Report on Signal strength optimization of Wireless Internet Experience

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INTRODUCTION

The experiment is designed and performed keeping in mind the fundamentals of Experimental Designs. As the title suggests the aim of the experiment is the optimization of the wireless experience by enhancing the signal strength.The Experiment is Examined with the statistical approach with the help of tools like JMP.The statistical analysis will lead us to the strong conclusions with the reference to the best signal strength experienced by the router varying different factors.

1. RECOGNITION OF AND STATEMENT OF THE PROBLEM

In today's age, it is almost impossible to live without internet. Also as the technology is becoming more and more advanced, people are opting for more wireless and portable devices. Hence ,It is also important to get the good signal strength to obtain best internet experience. Thus, this experiment is aimed to determine the best Internet experience for the users. During the experiment, we intend to check how the different factors affect the Signal strength.

2. CHOICE OF FACTORS, LEVELS AND RANGES

After analyzing the reasons which can affect the usage of wireless internet experience for the users, we came across three important factors influencing the process.

Distance:

Two levels for this factor includes:

- At the distance of 5 meter
- At the distance of 10 meter

Channel: Co-Channel interference is a major problem as there are too many Wi-Fi devices on the same channel. Adjacent-Channel interference on the other hand is where we run into problems and channel selection becomes critical. Luckily, these channel related interferences can be reduced or eliminated by selecting the proper Wi-Fi channel for your network.

Two levels for this factor include:

- Channel 5
- Channel 1

Physical Obstruction: Wireless signals can have trouble penetrating solid objects which can be any numbers of things such as hills, buildings, single walls or even people. The more obstructions you have between the transmitter and receiver, the more chance there is that the signal strength will be affected.

3. SELECTION OF RESPONSE VARIABLE.

Signal strength will be the response variable through which we can determine which combination of factors will give the best signal strength and hence the best Internet experience for the user. Signal strength is measured in decibel- milliwatts (dBm). Source of measuring the Signal strength is running an application which measures and compares the signal strength. It also helps us to find a less crowded channel for the wireless router.

4. EXPERIMENTAL SETUP & PROCEDURE

The experimental setup consists of measuring the output of signal strength from the application *Wi-Fi Analyzer*. The signal strength will be measured through the mobile device with varying operating conditions and factors. The output would be recorded against the run-order. Entire experiment was performed in randomized order. The whole experiment was performed in a single stretch with the same conditions so that the interference from the other Wi-Fi networks remains almost same for all runs of the experiment.

5. CHOICE OF EXPERIMENTAL DESIGN:

To perform this experiment, we assign two levels to each factor as shown in Table Each of the factor has high and low levels. Distance is a quantitative factor whereas the other two factors are categorical. Since the experiment design involves three factors at two levels each, we will follow 2^3 factorial design. Each trial will be replicated 3 times, so the total design matrix will have sample size of $2^3 * 3 = 24$ runs.

Factor	Type of Factor	Low Level	High Level
Distance	Continuous	5	10
Channel	Categorical	5	10
Physical Obstruction	Categorical	With	Without

Ramdomized	Run	Distance	Obstructic	Channel	Signal strength
2	1	5	with	5	-52
9	2	5	without	5	-40
16	3	10	with	10	-47
13	4	5	with	10	-38.5
5	5	10	with	5	-62
18	6	10	with	10	-46
19	7	10	without	10	-34
12	8	10	without	5	-44
11	9	10	without	5	-43
15	10	5	with	10	-36
1	11	5	with	5	-51
7	12	5	without	5	-42
10	13	10	without	5	-43.5
23	14	5	without	10	-32
8	15	5	without	5	-41
3	16	5	with	5	-54
17	17	10	with	10	-48
22	18	5	without	10	-31.5
4	19	10	with	5	-60
6	20	10	with	5	-60
20	21	10	without	10	-34.5
21	22	10	without	10	-33
24	23	5	without	10	-31
14	24	5	with	10	-38

24 run order in a randomized order is as shown in the table above and the response variable readings are incorporated in the last column of the table.

