An Intelligent Modulation Controller with Fuzzy Function for IEEE 802.11 Multi-Rate/Range Transmission

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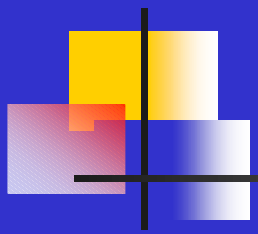
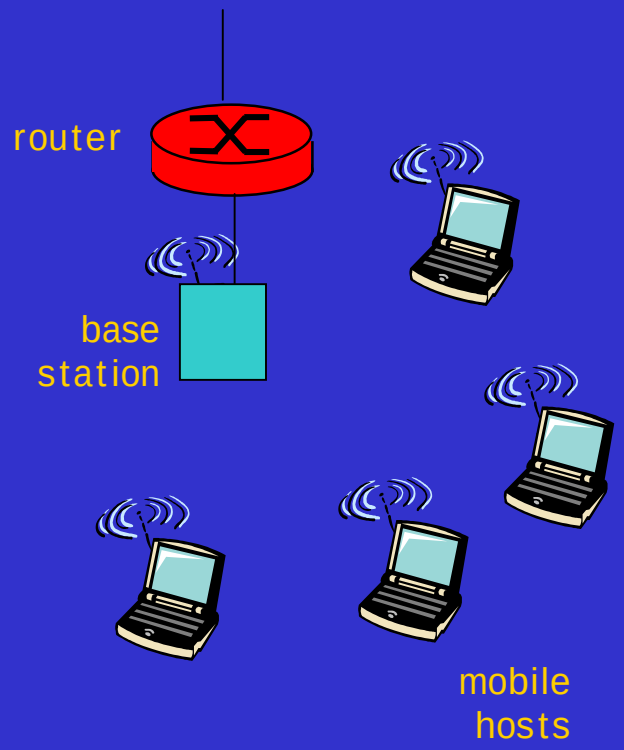


Outline

- IEEE 802.11 Network
- Multi-rate and Multi-range Transmission
- MAC Delay & Packet Error Rate
- Fuzzy Rate Controller
- Simulation Model
- Simulation Results

IEEE 802.11 Network

- shared wireless access network connects mobile hosts to internet
- Data rate can be up to 11Mbps
- The highest data rate is depending on the link quality and the transmission distance



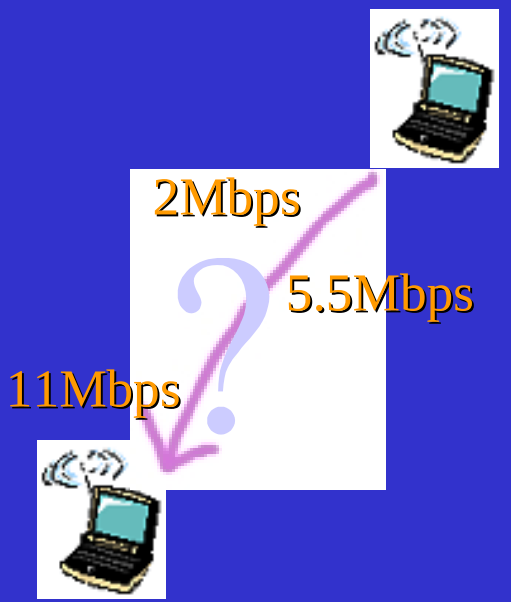
IEEE 802.11 Network

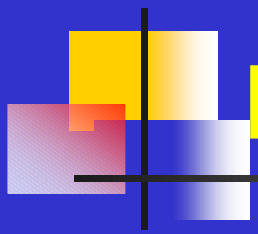
- The DSSS PHY
  1. 1Mbps uses Differential Binary Phase Shift Keying (DBPSK)
  2. 2Mbps uses Differential Quadrature Phase Shift Keying (DQPSK)
  3. 5.5 , 11Mbps uses complementary code keying (CCK)

- The FHSS PHY
  1. uses 2- or 4-level Gaussian Frequency Shift Keying (GFSK) modulation

Multiple Data Rates

- IEEE 802.11b PLCP sublayer supports
  - 2 / 5.5 / 11 Mbps
- A higher data rate may incurs a higher packet error rate
- Every mobile host needs decide a proper transmission rate to deliver packets



