Characterization of 802.11 Wireless Networks in the Home

BY MARK YARBIS, KONSTANTINA PAPAGIANNAKI, AND W. STEVEN CONNER

PRESENTED BY CHUNG TRAN CS 577

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Introduction

- Graphs are presented differently in the Intel Report versus the paper I have. I will uses 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 those the paper did not say too much about it the popular rise of mobile devices have made this even more in demand
- Experiment used IEEE 802.11a/b cards uses in home 3 to be exact 1 in United Kingdom 2 in the United State

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

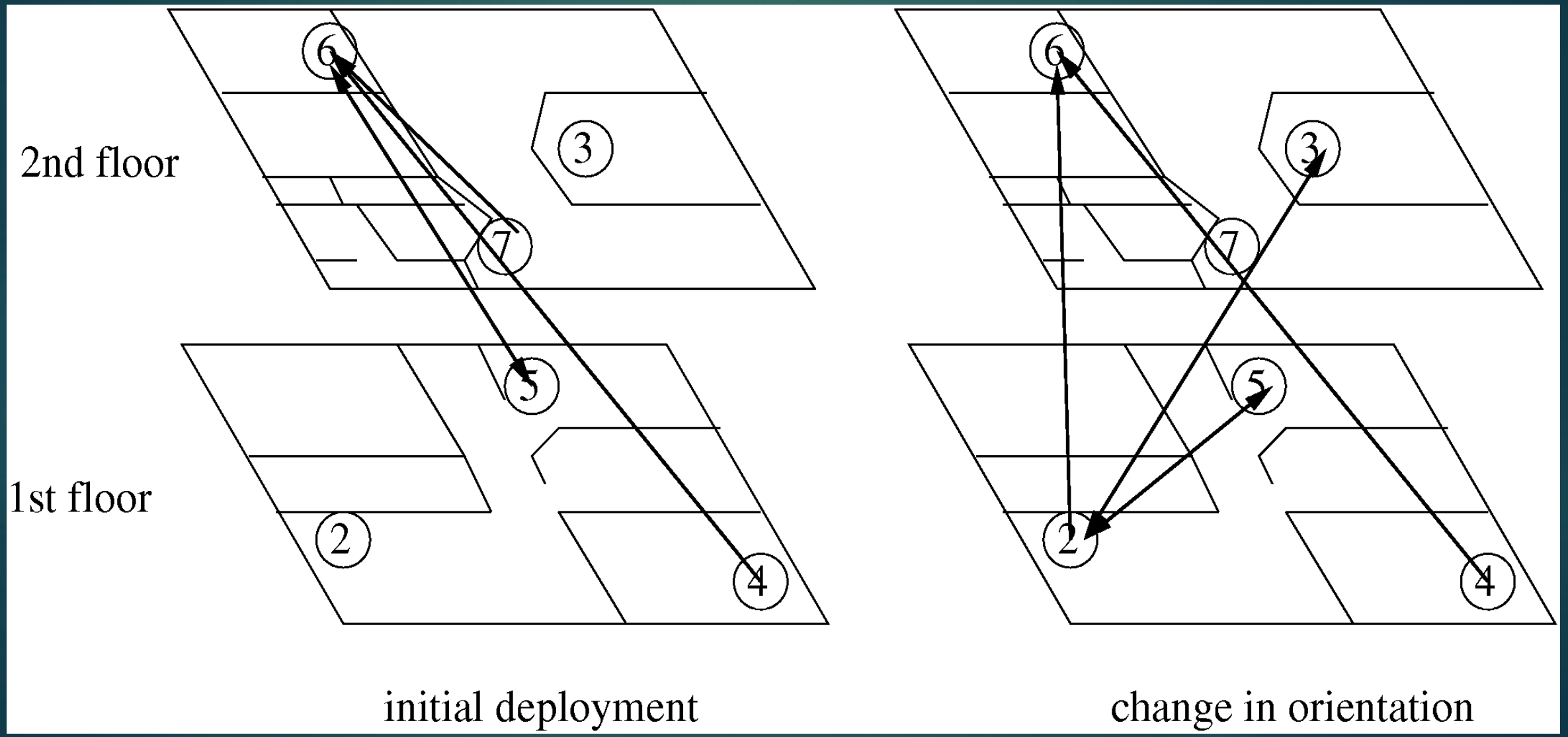
Table 1

TABLE I

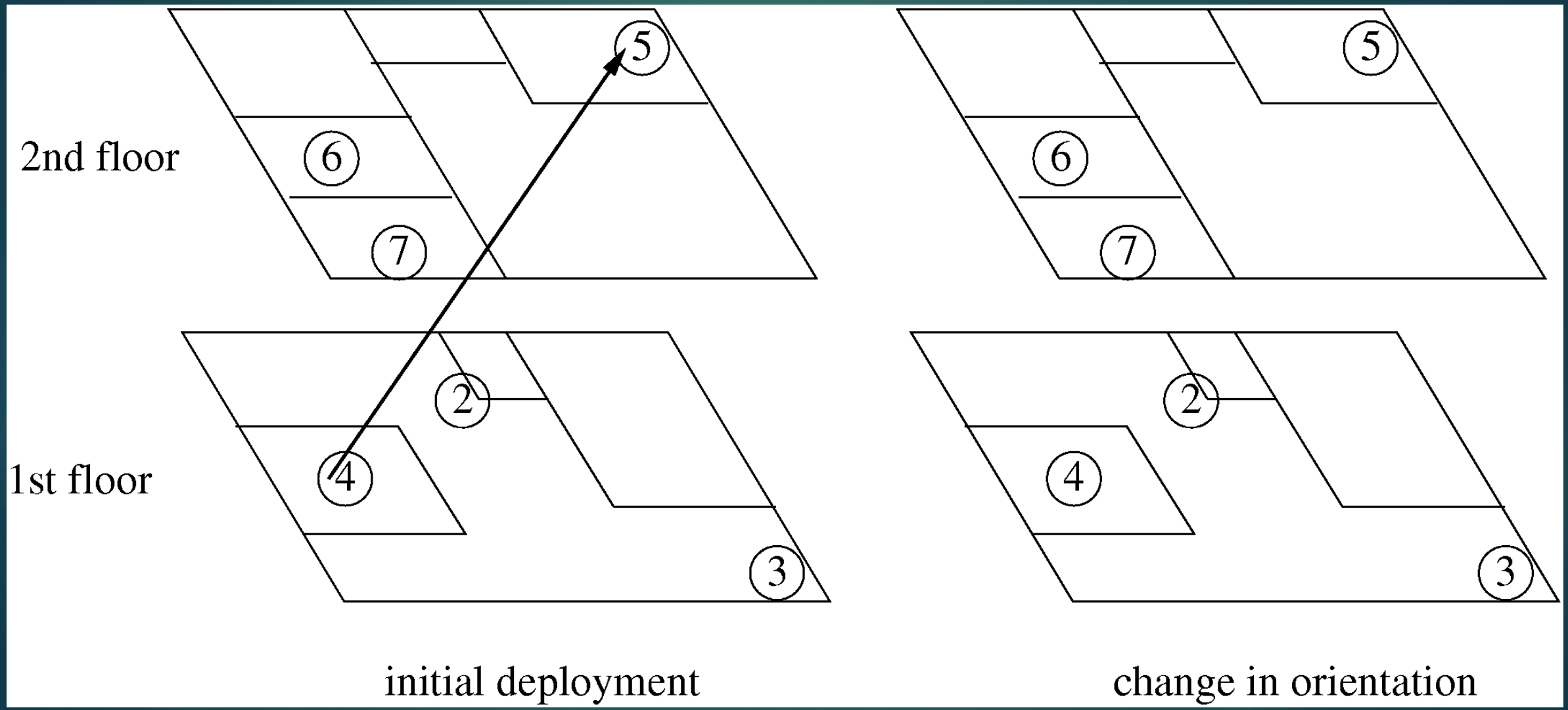
DESCRIPTION OF HOMES USED IN EXPERIMENTAL TESTBEDS.

Label	Size (ft2)	Construction	# Floors	# Nodes
ushome1	2,500	Wood	2	6
ushome2	2,000	Wood	2	6
ukhome1	1,500	Brick / steel	3	6

