



Characterization of 802.11 Wireless Networks in the Home

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Outline

- **Motivation**
- **Experimental Methodology**
- **Results**
- **Conclusions**

Motivation

- Home wireless networks are popular.
- Anecdotal evidence suggests “unpredictable” performance for home WLANs.
- This paper measures characteristics of home wireless networks.

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Experimental Methodology

- Evaluated three homes – two in U.S. and one in the U.K.

Table I
Description of homes used in experimental testbeds.

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

Parameters Studied

- Type of house
- 802.11a versus 802.11b
- Transmission power {txpower}
- Transmission rate {txrate}
- Node Location
- Appliance interference {microwave}.

Experimental Setup

- Studied configuration with six wireless nodes inside each home.
- Used an ad hoc configuration {no AP}.
- Each node sends 1024-byte UDP probe packets to every other node once every 500 ms.
- *Link layer retransmissions were disabled!*
- Each sub-experiment duration is 150 second (i.e., 300 samples per sub-experiment)
- No simultaneous transmissions.

Methodology

- Experiments were conducted at night to avoid interference from moving people.
- Varied txrate and txpower.
- Quantified loss rate observed by each wireless link.

UShome1

2Mbps 30 mW

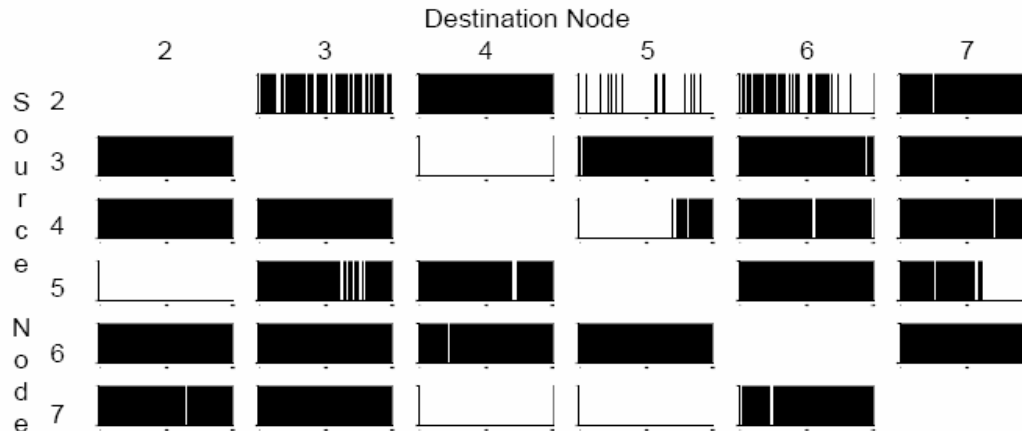


Fig. 1. Matrix of probe packets successfully delivered between each pair of nodes in *ushome1* at 30mW and 2Mbps.

- Communication for some nodes is extremely limited (e.g., 5 to 2).
- Results show asymmetric link behavior (e.g. $4 \leftrightarrow 3$).