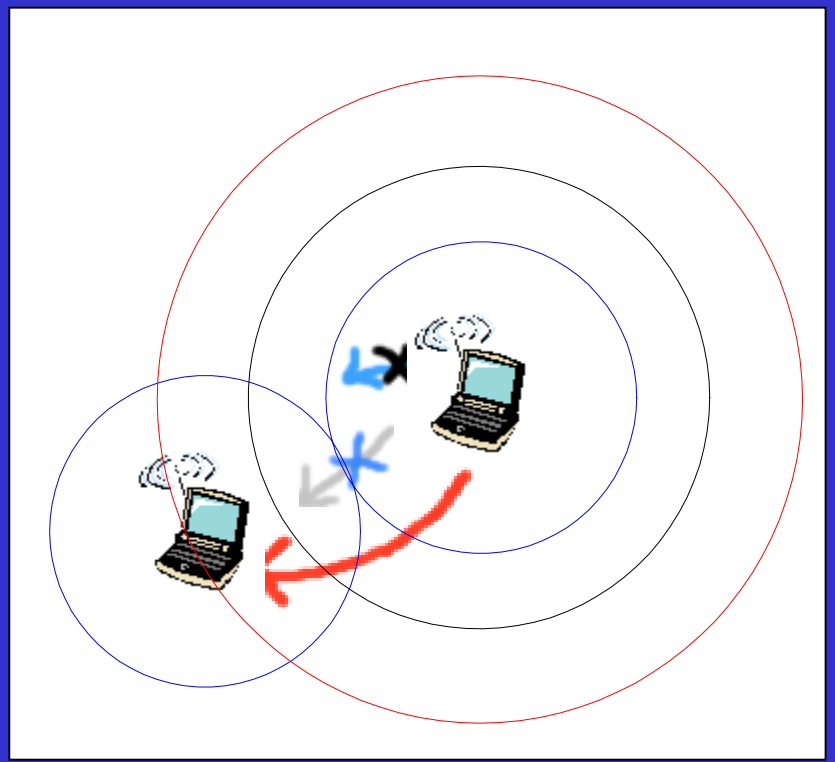


Multiple Data Rates

- Higher rate is the best choice ?
- When we need the lower rate ?

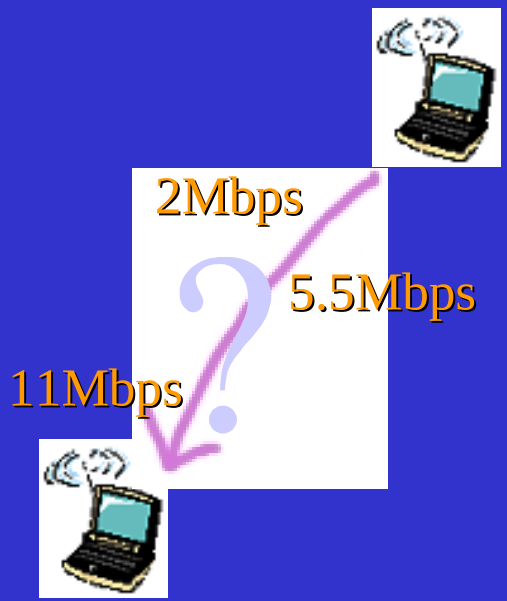
Transmission Range vs. Data Rate

- Different rates can be derived by using different modulation techniques
- Low speed data rate provides a longer transmission distance