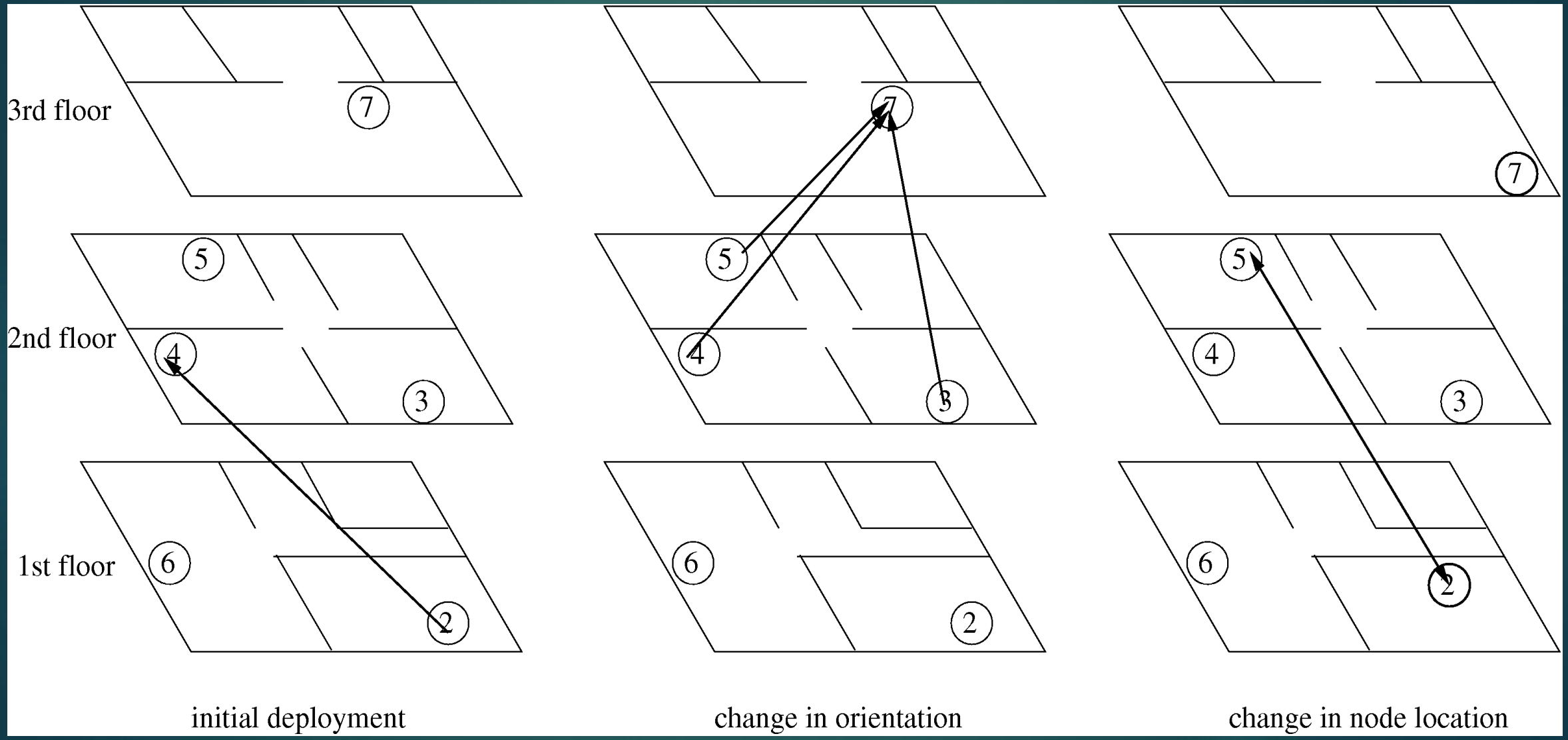
Layout UShome1



Layout UShome2



Layout UKHome



Details of Layouts

- 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

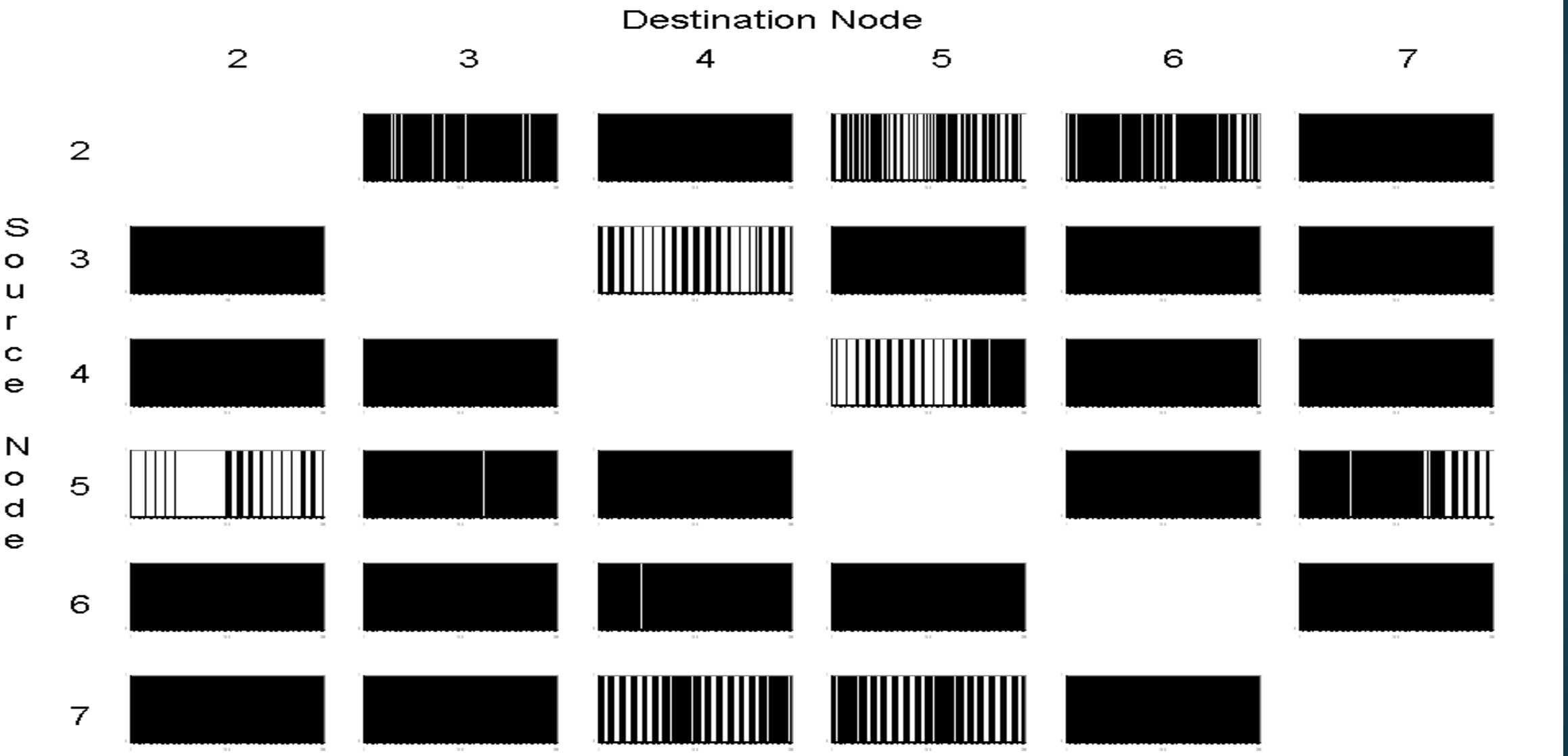
Experimental Setup 802.11a

- 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



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

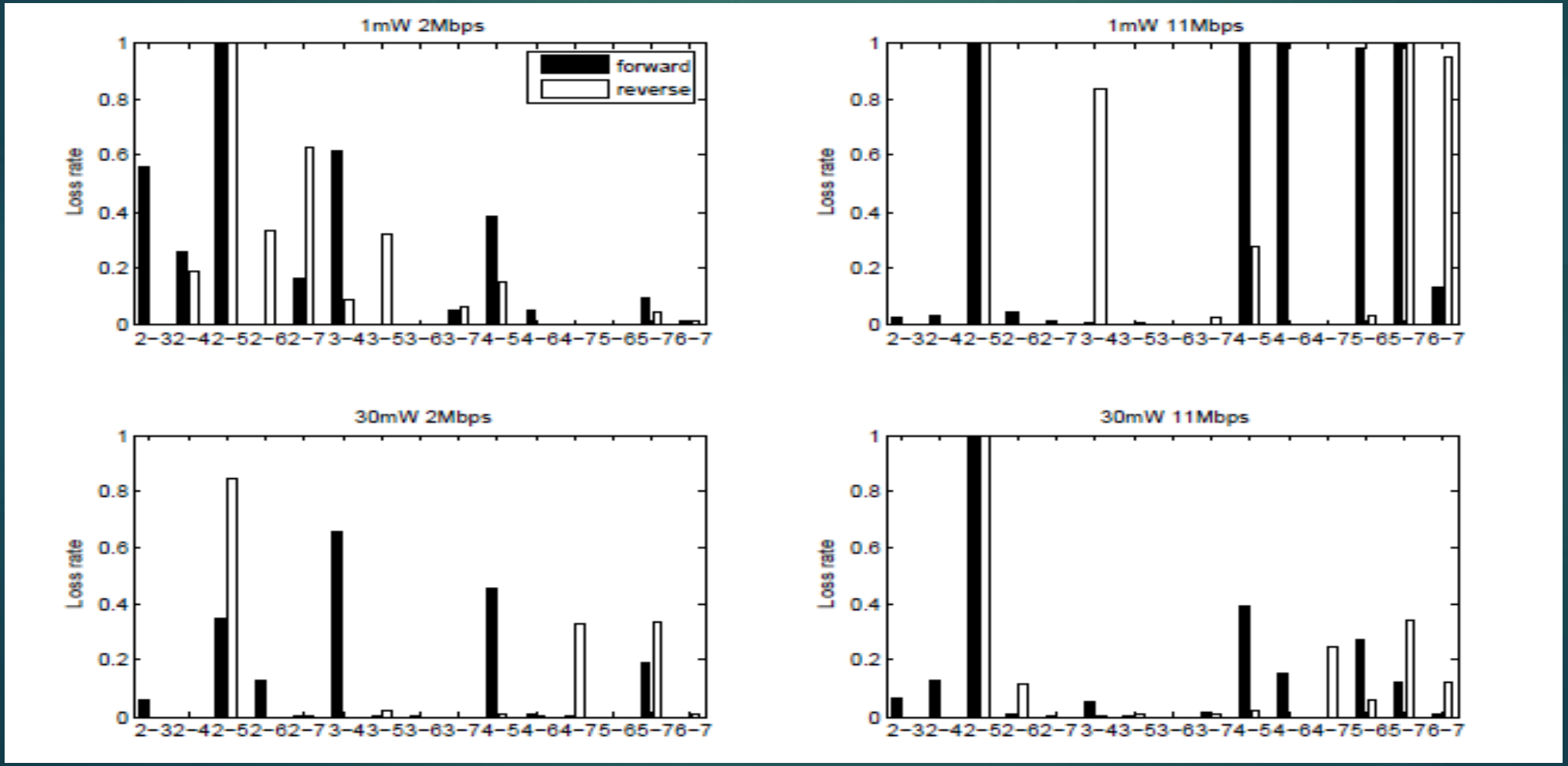
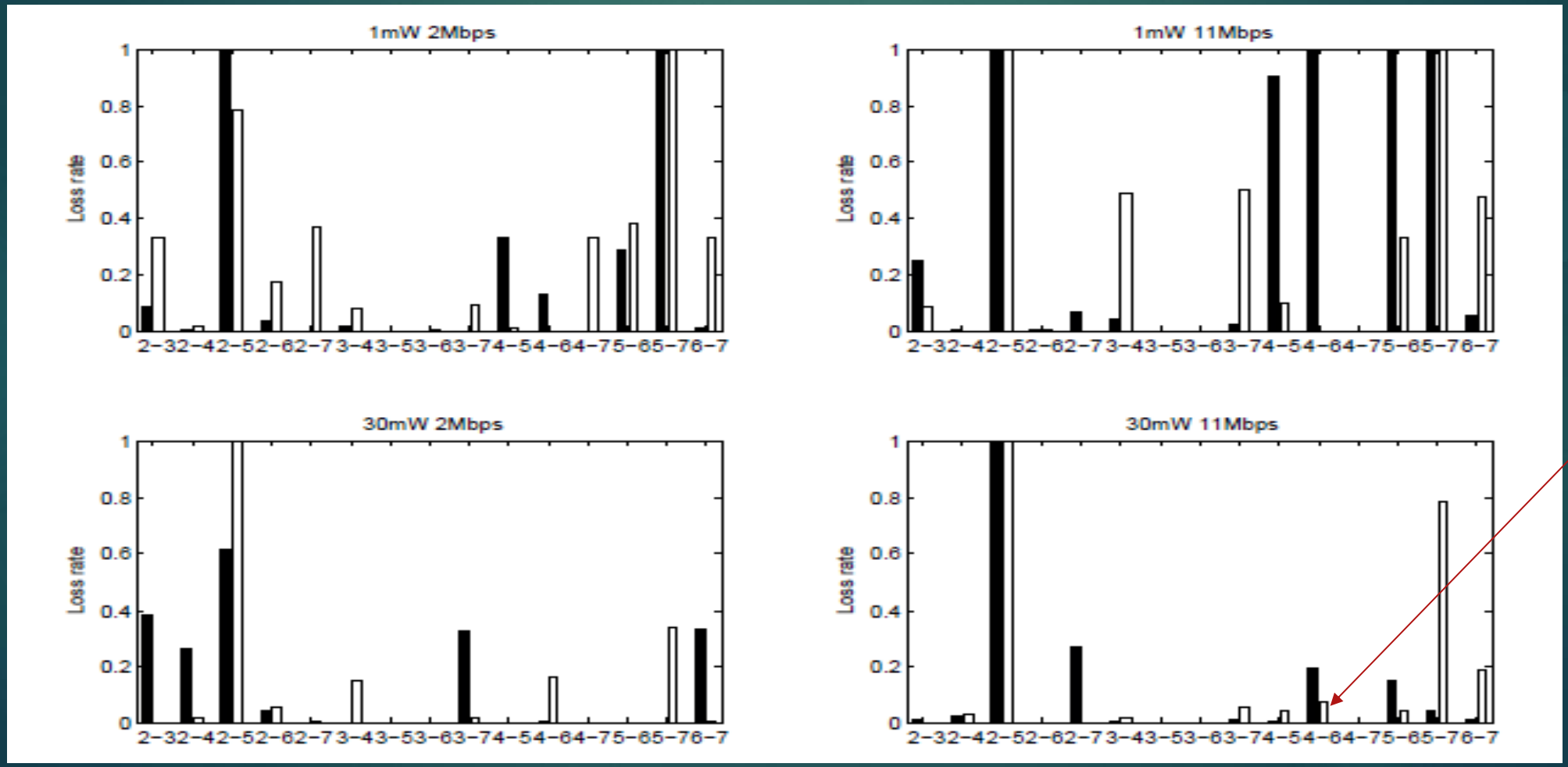


Fig 2b. Loss rates for each pair of nodes in two runs at ushome1



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

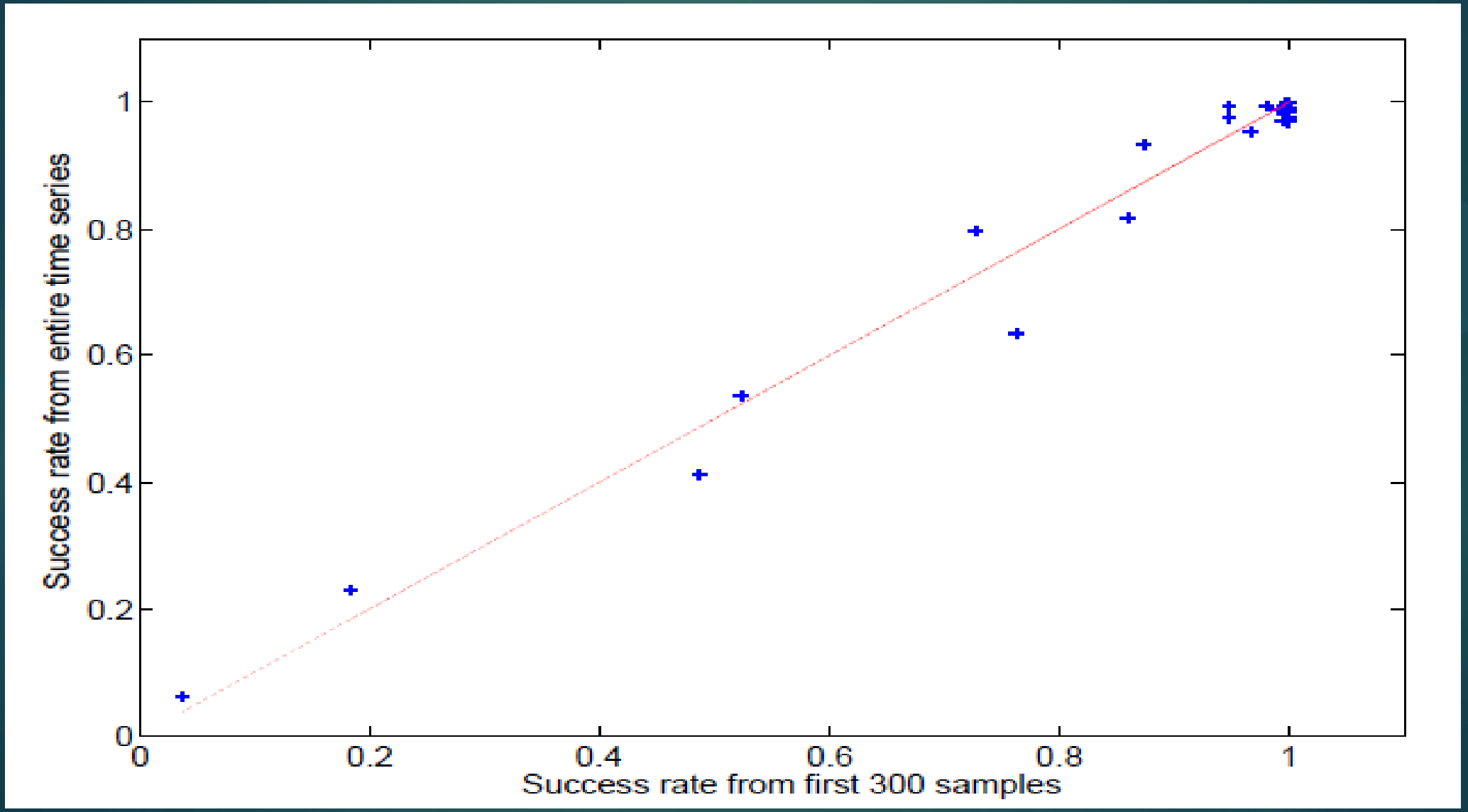


Fig 4 entire day

- Early in the paper it was stated that this experiment was conducted during night time to avoid human interference
- Fig 4 want to explore the effect of lose throughout the day
- Since figure 3 determine that 150 was acceptable measurement for testing that what they uses 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

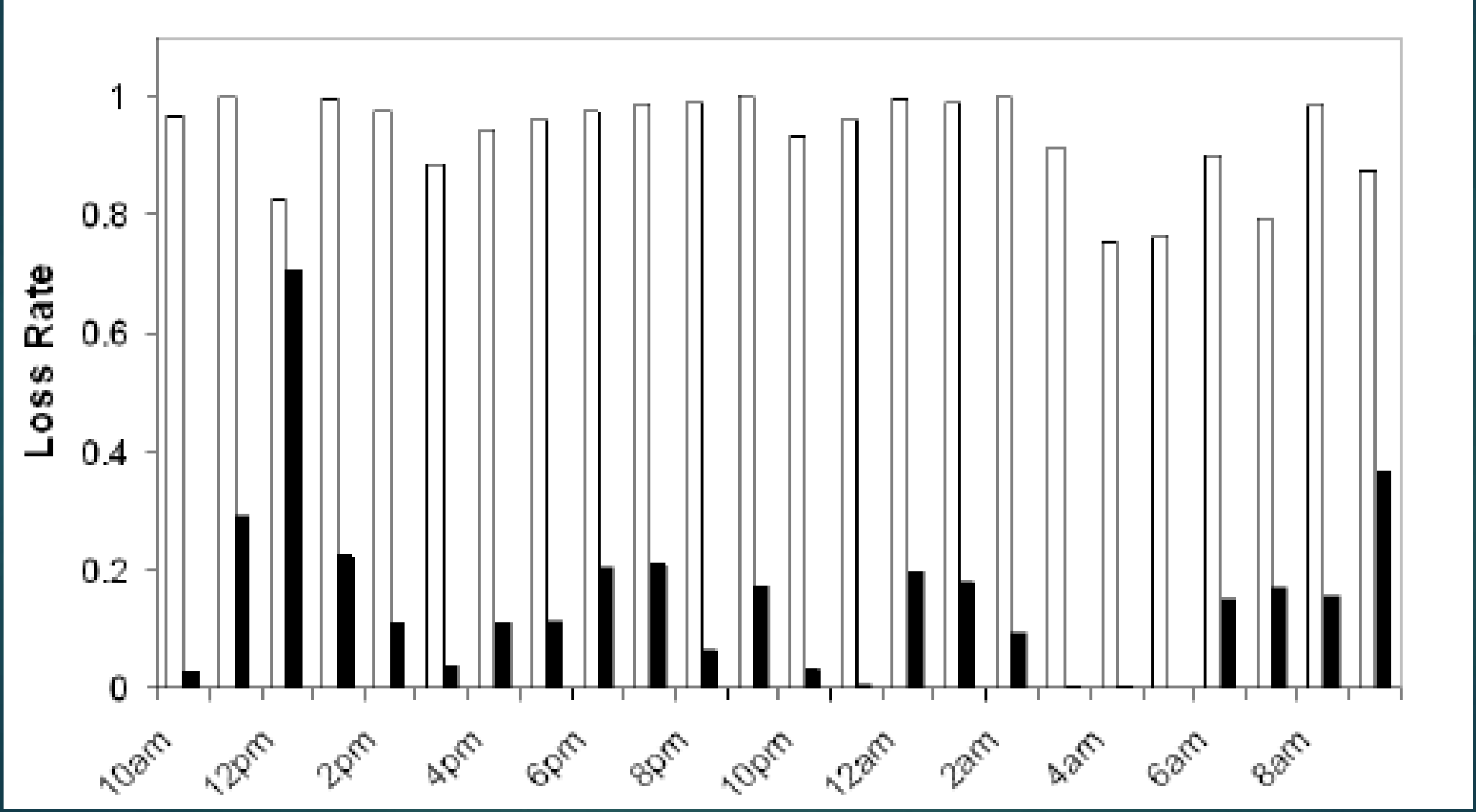

Loss Rate
1
0.8
0.6
0.4
0.2
0
10am
12pm
2pm
4pm
6pm
8pm
10pm
12am
2am
4am
6am
8am

