Taste of Research
Gough Yumu LUI
Engineer's Log Book

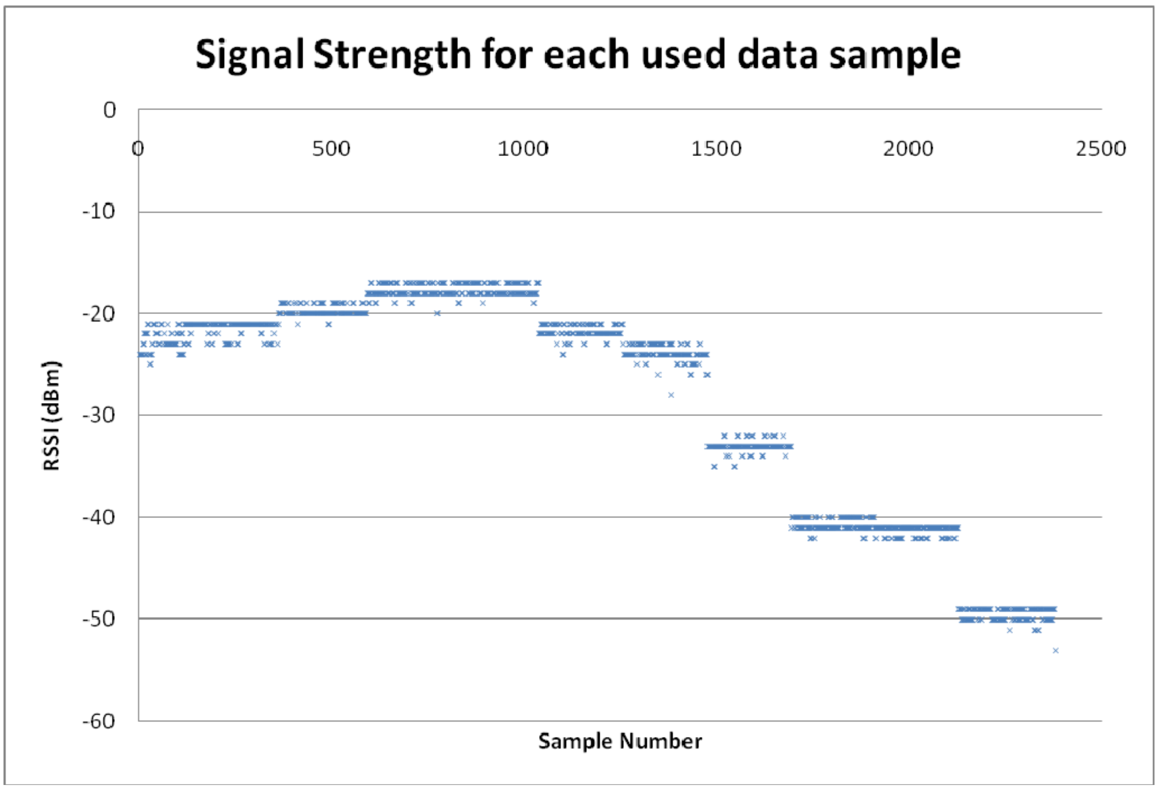
Week 3

- Monday 29th November 2010

I took a go at the iPaq rx5965 with the Sychip chipset, but unfortunately, it is not compatible with Ministumbler as well. WiFiFoFum is the only scanning software which is compatible with my PDAs and it doesn't seem to log all the necessary data for our experiments, despite being able to log to many formats.

That being said, I've managed to download an application to sync and display the GPS time based on the rx5965's internal GPS (SiRFstarIII based as well). This way, we can synchronize our testing with the GPS time to within a second. I consciously avoided the need to use a Bluetooth GPS (of which I have many) since their signals may interfere with our experiment as they use the same 2.4Ghz band.

And I thought I might as well make a chart which depicts the signal strength for used samples to visualize any temporal test trends – overall it looks like my trial tests are successful overall – with measurements above 1m affected by Fresnel zone obstruction and below 0.25m affected by near field effects.



I only just realized that I haven't completed the FSPL and Fresnel Zone calculations for 5Ghz. Lets use 5000Mhz for the lower 5Ghz band:

To find the distance, we'll solve for d:

$$
\begin{aligned}
\mathrm{FSPL(dB)} &= 10\log_{10}\left(\left(\frac{4\pi}{c}df\right)^2\right)\\
&= 20\log_{10}\left(\frac{4\pi}{c}df\right)\\
&= 20\log_{10}(d) + 20\log_{10}(f) + 20\log_{10}\left(\frac{4\pi}{c}\right)\\
&= 20\log_{10}(d) + 20\log_{10}(f) - 147.55
\end{aligned}
$$

114.3 = 20 log10 (d) + 20 log10 (5000x10^6) – 147.55
20 log10 (d) = 114.3 – 20 log10 (5000x10^6) + 147.55
20 log10 (d) = 67.870599…
Log10 (d) = 3.3935…
D = 2474.742
D = 2475 m

At 100m, the radius of the first Fresnel zone is:
Fn = sqrt((1*((3*10^8)/(5000*10^6))*50*50)/100)
Fn = 1.224m

At 50m, the radius of the first Fresnel zone is:
Fn = sqrt((1*((3*10^8)/(5000*10^6))*25*25)/50)
Fn = 0.866m

At 25m, the radius of the first Fresnel zone is:
Fn = sqrt((1*((3*10^8)/(5000*10^6))*12.5*12.5)/25)
Fn = 0.612m.

At 10m, the radius of the first Fresnel zone is:
Fn = sqrt((1*((3*10^8)/(5000*10^6))*5*5)/10)
Fn = 0.387m.

At 1m, the radius of the first Fresnel zone is:
Fn = sqrt((1*((3*10^8)/(5000*10^6))*0.5*0.5)/1)
Fn = 0.122m.

In all cases, the Fresnel zone for 5Ghz is smaller than 2.4Ghz, and also, the expected range is shorter than 2.4Ghz. This is only in the theoretical “free space” case – imperfections and reality will of course skew the result and possibly shorten the range.

Had a meeting with Binghao and Thomas – the discussion focused mainly on the trial run which I had run at home and showing some of the near field and Fresnel zone blockage effects. The decision was that there was too much talk and not enough “action” and that we should begin experimenting now. Binghao consulted with others and gathered equipment – we were testing a metal shielding plate to try and shield reflections from the ground from contributing to the experiment. An old motherboard tray was found and used for it. Some mentions were made of the Wi-Fi tags we had – however, it was decided that all “special” devices will be tested last due to their difficulty. All wireless cards were mounted 20cm from the front leading edge of the trolley. The bin with the accesspoint prevents access within 8cm – so the shortest distance was made to be 30cm. A larger number of distances was used, due to the limitations of the testing hallway. The final distances settled on was 30cm, 50cm, 80cm, 1m, 1.5m, 2m, 2.5m, 5m, 7.5m, 10m, 15m, 20m, 25m, 30m, 35m.

Unfortunately, I forgot to pack my USB GPS unit. Since we wanted to perform testing, Binghao provided me a Garmin Etrex unit with a serial cable. Unfortunately, we needed to hook this up to USB – the supplied Jaycar USB to RS232 converter would not work. It gave me a Code 10 error – which gives me a hint that the converter may not have a genuine Prolific Technology chip. Another converter was provided that did work. Unfortunately, it was soon detected that this GPS unit was not suitable. The indoor environment makes it almost impossible to get a GPS fix. Due to a re-radiator inside the SNAP lab, we were able to get a fix inside the lab, but at the ends of the hallway, the fix was lost – and when fix was lost, the time which was returned was static. My processing programs require the time to be correct so that it can automatically segment the arrays of data. Binghao did offer a modified version of inSSIDer which relies on the system clock for the time, however, logs in a custom text format. For the moment, I have not needed for this version but it was kept as a backup. I did consider writing a C program using the system time to send dummy position, satellite vehicle data and only offering the system time on a serial port. A software null modem cable would be used to connect this emulator to a piece of software as a GPS receiver. This approach would prevent needing to modify test programs and would allow this solution to work for multiple programs (and could even be useful in the future for other cases). That being said, I haven't actually needed to resort to this.

In order to continue and allow a test to be done – the decision was made to instead start and stop scanning manually in order to separate different distances into different files. We experienced multiple "Failed to save GPX file." error messages which were issued erroneously. Unfortunately due to variations in timing, and in one case, forgetting to do this procedure, the test results consists of a large variation in the sample sizes for each distance. The first test was performed for the Belkin Play USB with the plate. In order to process the data, two modified programs (grawv.c and arawv.c) were made that just dump the data as a matlab array without regards to time.

Initially while parsing the GPX data, the program had an assert failure which was tracked down to an assumption which was "incorrect". Due to inSSIDer escaping special characters in the SSID field, a 32 character SSID could be inflated five or six times. The SSID field has been increased in length and this problem was mitigated. I was satisfied with this being the only problem with the assert failure based on inspection of the resulting GPX files.

The data was not plotted and analysed as it was already about 7:30pm when I had completed the program fixes.