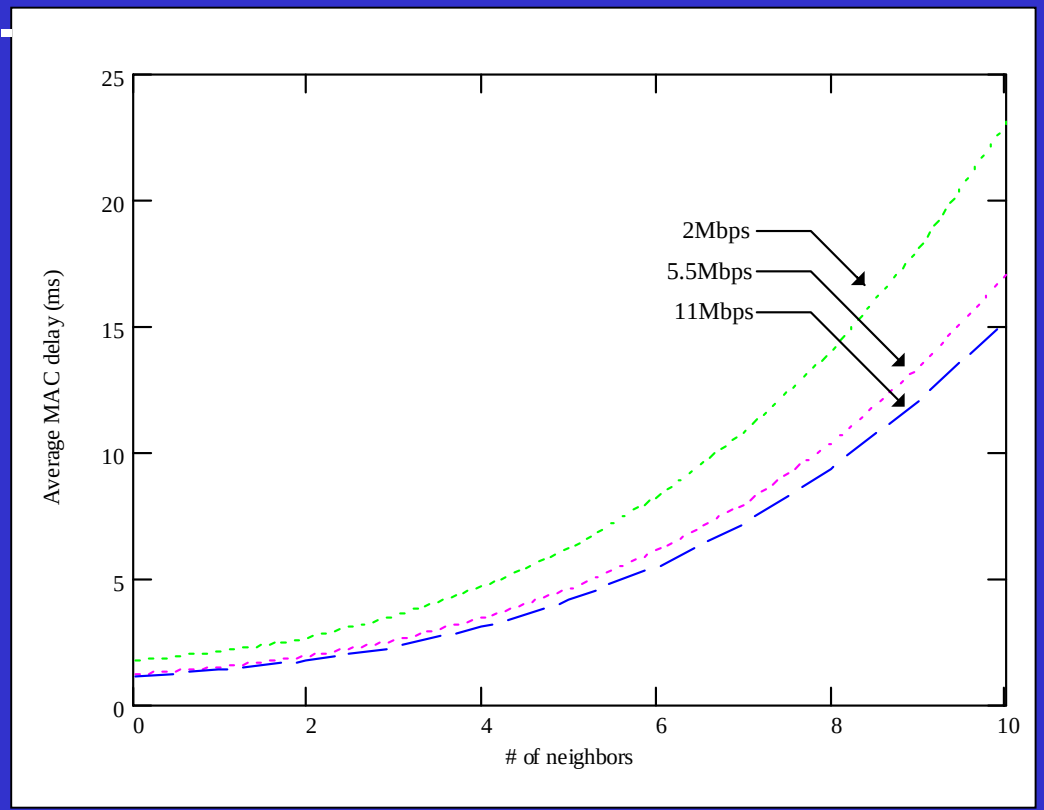
What Rate We Need

- High speed data rate improves throughput
- Low speed data rate guarantees packet error rate



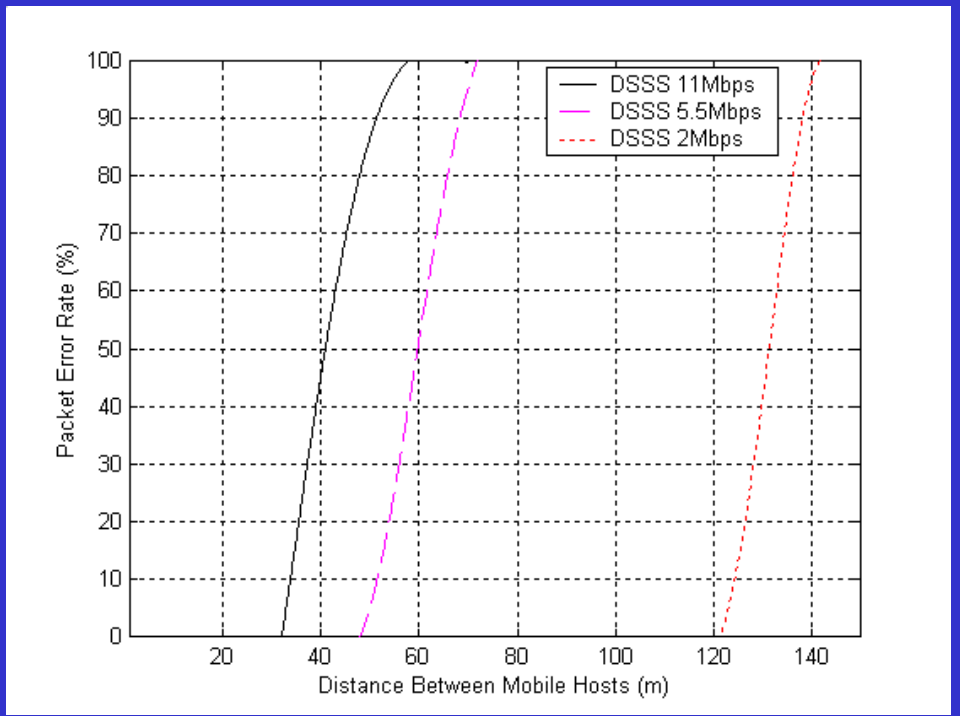
Average MAC Delay

- Analysis parameters:
  - 0.001 packet arrival rate
  - 200 bytes data payload



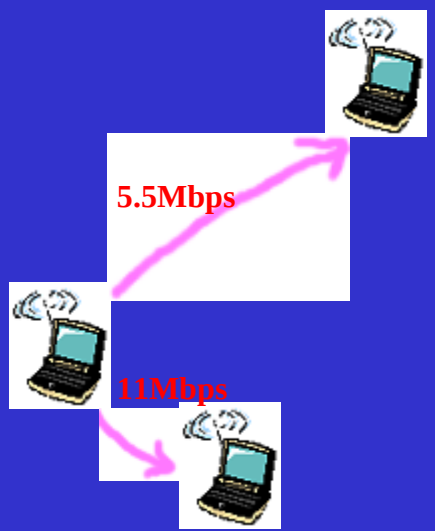
Packet Error Rate vs. Transmission Distance

