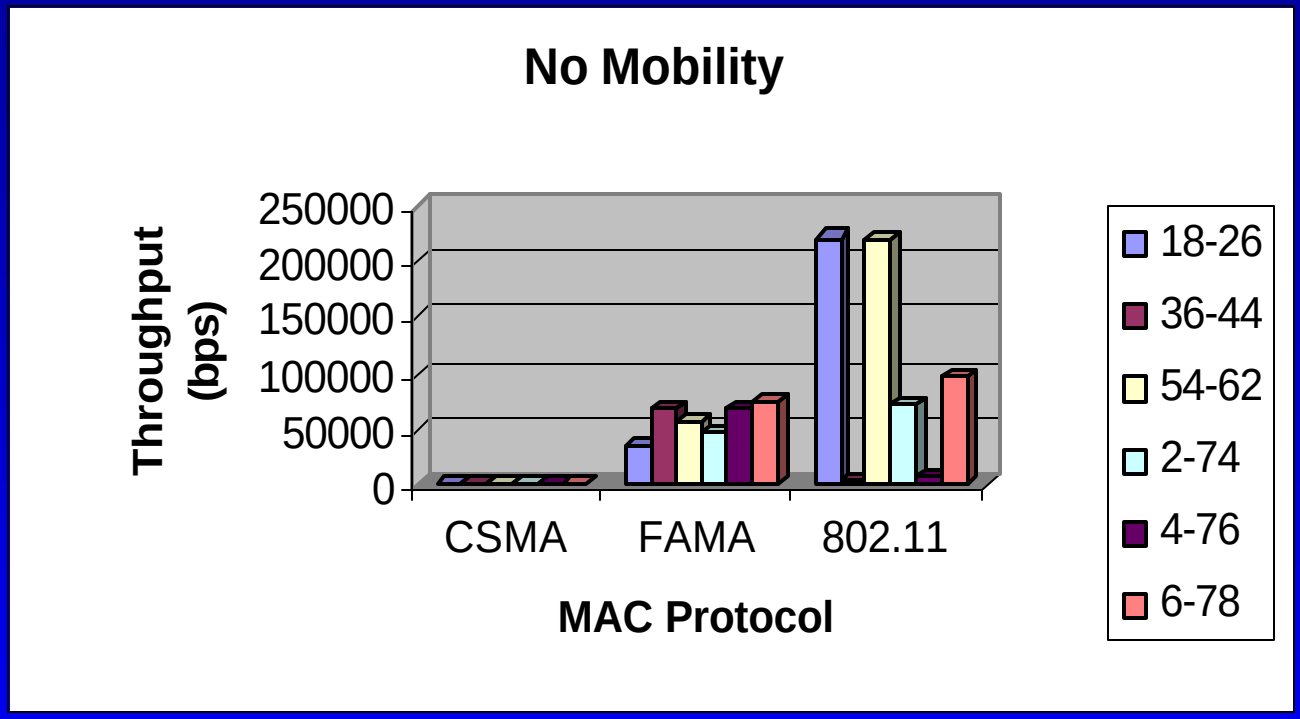


- **Each node is 10 meters apart from its horizontal and vertical neighbors.**
- **Each node has a radio power range of 30 meters.**
- **FTP connections are established between node 18 to node 26, node 36 to node 44, node 54 to node 62, node 2 to node 74, node 4 to node 76 and node 6 to node 78.**

Grid Experiment Configuration (Cont'd)