Figure 5 a ukhome layout1

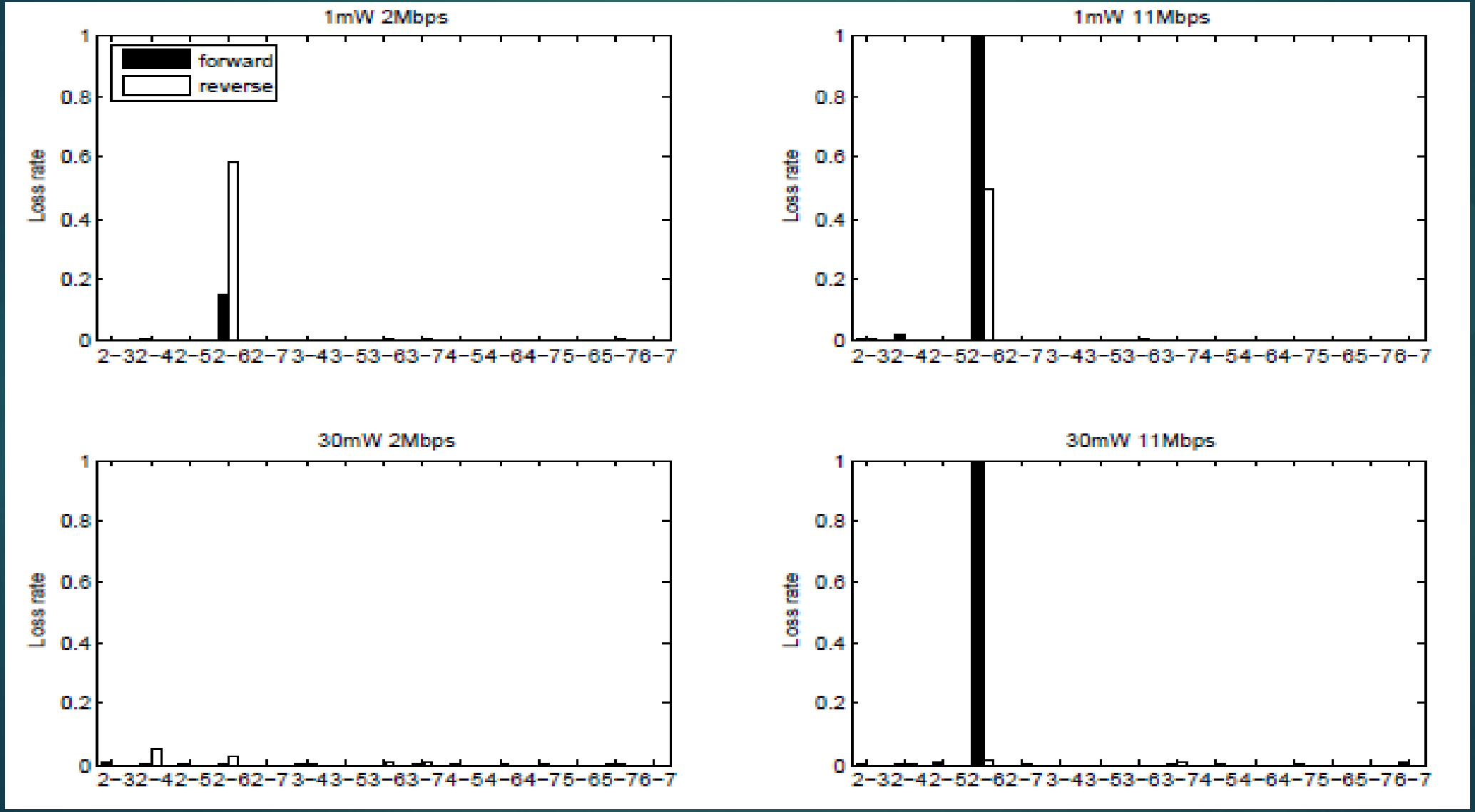


Figure 5 ushome1 layout 1

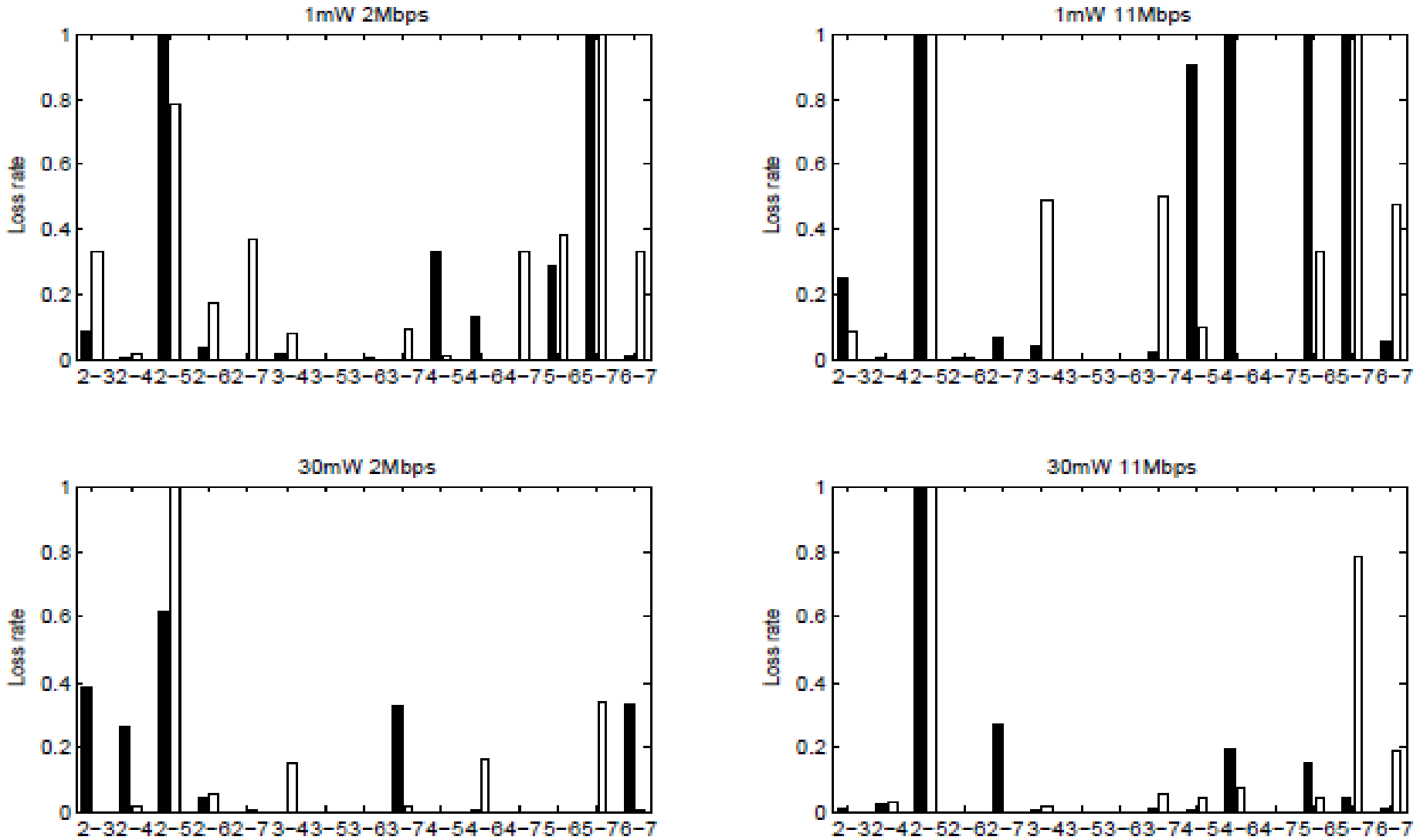
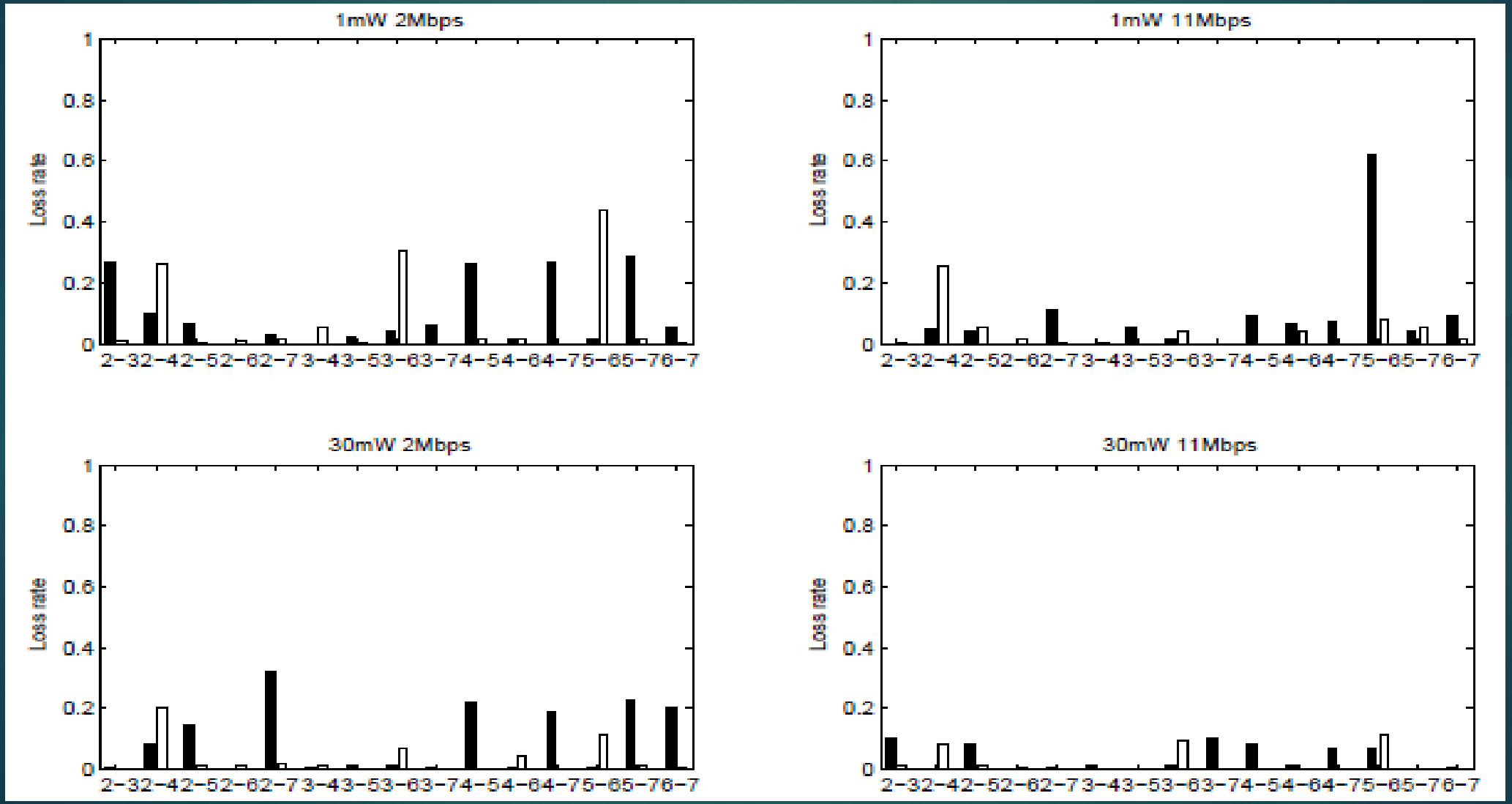