Reproducibility

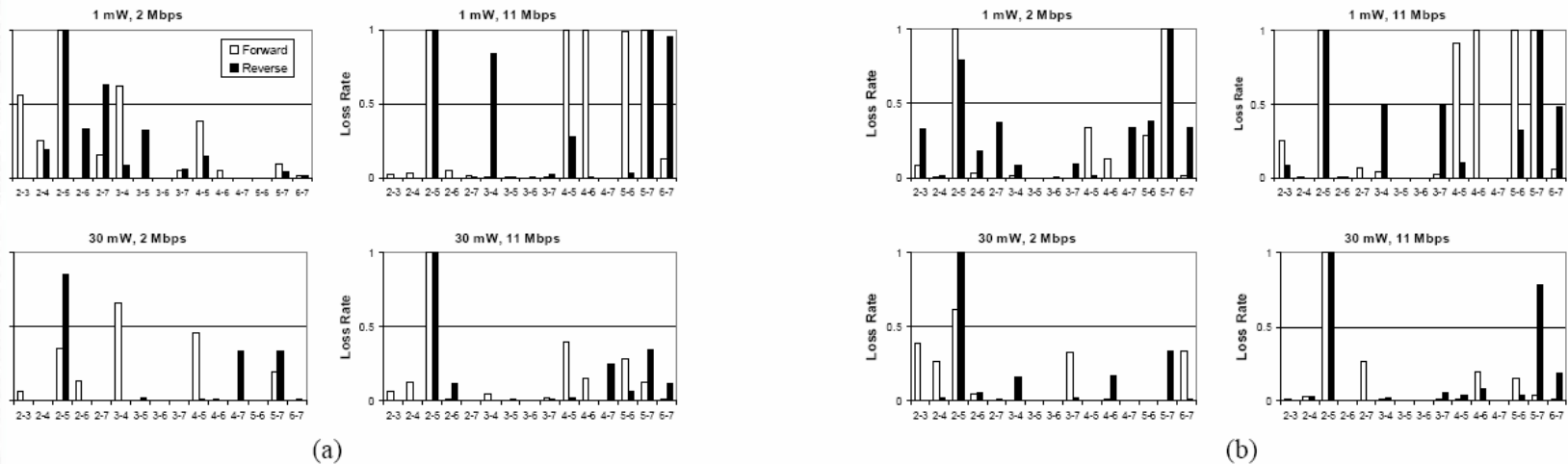


Fig. 2. Loss rates for each pair of nodes in two runs at *ushome1*

Experiment Duration

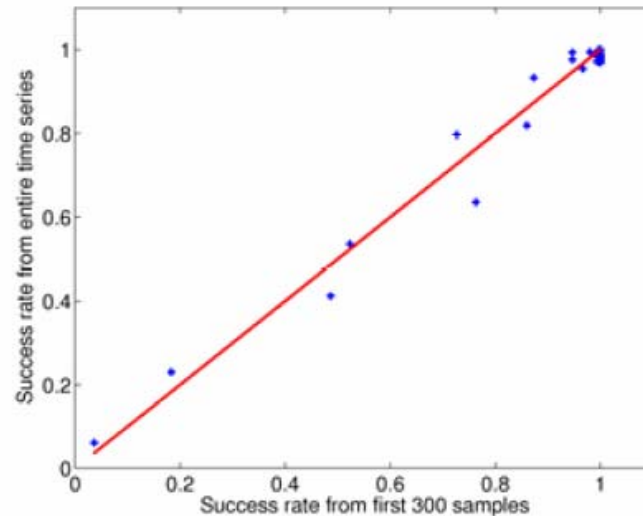


Fig. 3. Comparison of success rate results for 300 and 2400 sample lengths. The straight line provides a reference for equality ($y=x$).

The fact that the data points fit a straight line implies that 150 sec. runs are long enough to access medium-term properties of each link under the tested conditions.

