Department of Computer Science, Electrical and Space Engineering

Advanced Wireless Networks

Lab 1 - Measuring the influence of attenuation of radio signal on network performance for different radio propagation models

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Part 1 - The effect of signal attenuation on communication ranges in WiFi networks

1. Calculate the initial distance between nodes (d_i), which equals the value corresponding to the border of the transmission range for all the models.

2. Calculate the set of distances D = {d_i, $7d_i/8$, $6d_i/8$, ..., $d_i/8$} between node(0) and node(1) (totally 8 values).

3. For each value in D run an experiment. In each experiment measure the bit rate.

4. Plot the bit rate against the distance.

Two-Ray Ground propagation loss model

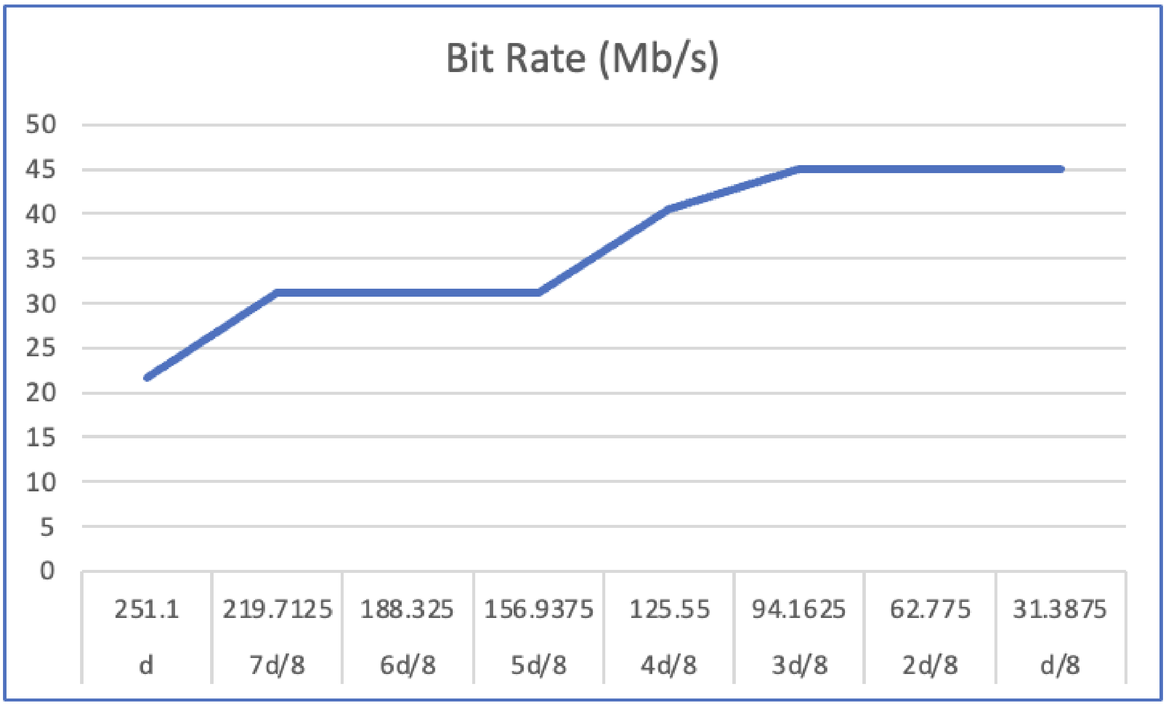
Initial distance between the node (d_i): 251.1 meters (loss = 96 dB)

$$P_r = \frac{P_t \ x \ G_t \ x \ G_r \ (h_t \ h_r)^2}{d_i^4 L}$$

$$d_i = \sqrt[4]{\frac{P_t \ x \ G_t \ x \ G_r \ (h_t \ h_r)^2}{P_r L}}$$

$P_t = transmission\ power$(W)
P_r = reception power (W)
G_t = transmission gain (no unit)
G_r = reception gain (no unit)
d = distance (m)
L= system loss (no unit)

Distance	Distance (m)	Sender (s)	Receiver (s)	Frame Size (bits)	Bit Rate (Mb/s)
d	251.1	16.000567	16.000943	8512	21.58956325
7d/8	219.7125	16.00039	16.00065	8512	31.22182993
6d/8	188.325	16.00039	16.00065	8512	31.22182993
5d/8	156.9375	16.00039	16.00065	8512	31.22182993
4d/8	125.55	16.00037	16.00057	8512	40.58837891
3d/8	94.1625	16	16.00018	8512	45.09819878
2d/8	62.775	16	16.00018	8512	45.09819878
d/8	31.3875	16	16.00018	8512	45.09819878