Figure 5 ushome2 layout 1

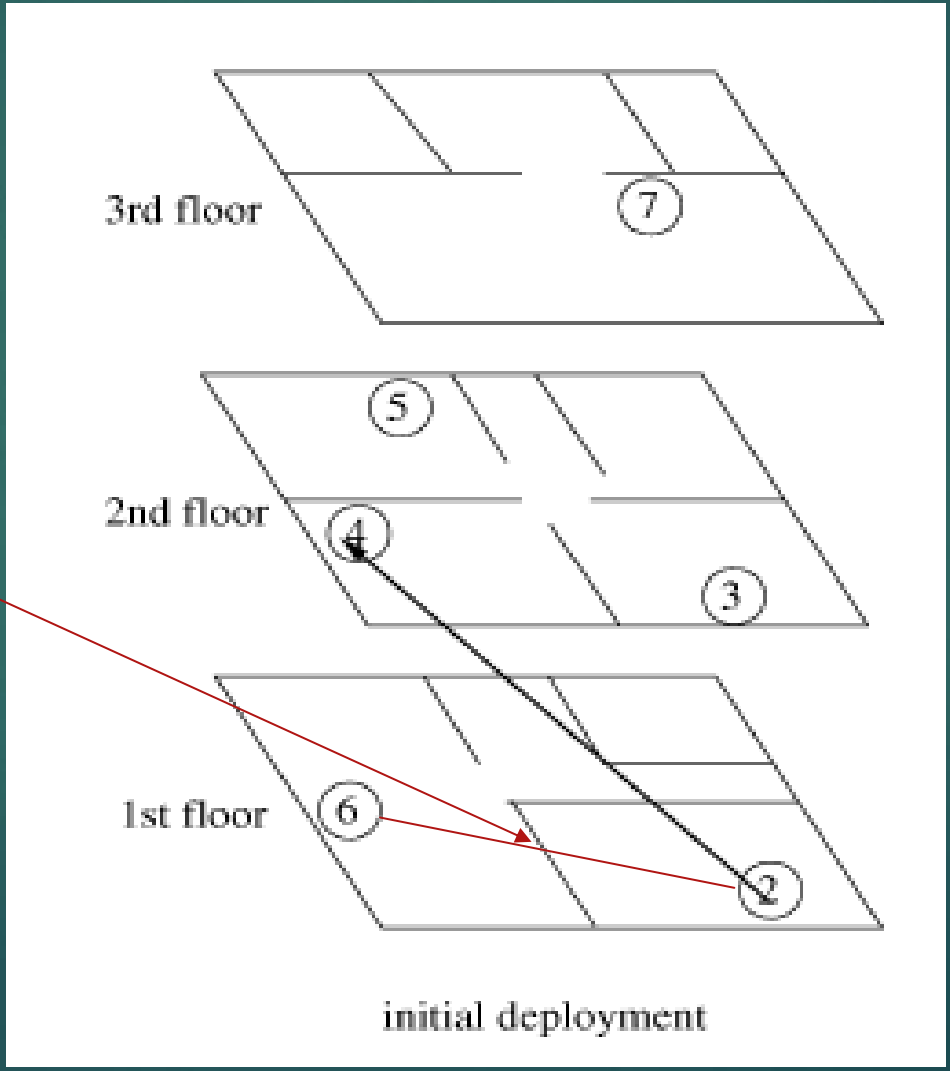


Something very interesting I want to point out

- 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

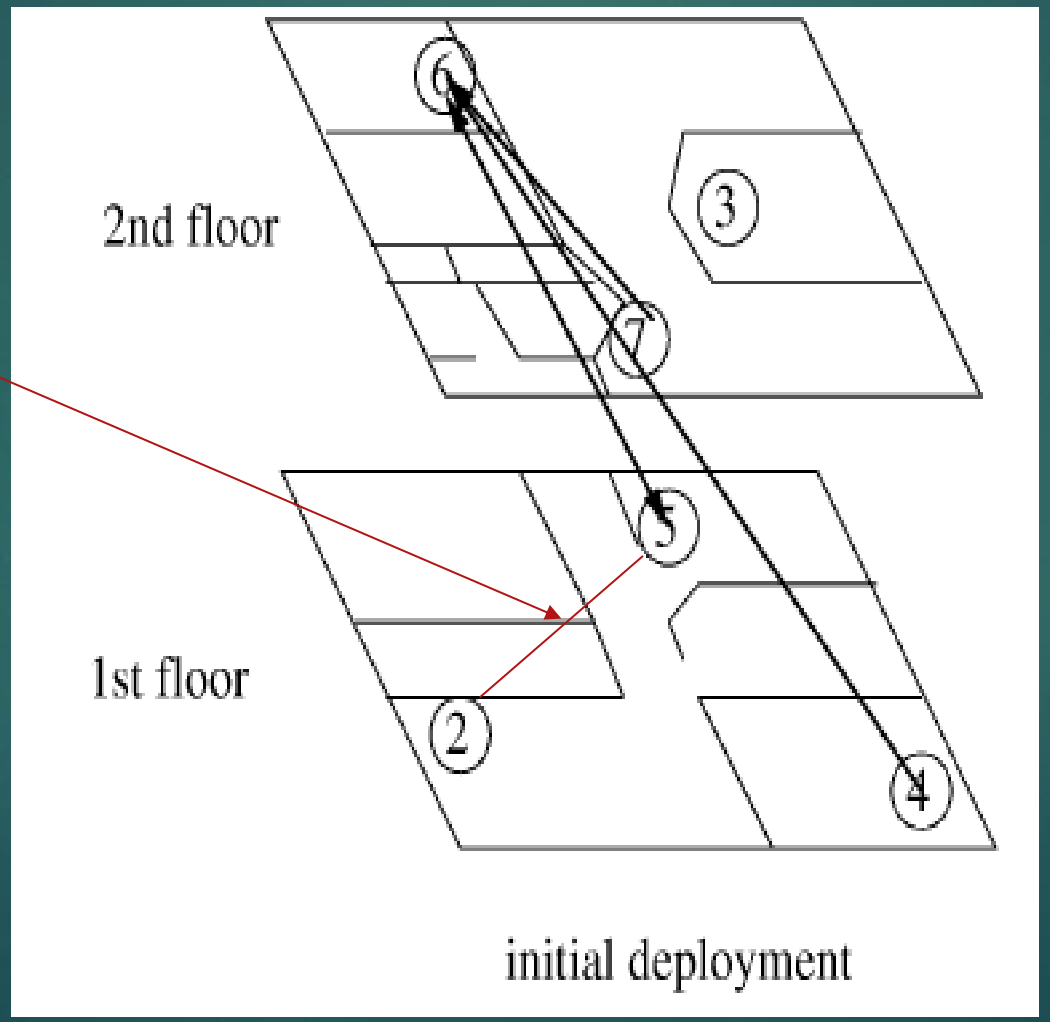
Ukhome Layout 1 on Figure 7

Strange 2-6



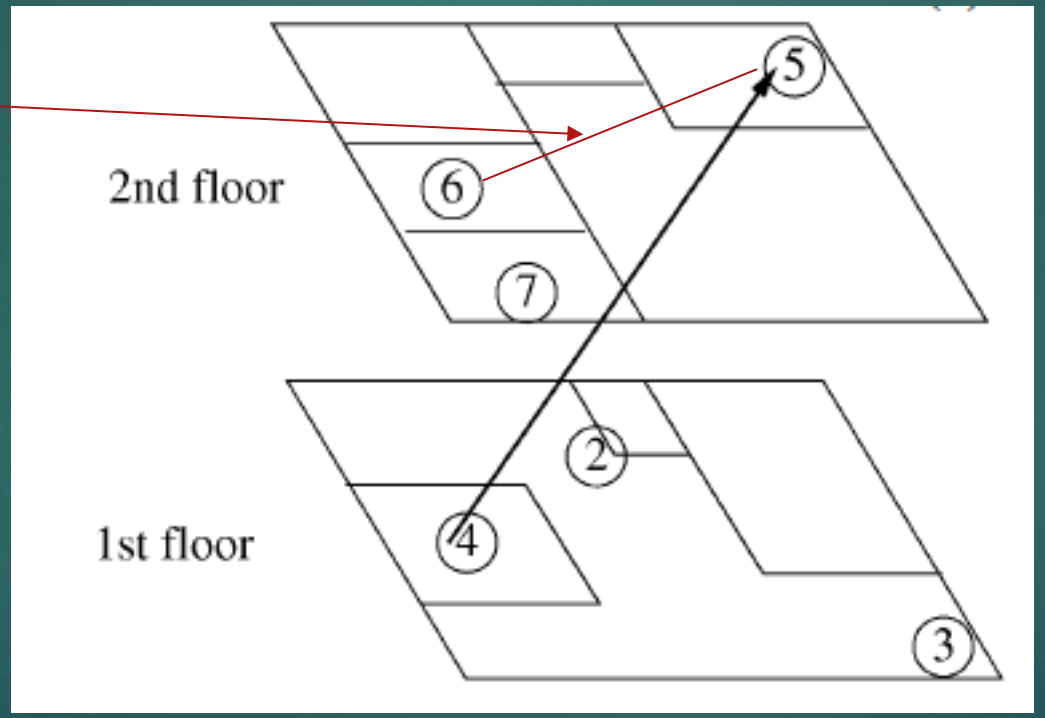
Ushome 1 layout 1 figure 7

Strange 2-5



Ushome2 layout 1 figure 7

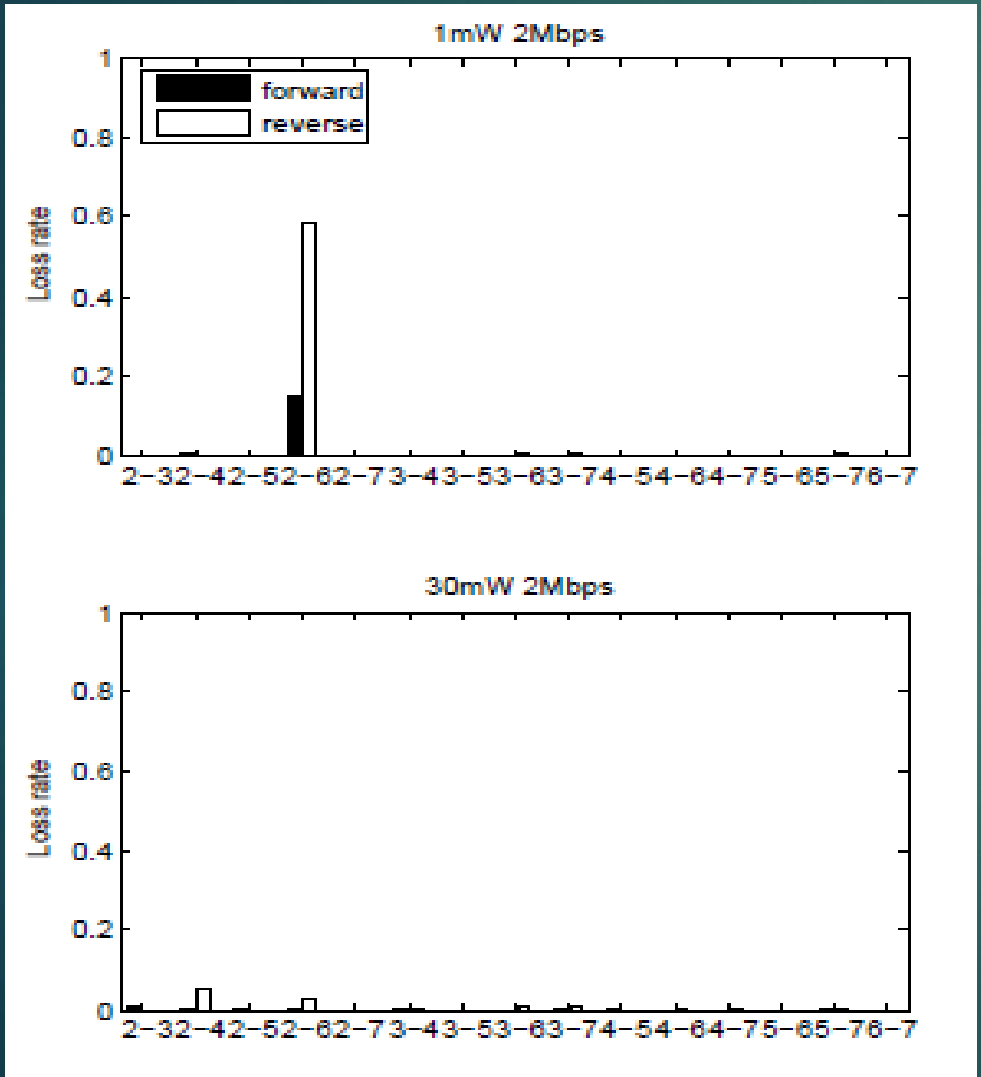
Strange 5-6

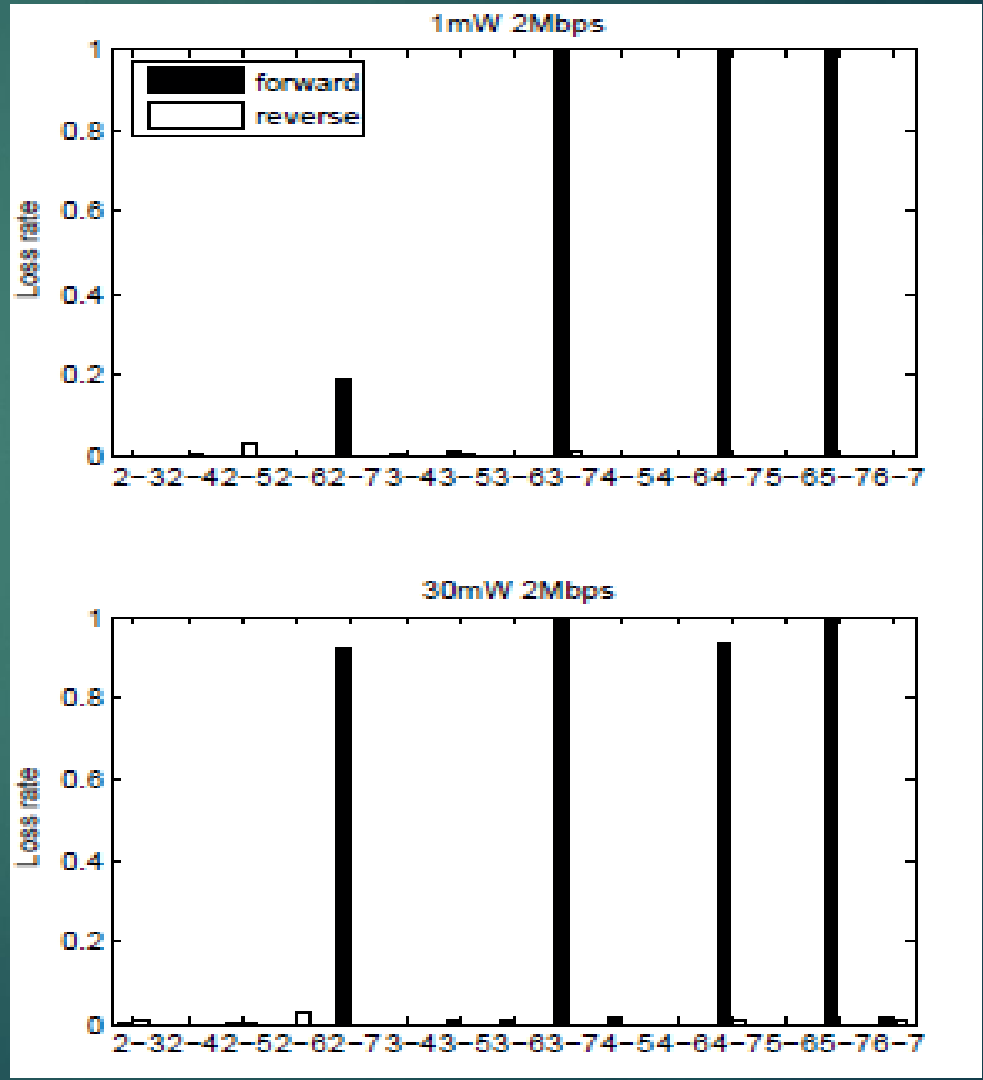


What does all the line means

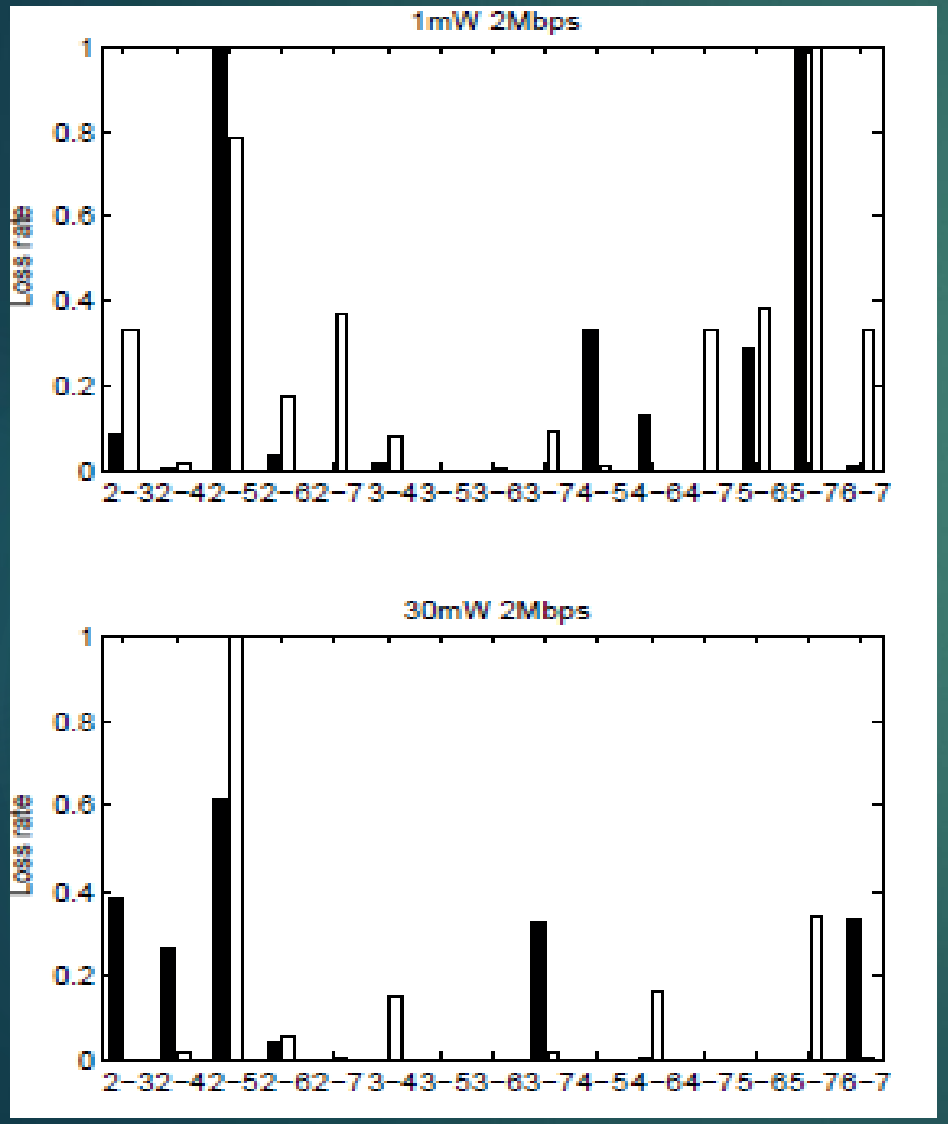
- The authors pointed out that their black line indicate asymmetry link
- I draw in the red line to focus on the loss-rate between these nodes
- However figure 7 only show when txrate = 11 Mbps and txpower = 1mW
- Layout 2 is to test location of nodes and orientation of antenna
