Characterization of 802.11 Wireless Networks in the Home

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Presented by:

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Outline

- Background
  - Motivation
  - Related Work
- Experimental Environment
  - Variables
  - Validation
- Results
- Conclusions

Motivation for Study

- Wireless Access Point deployment studied in commercial environment
- Home WLANs are considered less challenging to design
  - Little evidence supports this claim
  - Assumption needs to be investigated

Related Work

- Large Campus Networks
  - Kotz and Essien 2002
    - 475 access point WLAN
    - User traffic characteristics analyzed
  - Aguayo, et al. 2004
    - 38 node 802.11b mesh network
  - Low correlation between loss rate and distance

Related Work (cont)

- Zhao and Govindan 2003
  - 60 nodes in different environments
  - “many links operate in a ‘grey area’ with difficult to predict intermediate loss rates and performance”

Factors Investigated

- Type of house
- Wireless standard used
- Transmission Power
- Transmission Rate
- Node Location
- Interference

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Setup

- 6 Nodes
- Ad Hoc network
- At least 5 channels from nearest occupied frequency
- No retransmissions
- No simultaneous transmissions

Probe Packets

- Each node sends probe packet to all other nodes
- Probe Packet:
  - 1024 bytes
  - UDP
- 300 packets sent over 150 seconds

Methodology

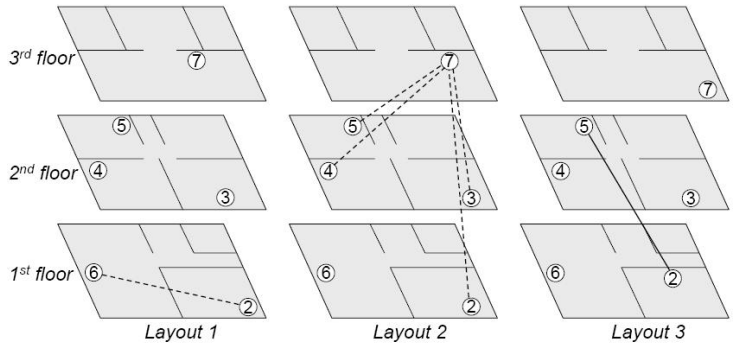
- Tests performed in three different homes

Description of homes used in experimental testbeds.

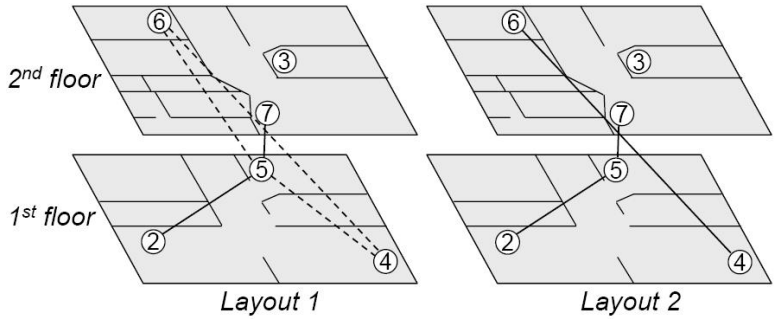
Label	Size (ft^2)	Construction	# Floors	# Nodes
ushome1	2,500	Wood	2	6
ushome2	2,000	Wood	2	6
ukhome1	1,500	Brick / steel	3	6

- 802.11a and 802.11b protocols tested under varying transmission rates and powers