6. RESULTS AND ANALYSIS

6.1 R-SQUARED

Summary of Fit

RSquare	0.991546
RSquare Adj	0.987847
Root Mean Square Error	1.030776
Mean of Response	-43.4167
Observations (or Sum Wgts)	24

The value of R-squared is 0.9915 which shows that the percentage of the variability explained by the model is 98.78 and thus the design is a good fit to the model. Also Pred R-square is in reasonable agreement with Adj R-squared.

The effect estimates are shown in the table below.

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-43.41667	0.210406	-206.3	<.0001*
Distance[5]	2.8333333	0.210406	13.47	<.0001*
Obstruction[with]	-5.958333	0.210406	-28.32	<.0001*
Distance[5]*Obstruction[with]	1.625	0.210406	7.72	<.0001*
Channel[5]	-5.958333	0.210406	-28.32	<.0001*
Distance[5]*Channel[5]	-0.125	0.210406	-0.59	0.5608
Obstruction[with]*Channel[5]	-1.166667	0.210406	-5.54	<.0001*
Distance[5]*Obstruction[with]*Channel[5]	-0.166667	0.210406	-0.79	0.4399

Based on the parameter estimates generated by JMP, taking P-value into consideration, it is evident that Factors Distance, obstruction, distance*obstruction, channel, obstruction*channel are significant model terms. Once the p-value goes below a certain value determined from the t-table and degrees of freedom, the factors can be declared as being significant.

6.2 ANOVA FOR SELECTED FACTORIAL MODEL:

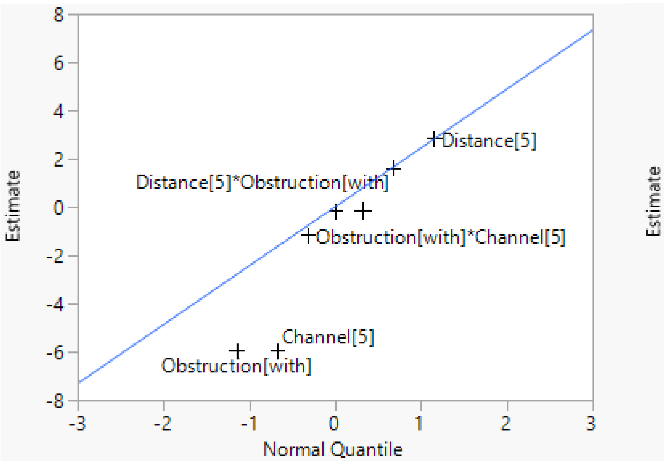
Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Distance	1	1	192.66667	181.3333	<.0001*
Obstruction	1	1	852.04167	801.9216	<.0001*
Distance*Obstruction	1	1	63.37500	59.6471	<.0001*
Channel	1	1	852.04167	801.9216	<.0001*
Distance*Channel	1	1	0.37500	0.3529	0.5608
Obstruction*Channel	1	1	32.66667	30.7451	<.0001*
Distance*Obstruction*Channel	1	1	0.66667	0.6275	0.4399

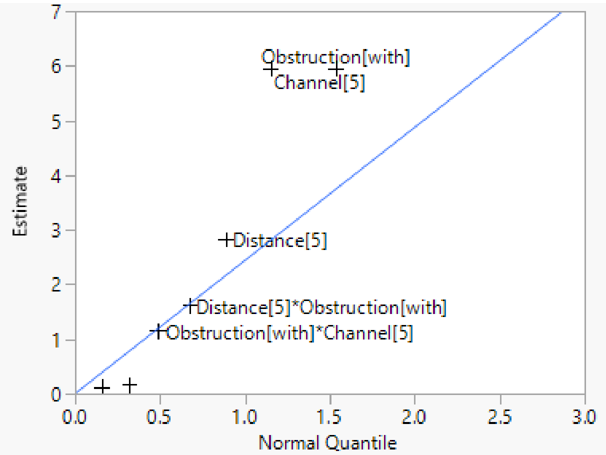
Looking at the F values from the Anova full factorial model, the same factors can be seen as significant. The F-statistic is calculated by taking the proportion of the mean square of the factor by the mean square of the residual.