Cost231PropagationLossModel

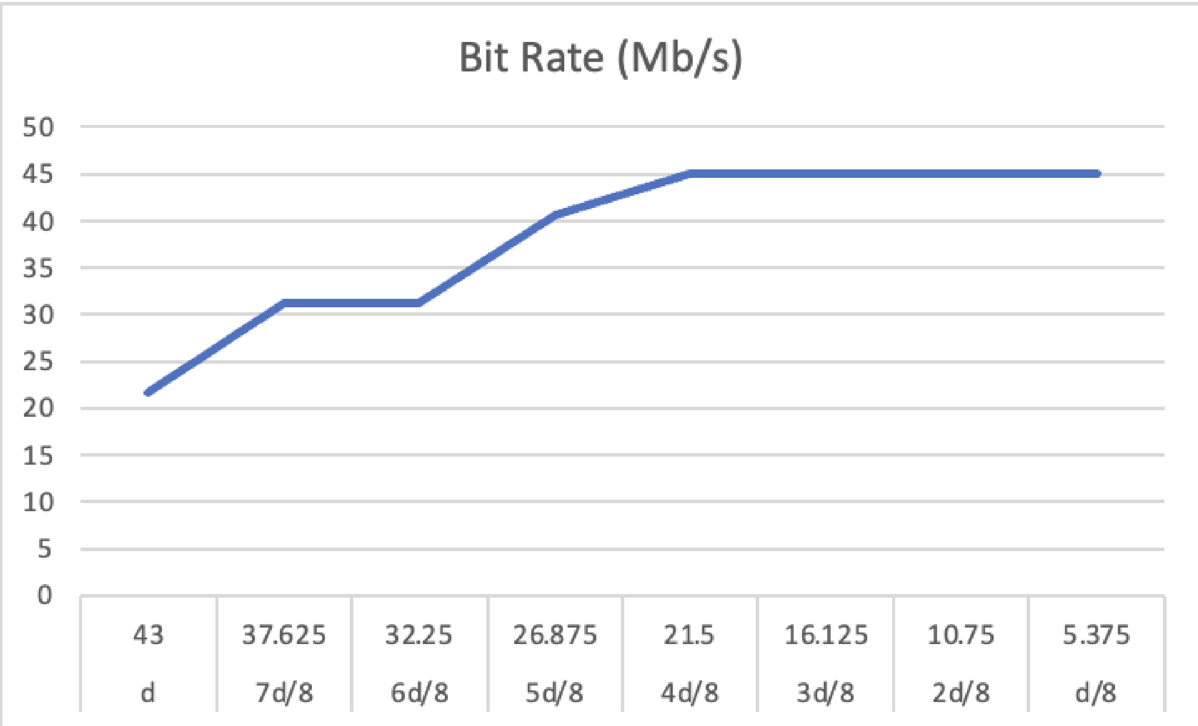
Initial distance between the node (d_i): 43 meters (loss = 96 dB)

$$L_b = 46.3 + 33.9 \log_{10} \frac{f}{\mathrm{MHz}} - 13.82 \log_{10} \frac{h_B}{\mathrm{m}} - a(h_R, f) + \left(44.9 - 6.55 \log_{10} \frac{h_B}{\mathrm{m}}\right) \log_{10} \frac{d}{\mathrm{km}} + C_m$$

$$a(h_R, f) = \left(1.1 \log_{10} \frac{f}{\mathrm{MHz}} - 0.7\right) \frac{h_R}{\mathrm{m}} - \left(1.56 \log_{10} \frac{f}{\mathrm{MHz}} - 0.8\right)$$

L_b: Median path loss (dB)
f: Frequency (MHz) (2300 MHz)
h_B: Base station antenna effective height (m) (50m)
d: Link distance (km)
h_R: Mobile station antenna effective height (m) (3m)
C:Constant offset (dB) (10)

Distance	Distance (m)	Sender (s)	Receiver (s)	Frame Size (bits)	Bit Rate (Mb/s)
d	43	16.000567	16.000943	8512	21.58956325
7d/8	37.625	16.002244	16.002504	8512	31.22182993
6d/8	32.25	16.00039	16.00065	8512	31.22182993
5d/8	26.875	16.00055	16.00075	8512	40.58837891
4d/8	21.5	16	16.00018	8512	45.09819878
3d/8	16.125	16	16.00018	8512	45.09819878
2d/8	10.75	16	16.00018	8512	45.09819878
d/8	5.375	16	16.00018	8512	45.09819878