Time of Day Effects

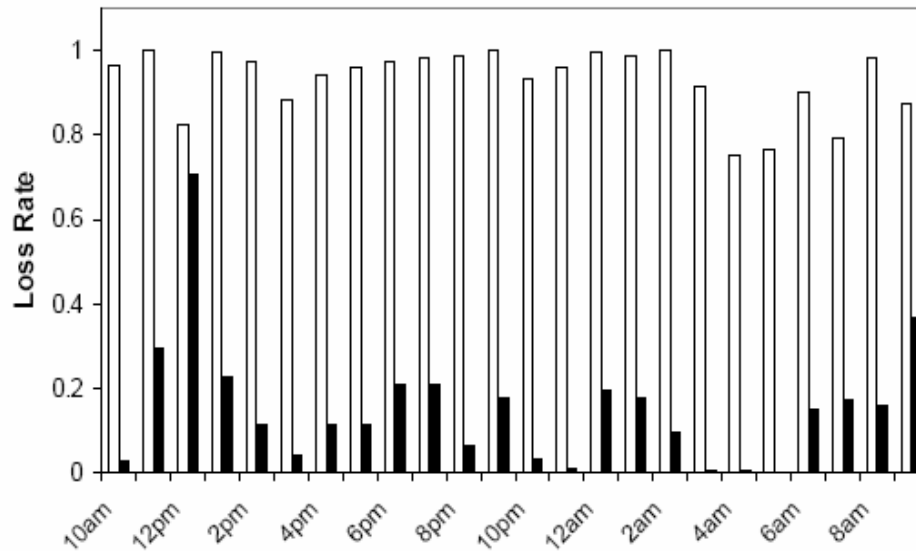


Fig. 4. Loss rate as a function of time of day for *ushome1* ($txpower=30mW$, $txrate=11M$). First bar is node-4 to node-6, second bar is node-6 to node-4.

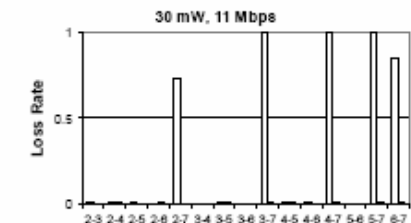
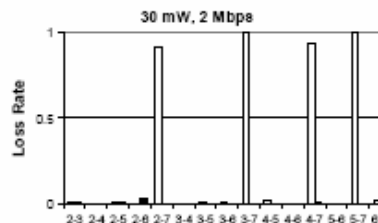
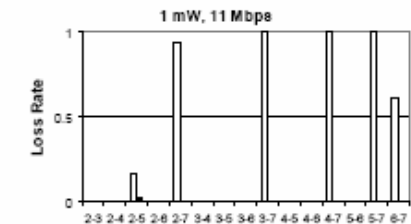
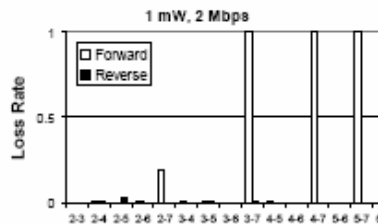
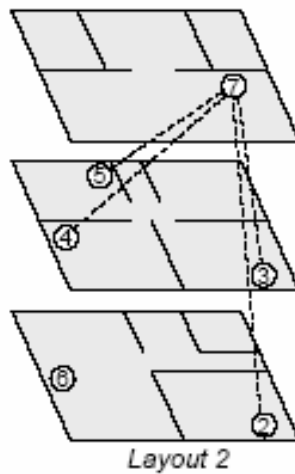
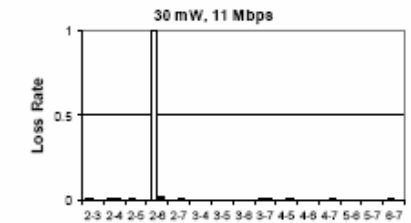
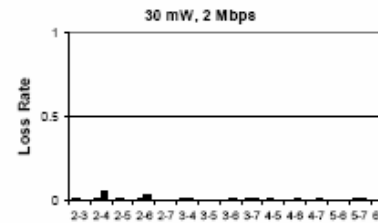
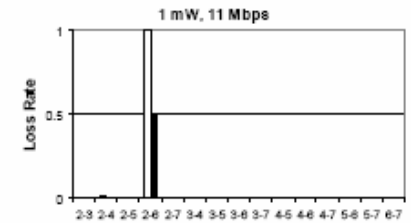
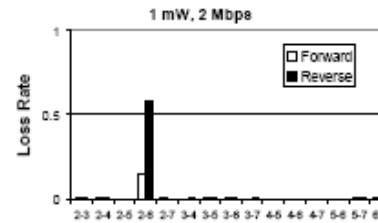
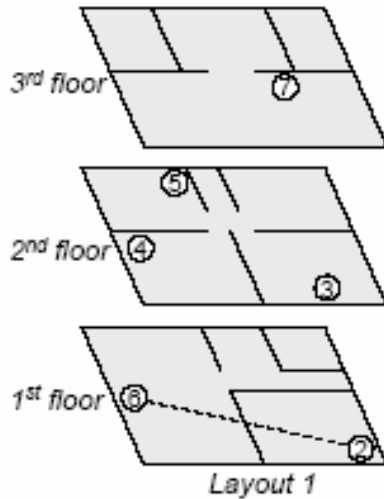
Authors' claim: good links tend to remain good and bad links tend to remain bad despite small deviations over time.