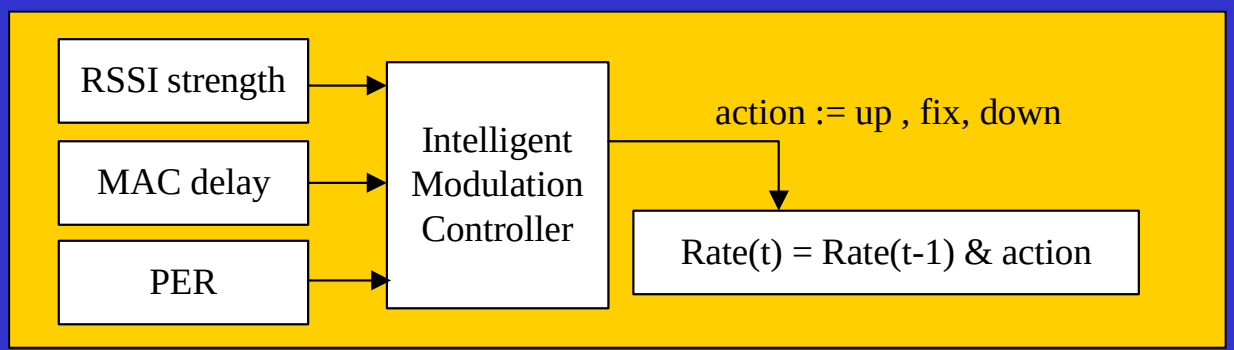
- The PER is measured under different transmission distance
- There are some gray areas
- Problem : how to choose to proper data rate to minimize the packet error rate ?



Fuzzy Rate Controller

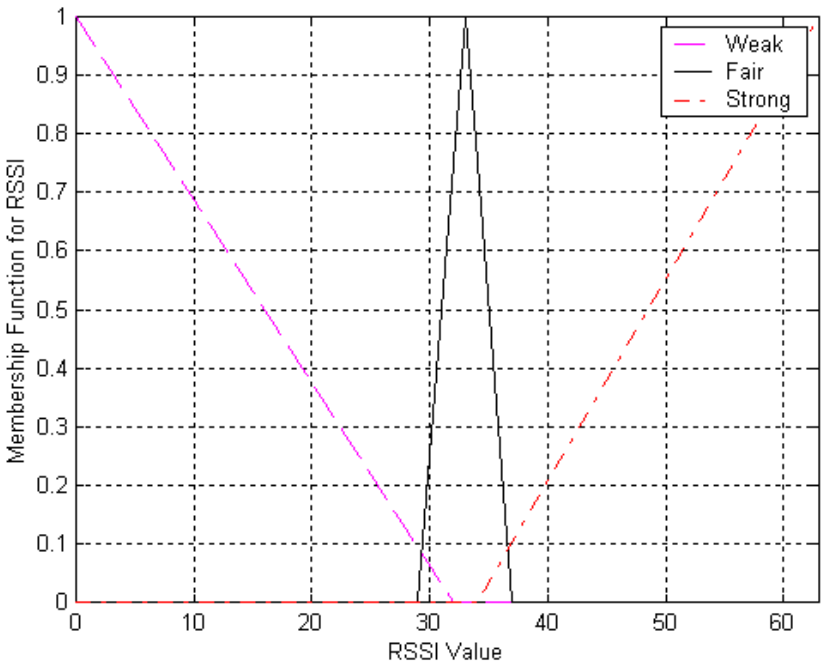
- Choose the proper transmission rate to transmit packets will derive the maximal network utilization
- We use fuzzy control to choose data rate to accommodate the varying channel condition and transmission distance from time to time





