Characterization of 802.11 Wireless Networks in the Home

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Introduction

- Home 802.11 networks have become popular
- Little is known about properties and performance of home wireless installations
- Experience: behavior of home 802.11 networks can be random or unpredictable
- Goal of the research was to evaluate the effects of common factors which might have an impact on wireless network behavior

Variables measured

- Transmission rate
- Transmission power
- Node location
- Type of house
- External interference (microwave)
- 802.11 physical layer technology (a/b)

Experimental Setup

- 3 home Wifi networks (2 in the US, 1 in the UK), with 6 nodes each.
- Setup: ad-hoc network, with communication frequency at least 5 channels apart from any other traffic
- UDP packets without link layer retransmissions between each two nodes (but with no simultaneous traffic)
- Packet: 1024 bytes, each 500ms for 150s

Testing Methodology

- Transmission rate: 2Mbps, 11Mbps
- Transmission power: 1mW, 30mW
- Each test run twice
- Variations exist between test runs, but overall trends are visible.

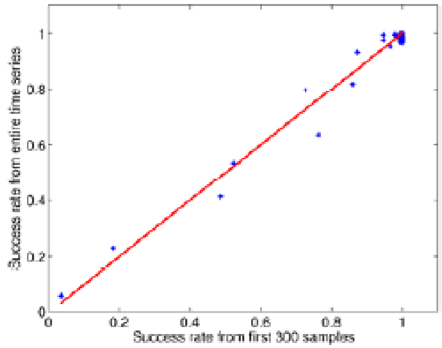


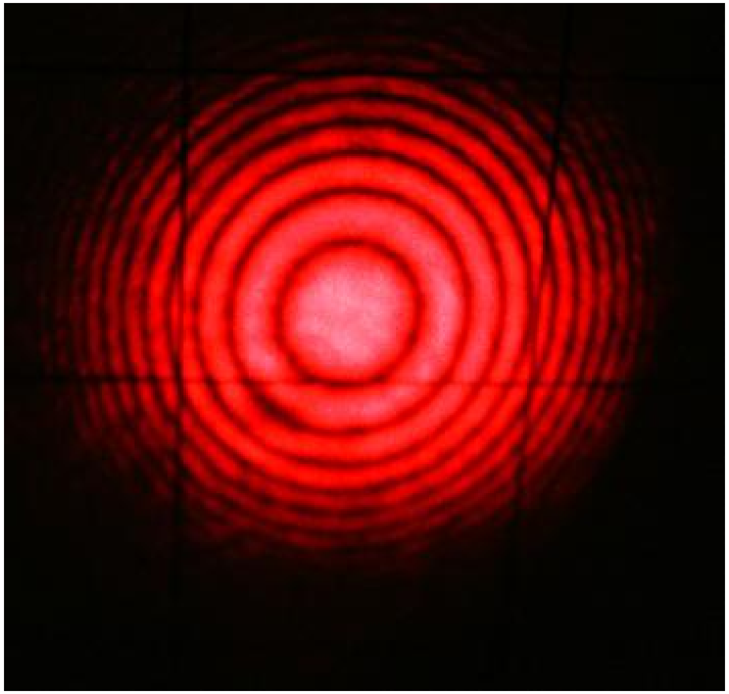
Fig. 3. Comparison of success rate results for 300 and 2400 sample lengths.