FriisPropagationLossModel

Initial distance between the node (d_i): 292.2 meters (loss = 96 dB)

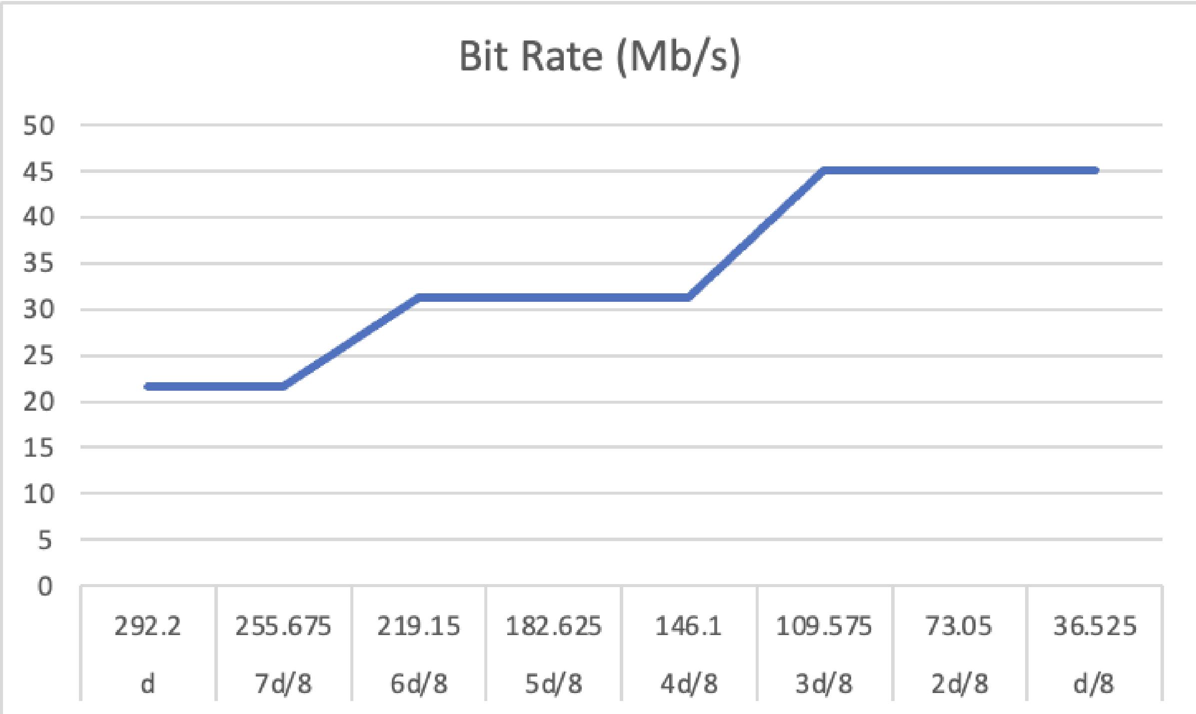
Free-space path loss in decibels:

$$\mathrm{FSPL(dB)} = 20\log_{10}(d) + 20\log_{10}(f) + 92.45$$

Frequency = 5.15 GHz

distance (km)

Distance	Distance (m)	Sender (s)	Receiver (s)	Frame Size (bits)	Bit Rate (Mb/s)
d	292.2	16.000567	16.000943	8512	21.58956325
7d/8	255.675	16.000567	16.000943	8512	21.58956325
6d/8	219.15	16.00039	16.00065	8512	31.22182993
5d/8	182.625	16.00039	16.00065	8512	31.22182993
4d/8	146.1	16.00039	16.00065	8512	31.22182993
3d/8	109.575	16	16.00018	8512	45.09819878
2d/8	73.05	16	16.00018	8512	45.09819878
d/8	36.525	16	16.00018	8512	45.09819878



