CS425 Computer Networks

Assignment 1

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Problem 1: Finding the Path Loss Exponent

The steps followed to find the path loss exponent were as follows:

- I connected my mobile phone with other phone's hotspot. Then, I identified the hotspot phone to which my mobile device is connected and made sure that the app was able to identify the connected WiFi AP.
- Then, I varied the distance between the transmitter (WiFi AP - hotspot mobile in this case) and the receiver (mobile phone) and measured the RSSI strength of the signal in four different orientations of the mobile phone at each distance.
- Then using the following formula (ignoring the noise term)

$$P_r(d)[dBm] = P_r(d_0)[dBm] - 10nlog_{10}(\frac{d}{d_0}) \tag{1}$$

$$P_r(d)[dBm] = P_r(d_0)[dBm] - 10n(log_{10}d - log_{10}d_0) \tag{2}$$

  The above equation is a equation of line with $P_r(d)$ on the $y-axis$, $log_{10}d$ on the $x-axis$ and slope of $-10n$.

- I plotted the RSSI strength(in dBm) on y-axis and the $log_{10}(d)$ on x-axis and find the best fit line and divide the obtained slope of line with -10 to get path loss exponent.
- The data observed is attached below along with the graph.

DISTANCE (in m)	LOG(DISTANCE)	OBSERVED RSSI(dBm)	CALCULATED RSSI(dBm) [best-fit-line	(OBSERVED_RSSI - CALCULATED_RSSI)^2
0.575	-0.240332155	-67	-67.57339107	0.328777319
0.575	-0.240332155	-66	-67.57339107	2.47555946
0.575	-0.240332155	-66	-67.57339107	2.47555946
0.575	-0.240332155	-68	-67.57339107	0.181995179
1	0	-71	-72.008	1.016064
1	0	-71	-72.008	1.016064
1	0	-72	-72.008	6.4E-05
1	0	-70	-72.008	4.032064
1.15	0.06069784	-74	-73.12799655	0.760390016
1.15	0.06069784	-74	-73.12799655	0.760390016
1.15	0.06069784	-75	-73.12799655	3.504396916
1.15	0.06069784	-76	-73.12799655	8.248403816
1.725	0.236789099	-78	-76.37723246	2.633374481
1.725	0.236789099	-79	-76.37723246	6.878909557
1.725	0.236789099	-77	-76.37723246	0.387839406
1.725	0.236789099	-77	-76.37723246	0.387839406
4.025	0.604765885	-81	-83.1671401	4.696496233
4.025	0.604765885	-80	-83.1671401	10.03077644
4.025	0.604765885	-82	-83.1671401	1.362216024
4.025	0.604765885	-83	-83.1671401	0.027935815
5.75	0.759667845	-86	-86.02539107	0.000644706
5.75	0.759667845	-87	-86.02539107	0.949862566
5.75	0.759667845	-87	-86.02539107	0.949862566
5.75	0.759667845	-86	-86.02539107	0.000644706
8.05	0.90579588	-88	-88.72174558	0.520916689
8.05	0.90579588	-90	-88.72174558	1.633934351
8.05	0.90579588	-89	-88.72174558	0.07742552
8.05	0.90579588	-88	-88.72174558	0.520916689
			VARIANCE	1.994975834

Figure 1: RSSI(dBm) and distance(m) data

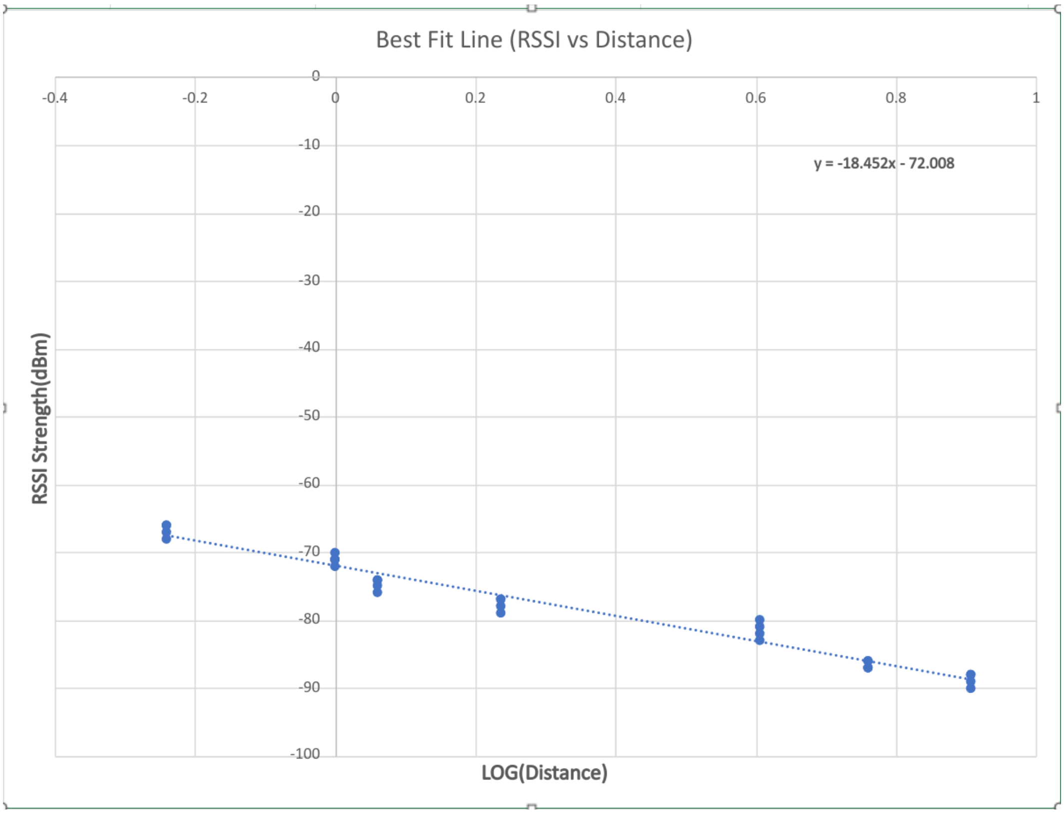

Figure 2: Graph for best fit line(RSSI vs log(distance)