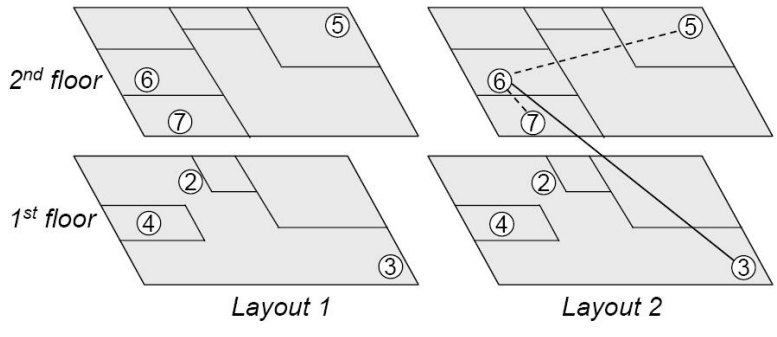
Node Deployment



ukhome1



ushome1



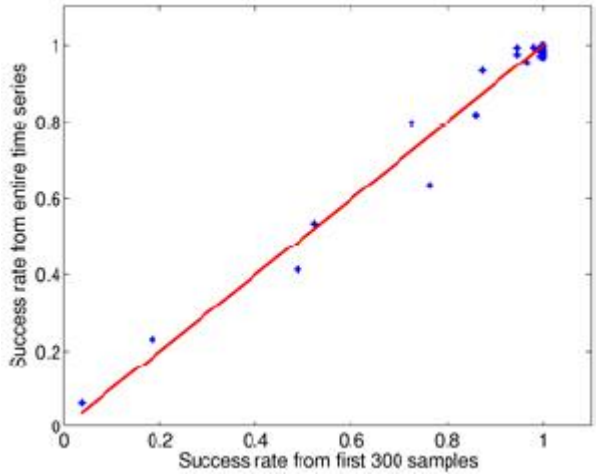
ushome2

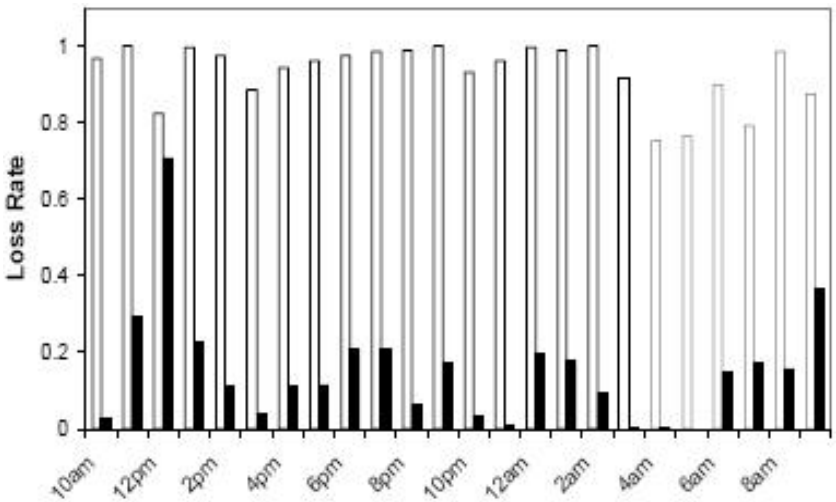
Variables

- 802.11a
  - txrate: 6Mbps, 18Mbps, 36Mbps, 54Mbps
  - txpower: 30mW
- 802.11b
  - txrate: 2Mbps, 11Mbps
  - txpower: 1mW, 30mW

Validation

- 150 seconds is a sufficient time frame
  - Estimate of success rate over 20 minute period





- Time of day not a factor
- Represents actual link characteristics
  - Multiple trials at same time of day

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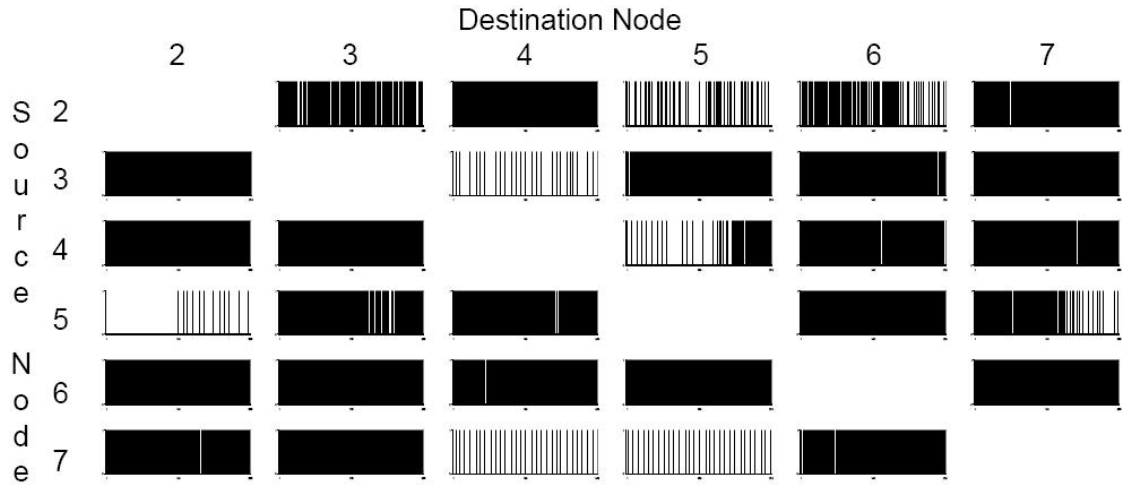
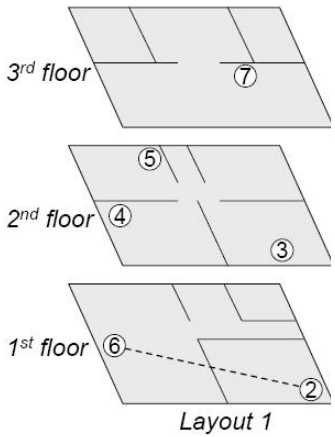
Overall Characteristics