Small Orientation Changes

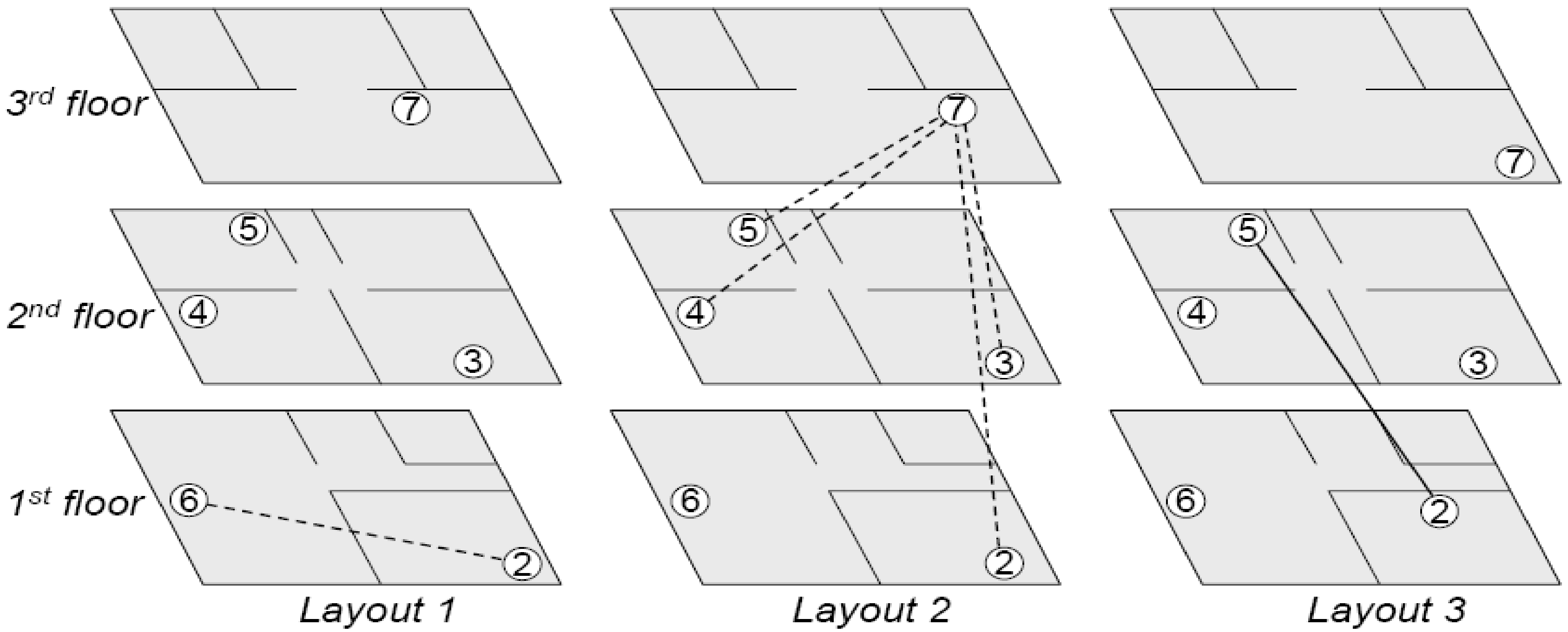
- Seemingly insignificant changes in location and direction of antennas make a big difference.
  - Multi-path fading occurs when a signal splits, following multiple paths and interfering with itself at the destination.
  - Small changes can make a big difference; this is due to the very short-range variations in signal quality that result from multi-path fading

Interference Patterns & Multi-path Fading

- The seeming randomness of multi-path fading results from the multitude of paths; in this interference pattern, only two paths were used. It becomes much more complicated in 3 dimensions with nearly an infinite number of paths.



Small modifications, big results



Asymmetry

Many links exhibit asymmetric behavior, with traffic in one direction suffering much more loss