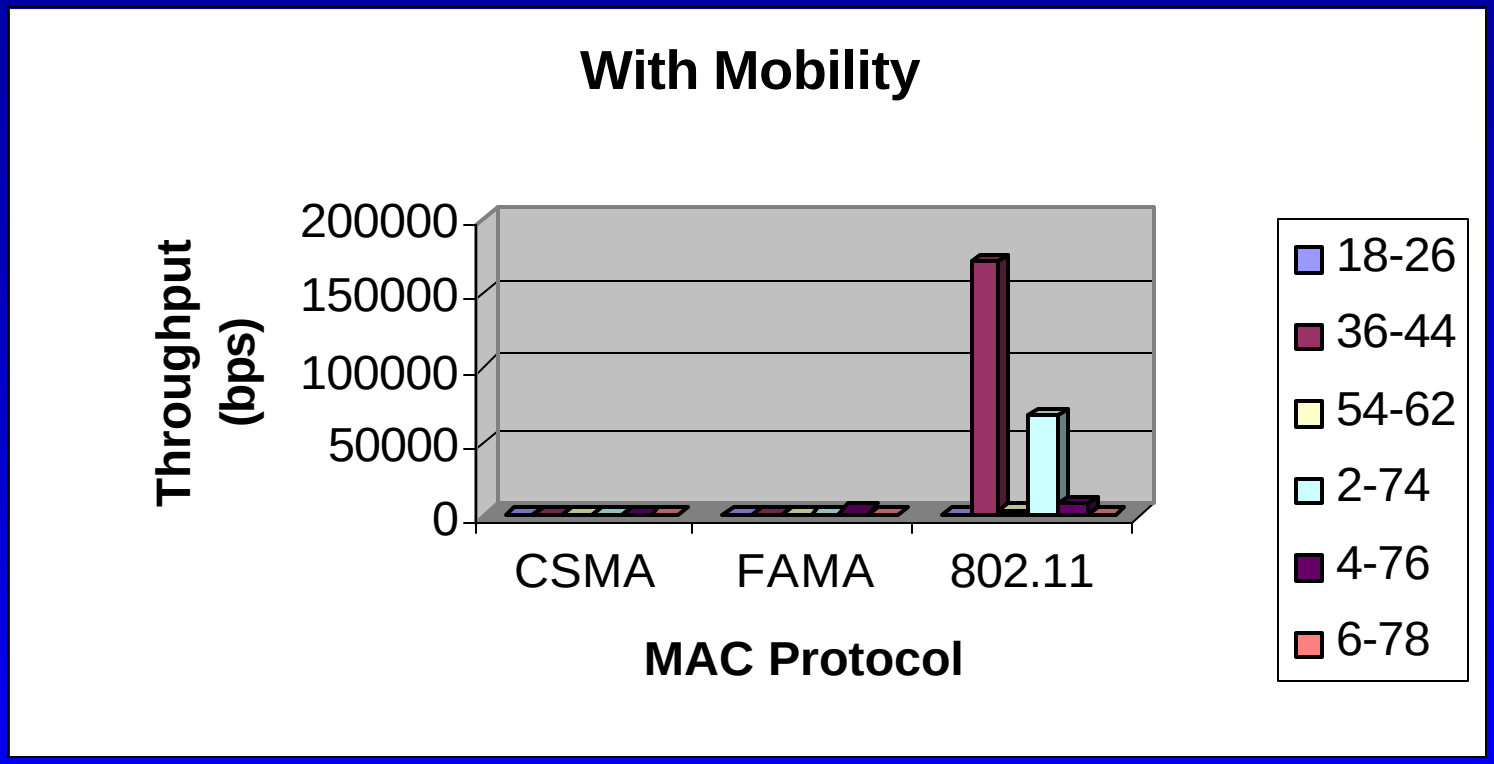
- **2Mbps channel bandwidth.**
- **Nodes move at a rate of 10 meters per second in a random direction with a probability of 0.5.**
- **When mobility is not considered, static routing is used.**
- **When mobility is introduced, Bellman-Ford routing is utilized with routing table updates occurring once every second.**

Grid Experiments Results (No Mobility)



- Without mobility
  - CSMA performs poorly due to interference by neighboring streams and by intersecting streams.
  - FAMA fair due to RTS/CTS and less aggressive yield time.
  - 802.11 exhibits capture.

Grid Experiments Results (With Mobility)



- CSMA and FAMA collapse with mobility due to lack of fast loss recovery facilities.
- 802.11 still operational.
  - Link level ACKs help recover from loss caused by transient nodes.
  - Capture exists.

Conclusion

- RTS/CTS exchange improves fairness.
- Link-level ACKs important to combat packet loss in wireless ad-hoc environment.
- Impact of MAC layer timers needs further study.
- More work required to understand and compensate for mobility