- <u>Tuesday 30th November 2010</u>

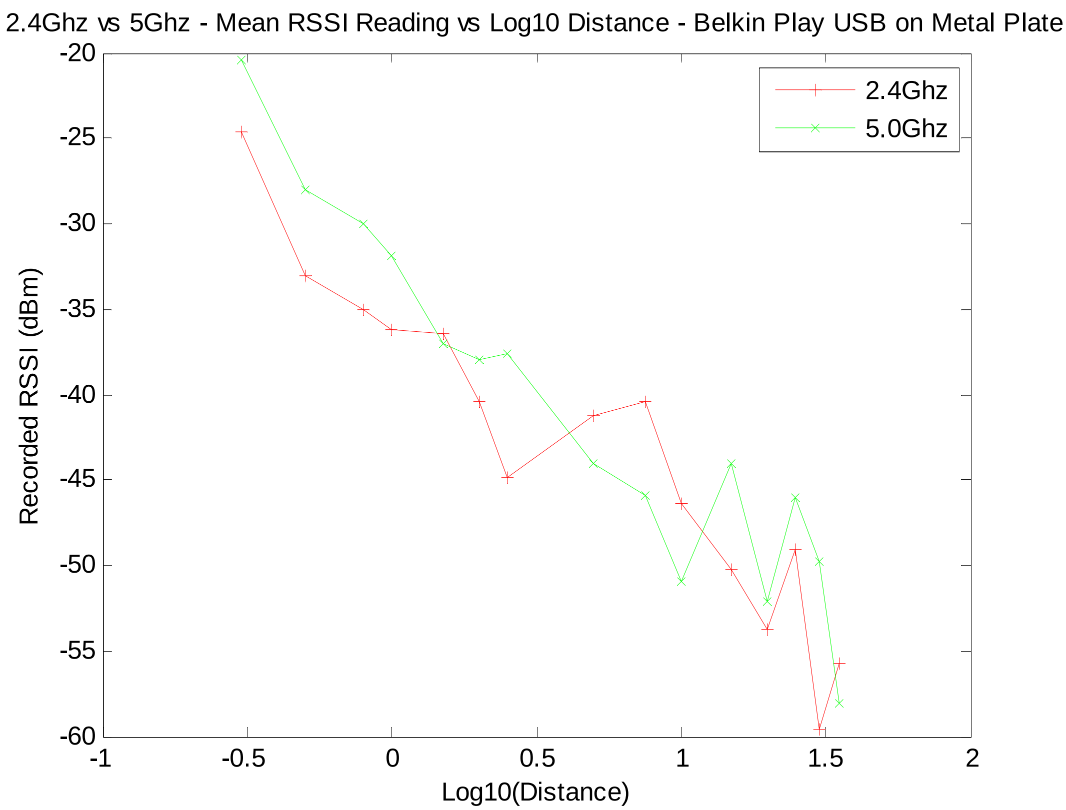
Today, the data was imported into matlab and analysed. The m code was written and saved with the intent that the same m code is used to analyse further trials. This set of tests was for the indoor test of the Belkin Play card with the plate installed. The test was performed manually, so the timings and samples were somewhat distorted. The raw data output was trimmed by 5 samples at the beginning and 5 samples at the end to compensate for interference from physically attending to the test rig.

The final number of samples vs distance is as follows:

Distance	**Number of Samples (2.4Ghz)**	**Number of Samples (5GHz)**
0.3m	229	229
0.5m	236	233
0.8m	240	240
1m	242	241
1.5m	226	226
2m	227	227
2.5m	236	238
5m	281	281
7.5m	324	324
10m	235	235
15m	244	241

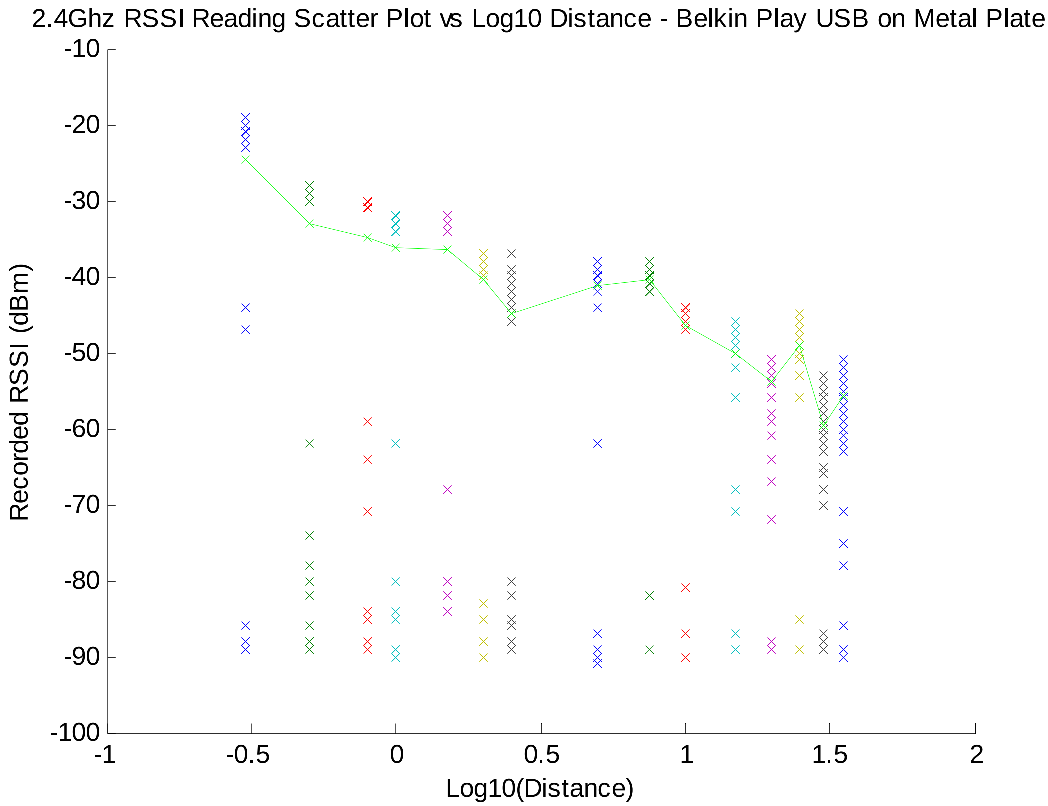
20m	245	245
25m	228	228
30m	242	242
35m	230	230

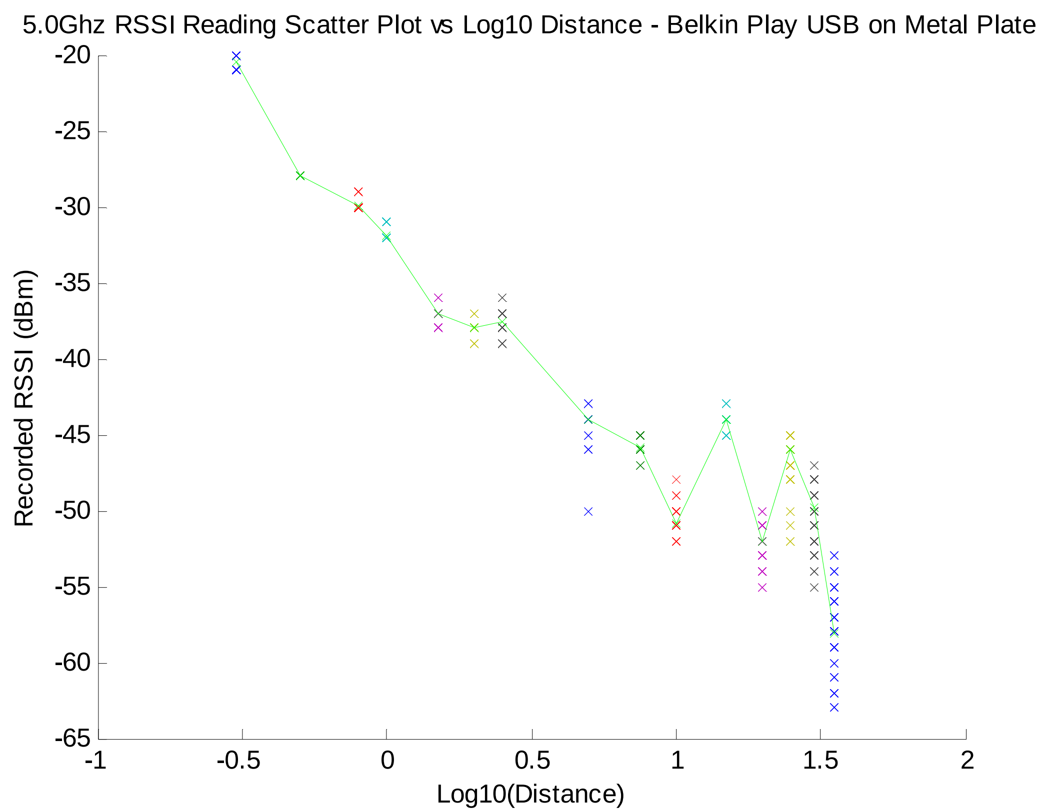
As can be seen in the table above, the number of samples for both bands were pretty close but not necessarily identical. This may have been because 2.4Ghz suffered interference from the vast number of other AP's in the area and have lost some beacon frames. The means as shown below show a decreasing trend, however, this becomes more uncertain as we go along for distance. The bouncing up and down suggests multipath from the building is, at certain points, adding to constructive or destructive interference.