Thus, higher the value of mean square, more significant the factor can be seen to be. In this case, it appears that the main effect channel and obstruction has the highest mean square and perhaps is the most significant factor.

6.3 NORMAL PLOTS



Normal Plot

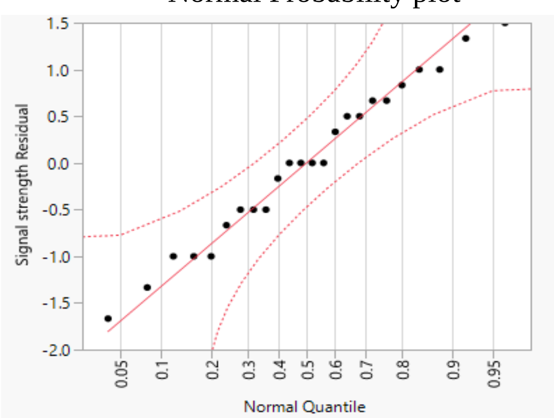


Half Normal

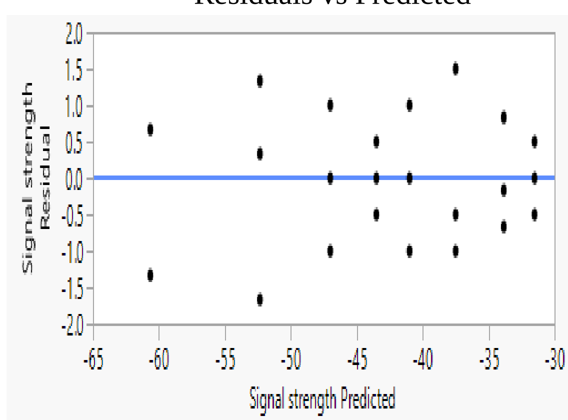
The half normal plot is used to identify which factors are significant in an experiment visually. It is a graph of Estimates against their normal quantile in a cumulative manner. The effects which are significant can be seen far away from the line. In this model, all the 3 factors and the Distance/Physical Obstruction interaction are significant, however the interaction effect is minimal when compared with main factors.