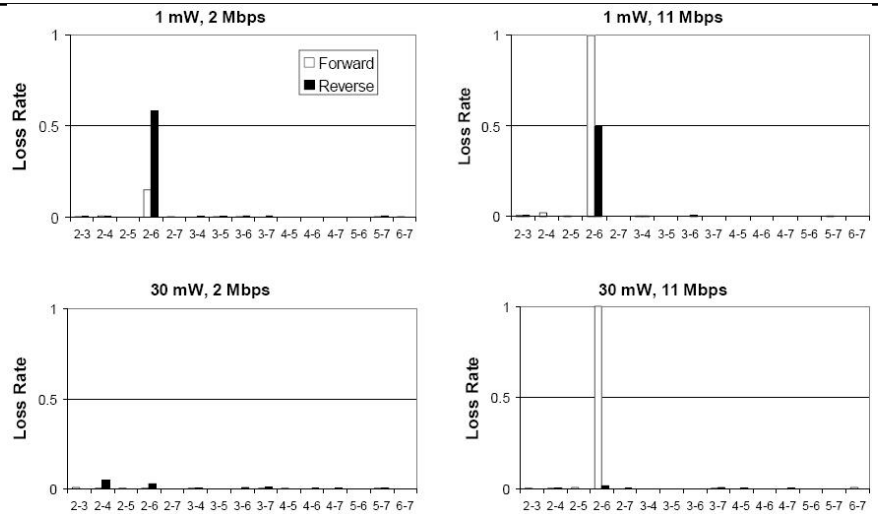
ushome1 at 30mW and 2Mbps

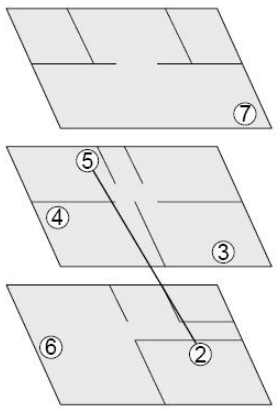
- Asymmetry
- Bursty errors
- High loss for at least one pair of nodes