- Let take a look at each 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

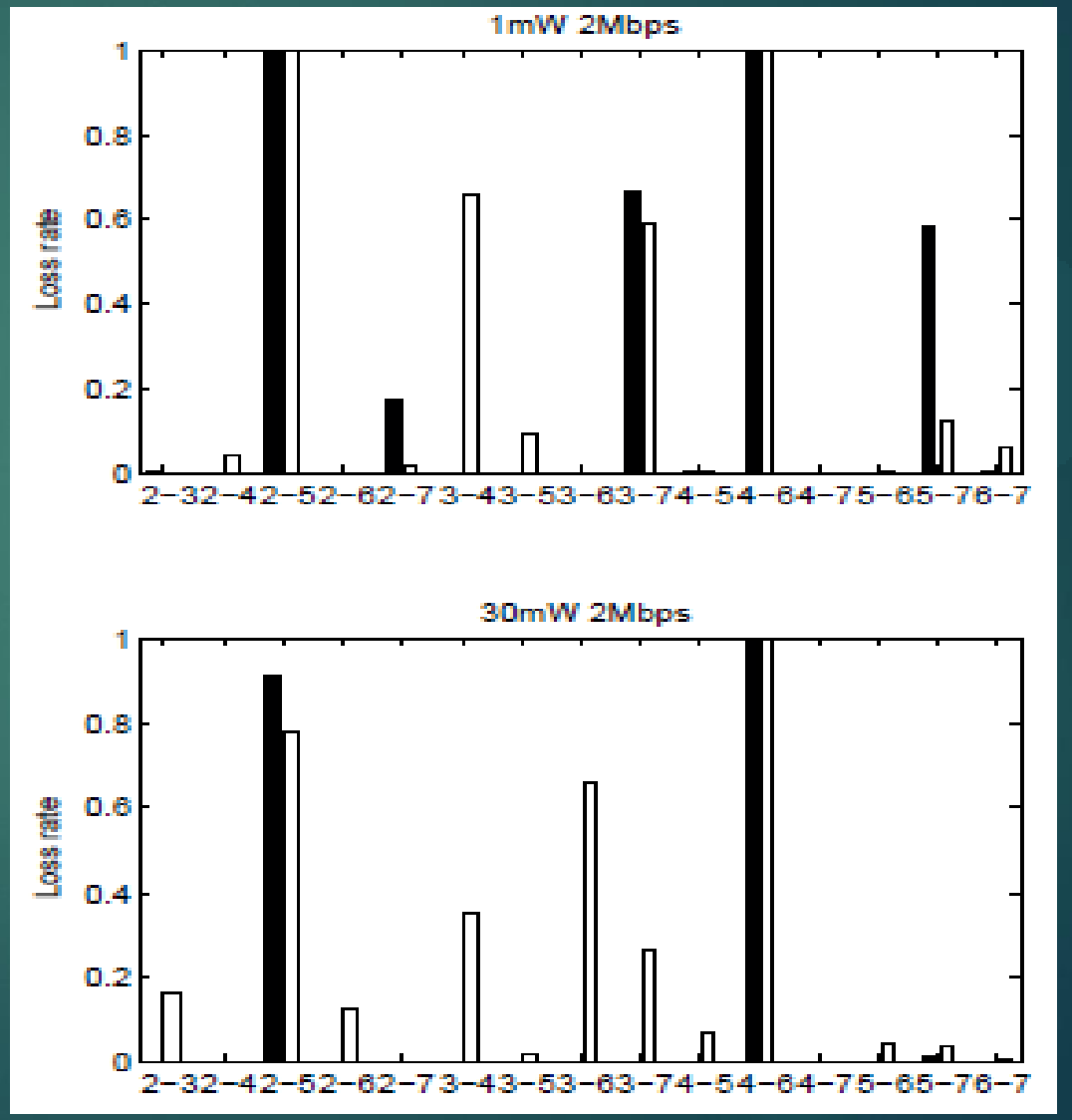
Ukhome layout 1 versus layout 2



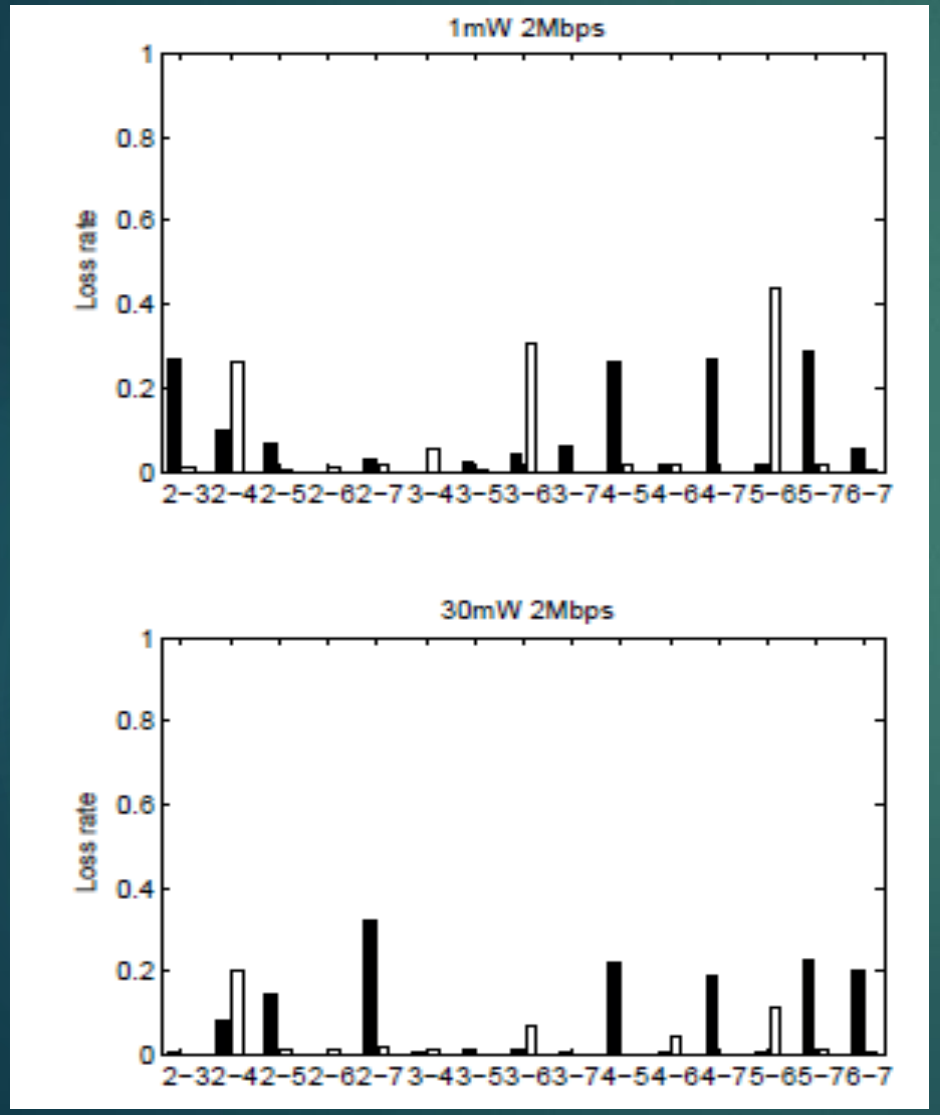


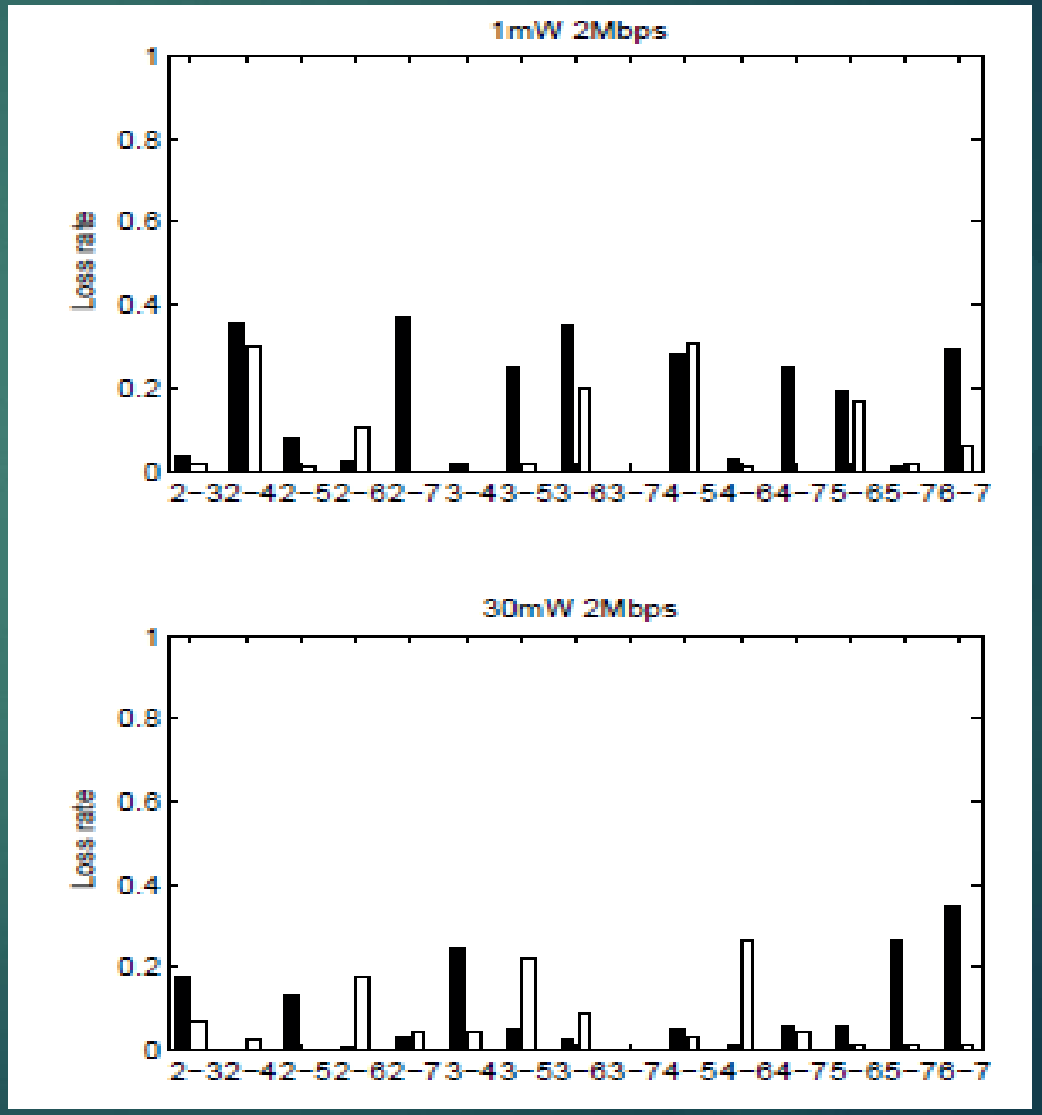
Ushome1 layout 1 versus layout 2





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 get to a node it send multiple copy throughout the network until it reach the final destination
- However, this cause it to interfere with itself when it reach the final destination, the following is a simple analogy
- I am a boss and I want a message deliver to someone
- I give 4 copy 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 deliver to they all uses different route
- When they get there the 4 underlings stand and wait and complaint about who should be first to give the message