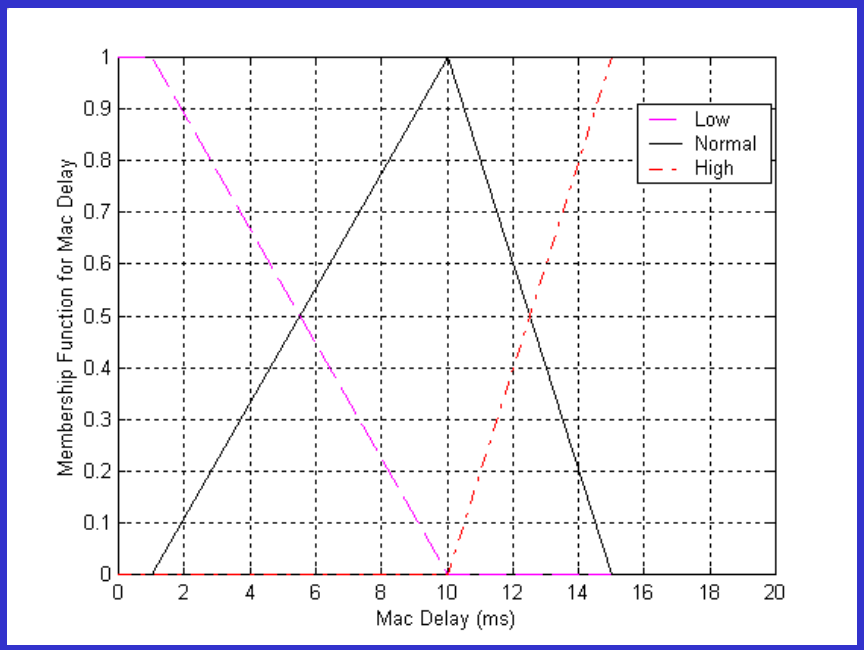
RSSI Membership Function

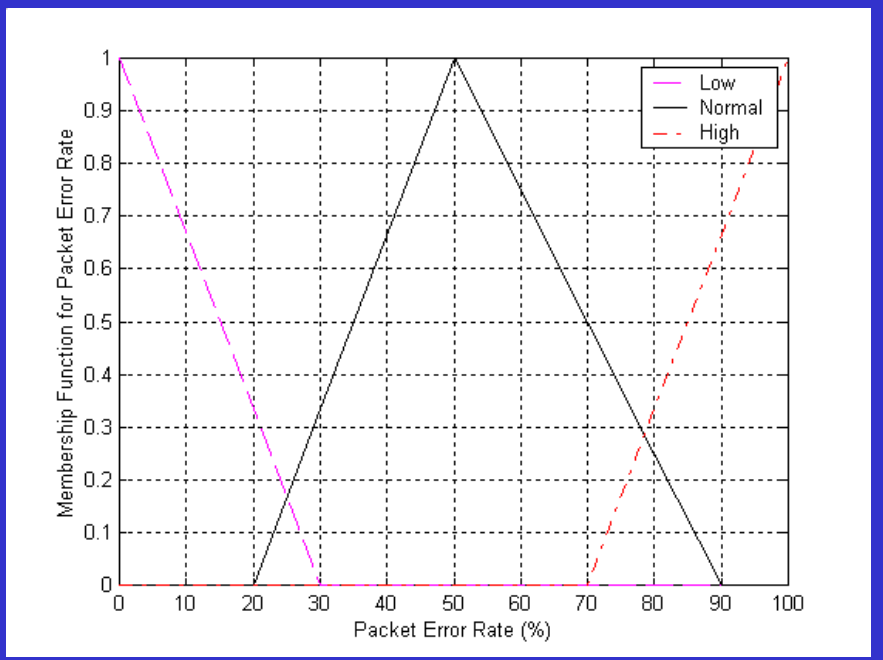
- In IEEE 802.11 , RSSI values are measured in the range from 0 through RSSI maximum
- This parameter can be obtained by the PHY sublayer from antenna when receiving a PPDU



- Max. RSSI value = 63 ,

MAC delay and PER Membership Functions





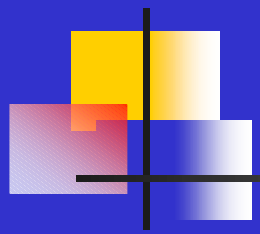
Rule Table

- Max–Min scheme is used to generate the fuzzy results
- Results indicate how to switch speed rate : un-change, raise or slowdown