Large Changes in Node Location

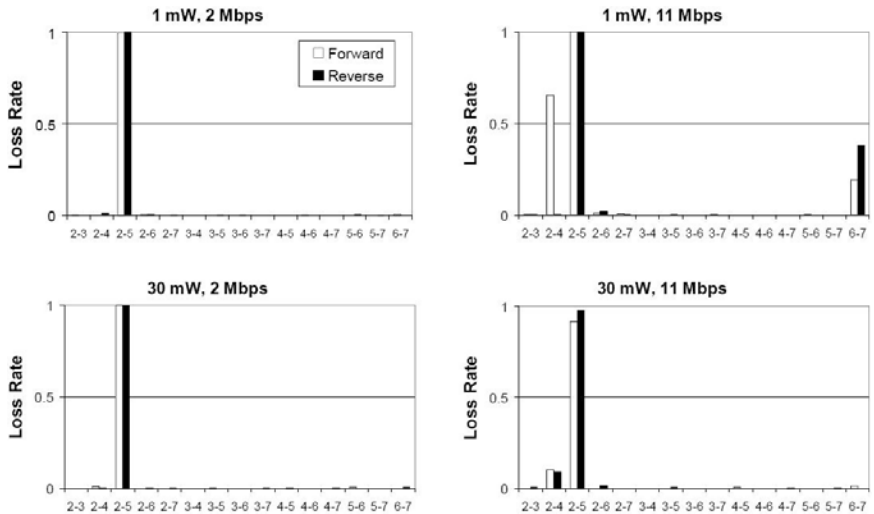


Layout 1

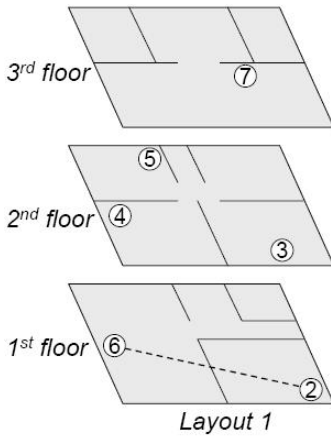




Layout 3



Small Changes in Antenna Location and Orientation



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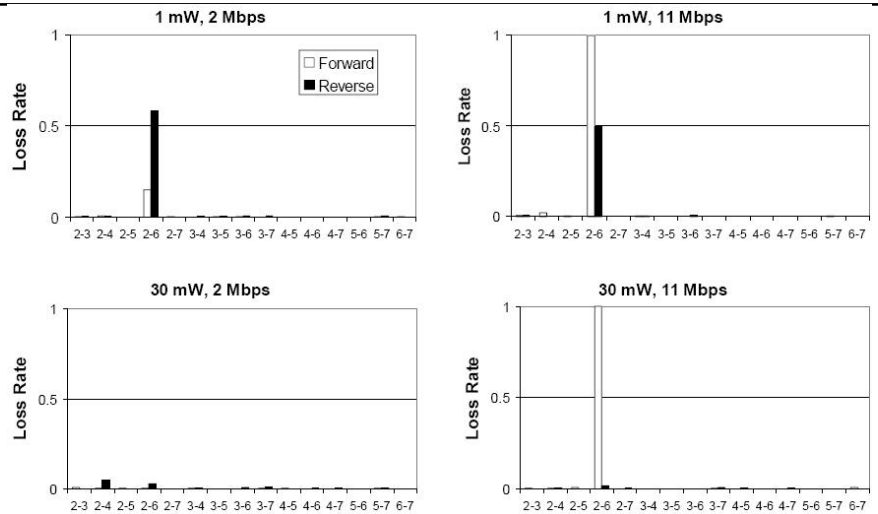

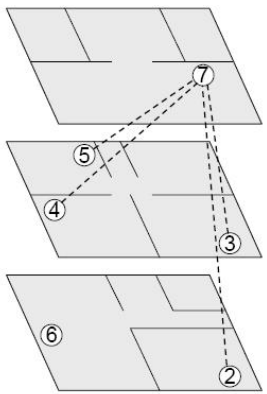

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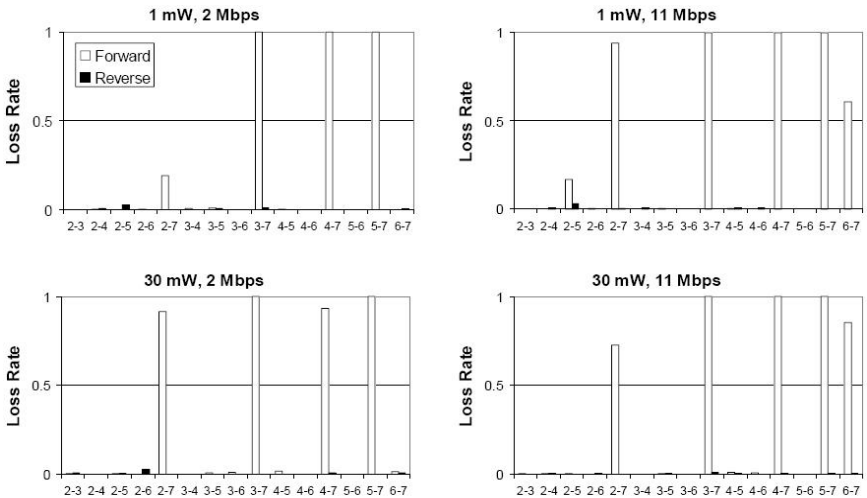
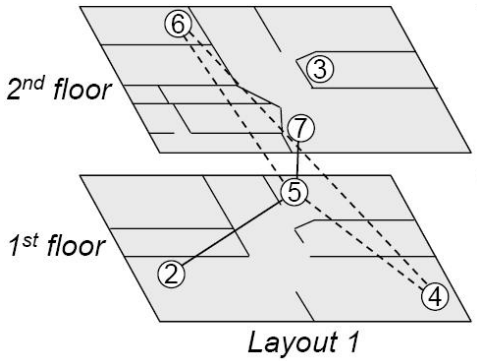


Small Changes in Antenna Location and Orientation (cont)



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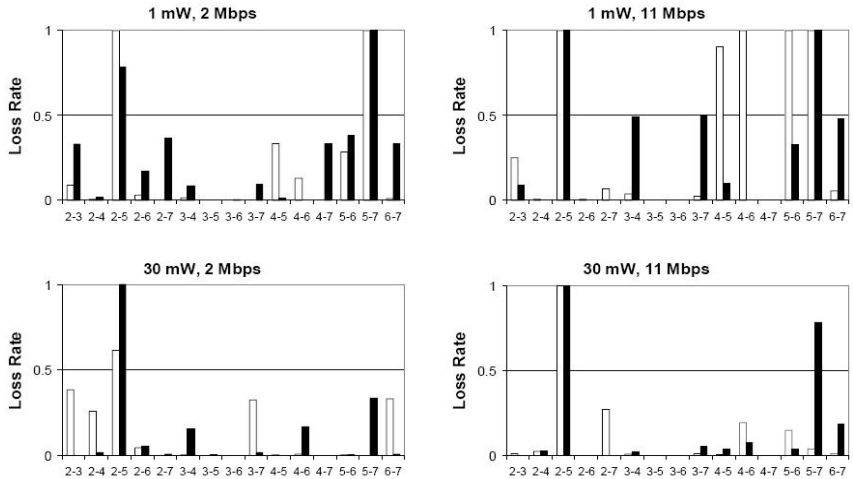