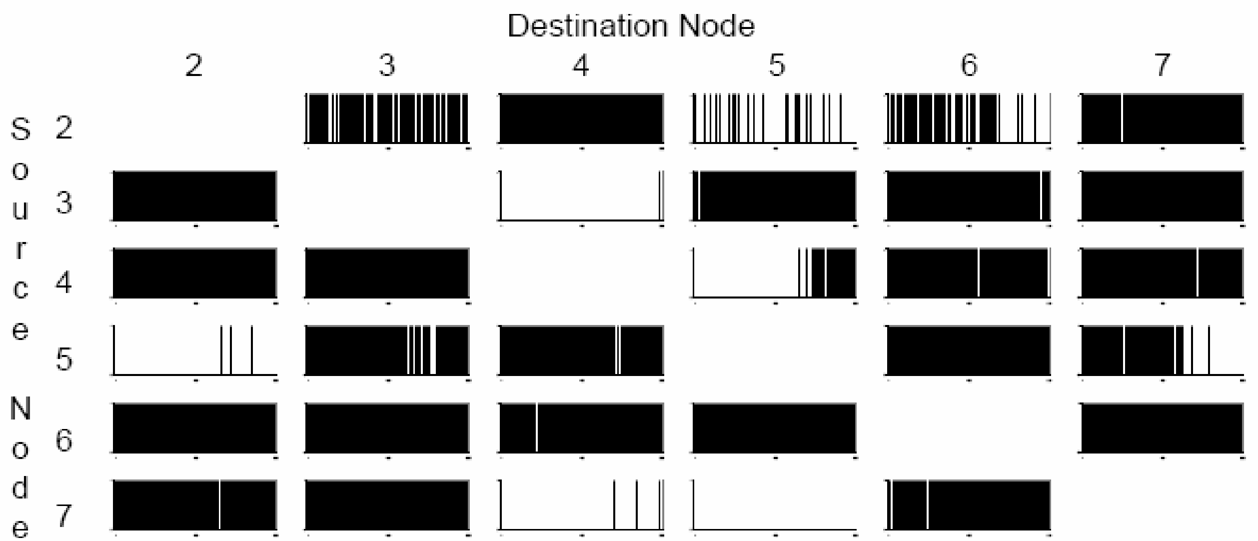


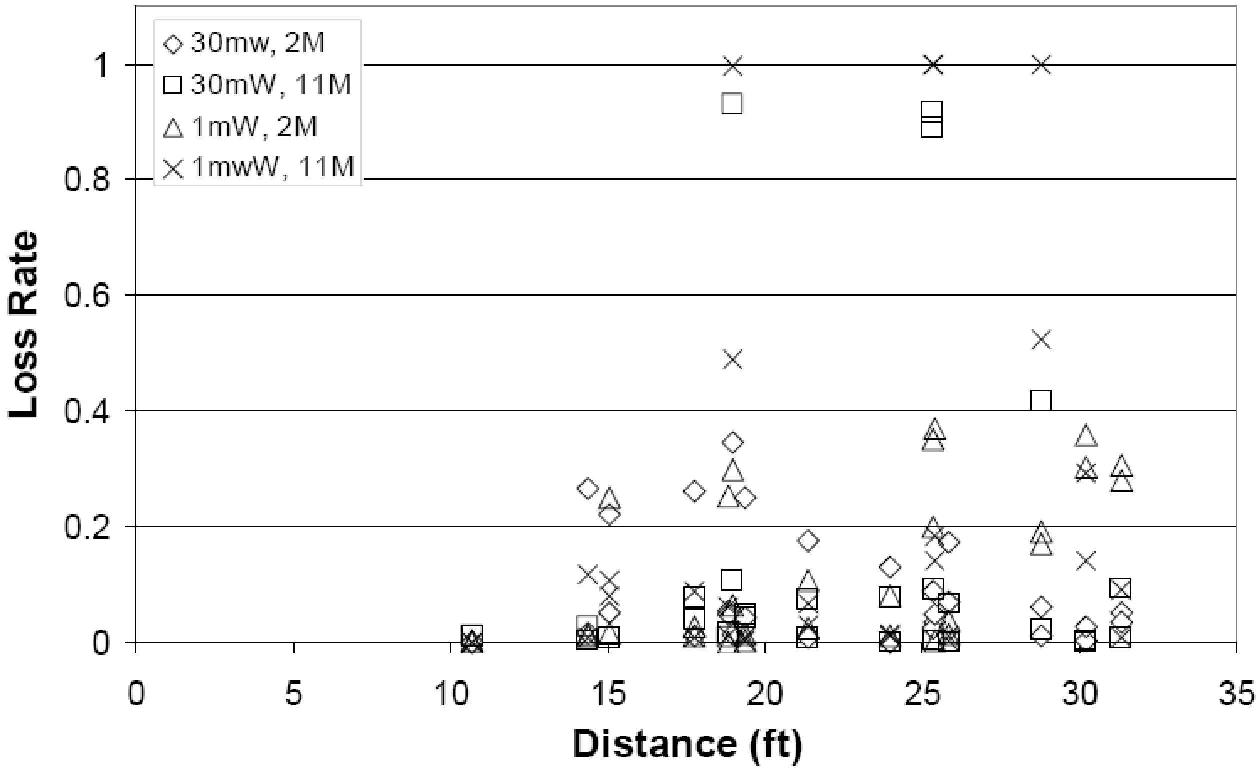
Fig. 1. Matrix of probe packets successfully delivered between each pair of nodes in *ushome1* at 30mW and 2Mbps.