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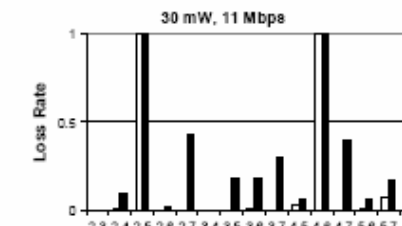
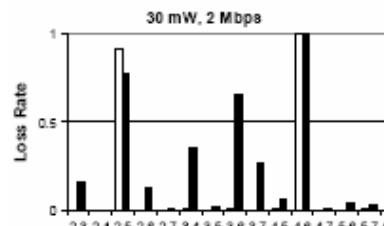
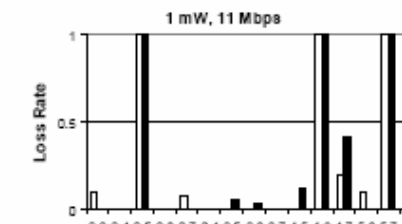
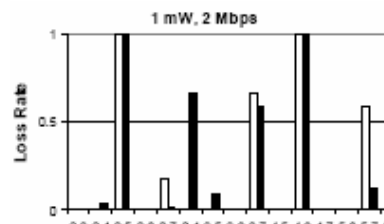
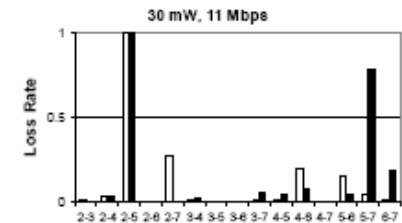
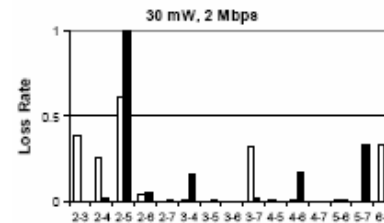
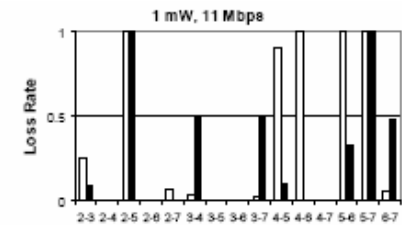
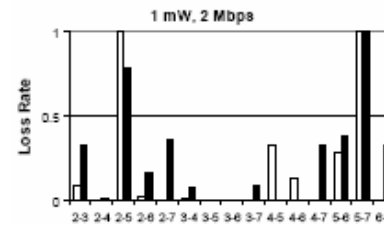
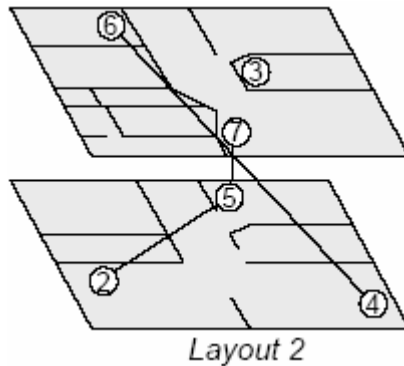
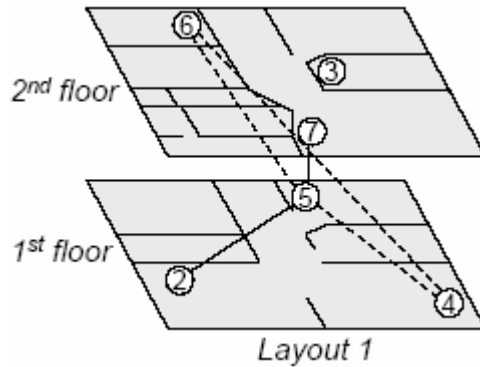
UKhome1

