Set the transmit power

Using a very high transmit power will result in longer range, but will also generate more interference with other devices in radio range.

Also, I think when the transmit power is higher, we'll have a same resolution of distance.

A commonly used radio propagation model is the log-distance path loss model with log-normal shadowing [16]. According to this model, the received signal strength $P_r(d)$ (in dBm) at a given distance d from the transmitter is given by:

$$P_r(d)[dBm] = P_r(d_0)[dBm] - 10n\log(\frac{d}{d_0}) - X_\sigma \tag{3}$$

where $P_r(d_0)$ is the expected signal strength at reference distance d_0, n is the path-loss exponent, and $X_\sigma \sim N(0, \sigma)$ is a normal random variable (in dB).

Higher TX power results in higher power consumption which reduces battery life time.

TXPOWER Register setting P24 of cc2530 datasheet

Table 2. Recommended Output Power Settings[1]

TXPOWER Register Setting	Typical Output Power (dBm)	Typical Current Consumption (mA)
0xF5	4.5	34
0xE5	2.5	31
0xD5	1	29
0xC5	–0.5	28
0xB5	–1.5	27
0xA5	–3	27
0x95	–4	26
0x85	–6	26
0x75	–8	25
0x65	–10	25
0x55	–12	25
0x45	–14	25
0x35	–16	25
0x25	–18	24
0x15	–20	24
0x05	–22	23
0x05 and TXCTRL = 0x09	–28	23

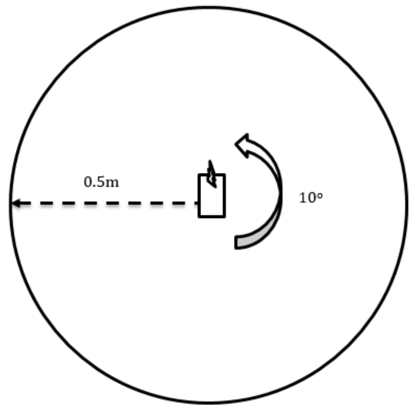
(1) Measured on Texas Instruments CC2530 EM reference design with T_A = 25°C, VDD = 3 V and f_c = 2440 MHz, unless otherwise noted. See References, Item 1, for recommended register settings.

Free space chamber or typical indoor environment?

Distance resolution: 0.5m for 10m. Hence 10/0.5 = 20 steps.

Angel resolution: 9 degree step for 360 degrees. Hence 360/9 = 40 directions. How to do this accurately and efficiently? Stepper motor?

Angel*Distance = 20*40 = 800 sample points.

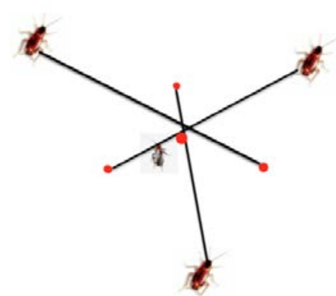


If the radiation pattern doesn't differ a lot on different orientations, a set of histograms of distance distribution at different RSSI value will do.

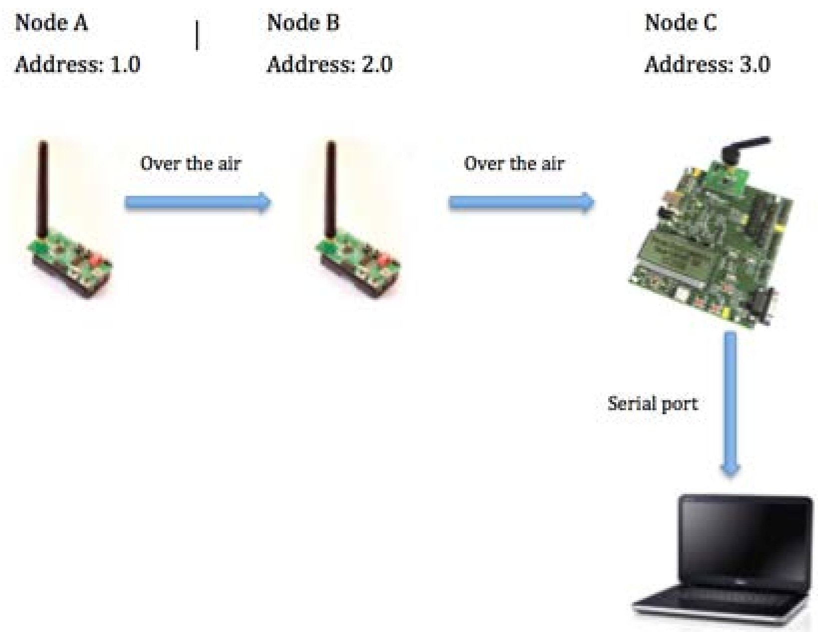
If the radiation pattern differs a lot on different orientations, can we utilize the difference rather than mitigate it?
"Spin" the insect and find the orientation with the largest RSSI, and localize the insect with both RSSI value and the orientation info.

Coarse localization with one insect:

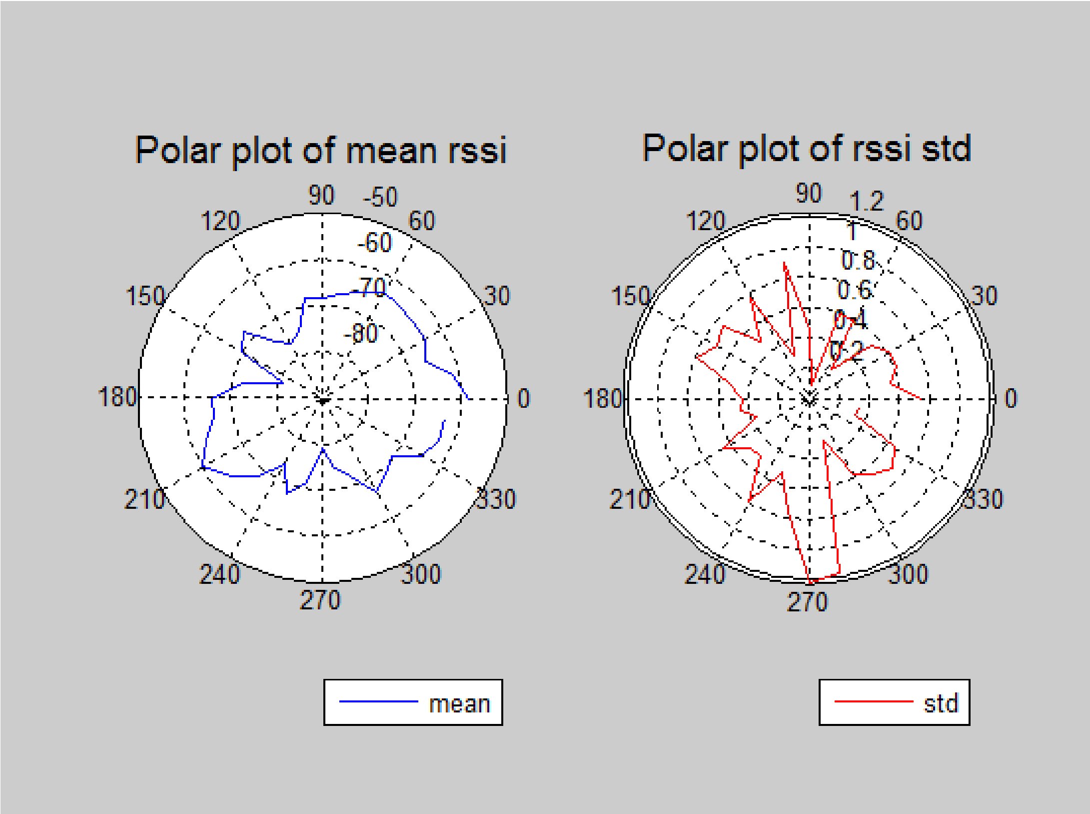
Accurate localization with multiple insects:

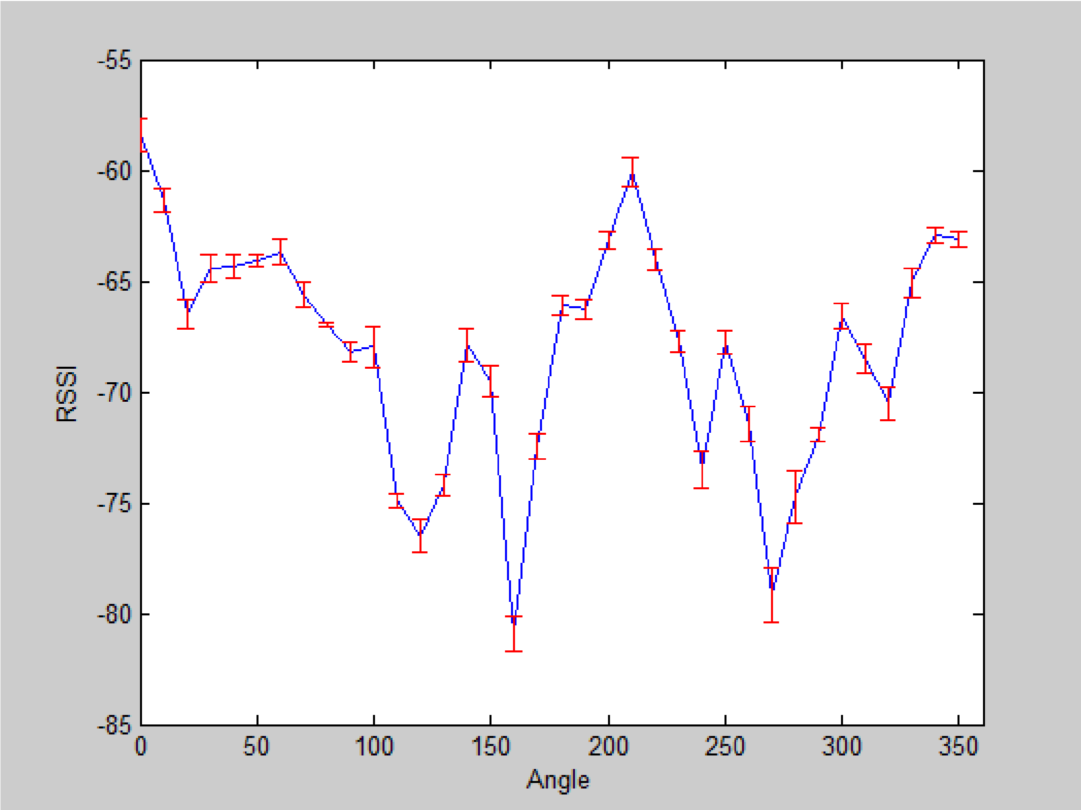


Calibration topology setup

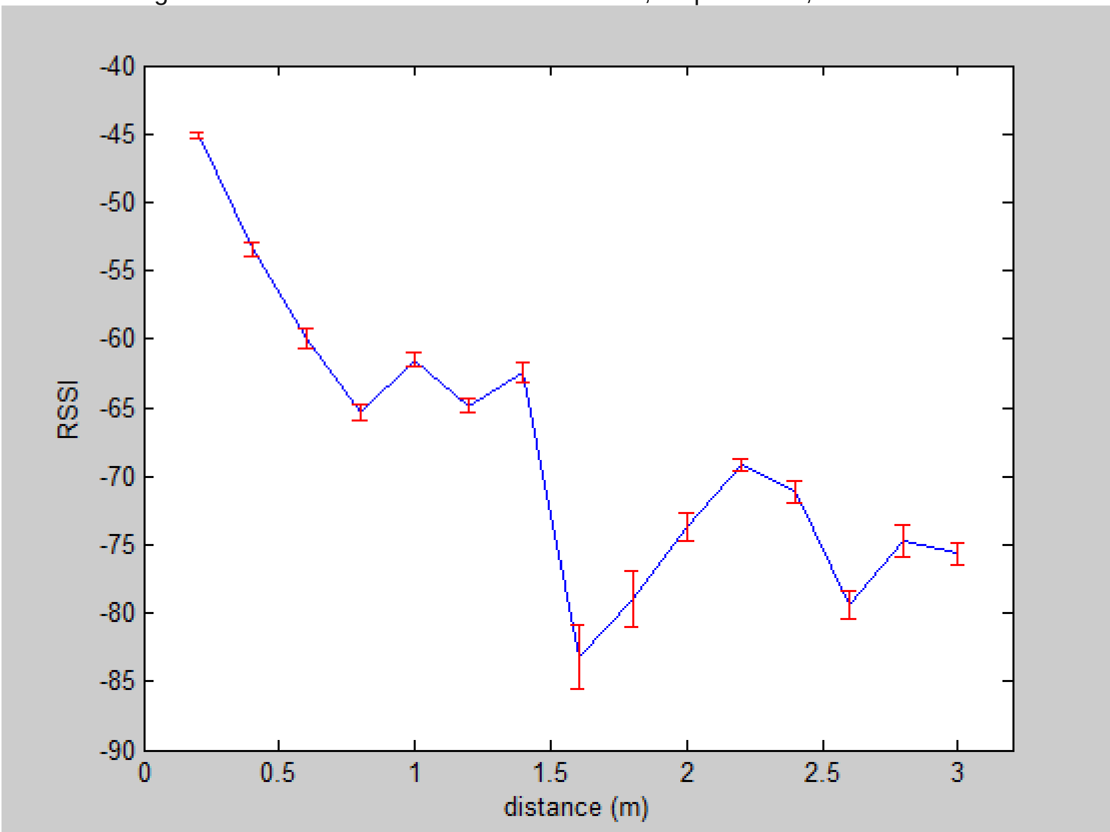


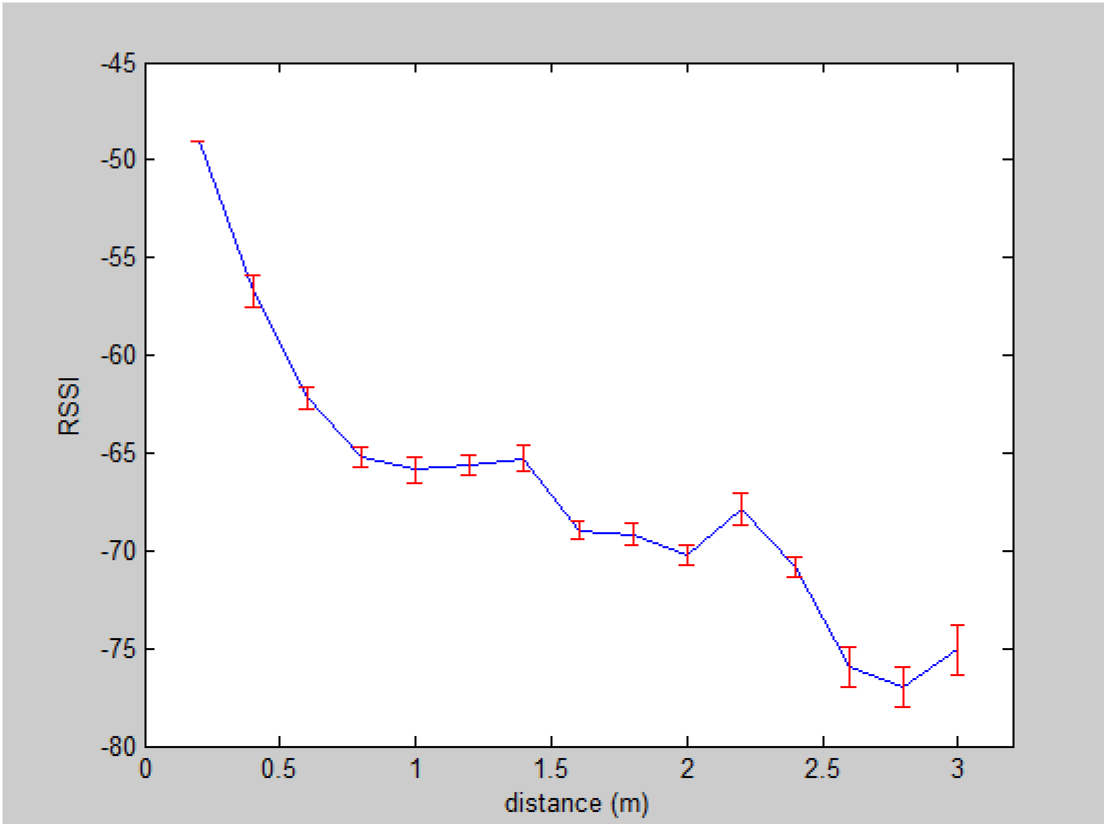
After collected data from 0° to 360°, we can draw a polar plot of mean rssi and its standard deviation:





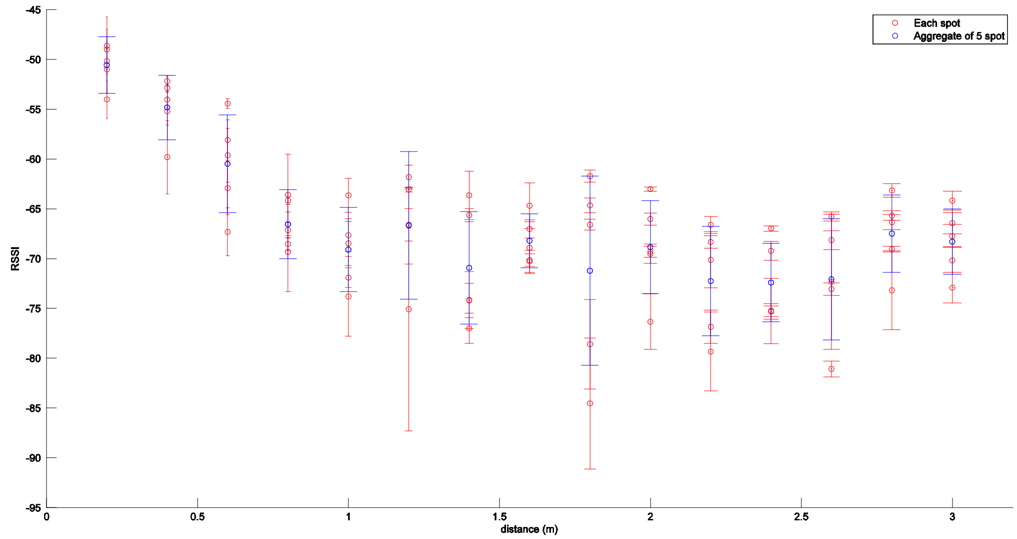
RSSI vs Range: Collect RSSI values from 0.2 m to 3m, step of 0.2m, orientation fixed at 0°.