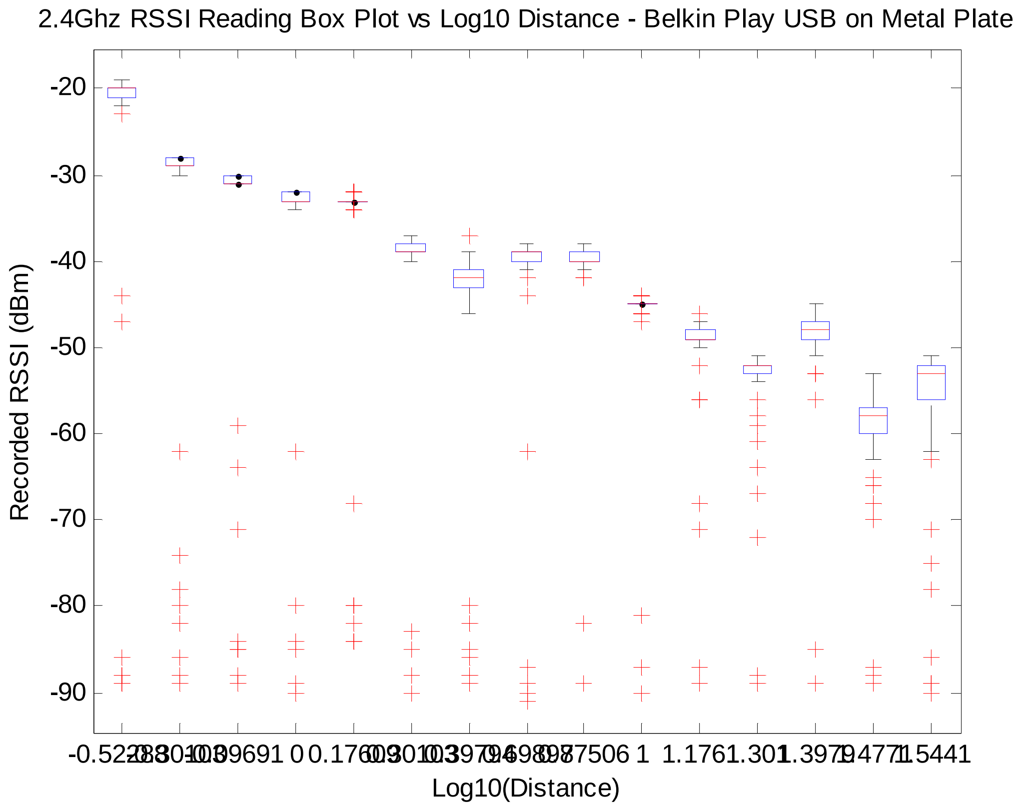


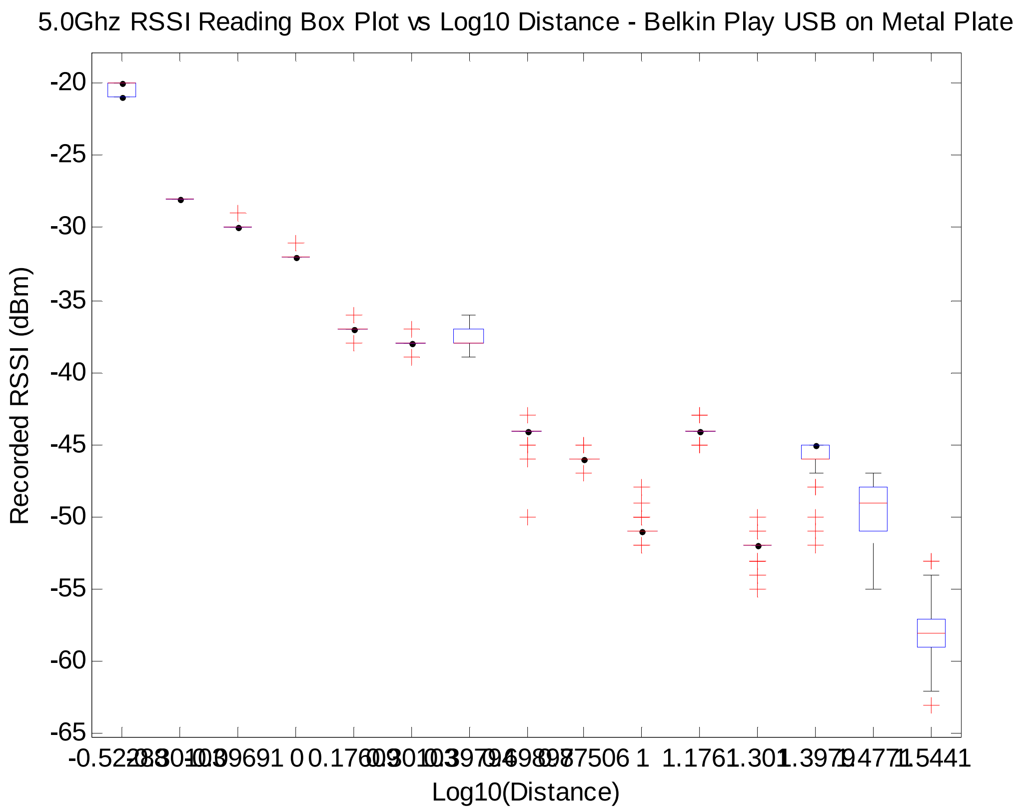
In the scatter plot, we see a vast difference between 2.4Ghz and 5Ghz with the variances in 2.4Ghz signal strength indications being fairly large, possibly due to the interference alluded to earlier. It also points to a bimodal distribution which Binghao had referred to in one of his papers when doing passive scanning. This could possibly suggest a hybrid of passive and active scanning for this particular chipset. It is noteworthy that the 5Ghz test was conducted with the AP on a channel which was not in use at the time. In both cases, the amount of variance in signal strength levels increased with distance – this is possibly due to the fact that people were more likely to walk past or in-between the card and the AP given a larger distance through the hallway. Ideas were thought of to minimize the interference from people, however, my observations have concluded that pedestrian traffic is still fairly high even at 7:30pm, so there may not be any significant benefit to testing later at night.

The box plots echo the scatter plot readings which suggest that there are many outliers. It is of note that the boxes do get larger with distance, which suggests that the variance increases with distance as noted earlier.


2.4Ghz RSSI Reading Scatter Plot vs Log10 Distance - Belkin Play USB on Metal Plate
Recorded RSSI (dBm)
Log10(Distance)
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-1
-0.5
0
0.5
1
1.5
2


5.0Ghz RSSI Reading Scatter Plot vs Log10 Distance - Belkin Play USB on Metal Plate
Recorded RSSI (dBm)
Log10(Distance)
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-1
-0.5
0
0.5
1
1.5
2


2.4Ghz RSSI Reading Box Plot vs Log10 Distance - Belkin Play USB on Metal Plate
Recorded RSSI (dBm)
Log10(Distance)


5.0Ghz RSSI Reading Box Plot vs Log10 Distance - Belkin Play USB on Metal Plate
Recorded RSSI (dBm)
Log10(Distance)

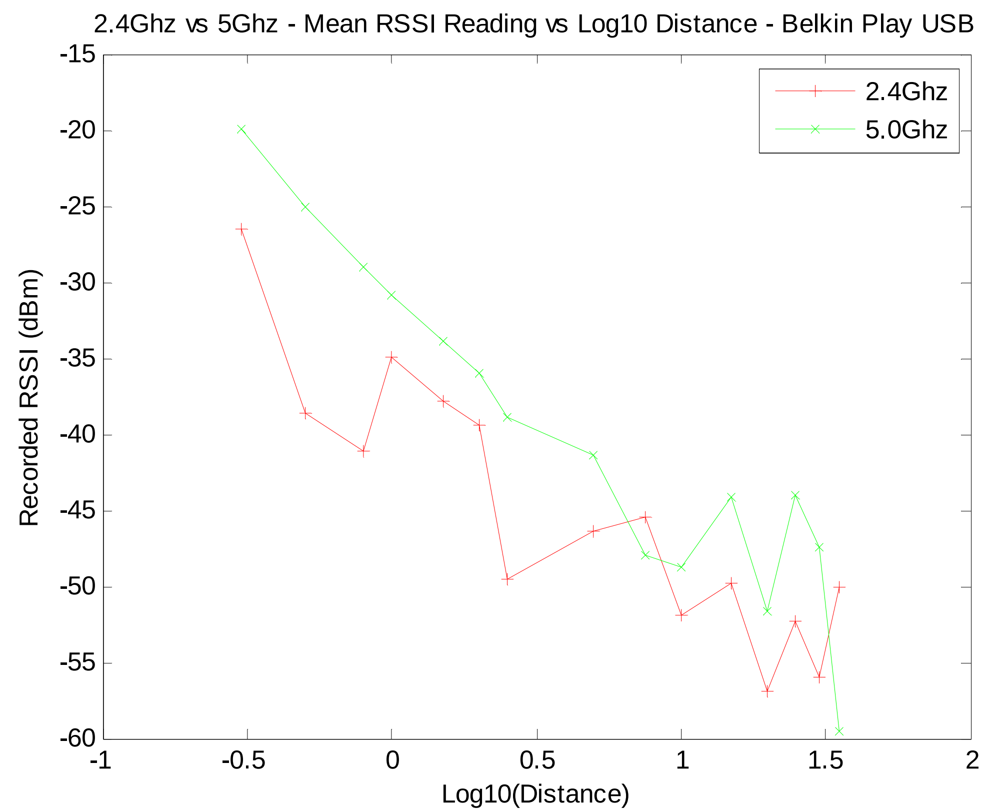
Testing hurdles from Monday were rectified – I had bought in my USB GPS unit which has a SiRFstarIII chipset, and confirmed that its time does go into free-running mode on loss of fix. Furthermore, the software inSSIDer will record the updated time despite the loss of fix – so I can go back to a GPS synchronized data collection system as initially intended. Difficulties with the positioning of the cart were improved upon as well – the measuring tape now has sections of packing tape stuck at all of the test points (distance minus 20cm so that when the cart is aligned to the front of the marker, the card is at the intended distance). The slit in the trolley is aligned over the tape every time, and the tape is strung out over the section between two tiles on the floor to ensure that the line is as straight as possible and the cart is oriented the same way each time. Furthermore, the witches hats positioning in the main lift foyer has been refined in such a way that it discourages people from crossing in front of the beam of the AP, instead they will hopefully go around. This still does not deter the casual conversation in the walkway which causes some disturbance in the data.