Distance’s impact on quality

- Distance between nodes did not make much of a difference
  - When signal range is hundreds of feet, attenuation is not an issue inside a 12 room house
- Experimental results suggest no correlation whatsoever
  - For all homes and all other parameters

Distance Results

It's hard to find any correlation in the data – the results appear to be chaotic and independent of transmission rate or power.



Microwave oven interference

- Impact of an operating microwave oven on network performance is low if receiver is more than a few feet away

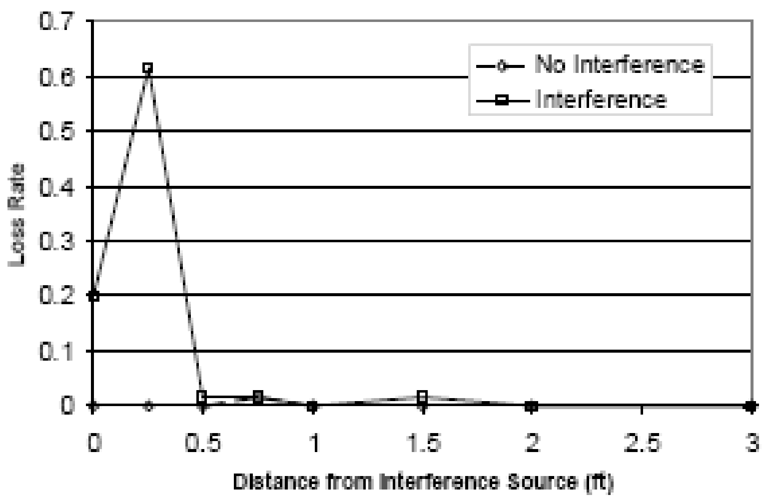


Fig. 10. The impact of a 600W microwave on a receiver at varying distance from the interference source and a distance of 15 feet from the sending node.