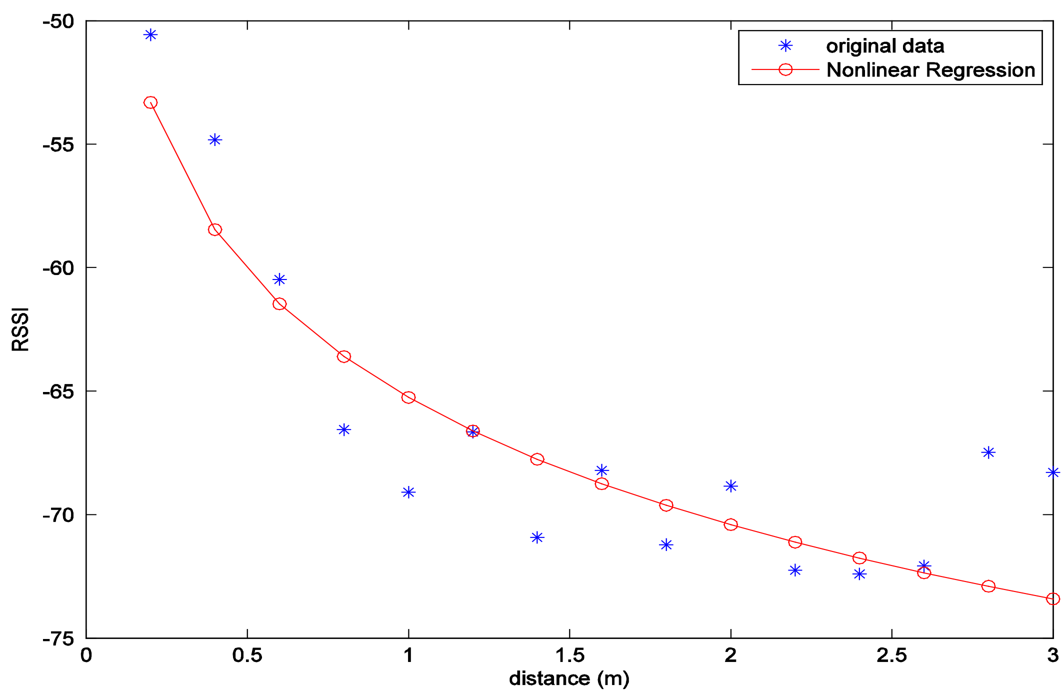


-45
-50
-55
-60
-65
-70
-75
-80
RSSI
0
0.5
1
1.5
2
2.5
3
distance (m)

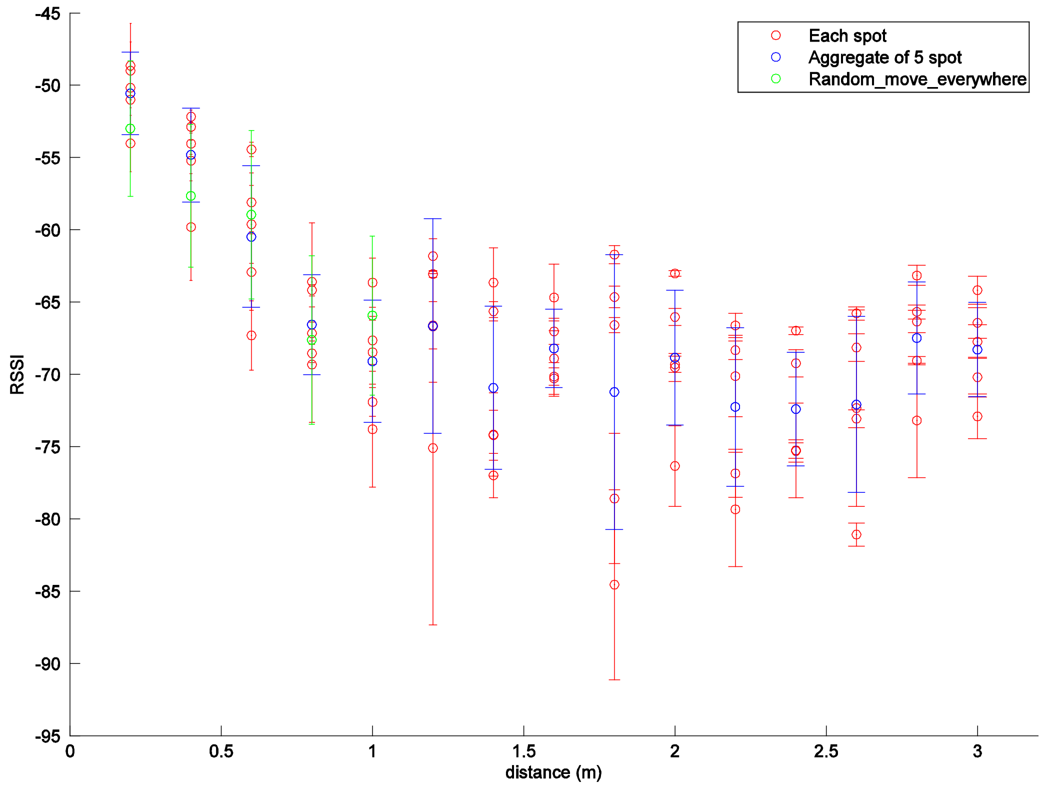
Collect RSSI from 0.2m to 3.0m, each distance with 5 random spot.