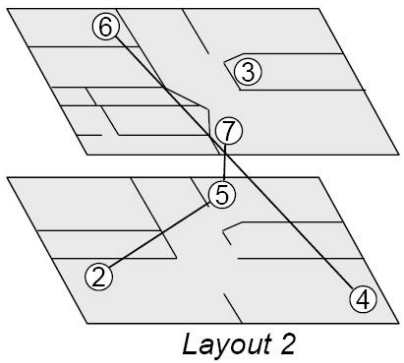

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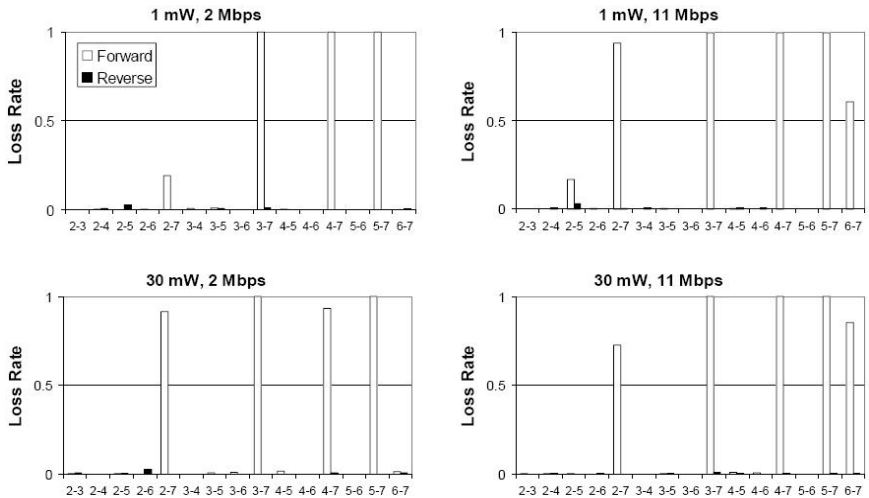
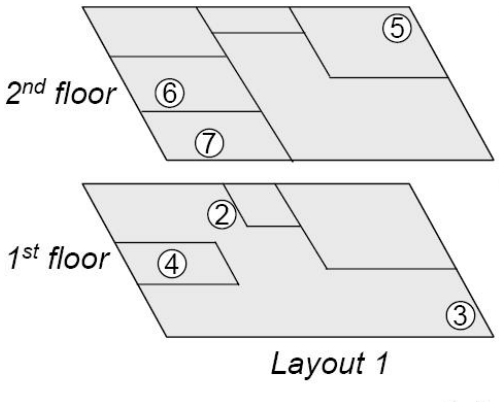


Small Changes in Antenna Location and Orientation (cont)



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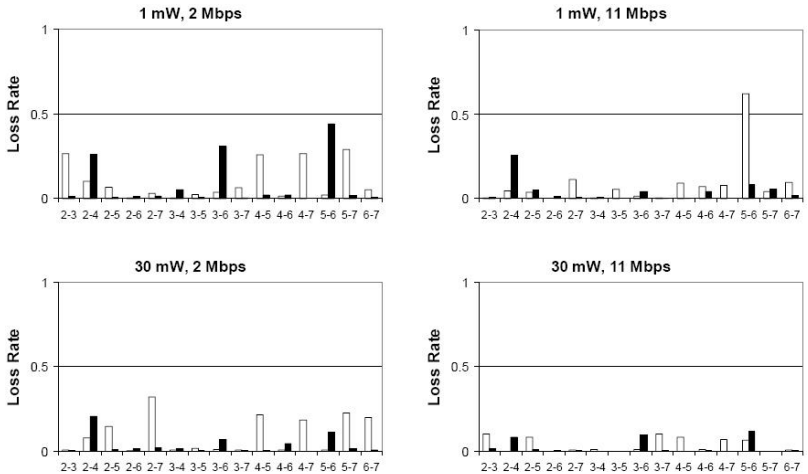