6.4 RESIDUAL ANALYSIS:

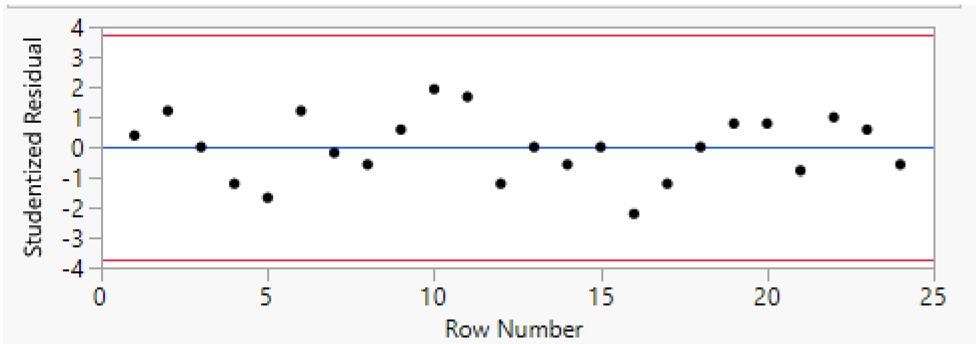
Normal Probability plot



Residuals vs Predicted

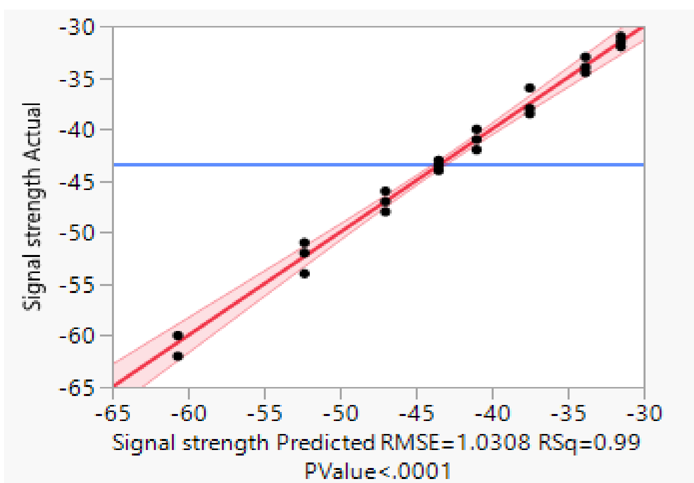


A normal probability plot of residuals is plotted to verify that data comes from a population of normal distribution. This assumption holds good if the residuals fall along the straight line with little deviation. In our case, majority of the residuals tend to fall in line with emphasis being laid on center values of plot than on extremes. Therefore we can conclude that there are no alarming problems with normality and the model is adequate.
Predicted values plot is a structureless model and shows no obvious pattern (like outward or inward funnel) or correlation between points, hence the model is correct and constant variance assumptions are satisfied.



Residuals vs Run order

Plot of residuals by run order helps in detecting strong correlation between residuals. The model seems good without violating independence and constant variance assumption.