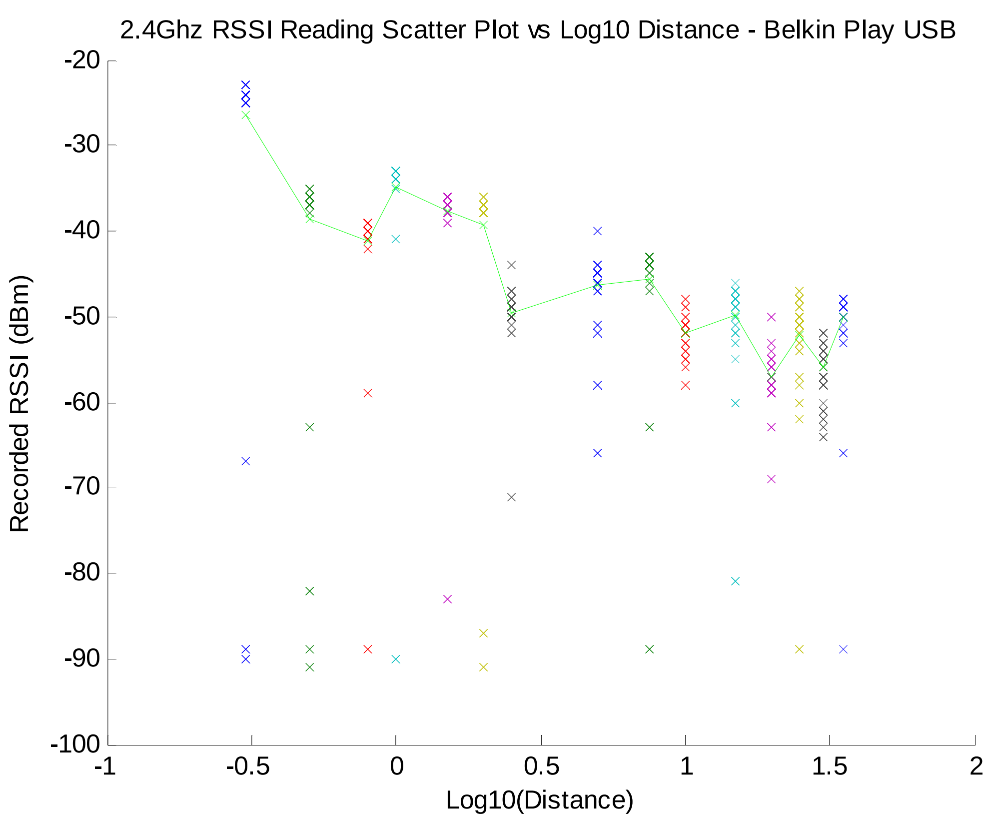
The Belkin Play was tested without the plate in place. The number of data points recorded are tabulated below:

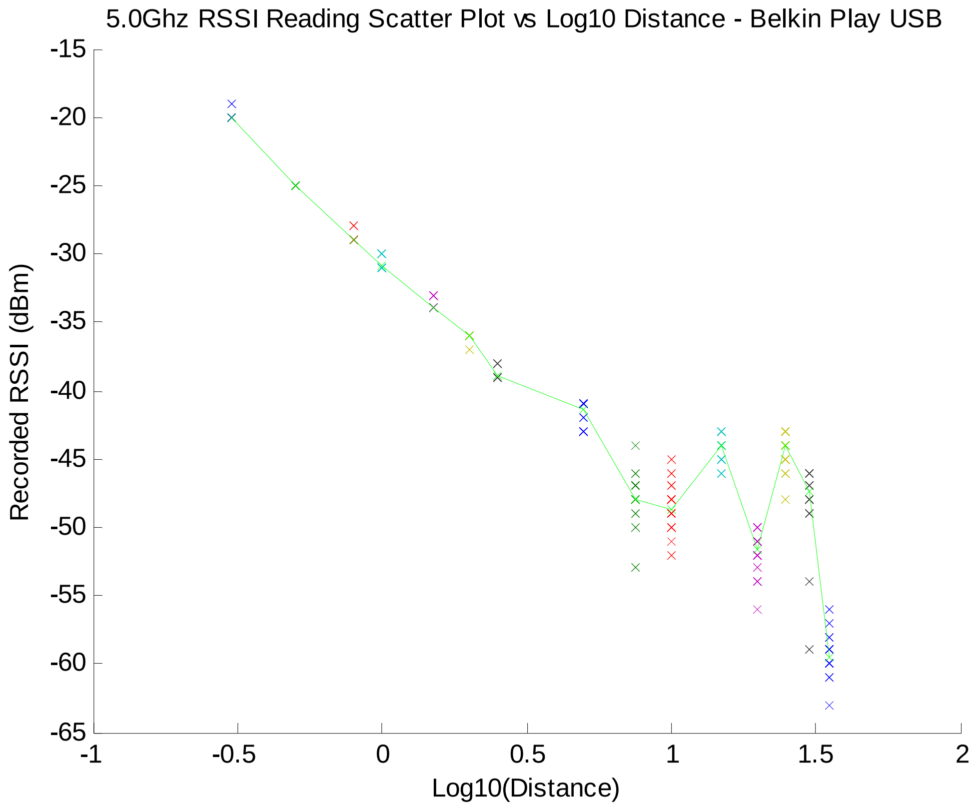
Distance	**Belkin Play (2.4Ghz)**	**Belkin Play (5GHz)**
0.3m	198	198
0.5m	184	184
0.8m	170	170
1m	156	156
1.5m	145	145
2m	139	139
2.5m	133	133
5m	123	123
7.5m	117	117
10m	111	111
15m	104	104
20m	101	101
25m	95	95
30m	94	94
35m	75	77

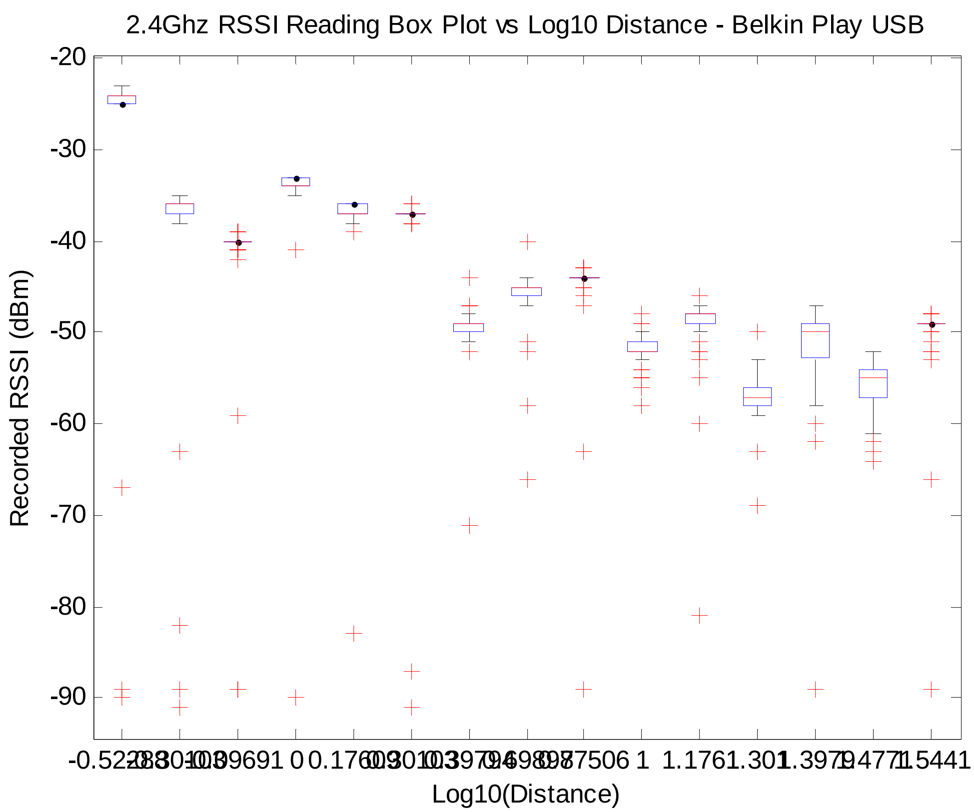
It seems unusual, but the data points seem to drop off with distance. At the moment, I am not entirely sure why this is, but it appears to be a possible signal weakening or a driver issue.

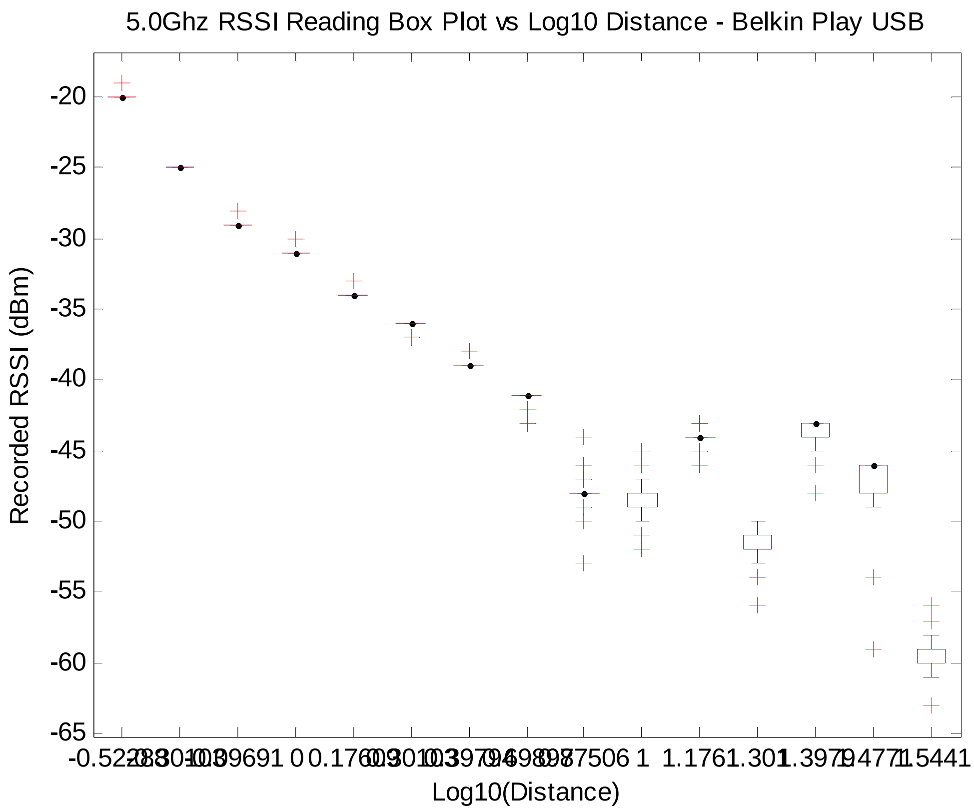
As we can see, the 5Ghz mean line shows a very nice, almost straight line relationship initially, which is encouraging. The noisy data on the 2.4Ghz still shows up as expected. It is still concerning the massive drop off in sample numbers.