small changes in rotation and antennas



UShome1

small changes in rotation and antennas



UKhome1

large change in node placement

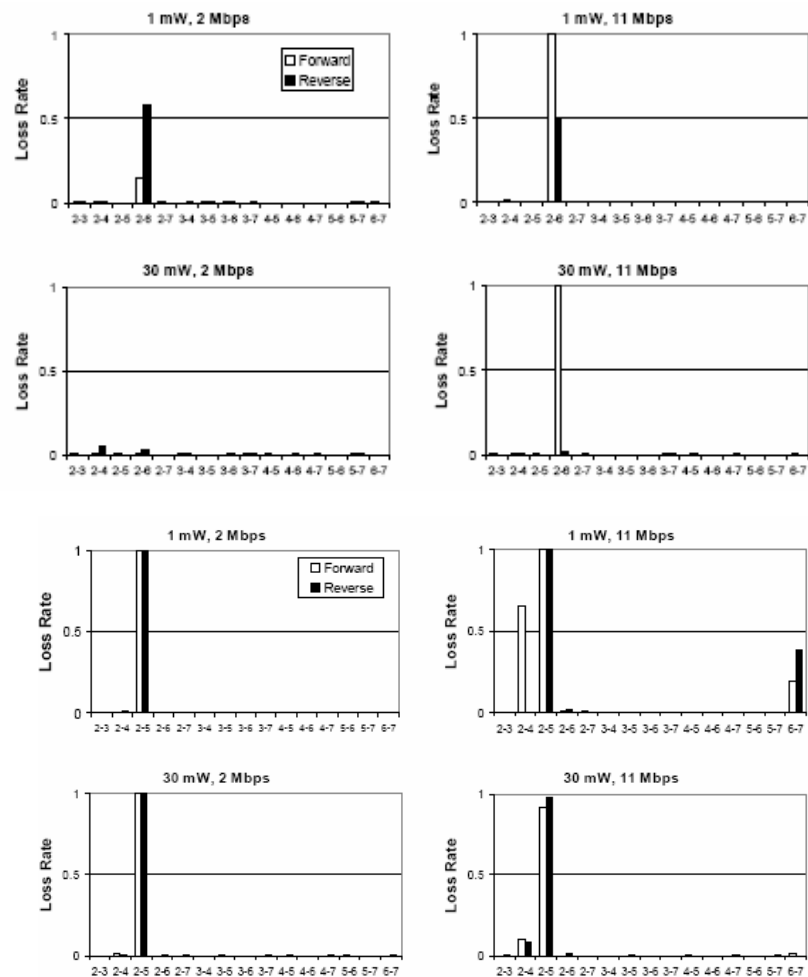
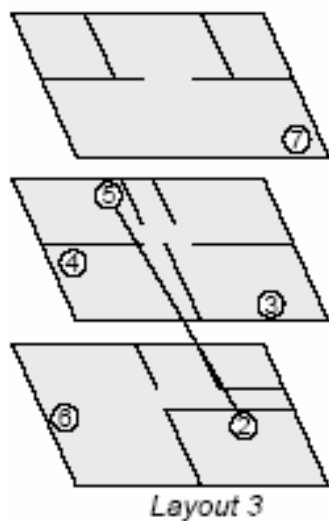
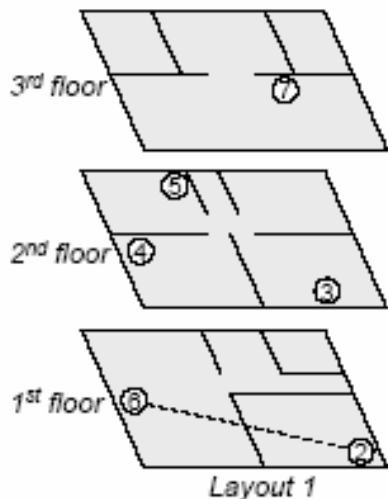
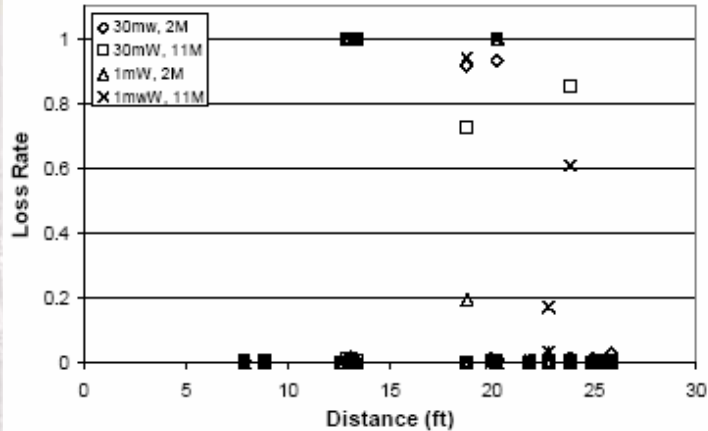
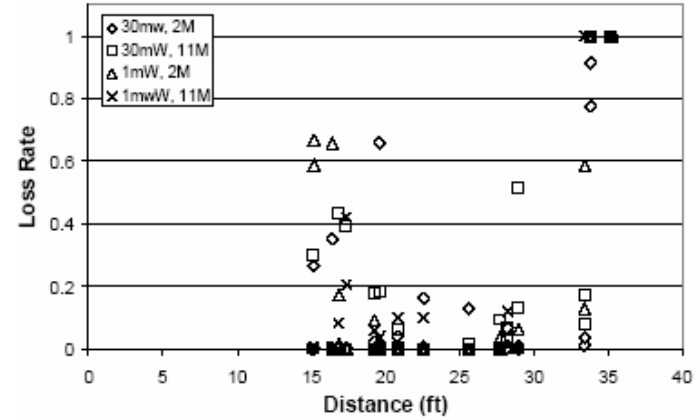