From the above plot we can observe that:

(a) Slope of the best fit line = -18.452
Path loss exponent(n) = $\frac{-18.452}{-10}$ = 1.8452

(b) Variance of the samples wrt the best fit line can be found out by using the following formula.(Calculations can also be seen in the attached excel sheet)

$$\frac{(Observed\_RSSI\_Value - RSSI\_Value\_BestFitLine)^2}{Num\_Sample\_Points} \tag{3}$$

So by applying the above formula to the graph points, we get

$$Variance = 1.994975834 \tag{4}$$

Problem 2: Range Estimation

The steps followed to do range estimation are as follows:

- Fix $d_0 = 1m$ and then find $P_r(d_0)$, which is receiver's RSSI strength at distance of 1m.
- Now by varying the distance, take different samples of RSSI strength at different position($P_r(d)$).
- Now log the values in the below formula to find the theoretical calculated distance and compare it with the observed distance values. Use the path loss exponent(n) calculated above.

$$P_r(d)[dBm] = P_r(d_0)[dBm] - 10nlog_{10}(\frac{d}{d_0}) \tag{5}$$

DISTANCE (in m)	LOG(DISTANCE)	OBSERVED RSSI(dBm)	CALCULATED RSSI(dBm) [best-fit-line	(OBSERVED_RSSI - CALCULATED_RSSI)^2	CALCULATED DISTANCE(in m)	| OBSERVED_DIS - CALCULATED_DIS|
0.575	-0.240332155	-67	-67.57339107	0.328777319	0.607045622	0.032045622
0.575	-0.240332155	-66	-67.57339107	2.47555946	0.535829554	0.039170446
0.575	-0.240332155	-66	-67.57339107	2.47555946	0.535829554	0.039170446
0.575	-0.240332155	-68	-67.57339107	0.181995179	0.687726879	0.112726879
1	0	-71	-72.008	1.016064	1	0
1	0	-71	-72.008	1.016064	1	0
1	0	-72	-72.008	6.4E-05	1.132908062	0.132908062
1	0	-70	-72.008	4.032064	0.882684159	0.117315841
1.15	0.06069784	-74	-73.12799655	0.760390016	1.454065605	0.304065605
1.15	0.06069784	-74	-73.12799655	0.760390016	1.454065605	0.304065605
1.15	0.06069784	-75	-73.12799655	3.504396916	1.647322647	0.497322647
1.15	0.06069784	-76	-73.12799655	8.248403816	1.866265107	0.716265107
1.725	0.236789099	-78	-76.37723246	2.633374481	2.395315202	0.670315202
1.725	0.236789099	-79	-76.37723246	6.878909557	2.713671902	0.988671902
1.725	0.236789099	-77	-76.37723246	0.387839406	2.114306785	0.389306785
1.725	0.236789099	-77	-76.37723246	0.387839406	2.114306785	0.389306785
4.025	0.604765885	-81	-83.1671401	4.696496233	3.482945449	0.542054551
4.025	0.604765885	-80	-83.1671401	10.03077644	3.074340775	0.950659225
4.025	0.604765885	-82	-83.1671401	1.362216024	3.945856978	0.079143022
4.025	0.604765885	-83	-83.1671401	0.027935815	4.470293181	0.445293181
5.75	0.759667845	-86	-86.02539107	0.000644706	6.50009956	0.75009956
5.75	0.759667845	-87	-86.02539107	0.949862566	7.364015194	1.614015194
5.75	0.759667845	-87	-86.02539107	0.949862566	7.364015194	1.614015194
5.75	0.759667845	-86	-86.02539107	0.000644706	6.50009956	0.75009956
8.05	0.90579588	-88	-88.72174558	0.520916689	8.342752181	0.292752181
8.05	0.90579588	-90	-88.72174558	1.633934351	10.70776121	2.657761212
8.05	0.90579588	-89	-88.72174558	0.07742552	9.451571203	1.401571203
8.05	0.90579588	-88	-88.72174558	0.520916689	8.342752181	0.292752181
			VARIANCE	1.994975834	AVERAGE ERROR	0.5758169
					Pr(d0=1m)	-71

Figure 3: Data for calculated distance and average error

From the above table and graph data, calculate the distance as

(a) We calculate the distance using the following formula

$$calculated\_distance = 10^{\left(\frac{P_r(d_0=1m)[dBm]-P_r(d)[dBm]}{10n}\right)} = 10^{\left(\frac{-71-P_r(d)[dBm]}{10*1.8452}\right)} \tag{6}$$

(b) Calculate the average error using

$$\sum \frac{abs(observed\_dist - calculated\_dis)}{num\_samples} \tag{7}$$

Average error = 0.5758169 m

Observations

(a) In Problem1, the data was measured in a building by keeping the hotspot phone(the tranmitter) within the line of sight of the receiver. The experiment was performed in a obstruction-free environment, with no obstacles in between the transmitter and receiver. Hence the observed value of path loss exponent is 1.8452 which is close to ideal range of $1.6 - 1.8$ in the same environment.

(b) The average error between the distance estimated using the method and the actual distance is 0.5758169, indicating good path loss exponent findings.