RSSI	PLR	MD	Rate Control
S	H	H	↓
S	H	M	↓
S	H	L	↓
S	M	H	↑
S	M	M	↑
S	M	L	—
S	L	H	↑
S	L	M	—
S	L	L	—

RSSI	PLR	MD	Rate Control
F	H	H	↓
F	H	M	↓
F	H	L	↓
F	M	H	↑
F	M	M	—
F	M	L	↓
F	L	H	↑
F	L	M	—
F	L	L	↓

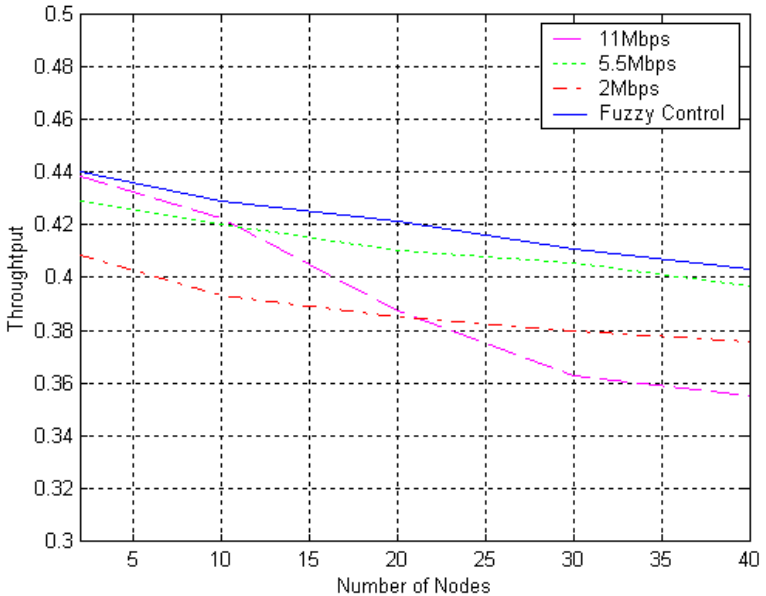
RSSI	PLR	MD	Rate Control
W	H	H	↓
W	H	M	↓
W	H	L	↓
W	M	H	—
W	M	M	—
W	M	L	—
W	L	H	—
W	L	M	—
W	L	L	↑

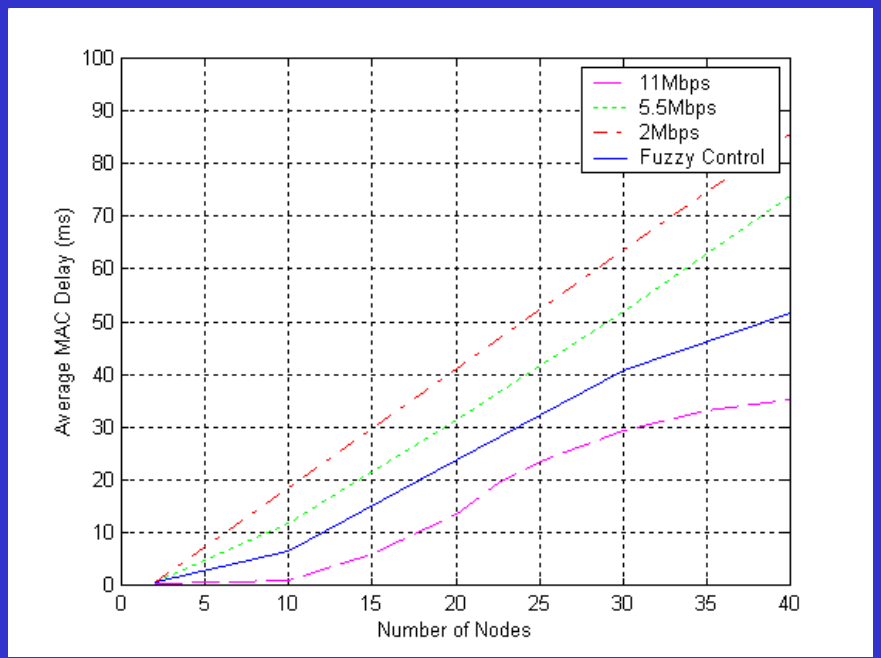


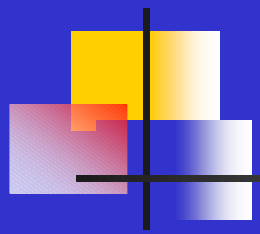
Simulation Model

- 100m X 100m square area
- The considered data rates and the associated transmission ranges :
  - 2Mbps - 150m
  - 5.5Mbps - 80m
  - 11Mbps - 50m
- Destination is randomly selected form all mobile hosts.
- Packet arrival rate is 0.001.
- Average packet length is 200Bytes.

Simulation Results







Conclusions

- The proposed fuzzy controller can provide
  - low packet error rate
  - low access delay
  - maximal channel utilization