Comparison of 802.11a & 802.11b

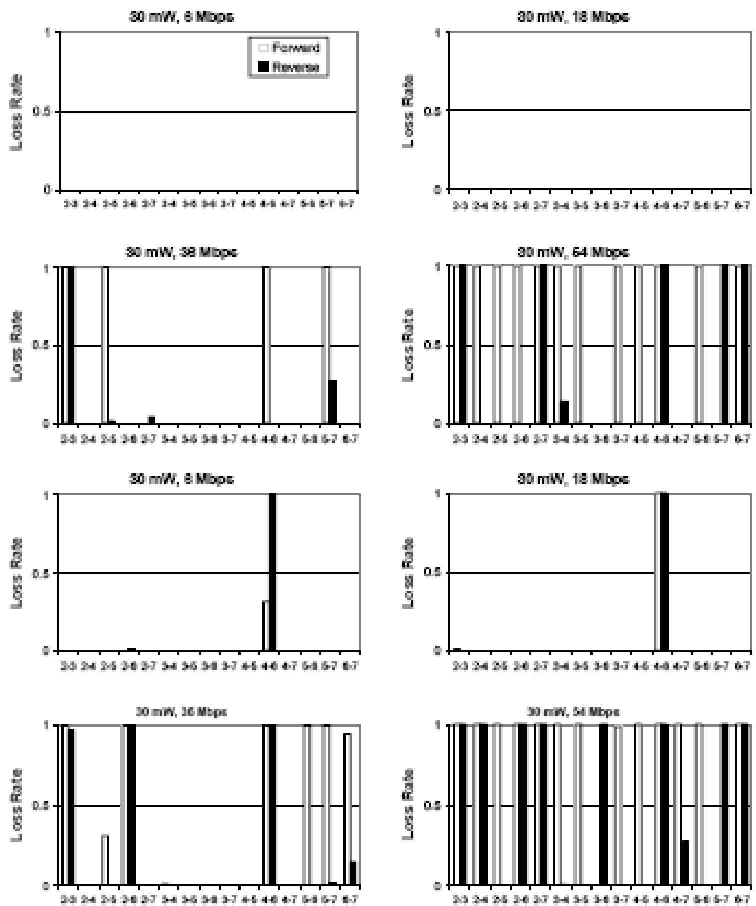
- Many similarities:
  - As transmission rate increases, loss increases
  - Many links lossy, some highly asymmetric
  - Sensitive to small changes in position
  - No correlation between loss rates and distance
- Difference:
  - 802.11a shows ‘binary’ behavior, links have either no loss, or very high loss percentage

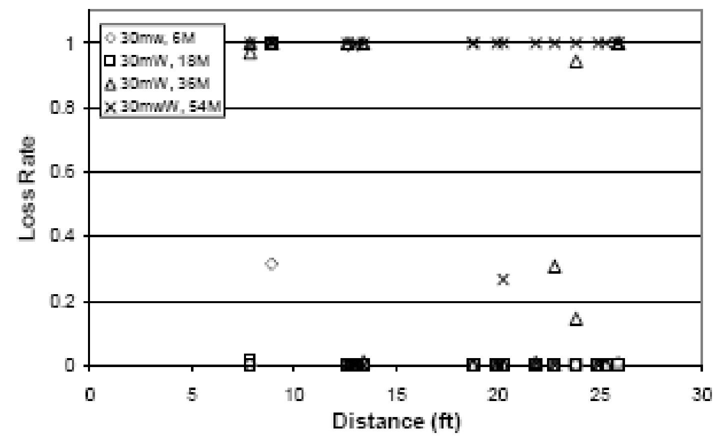
‘Binary’ behavior

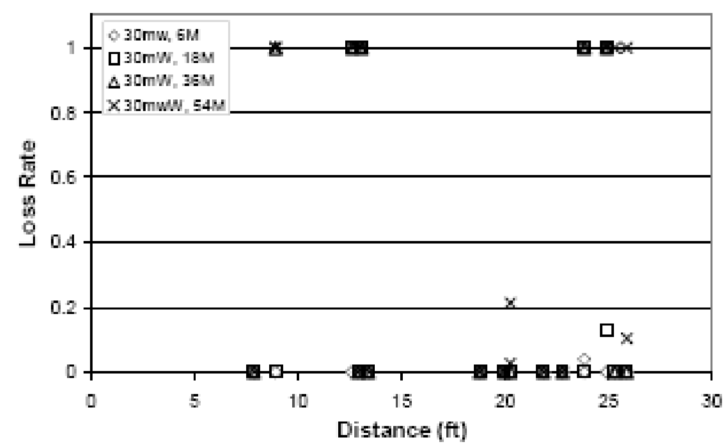
No correlation between distance and loss rate

(a)

(b)







Overall, the performance of 802.11a is slightly better than 802.11b.

Results

- Most preconceptions about wifi were upheld:
  - Loss rate increases with transmission rate increase
  - Loss rate decreases with transmission power increase
  - Some links are highly asymmetric
  - Exact positioning of nodes is the biggest factor in wifi connectivity
    - Trial and error

Implications

- Large numbers of obstacles produce chaotic distribution of optimal access point locations
  - Most home users do not realize this, and assume centrally locating the AP is the best strategy
- Need for self-configuration technologies