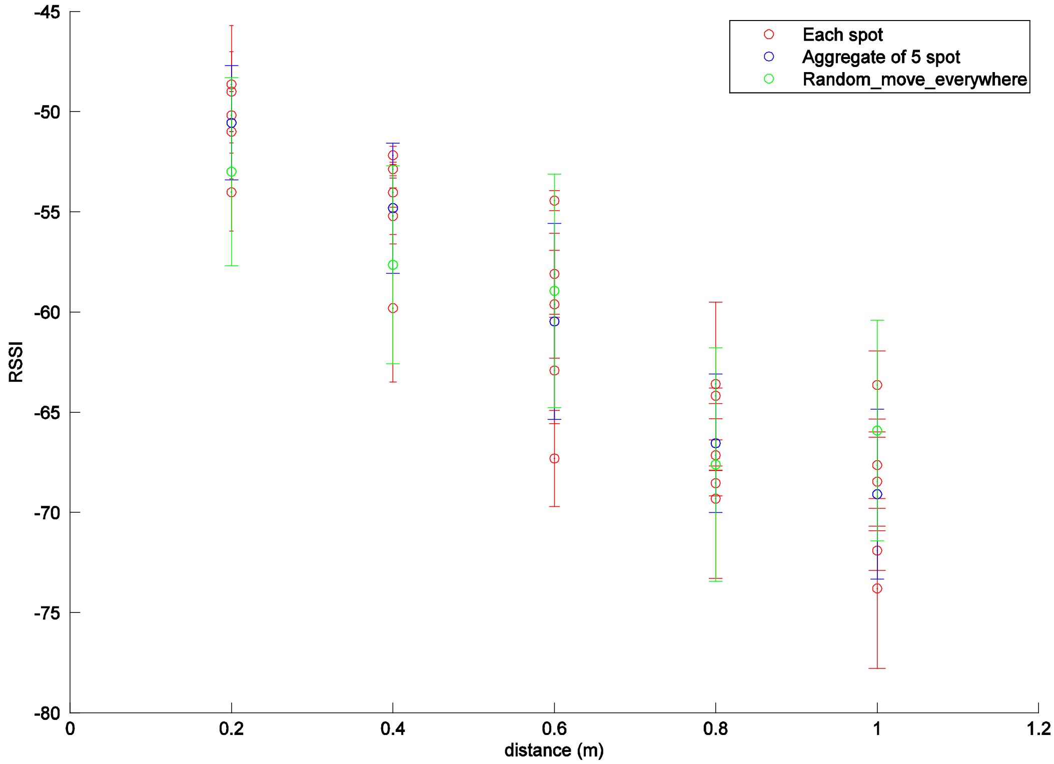
Take a look at the aggregated mean and the nonlinear regression according to the path loss model.



Compare the result of aggregation of 5 spots with constantly moving the nodes. (Data collected between 0.2m to 1.0m, 1000 samples per distance.)



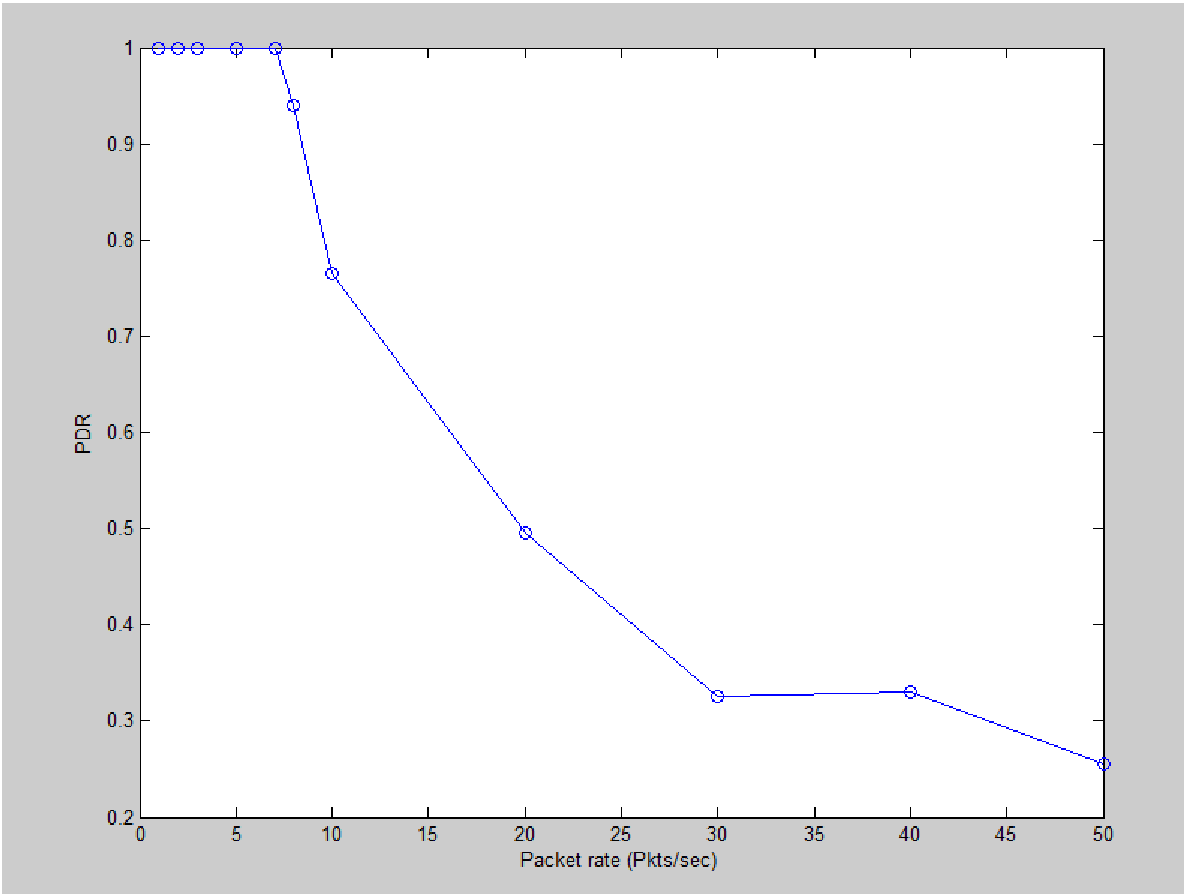
zoom in:



Each spot
Aggregate of 5 spot
Random_move_everywhere
RSSI
-45
-50
-55
-60
-65
-70
-75
-80
0
0.2
0.4
0.6
0.8
1
1.2
distance (m)