Figure 9 loss-rate versus distance ukhome layout2

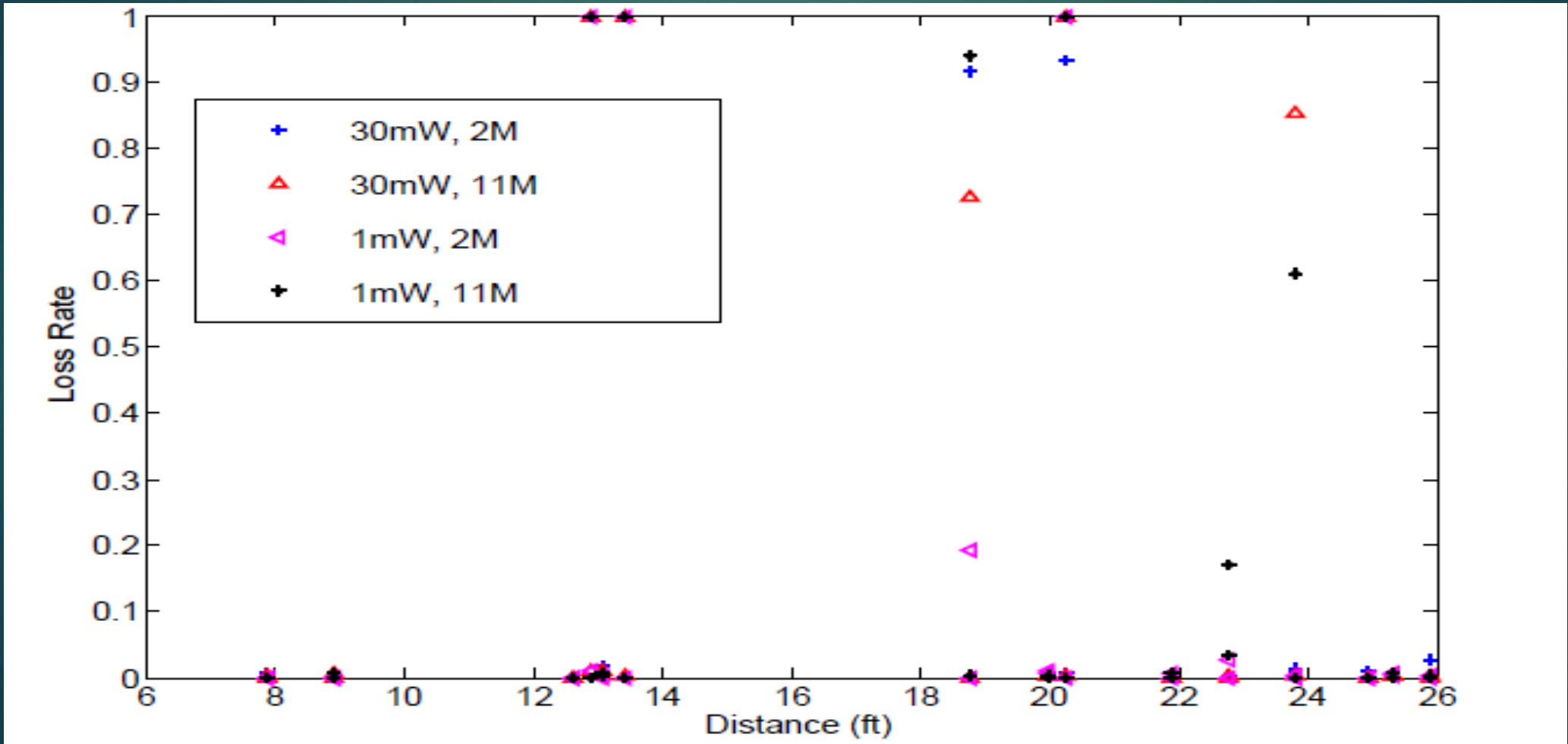


Figure 9 loss-rate versus distance ushome1 layout2

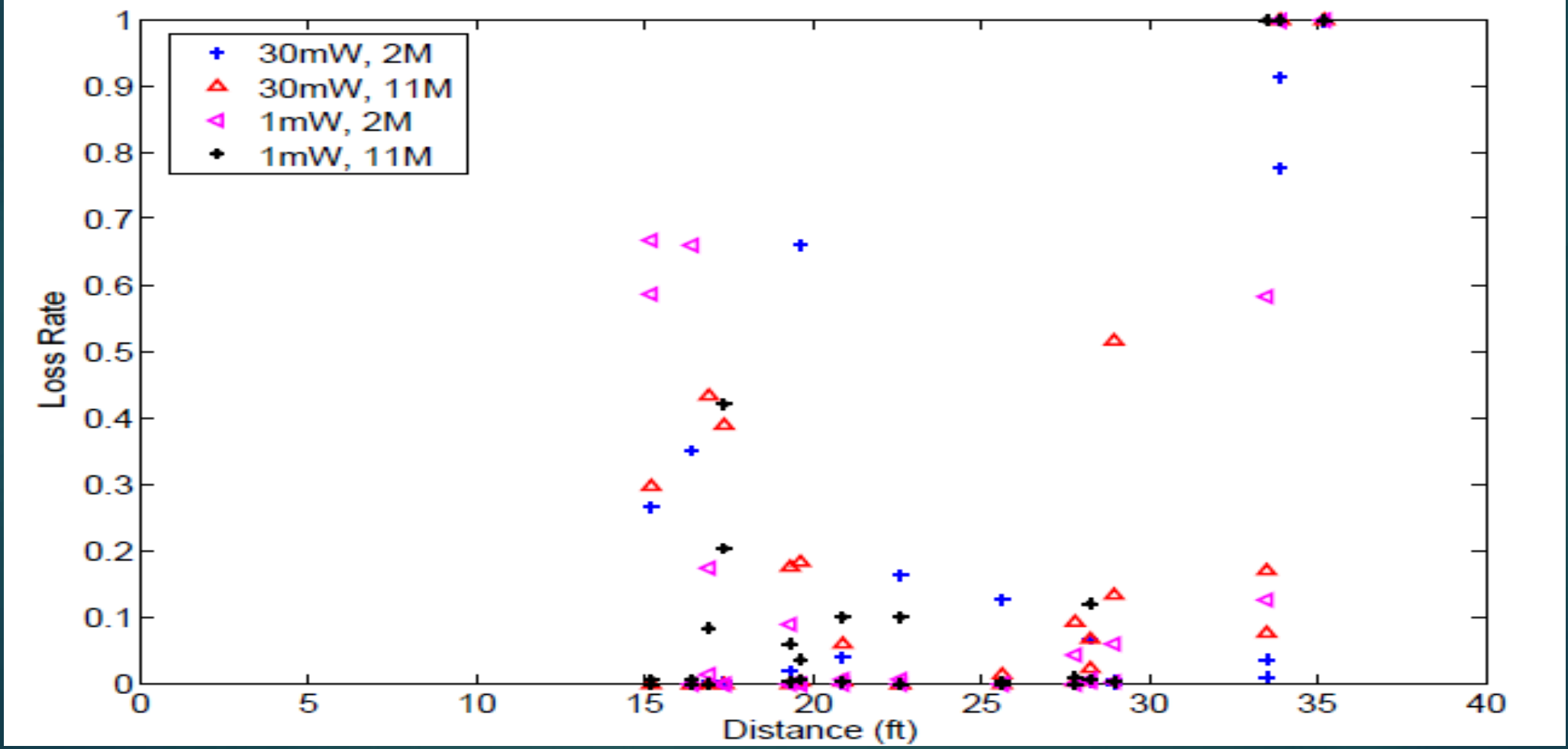
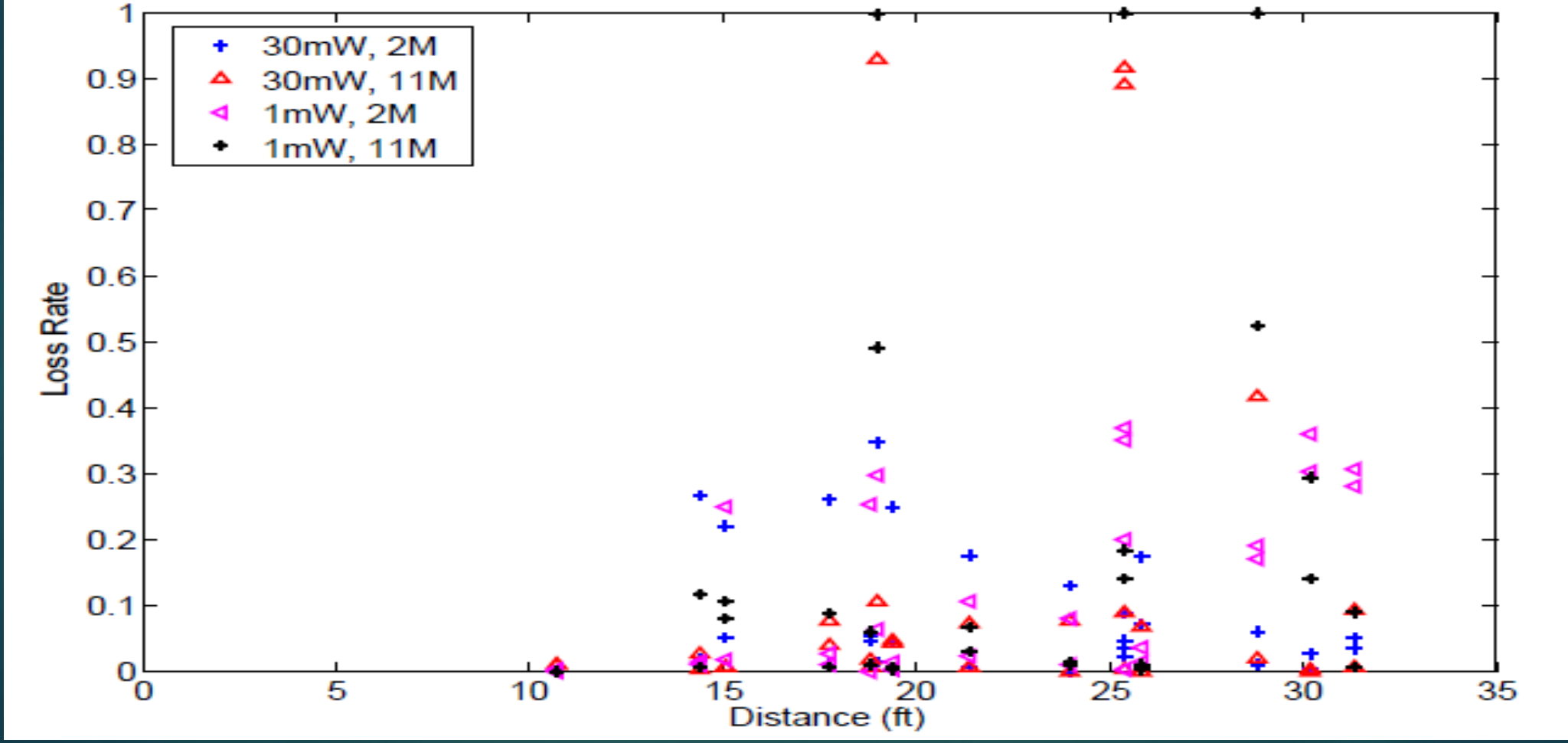


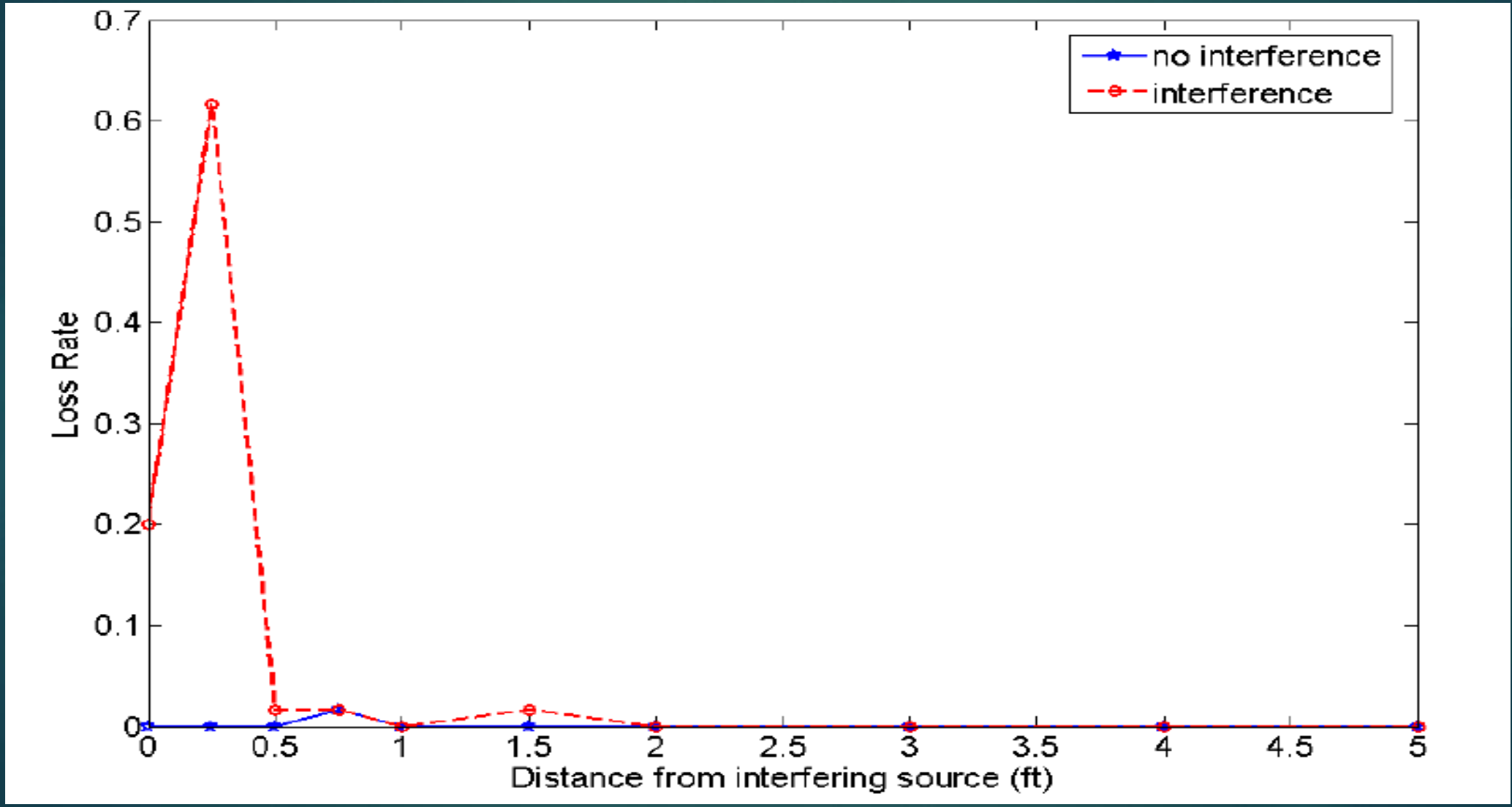
Figure 9 loss-rate versus distance ushome2 layout2