2.4Ghz vs 5Ghz - Mean RSSI Reading vs Log10 Distance - Belkin Play USB
2.4Ghz
5.0Ghz
Recorded RSSI (dBm)
Log10(Distance)
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-1
-0.5
0
0.5
1
1.5
2


2.4Ghz RSSI Reading Scatter Plot vs Log10 Distance - Belkin Play USB
Recorded RSSI (dBm)
Log10(Distance)
-20
-30
-40
-50
-60
-70
-80
-90
-100
-1
-0.5
0
0.5
1
1.5
2

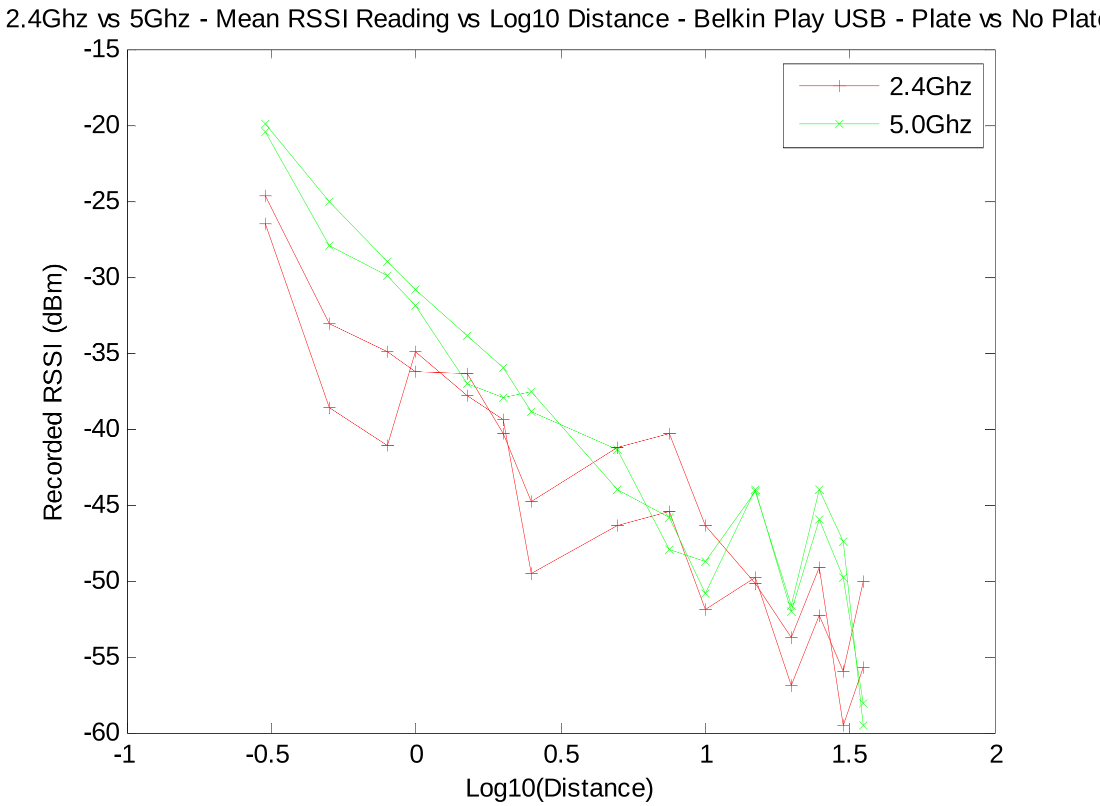

5.0Ghz RSSI Reading Scatter Plot vs Log10 Distance - Belkin Play USB
Recorded RSSI (dBm)
Log10(Distance)


2.4Ghz RSSI Reading Box Plot vs Log10 Distance - Belkin Play USB
Recorded RSSI (dBm)
Log10(Distance)



All in all, this first test was designed to try and decide whether testing should proceed with or without a shield. The plot below shows the shield and no shield means – in all, it does look like the shield might be doing something for 2.4Ghz, but there is usually no shield when someone uses their cards indoor, and I'm not entirely convinced the shield is working as expected since it is not attached to any ground whatsoever.

It was heartening to see that the 5Ghz lines followed each other within a few dB for almost all test points which implies a validation of our testing methodology. Unfortunately the 2.4Ghz seemed much more prone to differences and may have been affected by the presence of the plate. I am not sure I can conclusively say that the plate did much to alter the test results as the environment would have been altered as well, and so this test is rendered inconclusive. If there were any great effects, I would expect them to show up on both 2.4Ghz and 5Ghz and to be much more substantial.



Data collection was also performed for the Netgear WG111U SuperAG card, however, this time, something unusual happened. The recorded GPX tripped an assertion in my code – the file was incomplete and ended mid-tag. This unfortunately meant that one third of the test distances were lost. There was no way to recover them as they were never recorded – three versions of the file were checked. The data was to be re-collected the next day. It was of note that the GPX files at this point were roughly 50-60Mb in size, and I thought there may have been some size limitation in the system.

- Wednesday 1st December 2010

So far, it was evident that the data was, especially for the Belkin Play card, very noisy. It was assumed that measured signal strengths fit a Gaussian profile, means and standard distributions were found. The m code was updated (at significant length) to automatically produce the means and standard distributions and exclude signals that were two standard distributions or more away from the mean. This approach was found to be problematic, especially with the 5Ghz in that the two-standard-deviation figure was less than 1dBm producing many excluded samples at certain data points, and at 2.4Ghz due to the spurious points, the exclusion parameters were too wide and resulted in minimal filtering occurring. A better method to filter the data will be explored later, when a larger amount of data is collected, but the code has been retained for the present moment.

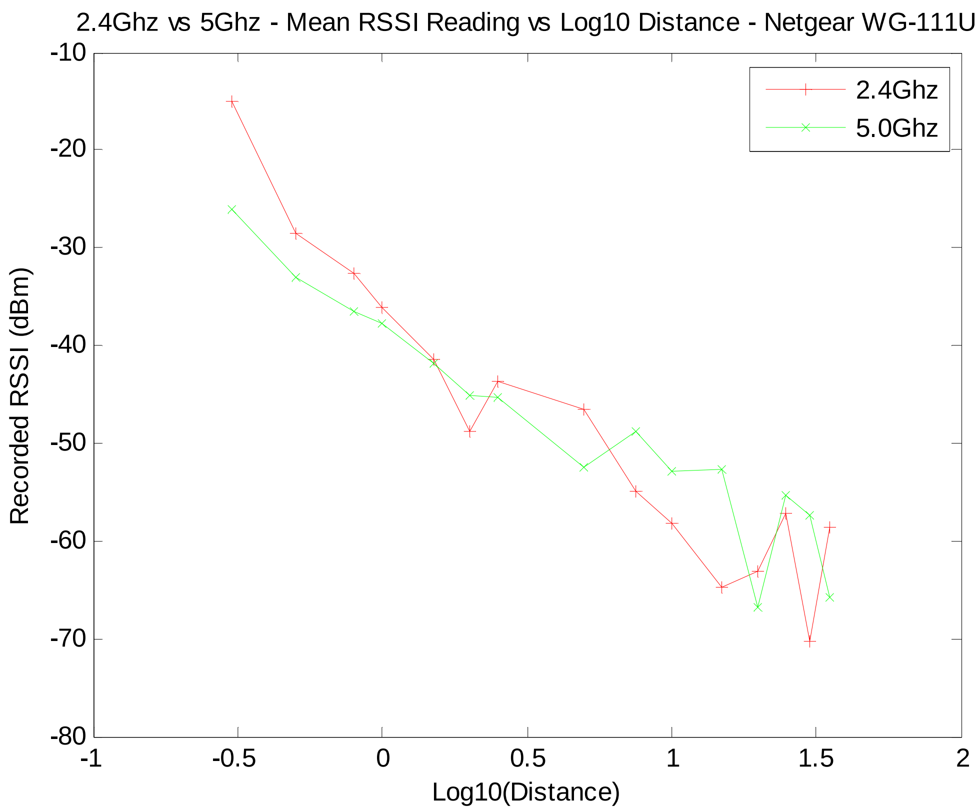
The missing data points were collected from the Netgear WG-111U SuperAG card, the total data points are as follows:

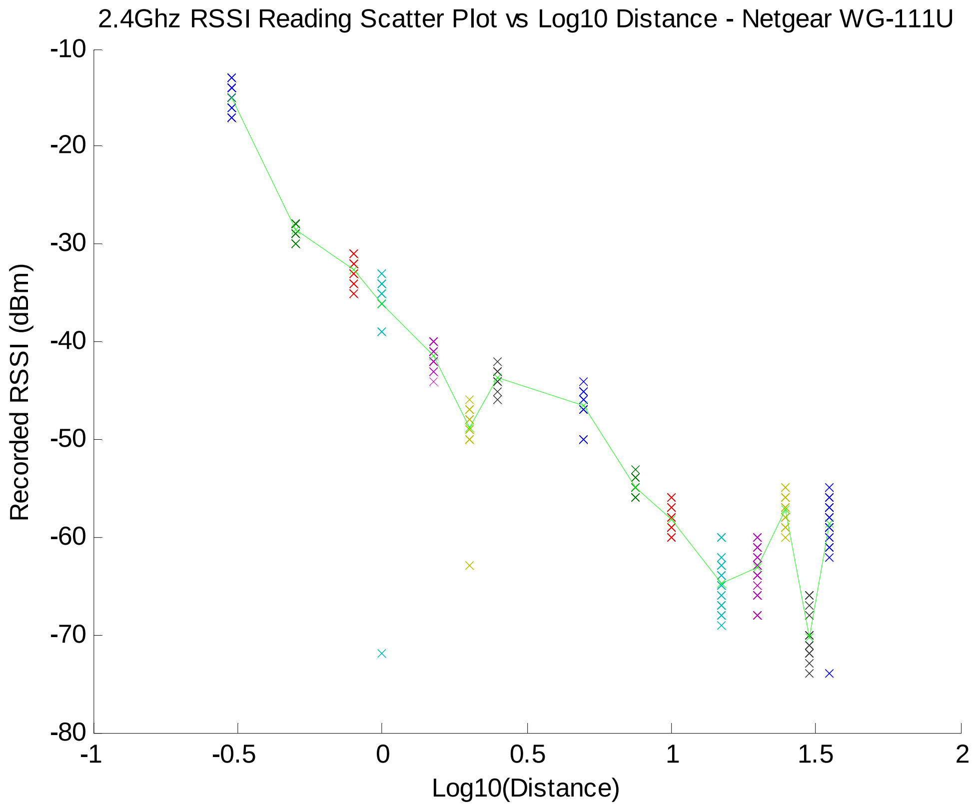
Distance	**WG-111U 2.4Ghz**	**WG-111U 5GHz**
0.3m	183	183
0.5m	163	163
0.8m	143	143
1m	130	130
1.5m	116	116
2m	103	103

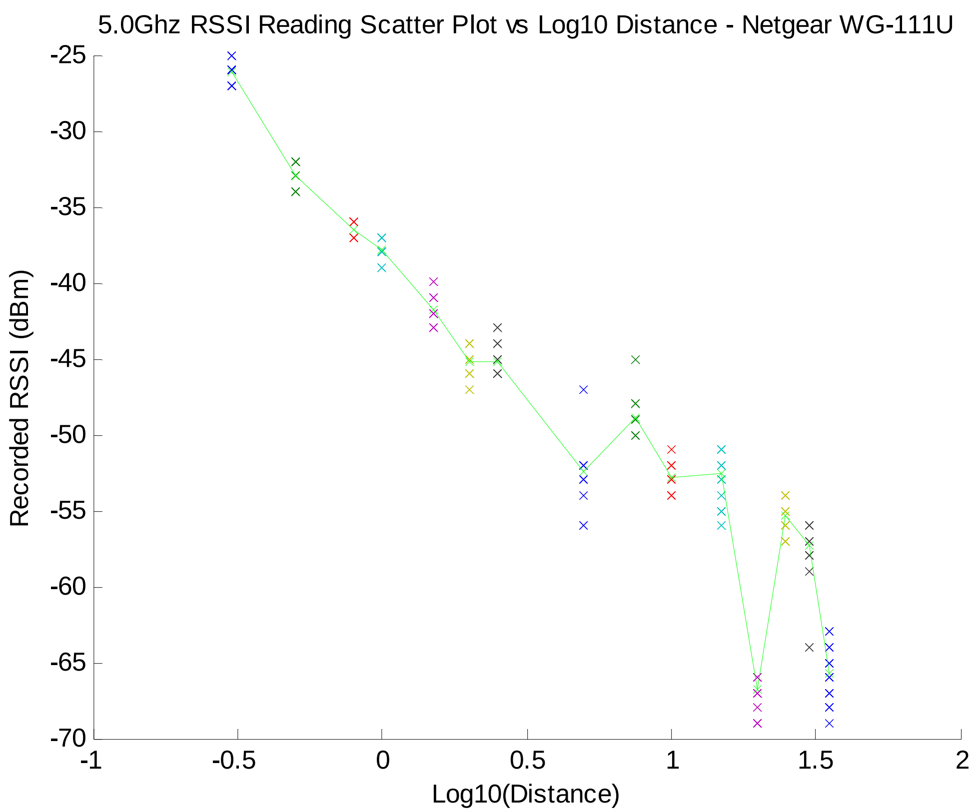
2.5m	90	90
5m	82	82
7.5m	79	78
10m	193	193
15m	180	180
20m	158	158
25m	148	148
30m	140	140
35m	121	121

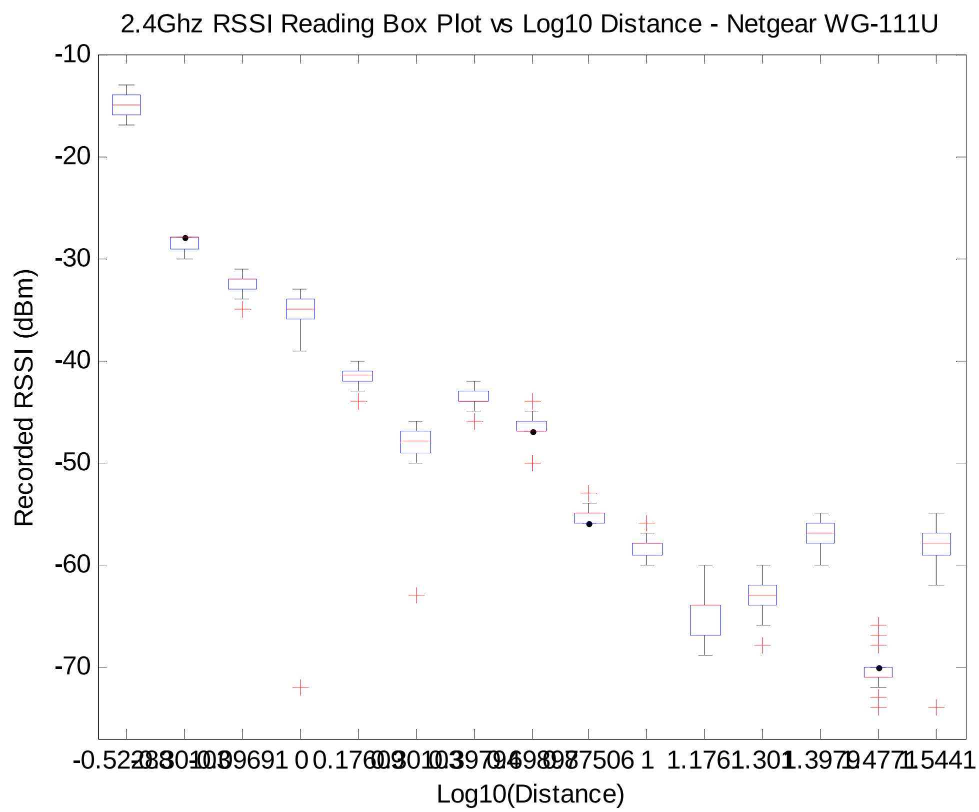
I notified Binghao about the problem with the GPX file, however, he was able to show me that he had GPX files which were bigger than the ones I had and apparently, even though there's a dialogue that tells us it was unable to save, in all cases, this was incorrect. This time it shows an interesting trend – it appears that when I restarted the test, that the collected number of data points increased back to normal values. This suggests an ongoing program resource leak or something which is probably slowing down the collection system. I only just realized this looking back on the data (this write-up was done on Friday of the week), and this might mean that our whole testing is set back by one week. All this time for nothing … this is quite disconcerting.

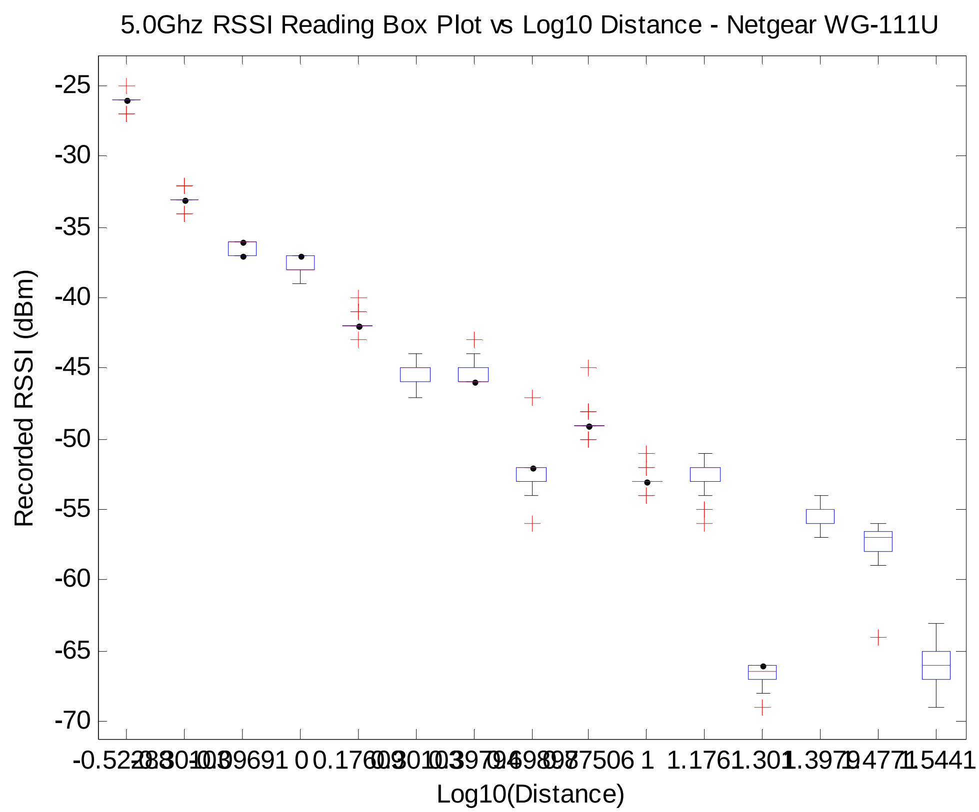
From the graph though, we can see some of the trends are similar to that of the Belkin card. This card seems to be much more well behaved when it comes to 2.4Ghz and spurious reports. Unfortunately, this card also has a habit of returning the same value for a while, then giving a new value or two, then holding that value going on for another 10 to 20 seconds. The total amount of true measurements is almost certainly less than that of the number of values recorded.