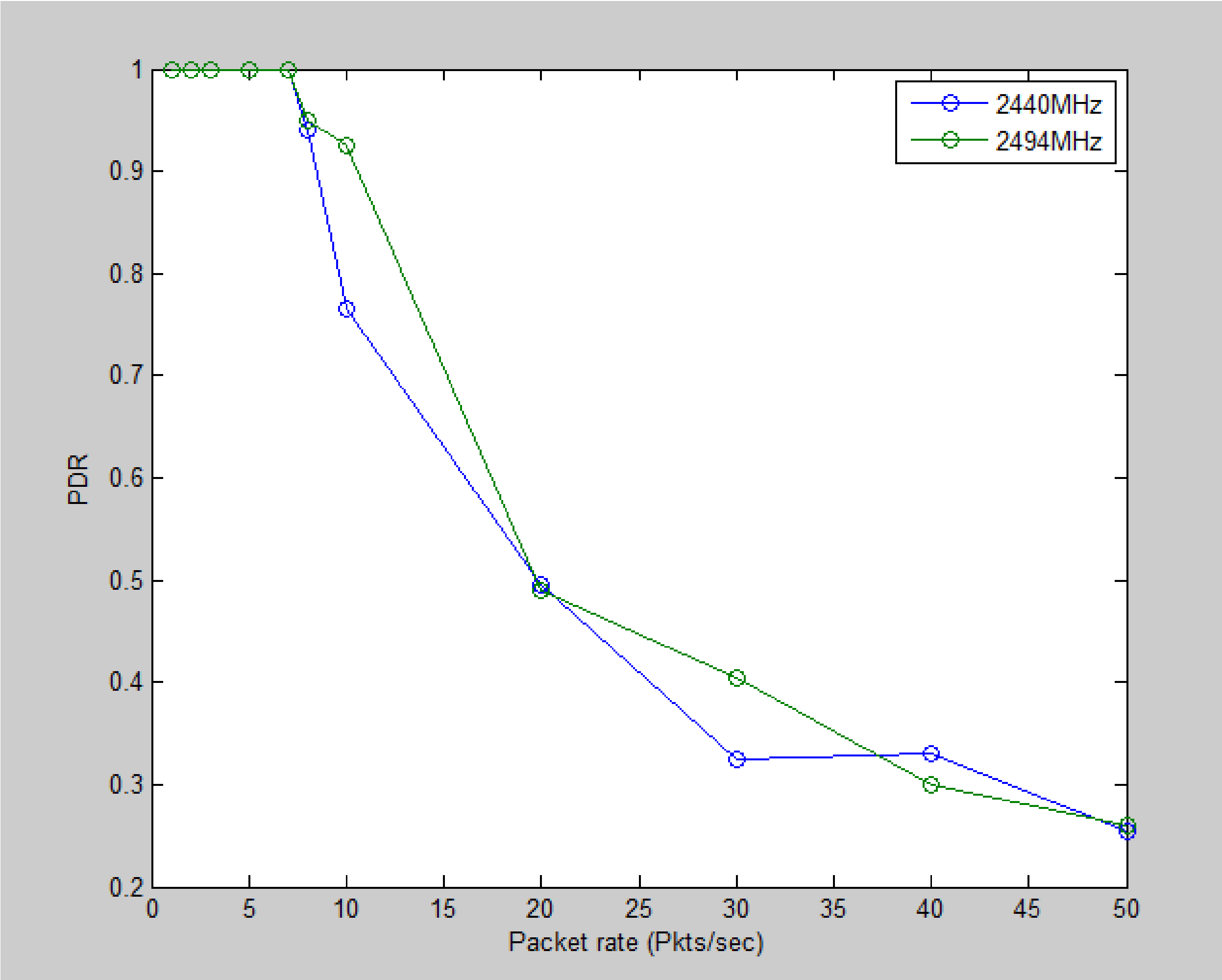
Experiment to test the relationship between PDR and packets inter-arrival time. The Tx and Rx are 1m apart, and I change the packet rate from 1 pkts/sec to 50 pkts/sec.

The result is as below:



The PDR is 1 until packet rate increases to 8 pkts/sec. I changed the distance from 1m to 2m, 3m and 4m, with 7 pkts/sec, all give PDR equal to 1.

After I changed the RF frequency from 2.44GHz to 2.494GHz, the PDR plot is as below:



INTERFERER REJECTION (802.15.4 INTERFERER)
vs
INTERFERER FREQUENCY (CARRIER AT –82 dBm, 2440 MHz)