Fig. 8. Loss rate for each pair of nodes in *ukhome1*, *layout3*.

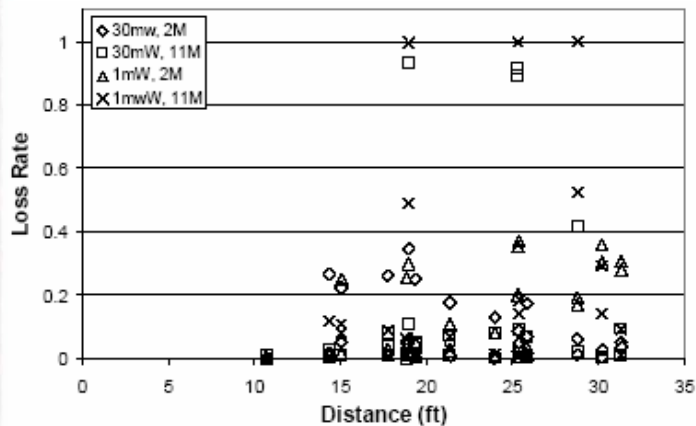
Link Quality versus Distance



(a)



(b)



(c)

There is no correlation between distance and wireless link quality!

Microwave Oven Effect

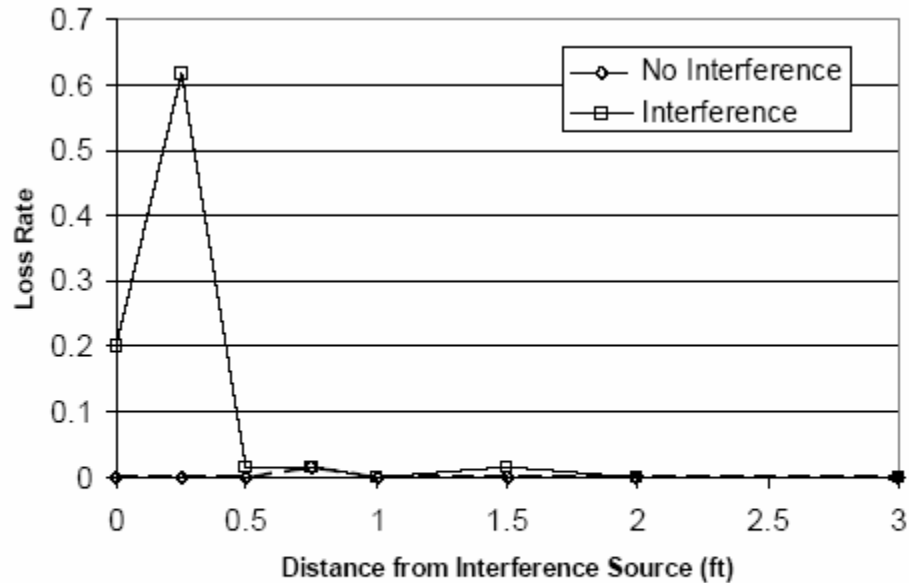