2.4Ghz RSSI Reading Scatter Plot vs Log10 Distance - Netgear WG-111U
Recorded RSSI (dBm)
-10
-20
-30
-40
-50
-60
-70
-80
-1
-0.5
0
0.5
1
1.5
2
Log10(Distance)


5.0Ghz RSSI Reading Scatter Plot vs Log10 Distance - Netgear WG-111U
Recorded RSSI (dBm)
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-1
-0.5
0
0.5
1
1.5
2
Log10(Distance)


2.4Ghz RSSI Reading Box Plot vs Log10 Distance - Netgear WG-111U
Recorded RSSI (dBm)
Log10(Distance)


5.0Ghz RSSI Reading Box Plot vs Log10 Distance - Netgear WG-111U
Recorded RSSI (dBm)
Log10(Distance)

In order to get moving somewhat more quickly with testing, I had also bought in Nonie's old laptop which I had rebuilt to participate in data gathering. Up till now, our ability to do two cards per day was pretty much limited by the battery power available on the laptop we are using to test. By having another laptop, we could extend our ability to test somewhat more. Unfortunately, Nonie's laptop is fairly old and its battery only has enough capacity to perform one test – one is better than none however.

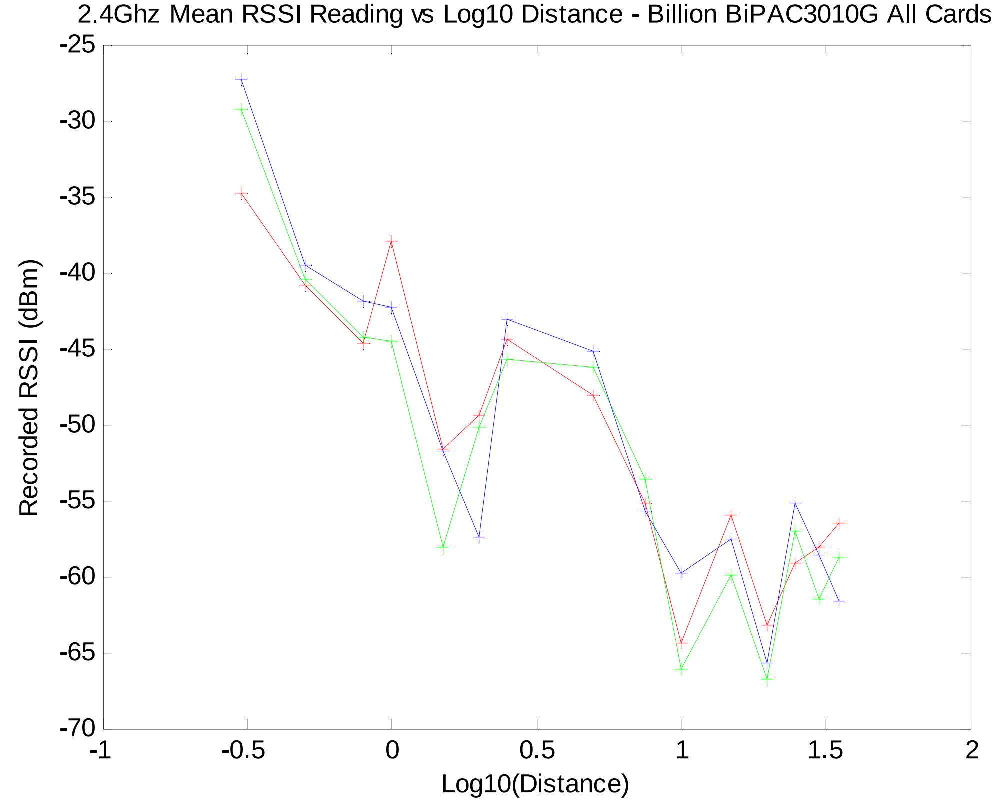
Unknowingly, I may have wasted time on this due to this problem which was not caught early on enough. I tested three cards of the same chipset – all three are based on Zydas ZD1211 and all three are branded Billion BiPAC 3011G. The number of data points collected for each card is below – note that the first two cards was collected on my MSI Wind U100 netbook which has been the standard test-bench with the last card being collected on the Acer Travelmate 200.

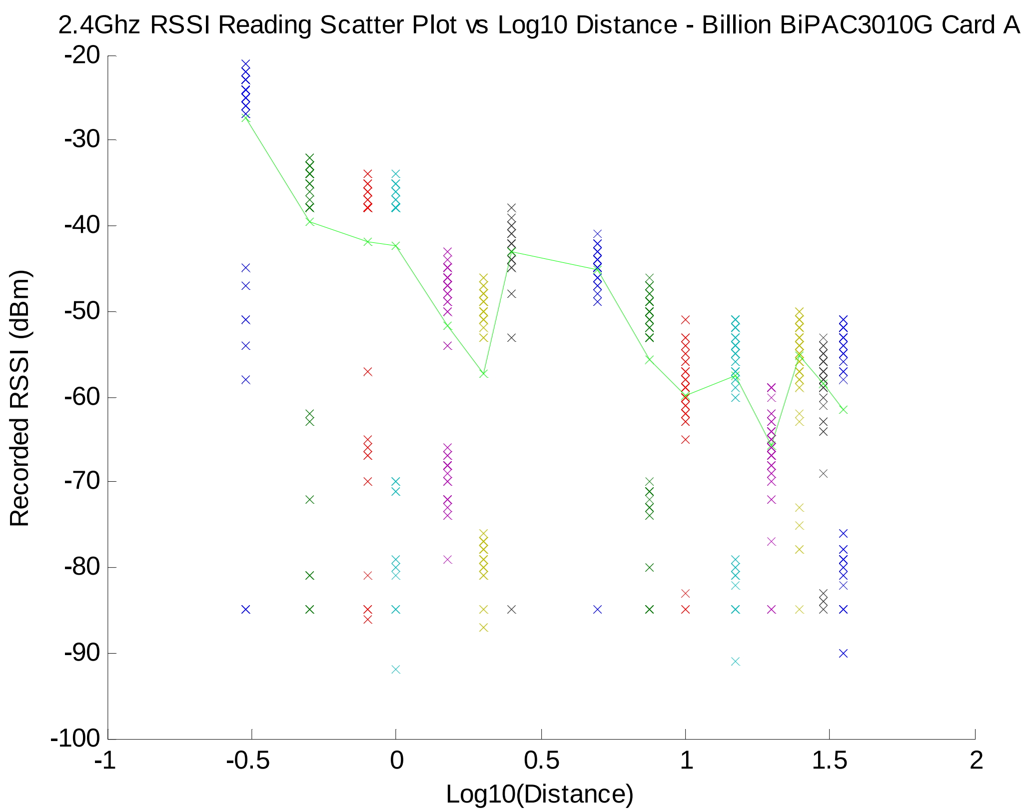
Distance	**ZD1211-A**	**ZD1211-B**	**ZD1211-C**
0.3m	215	217	186
0.5m	202	206	185
0.8m	194	200	185
1m	186	189	182
1.5m	173	177	180
2m	163	172	163
2.5m	161	164	177
5m	160	162	176
7.5m	150	153	169
10m	140	146	163
15m	139	137	165
20m	124	124	151
25m	125	127	165
30m	121	124	186
35m	117	110	159

It is interesting to note that the sample numbers generally decrease with distance – but for ZD1211-A and ZD1211-B on the same laptop running two test runs, both showed a slight increase in sample numbers from 20m to 25m. But this is, generally speaking, a small anomaly as at the end of the test, the number of sample points are approximately halved. The ZD1211-C running on the Acer Travelmate showed reduced numbers from the beginning but the sample set seemed to decrease at a slower rate, the trend reversing several times during the test. However, there was still a net decrease in sampled points which could be something which is noteworthy. All cards seemed to have a trend to produce relatively noisy data with spurious points – the most popular one being around -85dBm. The boxplot for Card A is especially concerning as the box is fairly wide for two different distances implying some significant interference in the test results.