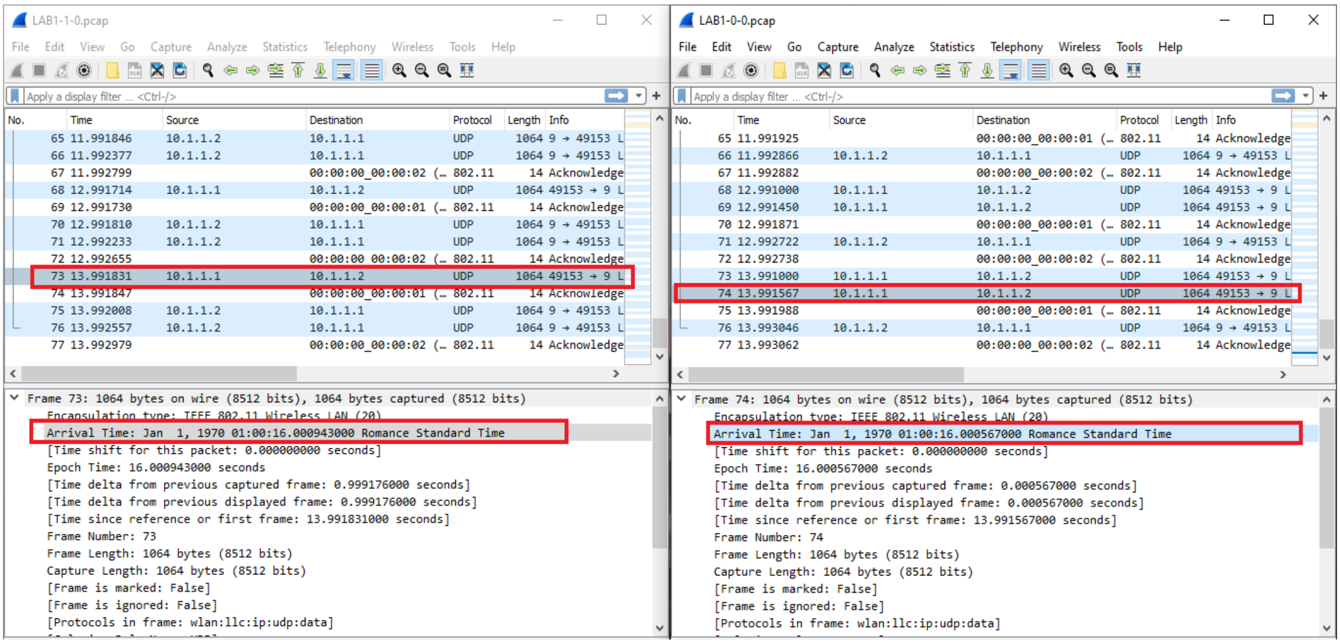
Distance Calculation

For the Two-Ray Ground propagation loss model distance was given, whereas distance for the other two models was determined using experiments. The distance was gradually increased such that two nodes were no longer able to communicate with each other. And the maximum distance at which two nodes were able to communicate was taken as d_i. Distance could not be calculated using the equation since the maximum loss value for each model was not known.

Bit Rate Calculation

For bit rate calculation following formula was used:

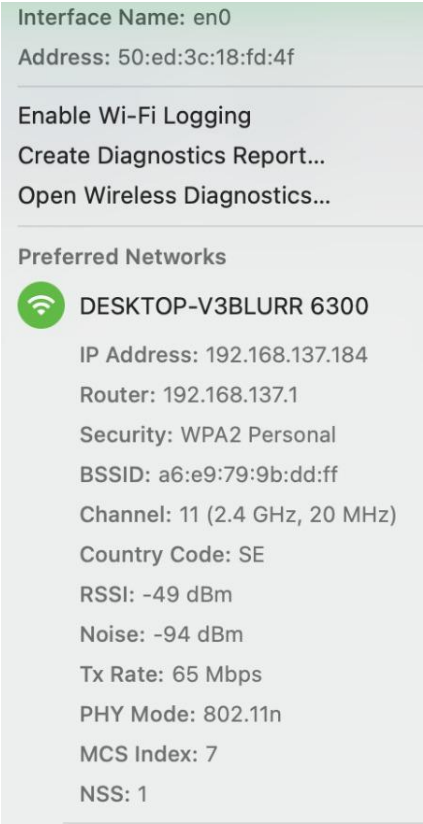
$$\frac{Frame\ Size}{Receivers\ Epoch\ time - Senders\ Epoch\ time}$$



Part 2 - Measurements in a real environment

Our experiment has been conducted based on the steps below:

1. Creating a hotspot on one laptop
2. Connecting to the network from another laptop
3. Moving the second laptop and measuring RSSI on it, every 1 meter



For measuring RSSI, the default system info in MacOS was used. The continuous ping command was used on the first laptop.

4. Following the same path structure given in the assignment.
5. Calculating Path Loss every one meter (for Tx power, we took an average value of 20 dBm, following the specifications of the laptop).
6. Calculating the path loss with the Friis model for each distance.
7. Plotting the actual and Friis-model-based path loss values.