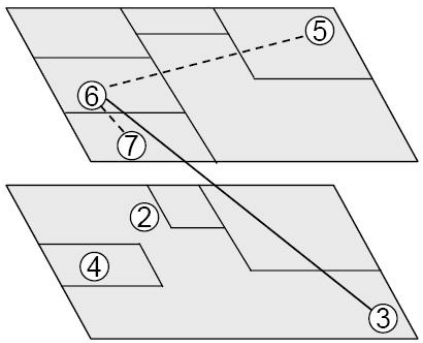

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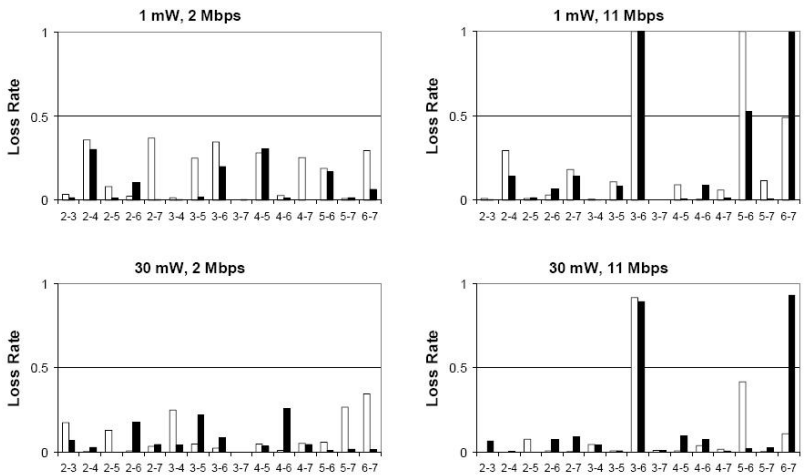
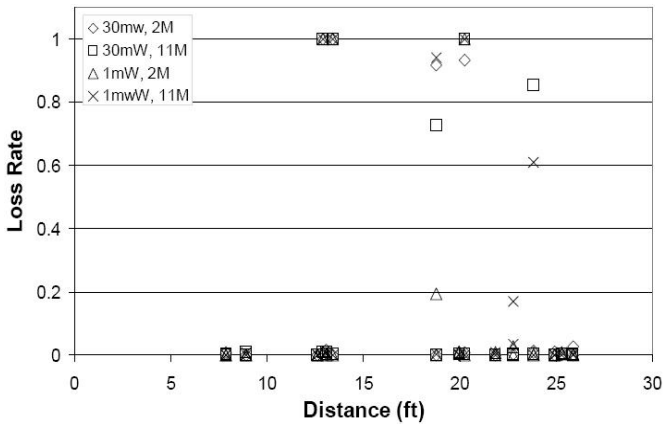
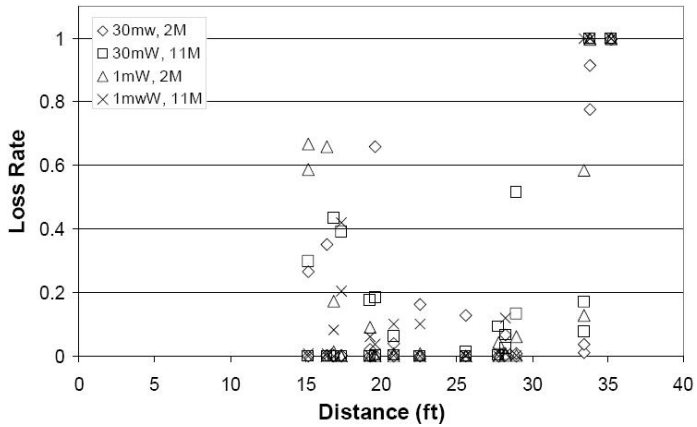