Fig. 10. The impact of a 600W microwave on a receiver at varying distance from the interference source and a distance of 15 feet from the sending node.



802.11a Tests

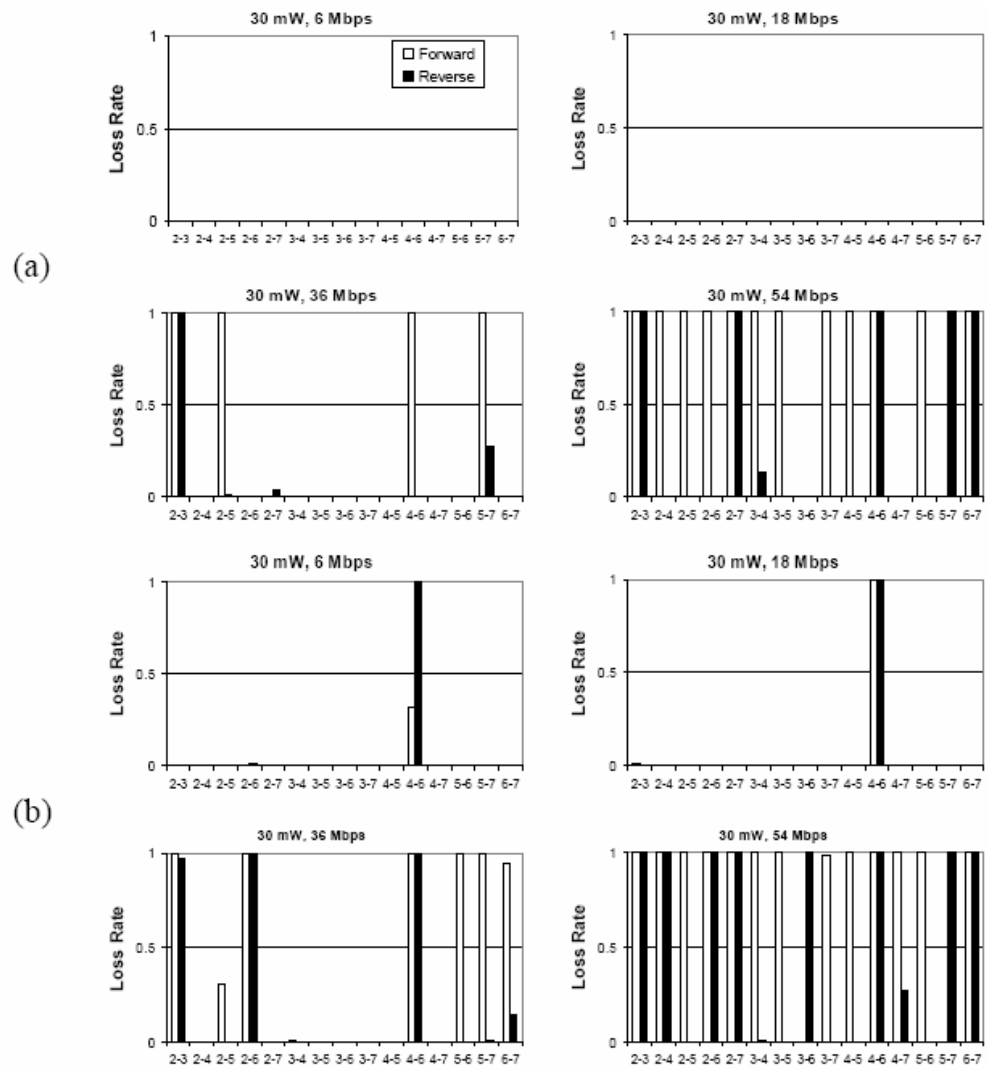


Fig. 11. Loss rate for each pair of nodes for *ushome1* under IEEE 802.11a, with two different node orientations, (a) *layout1* and (b) *layout2*.