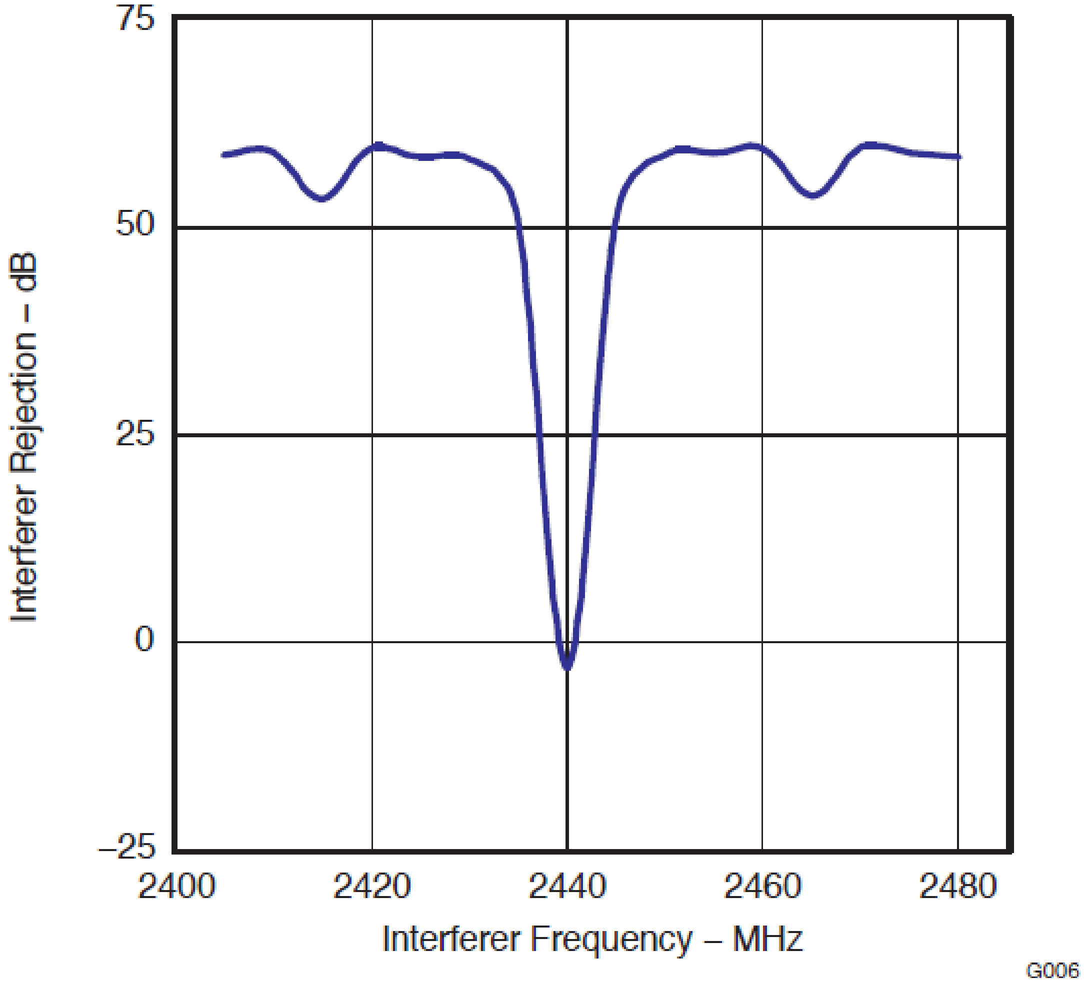
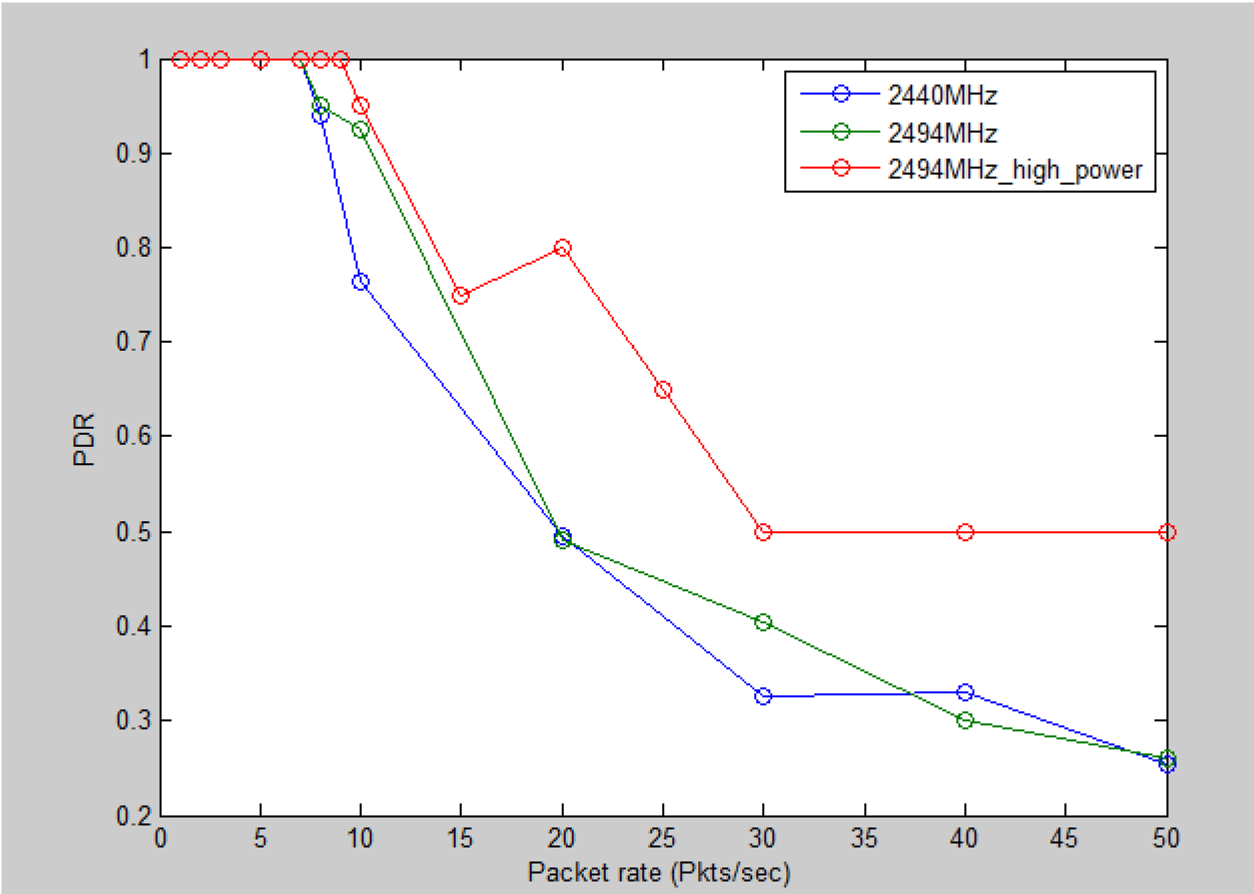


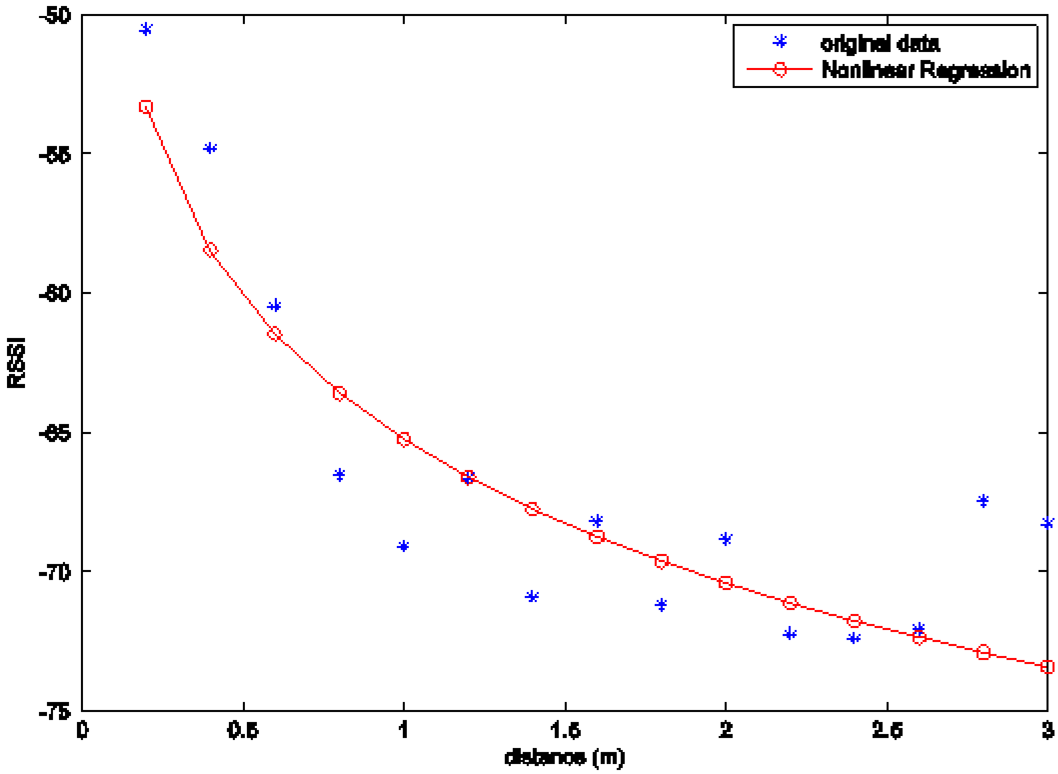
Figure 14.

