Characterization of 802.11 Wireless Networks in the Home

By Mark Yarbis, Konstantina Papagiannaki, and W. Steven Conner

Presented by Chung Tran CS 577
Introduction

- Graphs are presented differently in the Intel Report versus the paper I have. I will use the graphs and table from the Intel report because I can copy it and put it into this PowerPoint presentation.
- This experiment is important because of the popular rise of wireless network versus wired network.
- Even though the paper did not say too much about it, the popular rise of mobile devices has made this even more in demand.
- Experiment used IEEE 802.11a/b cards used in home 3 to be exact 1 in United Kingdom 2 in the United States.
Experimental Environment

A. Experiment Setup
   - 6 wireless nodes in each homes.
   - Node deployed in different rooms

B. Methodology

C. Validation
Experimental Environment

- Determine the quality of wireless links in home environment
- Ad-Hoc network 5 channels away from the next 802.11 frequency
- Each nodes are to send series of UDP probe packets
- Size 1024 bytes
- Duration of 150 seconds
- Frequency of 500 ms/packet
- Wireless link access independently and no simulation transmissions take place inside the network
- Take place at night time to avoid human interference
Factors this papers investigate

- Type of house; size, construction materials
- Wireless Technology used 802.11a and 802.11b
- Transmission rate = txrate
- Transmission power = txpower
- Node location
- Interference with appliances
TABLE 1

DESCRIPTION OF HOMES USED IN EXPERIMENTAL TESTBEDS.

<table>
<thead>
<tr>
<th>Label</th>
<th>Size (ft²)</th>
<th>Construction</th>
<th># Floors</th>
<th># Nodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>ushome1</td>
<td>2,500</td>
<td>Wood</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>ushome2</td>
<td>2,000</td>
<td>Wood</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>ukhome1</td>
<td>1,500</td>
<td>Brick/steel</td>
<td>3</td>
<td>6</td>
</tr>
</tbody>
</table>
2nd floor

1st floor

initial deployment

change in orientation
Layout UKHome

3rd floor

2nd floor

1st floor

initial deployment

change in orientation

change in node location
Fig. 7. Abstract home floorplans and location of links with greater than 95% loss rate at 1 mW and 11 Mbps under different configurations: (a) ukhome1

For layout1, layout2, and layout3, (b) ushome1, and (c) ushome2 for layout1 and layout2. Dashed lines indicate asymmetric links.

The original layout put Ukhome for layout 1 I decided to switch it up so it lineup with the Table 1. This layout help explain how they deploy the nodes.
Experimental Setup 802.11b

- 802.11b
  - Small form-factor PCs with Netgear MA701
  - Compact flash 802.11b wireless cards
  - Linux Kernel 2.4.19
  - Hostap driver
Experimental Setup 802.11a

- 802.11a
  - Laptops with NetGear WAG511
  - BusCard 802.11a
  - Linux Kernel 2.4.26
  - MIT madwifi-stripped driver
Methodology 3 Factors

- Here they test 3 factors this is done using the layout I show earlier
  - Node Location
  - Antenna Orientation
  - Obstacles
- txrate from 2Mbps to 11Mbps
- txpower from 1 mW to 30 mw
Figure 1: 30mW and 2Mbps

<table>
<thead>
<tr>
<th>Source Node</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Interesting notes about figure 1

- Communication between 5-2 is very low
- Communication between 3-4 very low success rate
  - But the reverse 4-3 is very high success rate nearly loss-free
- We can continue to find this asymmetry link from other studies this seems to be quite common in home environments stated by the authors in the experiment
- There other cases these are just the extreme cases the author point out so reader can have a better understanding of the experiment
Fig 2a. Loss rates for each pair of nodes in two runs at ushome1
Fig 2b. Loss rates for each pair of nodes in two runs at ushome1.
Authors comments and my personal thought

- There are 2 run on ushome1 so there is fig.2a and fig.2b
- The authors suggest that fig.2 where poor or asymmetry in 1 run will be the same in run 2
- The graphs seems to support their claim
- The next graph fig.3 is to valid weather 150 seconds was long enough to determine if loss-rate is enough to uses as a measurement
- This graphs is base on 150 seconds versus 20 minutes
Fig 3 x-for 150 sec y-for entire 20 min
Fig 4 entire day

- Early in the paper it was stated that this experiment was conducted during night time to avoid human interference.
- Fig 4 wants to explore the effect of loss throughout the day.
- Since figure 3 determined that 150 was an acceptable measurement for testing, they used it to determine different times of day for fig 4.
- First bar is from node 4 to node 6.
- Second bar is from node 6 to node 4.
- txrate = 11 Mbps, txpower = 30mW.
Figure 4
Figure 5 a ukhome layout1
Figure 5 ushome1 layout 1
Figure 5 ushome2 layout 1
Something very interesting I want to point out