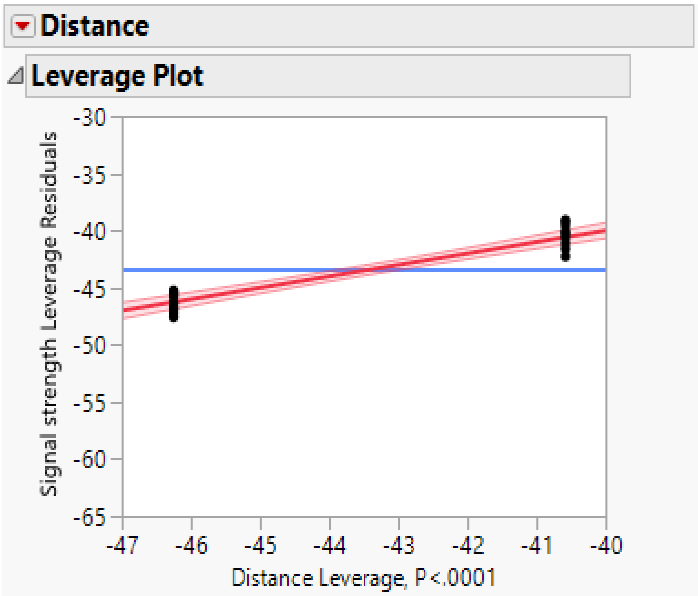


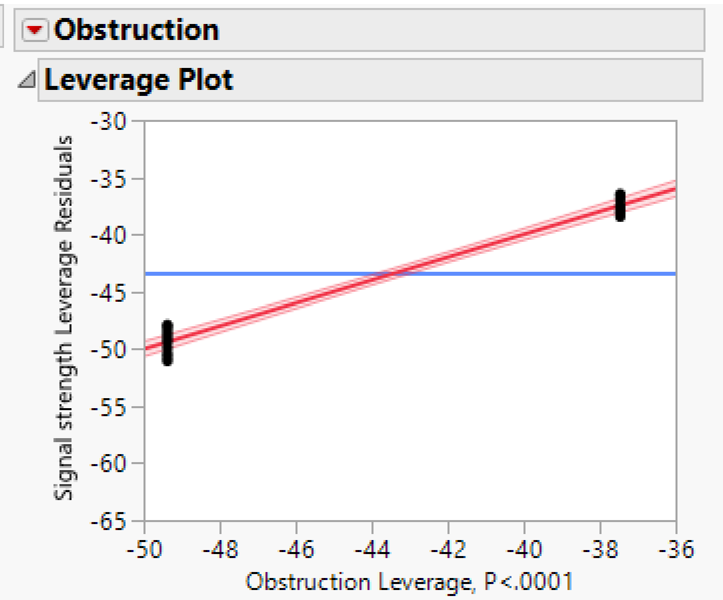
Predicted vs Actual

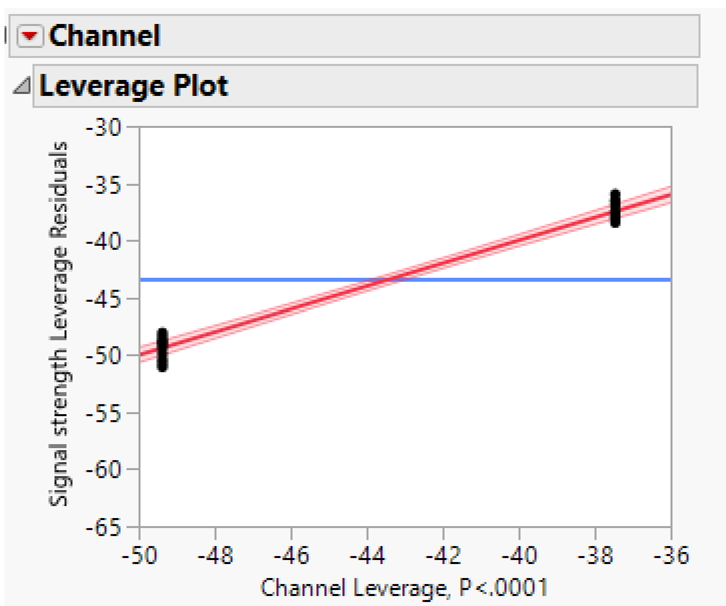
By plotting predicted by actual values, we can determine how well the model fits the data. In this case the points fall along a straight line and makes a complete fit for the data. With little variance between the values, we can confirm that model provides a good fit.

LEVERAGE PLOTS

Individual factors:

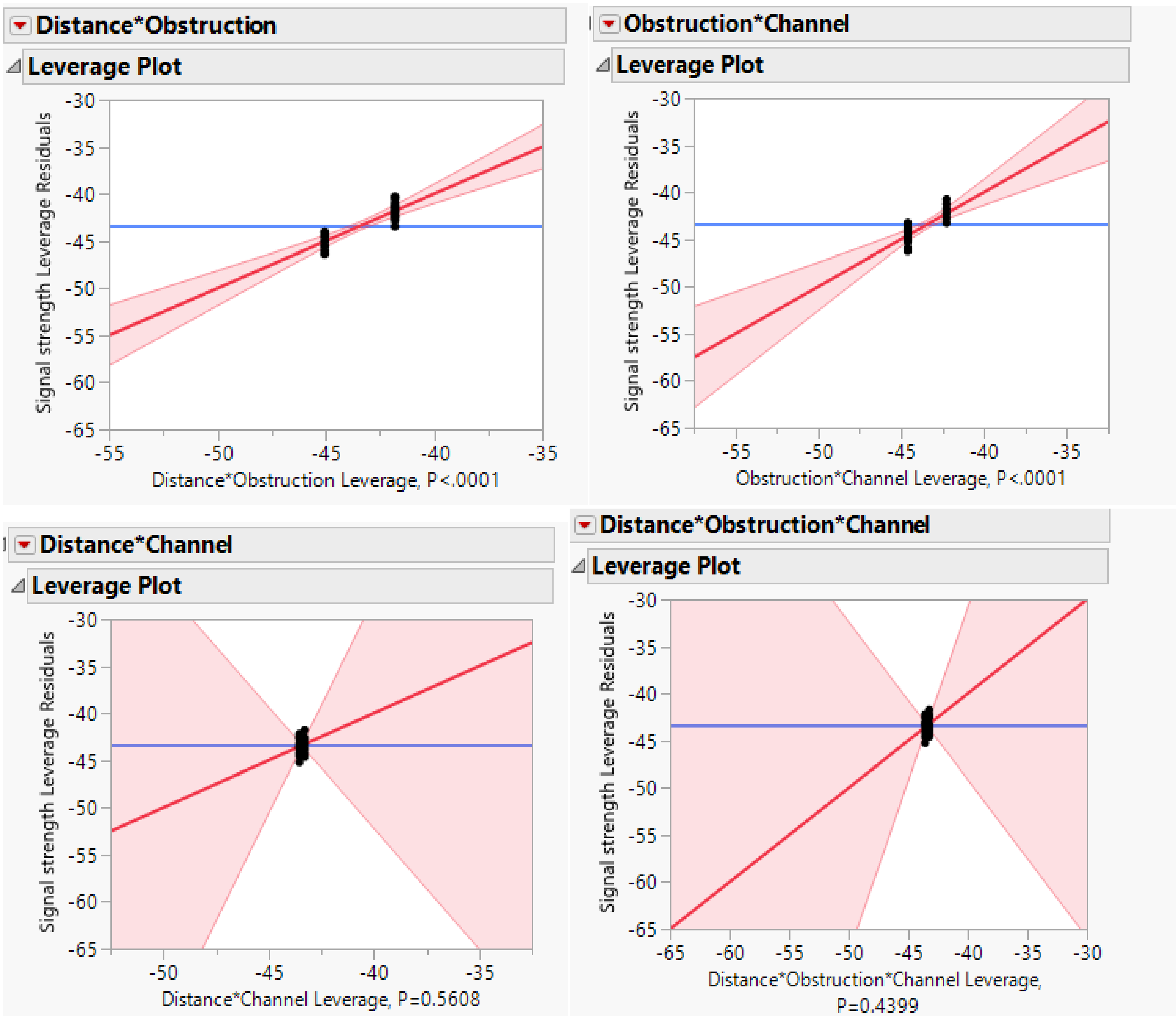






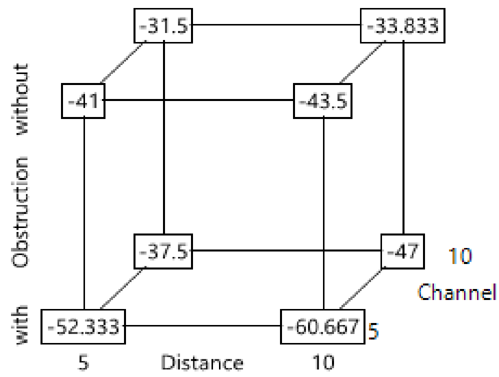
As we can see from the Leverage plots above, all the variables, i.e. distance, obstruction and channel are all significant as the confidence curve crosses the horizontal line. Thus, all the three factors are significant.

Interaction factors:



The Interaction Variables Distance*Obstruction and Obstruction*Channel are significant as we can see clearly that the confidence interval crosses the horizontal line. The interaction variables Distance*Channel and Distance*Obstruction*Channel are not significant as the confidence interval contains the horizontal line. This validates the results that we got from the normal and half-normal plots.

Cube Matrix



The cube matrix is as shown in the figure. The best value (in this case the least positive) of the response variable is when the factors Obstruction and Channel are at high value and distance is at low value. In other words, the best signal strength can be observed at a distance of 5 meters from the router without the physical obstruction and at channel 10.

7. CONCLUSION

- Analyzing the experimental results, it can be concluded that the conditions that would yield best internet experience for users are:
  Distance: 5 meters. (Devices connected to Wi-Fi should be closer to the router).
  Physical obstruction: Without. (Less physical obstruction between router and device).
  Channel: 10 (Optimum channel should be selected with less or no overlapping of Wi-Fi networks).
- Choosing the best Wi-Fi channel on your router helps to reduce interference and improve your Wi-Fi signal strength.
- There are tools that can help you find the clearest channel, such as Vistumbler. It helps you to just switch between channels until you find one that works well. Using these tools, we can make sure that we are using the optimum channel (with least interference) and get the best signal strength. Changes were made at home according to the significant factor combinations obtained in our analysis and internet experience were made even better.
- We can carry out the regression and Lasso variable selection to further analyze the model extensively

8. REFERENCES

- 'Design and Analysis of Experiments', Eighth Edition by Douglas C Montgomery, John Wiley & Sons, Inc.
- https://www.microsoft.com/en-nz/store/p/wifi-analyzer/9nblggh33n0n