802.11a versus 802.11b

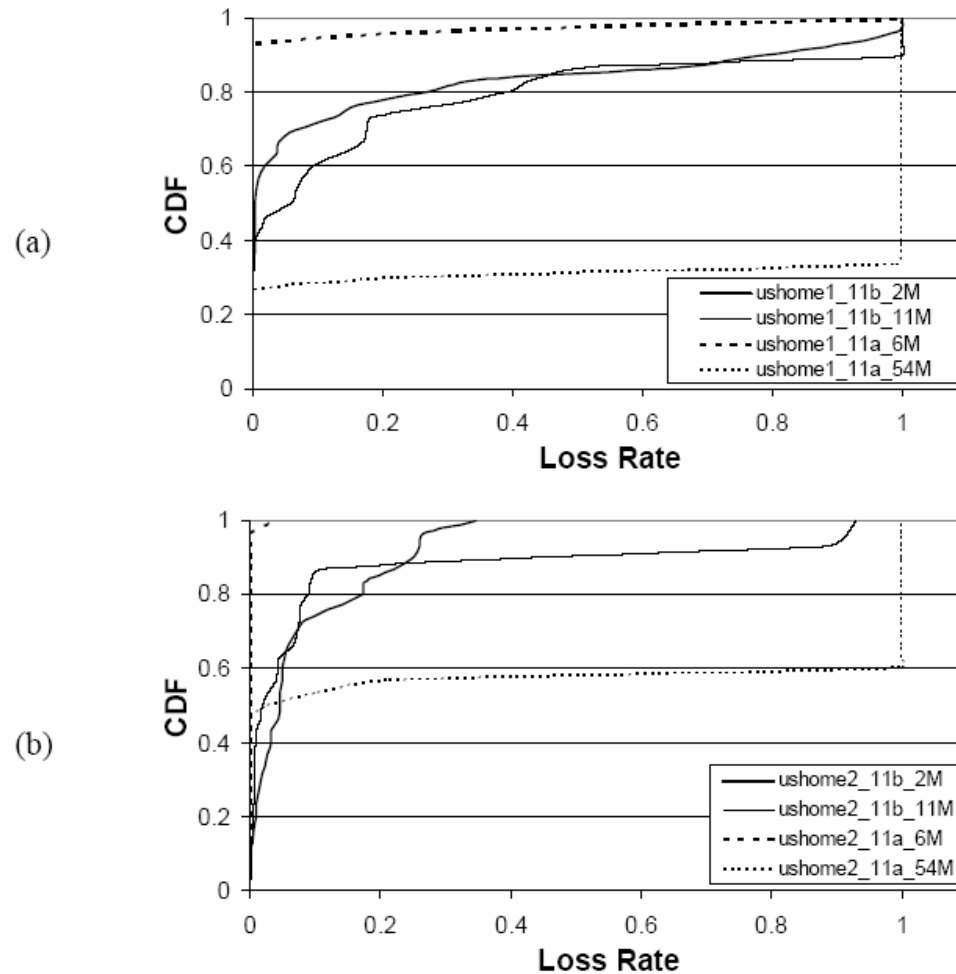


Fig. 14. Cumulative density function of loss rates under IEEE 802.11b and IEEE 802.11a in (a) *ushome1* and (b) *ushome2*.

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Conclusions

Home measurements show:

- **Precise location is the single most important factor in determining quality of wireless communications.**
- **Wireless communication can be very asymmetric and variable by location.**
- **Small changes in antenna orientation and node location can dramatically change link quality.**

Conclusions

Home measurements show:

- **802.11a and 802.11b perform similarly with respect to loss rate.**
- **The highest allowable rate may not be possible due to high loss.**