Result of figure 9

- 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

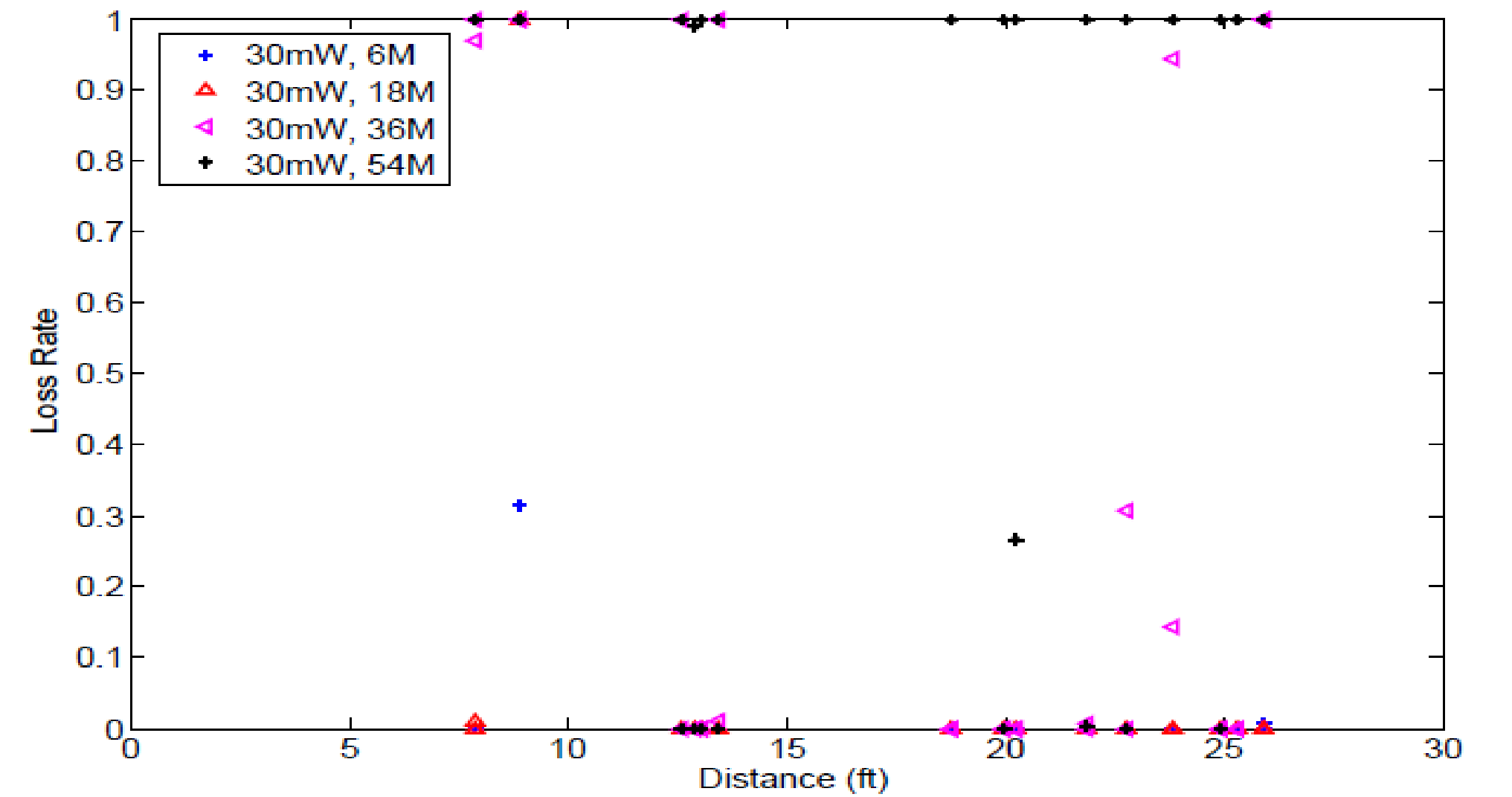
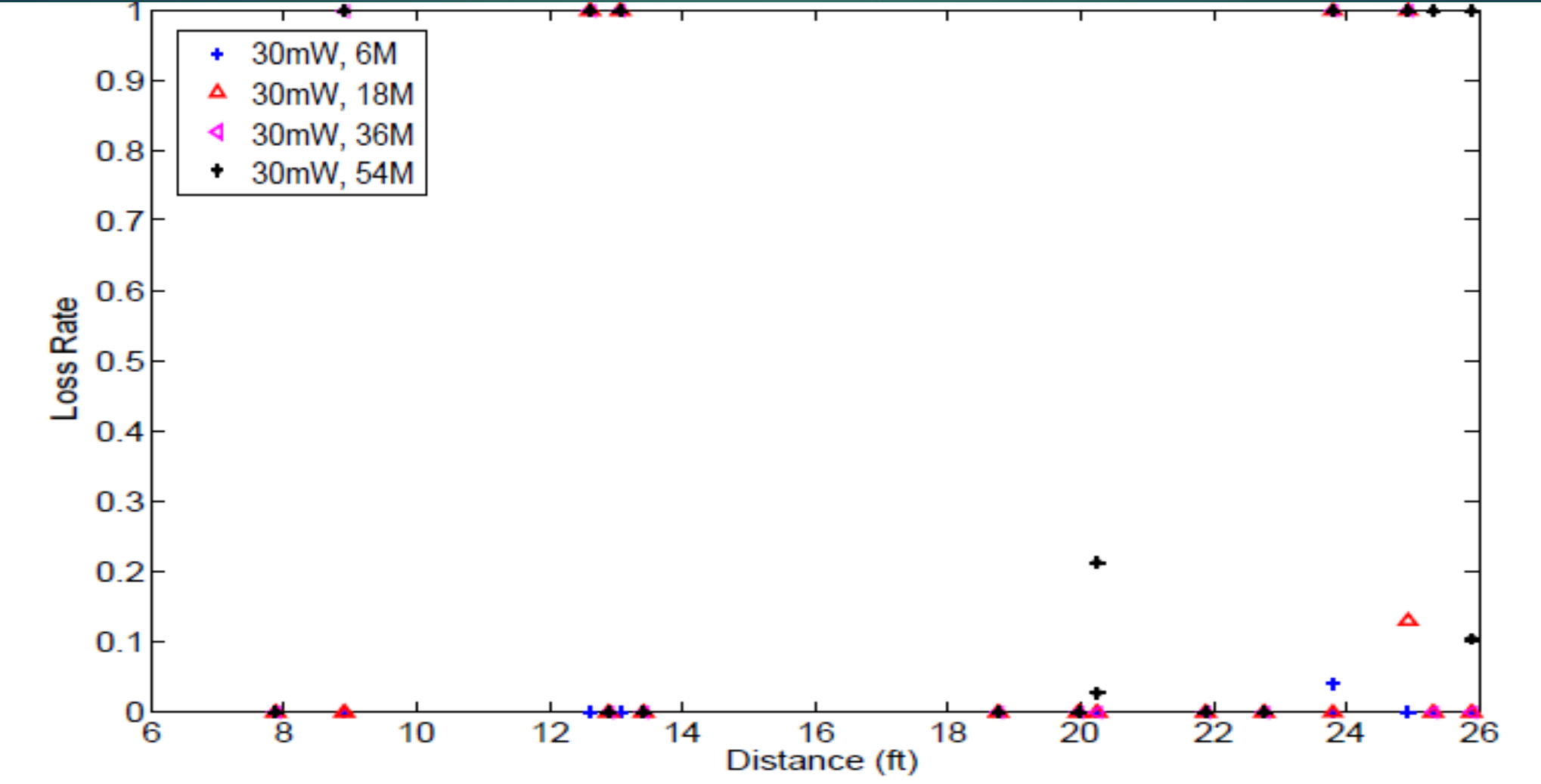


Figure 13 802.11a ushome2



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 follows 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

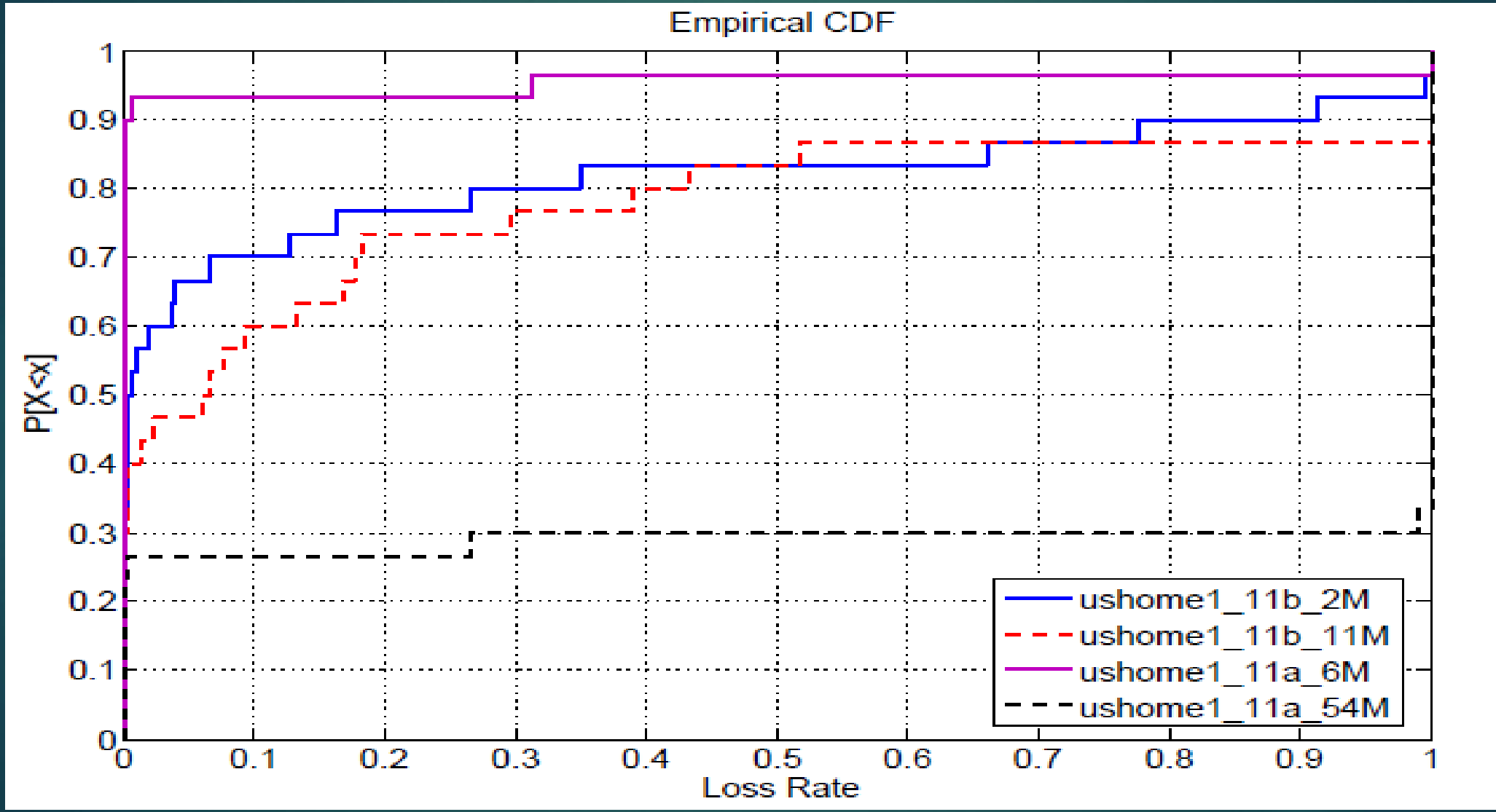


Figure 14 ushome2

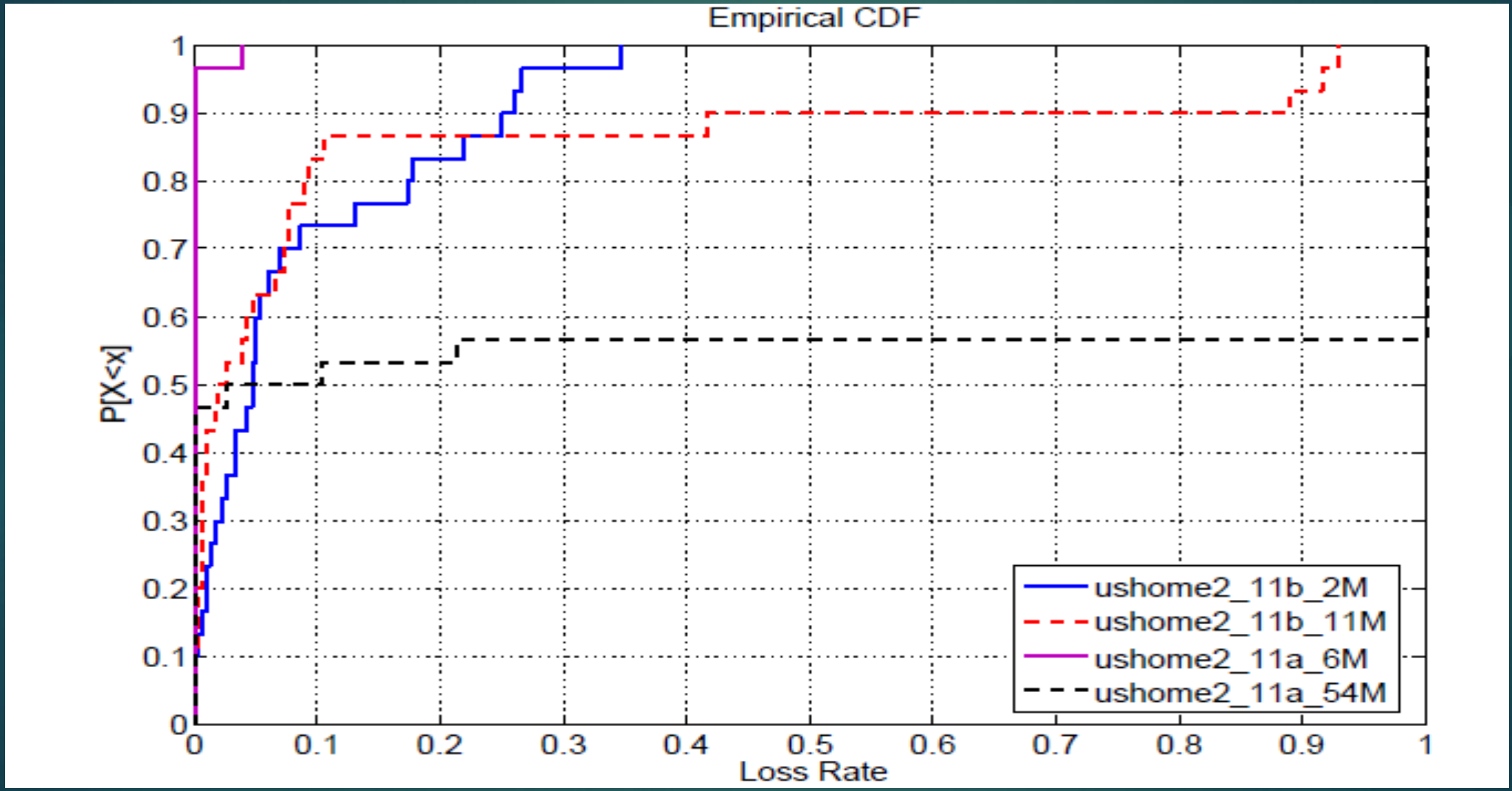


Figure 14

- Graph are base 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 compare to 2 or 11 Mbps of 802.11b
- However, when they uses 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