Distance(m)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
RSSI	-42	-41	-43	-43	-44	-49	-50	-54	-51	-52	-54	-64	-65	-60	-63	-61	-62
Path Loss - Actual (dBm)	62	61	63	63	64	69	70	74	71	72	74	84	85	80	83	81	82
Path Loss - Firss (dBm)	40.05	46.07	49.60	52.10	54.03	55.62	56.96	58.12	59.14	60.05	60.88	61.64	62.33	62.98	63.58	64.14	64.66

Distance(m)	18	19	20	21	22	23	24	25	26	27	28	29	30	30.02	30.07	30.15	30.27
RSSI	-63	-66	-63	-66	-62	-65	-64	-65	-61	-62	-67	-68	-71	-71	-77	-81	-89
Path Loss - Actual (dBm)	83	86	83	86	82	85	84	85	81	82	87	88	91	91	97	101	109
Path Loss - Firss (dBm)	65.16	65.63	66.07	66.50	66.90	67.29	67.66	68.01	68.35	68.68	69.00	69.30	69.60	69.60	69.62	69.64	69.67

Distance(m)	30.41	30.59	30.81	31.05	31.32	31.62	31.95	32.31	32.70	33.11	33.54	34	34.48	34.99	35.51	36.06
RSSI	-94	-90	-86	-91	-91	-91	-92	Signal lost	Signal lost	Signal lost	Signal lost	Signal lost	Signal lost	Signal lost	Signa l lost	Signa l lost
Path Loss - Actual (dBm)	114	110	106	111	111	111	112	-	-	-	-	-	-	-	-	-
Path Loss - Firss (dBm)	69.72	69.77	69.83	69.89	69.97	70.05	70.14	-	-	-	-	-	-	-	-	-

Table 4. **Actual** and **Friis-model-based** path loss values

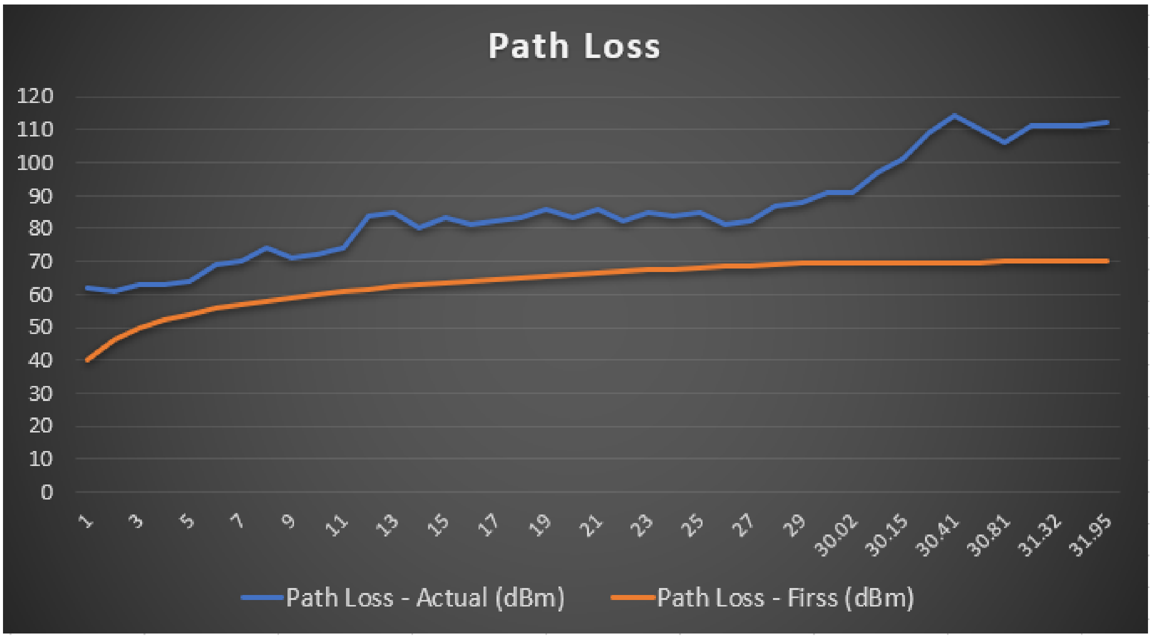


Figure 4. **Actual** vs. **Friis** model path loss

The figures of the actual and Friis model values have almost the same pattern. The path loss increases as the distance becomes longer. However, in the actual experiment, there is a sudden increase in Path Loss after turning around the corner (between 30 and 31 meters). The building walls and structure caused signal blocking and interference. The Friis Model does not show a sudden change in path loss (after turning around the corner) since it is a free space propagation model for measuring the line of sight (LOS) path loss and it does not consider the real environmental obstacles that cause signal absorption, diffraction, and reflections.