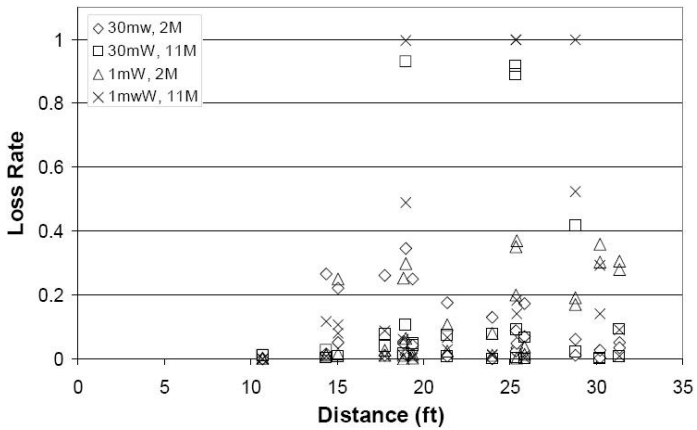
Link Quality vs. Distance



ukhome1



ushome1



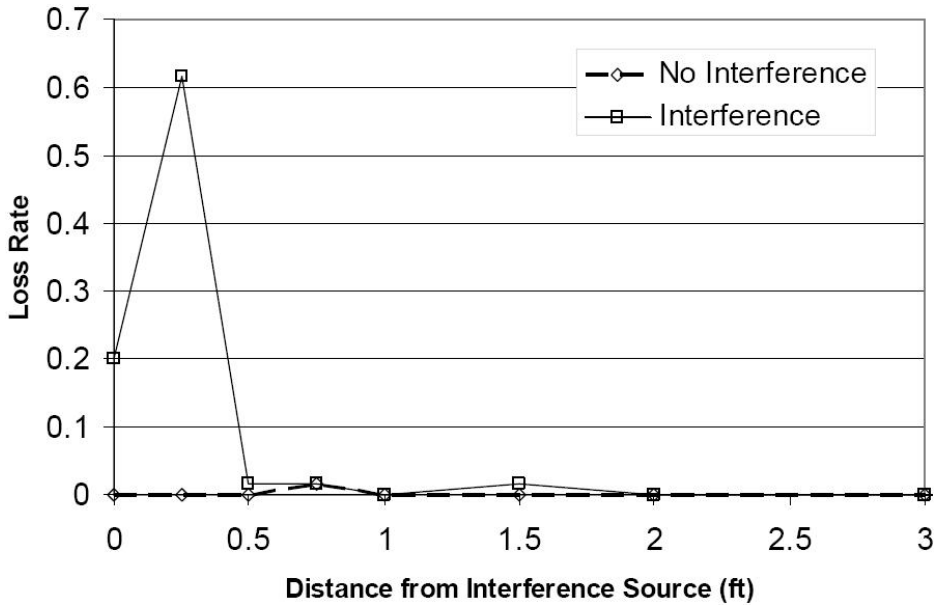
ushome2

Analysis of Changes in Antenna Location and Orientation

- Small changes more important than distance
  - Obstacles influence multipath fading and attenuation
  - More effect on link quality
- High data rate, low transmission power, resulted in lower link quality
  - Bad connections tend to stay bad

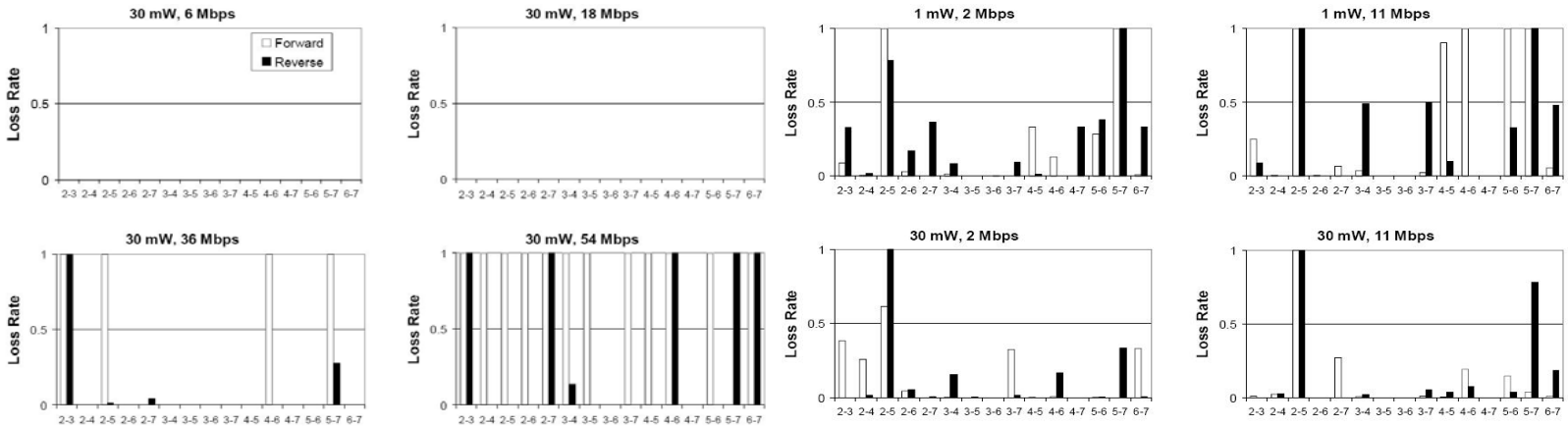
Interference

- Microwave
  - Broad-spectrum interference
- Extreme short-range interference
  - Shielding at 0ft negated some interference?
- Negligible at distances greater than 2ft