I then change the transmit power from the default 1dBm to recommended maximum 4.5dBm, the PDR is as below:



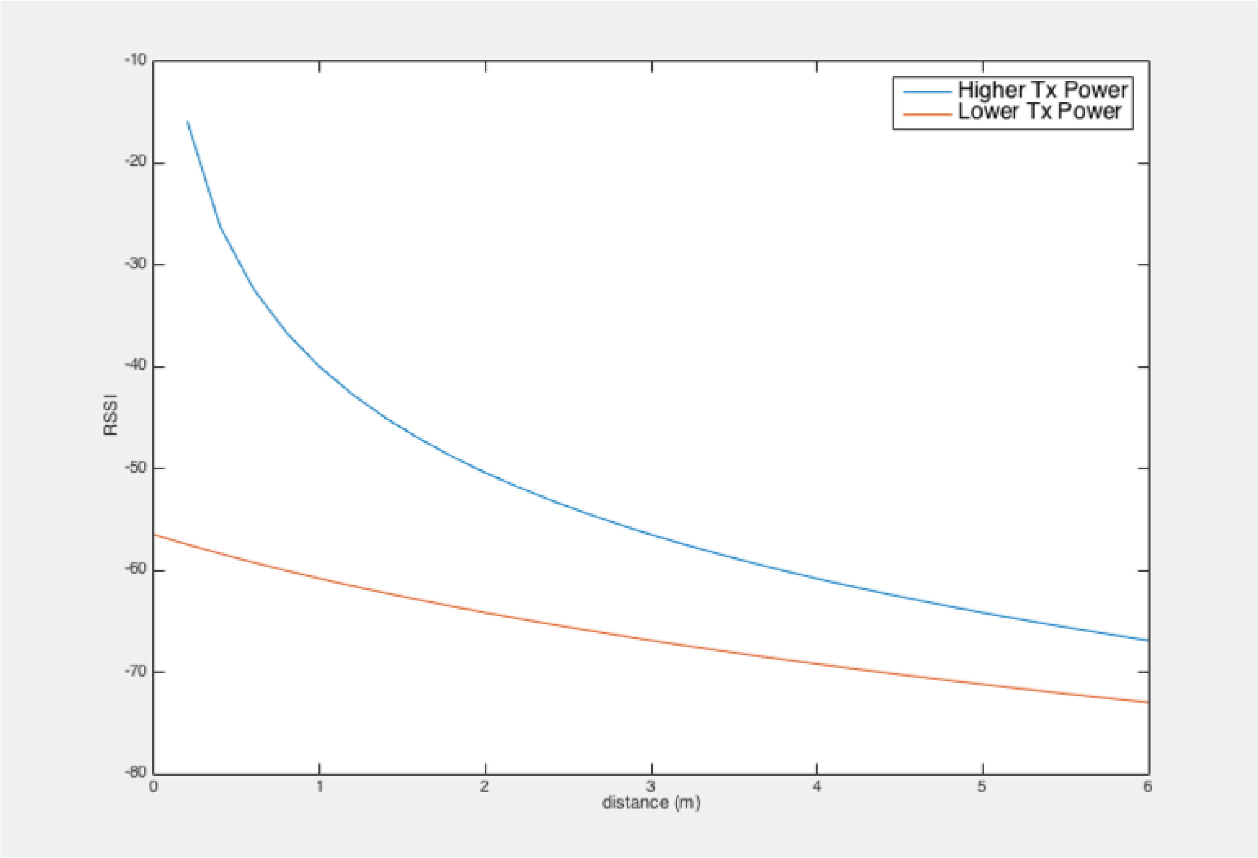
The PDR has improved. The PDR is 1 until packet rate increases to 10 pkts/sec. I changed the distance from 1m to 2m,3m and 4m, with **8 pkts/sec**, all give PDR equal to 1. However, with 9 pkts/sec, there're some packets loss when the distance gets larger.

With default setting, I tried on the table and outside in the corridor, the RSSI goes back and forth within -55 to -70 in a long range, which provides a very bad resolution, similar to my previous result.



This is partly because the power setting of the chip. As we can see from the plot, the RSSI drops to about -60 to -70db even within 1 meters, which is already the typical RSSI for a middle range or edge range distance. That partly explains why the RSSI goes back and forth within -55 to -70 in a long range - if we’re dealing with middle range or edge range localization, 0.2m resolution is too delicate, that’s why there’s no obvious decreasing patterns there.

What we're expecting is a RSSI vs Distance mapping like this:



What we have with the lower TX Power settings, is a left-shifted version of the Higher TX Power settings, and have a much worse resolution. With the fickle characteristics that RSSI have (Temporal variance and deep fading, multipath), we cannot tell anything within range of 0.2m.

Should we increase the TX Power?

Using a very high transmit power will result in longer range, but will also generate more interference with other devices in radio range.

Higher TX power results in higher power consumption which reduces battery life time.

Table 2. Recommended Output Power Settings(1)

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0x75	–8	25
0x65	–10	25
0x55	–12	25
0x45	–14	25
0x35	–16	25
0x25	–18	24
0x15	–20	24
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