- I will show figure 7 again this is the layout where these graphs are presented.
- In ukhome layout 1 the most loss happen between nodes 2 to 6 or 6 to 2
- However those 2 are actually on the same floor yet their loss-rate in layout 1 show they are have the highest loss-rate
- Same with ushome1 2-5 and 5-2 have the same problem in all 4 graphs it show it have the consistence high loss-rate
- As for ushome2 I cannot conclude the same because the loss-rate however I can see that 5-6 still have a consistence loss-rate higher then the rest even those it on the same floor
Ukhome Layout 1 on Figure 7
Strange 2.5
Ushome2 layout 1 figure 7

Strange 5-6
What does all the line means

- The authors pointed out that their black line indicate asymmetry link.
- I draw in the red line to focus on the loss-rate between these nodes.
- However figure 7 only show when txrate = 11 Mbps and txpower = 1mW.
- Layout 2 is to test location of nodes and orientation of antenna.
- Let take a look at each graph when we show them next to each other, by putting them side-by-side I hope to show the effect of layout 1 versus layout 2.
Ukhome layout 1 versus layout 2
Ushome1 layout 1 versus layout 2
Ushome2 layout1 versus layout2
Result of changing the layout

- Ukhome there was a significant changes as we can see with the loss-rate
- The drastic loss-rate are shown in all the graph it was just easier to see in ukhome that why I point that out first
- These small changes cause big change in the results
- This is cause by multi-path fading
Multi-path fading

- This is actually a very simple concept.
- We have a packet when it gets to a node it sends multiple copies throughout the network until it reaches the final destination.
- However, this causes it to interfere with itself when it reaches the final destination, the following is a simple analogy.
- I am a boss and I want a message delivered to someone.
- I give 4 copies of the message to my team (consist of 4) to see who can get it done the fastest.
- They run to the person I want the message to be delivered to, they all use different routes.
- When they get there the 4 underlings stand and wait and complain about who should be first to give the message.
Figure 9 loss-rate versus distance ukhome layout2
Figure 9 loss-rate versus distance ushome1 layout2
Figure 9 loss-rate versus distance ushome2 layout2
The authors suggest that obstacles is what determine the performance of home wireless link

Instead of what common sense would suggest of physical distance and power

This was pointed out at result III.D where loss-rate is not base on physical distance

I cannot follow these graph because the labeling was not very good

I only put it in because the authors seems to rely on this results and what they indicate very strongly
Inference source 600w microwave
What does preview graphs means?

- This use a microwave with vary distance to show how it interfere with the receiver side.
- The blue line show no interference so there almost no loss-rate.
- While the red line show that it lose rate will be effected by the interference at .25 it loss-rate was over 60 percent.
- Once it reach the distance of .5 the loss-rate almost become the same as no interference.
Figure 13 802.11a ushome1
Figure 13 802.11a ushome2

![Graph showing loss rate versus distance for different power levels. The graph includes data points for 30mW, 6M, 30mW, 18M, 30mW, 36M, and 30mW, 54M power levels. The x-axis represents distance in feet, ranging from 6 to 26 feet, and the y-axis represents loss rate, ranging from 0 to 1.]
Result of figure 13

- This should have shown us that loss-rate does not correlate with the distance between node pairs.
- I feel they need to label this better for reader to follow. I have a hard time following the graphs so no comment about it.
- Asymmetry link are going to occur there no way to prevent it on wireless network.
- To achieve a no loss-rate it possible but that require exact orientation and location of the nodes.
Figure 14 ushome1
Figure 14 ushome2
The graphs are based on Cumulative density function of loss rates under 802.11b and 802.11a in ushome1 and ushome2.

First thing I notice when I read this part is that 802.11a act very binary.

It seems that 802.11a at 6 Mbps seems the most reliable compared to 2 or 11 Mbps of 802.11b.

However, when they use 54 Mbps link encoded it performed very poorly between all pairs those values can be seen in figure 11 and 12.

The authors suggest that 802.11a uses 5 GHz band may be a contribute to the performance.
Figure 11a layout1
Figure 11b Layout2
Figure 12a Layout1
Figure 12b
This research shows that wireless links in home are:

- Stable over time
- Highly asymmetric
- Highly variable from one node to the next

In home precise node location is the single most important factor in network communication.

Before I read this paper, I thought it was going to be physical distance now I know it has more to do with how everything is oriented and what interfering with it, placement.