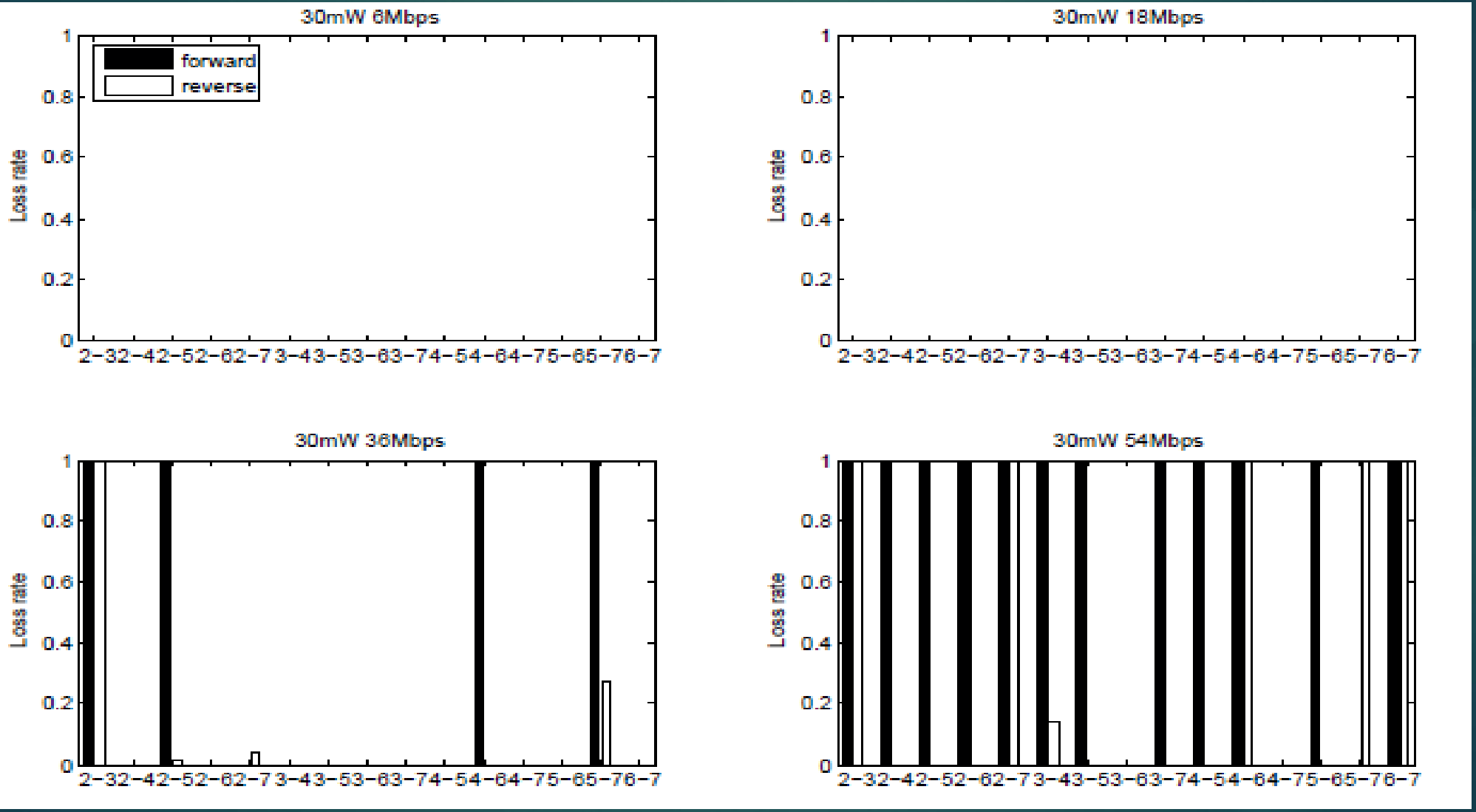


Figure 11b Layout2

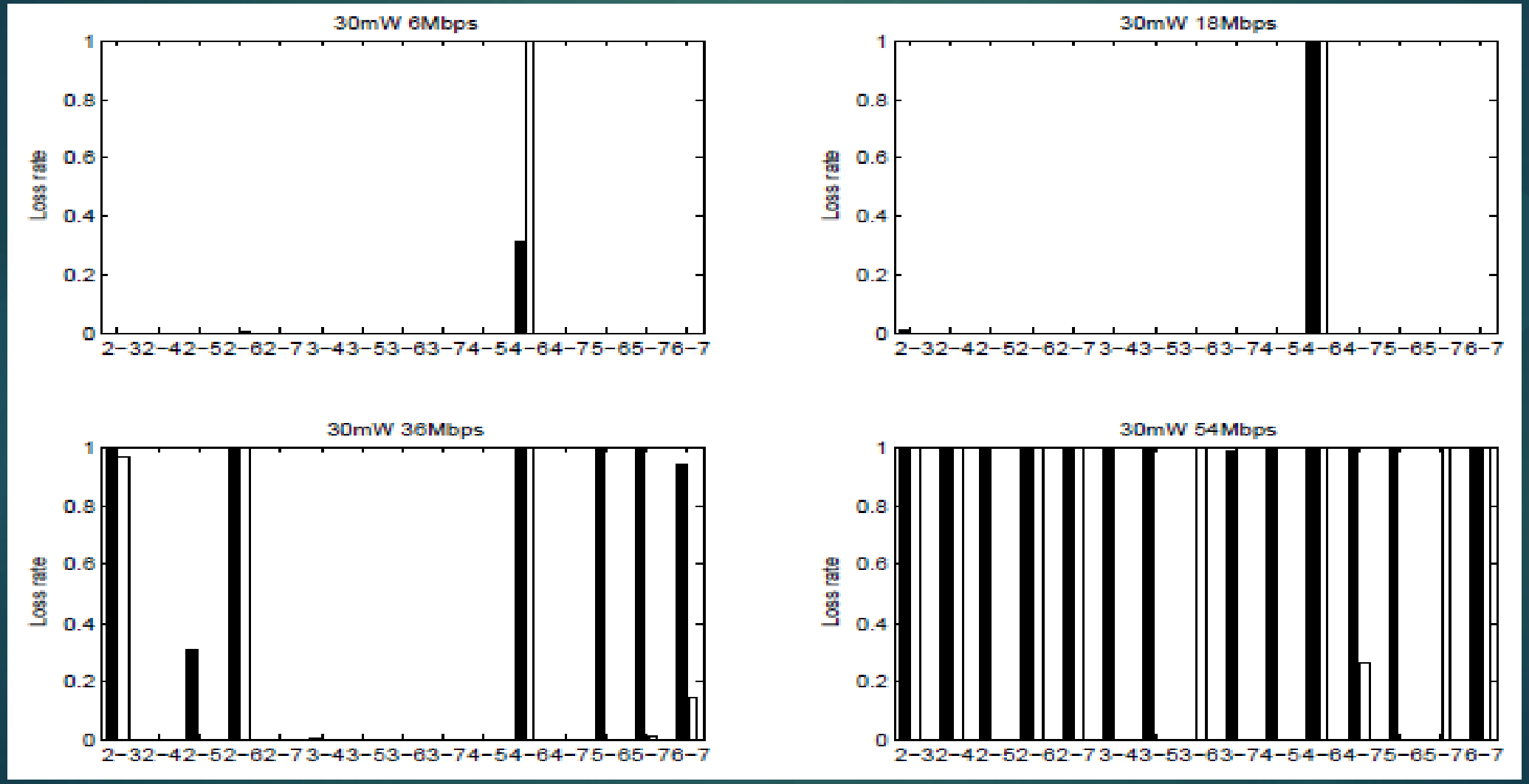


Figure 12a Layout1

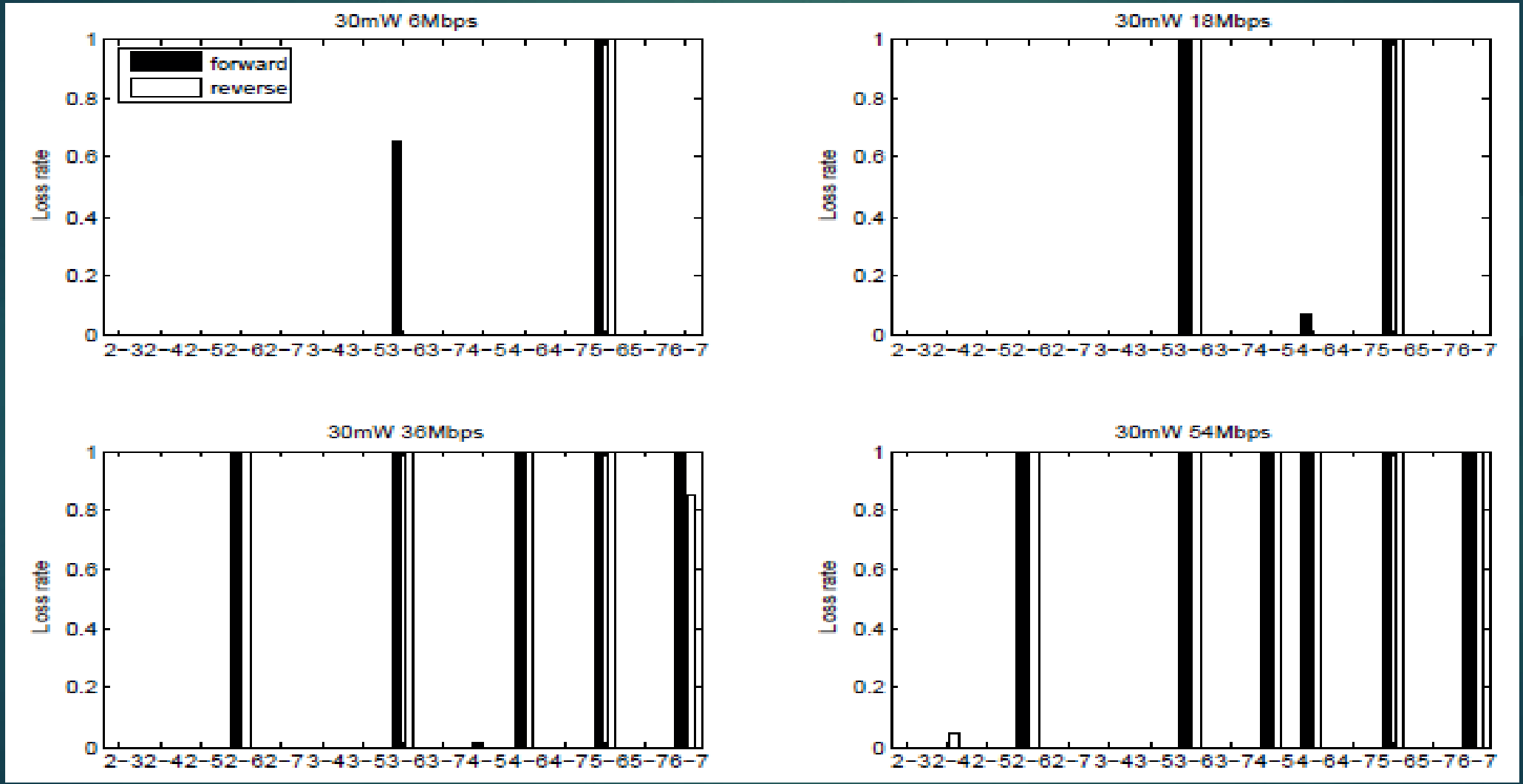
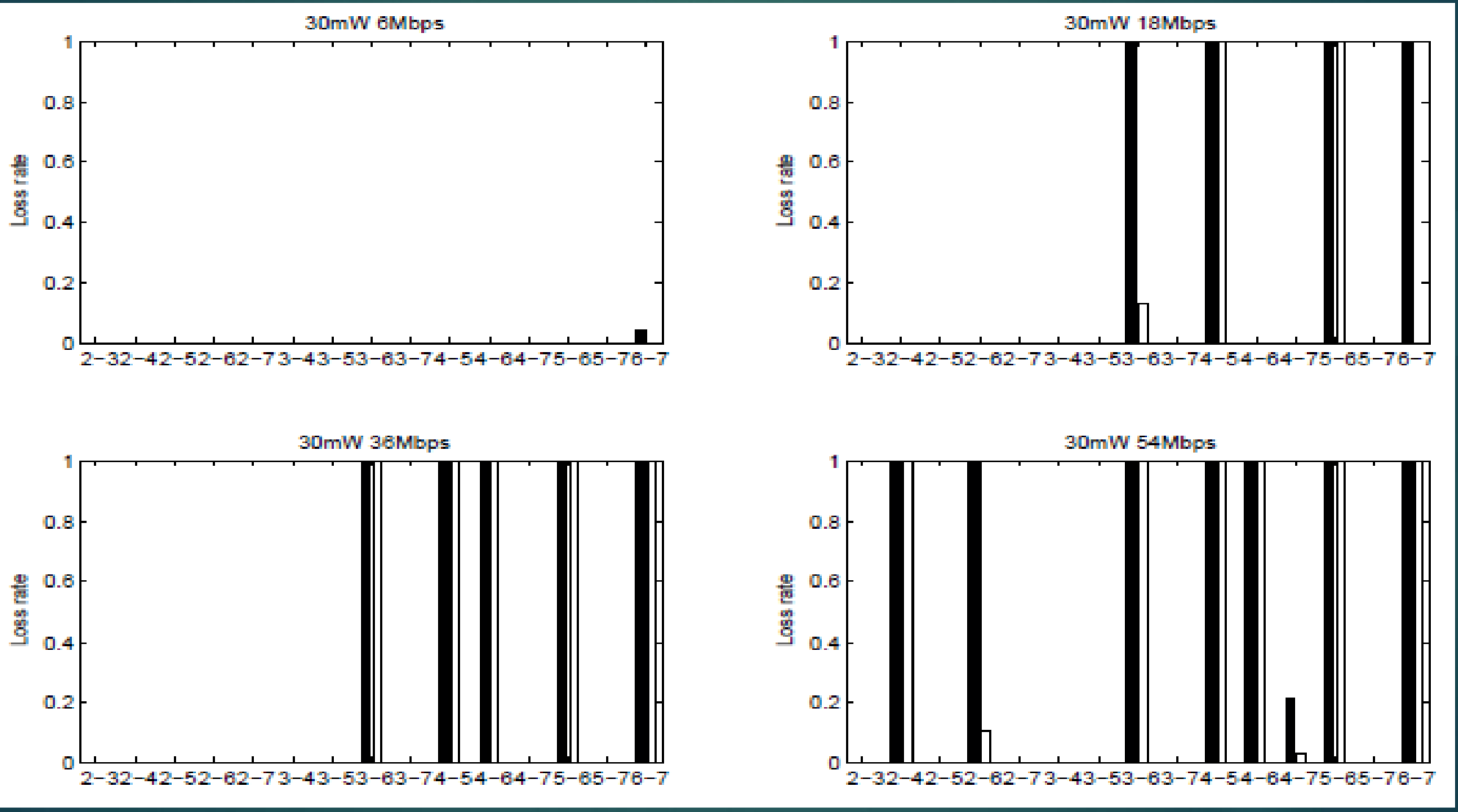


Figure 12b


30mW 6Mbps
30mW 18Mbps
30mW 36Mbps
30mW 54Mbps
Loss rate
0
0.2
0.4
0.6
0.8
1
2-32-42-52-62-73-43-53-63-74-54-64-75-65-76-7

Conclusion

- This research show that wireless link in home are:
  - Stable over time
  - Highly asymmetric
  - Highly variable from 1 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 have more to do with how everything is oriented and what interfering with it, placement.