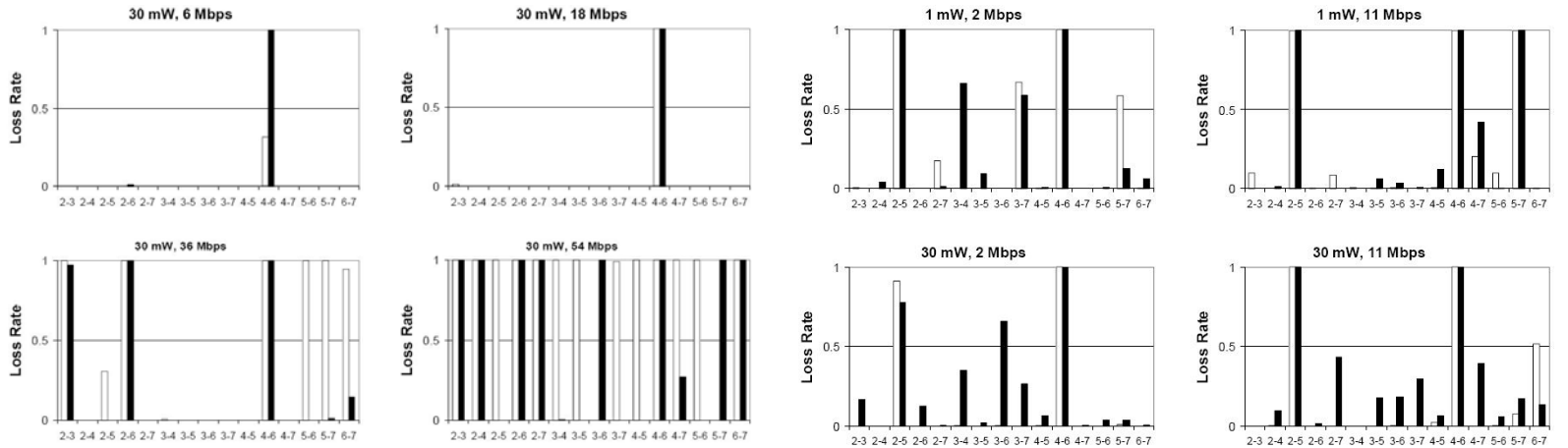
Impact of a 600W microwave on a receiver at varying distance from the interference source and a distance of 15ft from the sending unit

802.11a vs. 802.11b



ushome1, layout1, 802.11a

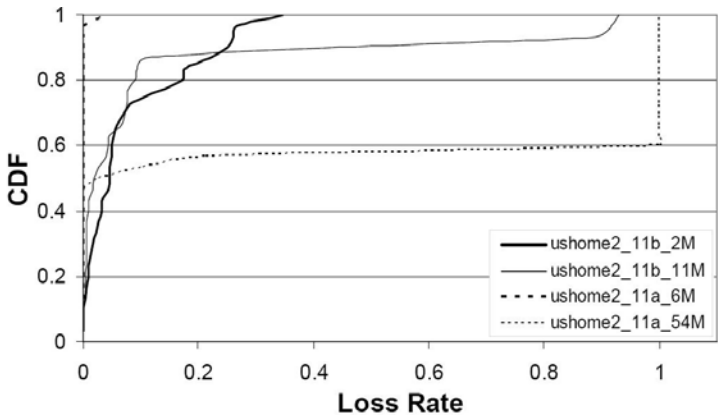
ushome1, layout1, 802.11b

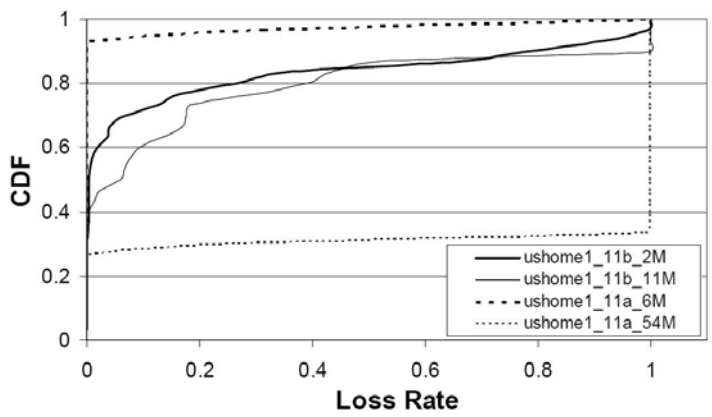


ushome1, layout2, 802.11a

ushome1, layout2, 802.11b

802.11a vs. 802.11b





- “Binary” Behavior
- Potentially better performance in home applications
- 54Mbps has very poor link quality

Conclusions

- Placement of a wireless access point in the home is more difficult than normally assumed
  - Precise node alignment is critical
  - Distance is less important
  - External interference from appliances must be taken into account
- 802.11a may be more suitable for home environments
  - Shorter range than 802.11b
  - Better link quality