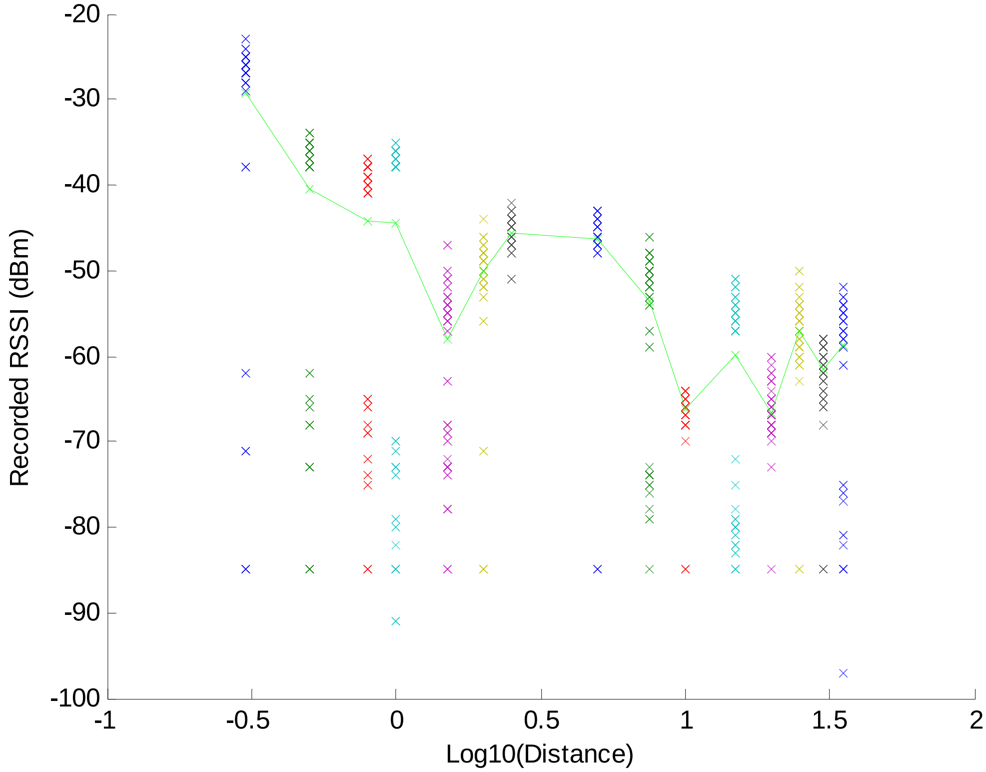
I felt no need to generate individual means graphs as it makes it difficult to compare, so a combined means graph was generated. Individual scatter plots and box plots were generated as it makes more sense to examine these on a card by card basis.

Again it is heartening to see that the cards followed a similar trend, however, the red line (card C) seems to show significantly reduced near field strength and an unusual rise at 1m.

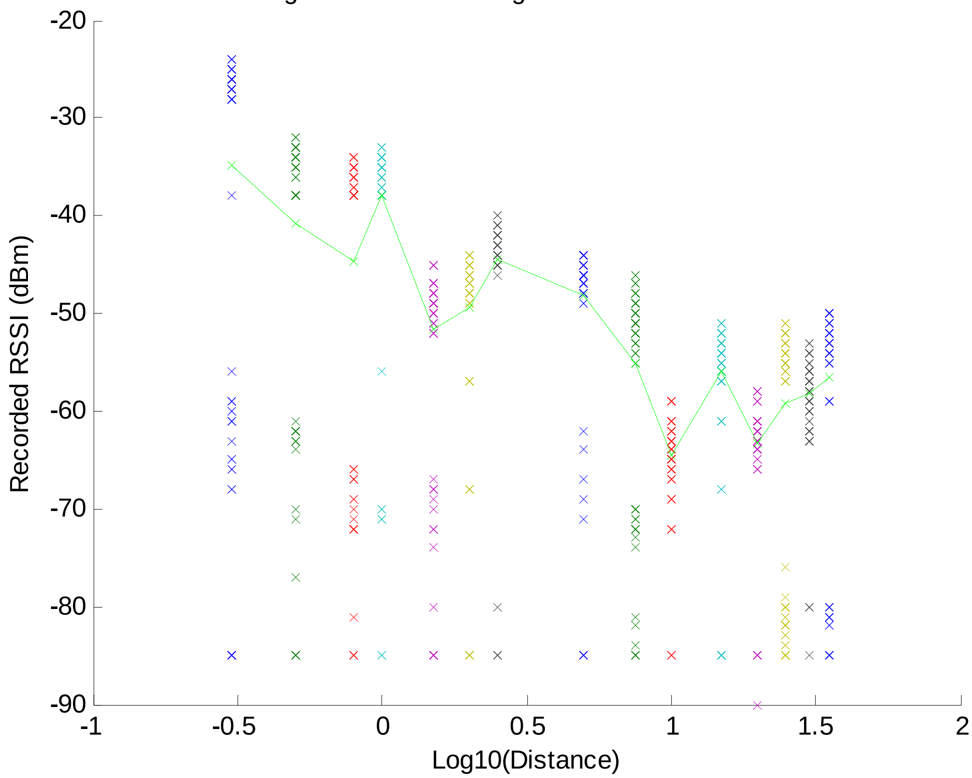

2.4Ghz Mean RSSI Reading vs Log10 Distance - Billion BiPAC3010G All Cards
Recorded RSSI (dBm)
Log10(Distance)
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-1
-0.5
0
0.5
1
1.5
2

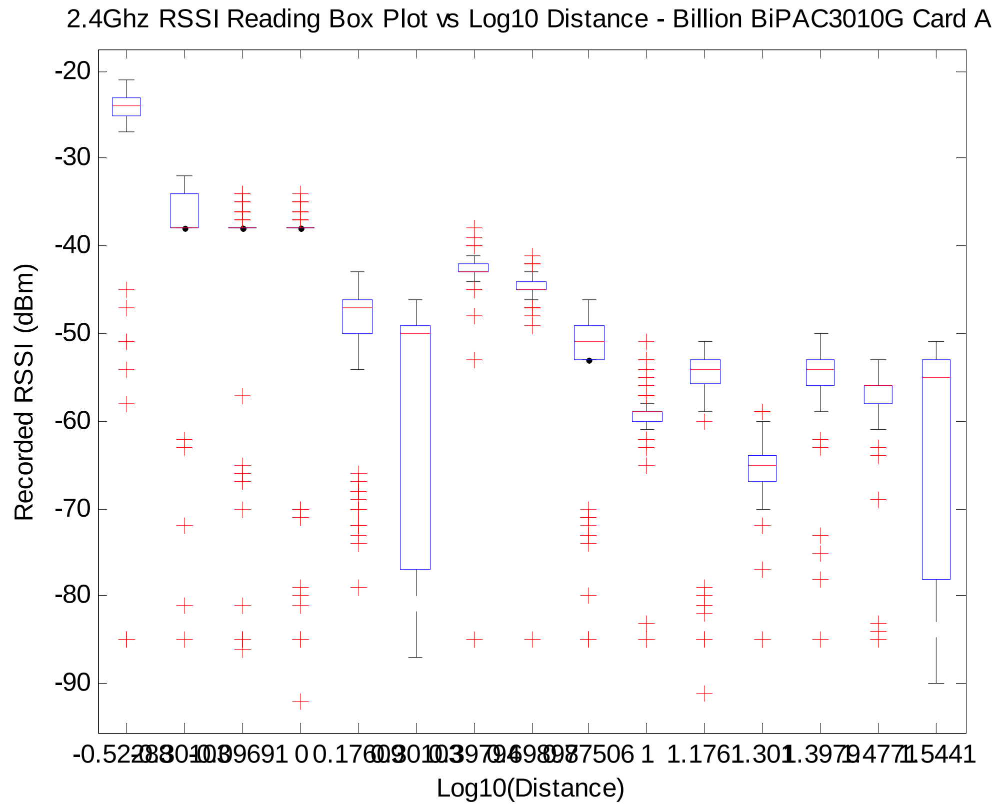

2.4Ghz RSSI Reading Scatter Plot vs Log10 Distance - Billion BiPAC3010G Card A
Recorded RSSI (dBm)
Log10(Distance)
-20
-30
-40
-50
-60
-70
-80
-90
-100
-1
-0.5
0
0.5
1
1.5
2

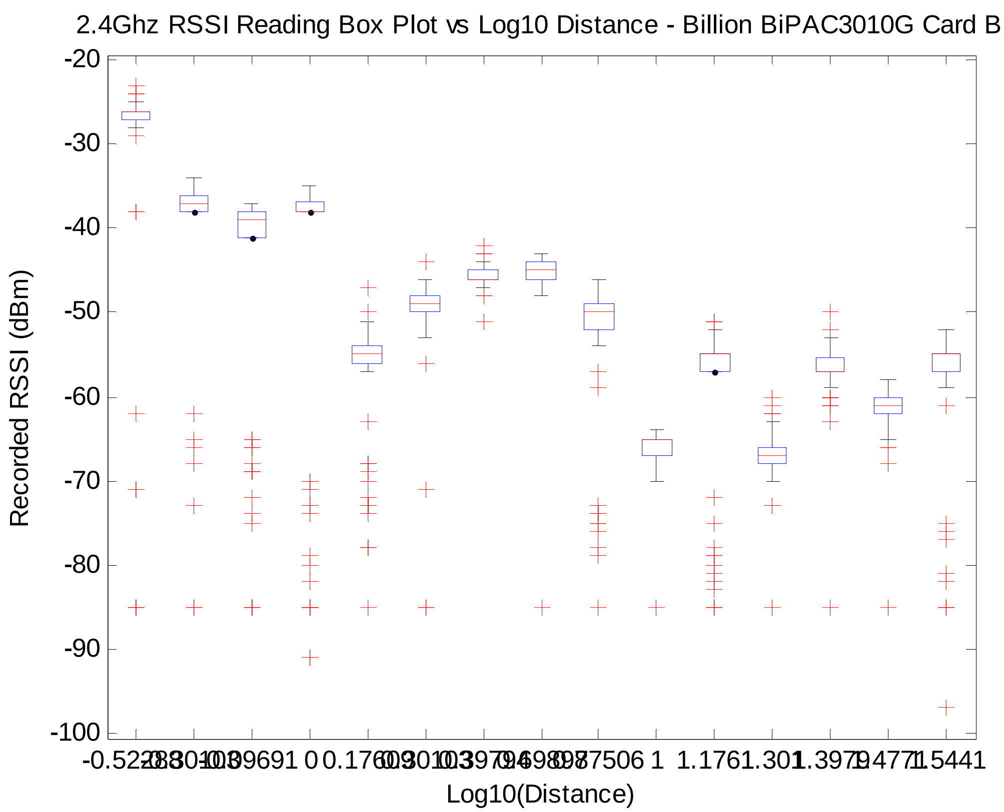
2.4Ghz RSSI Reading Scatter Plot vs Log10 Distance - Billion BiPAC3010G Card B

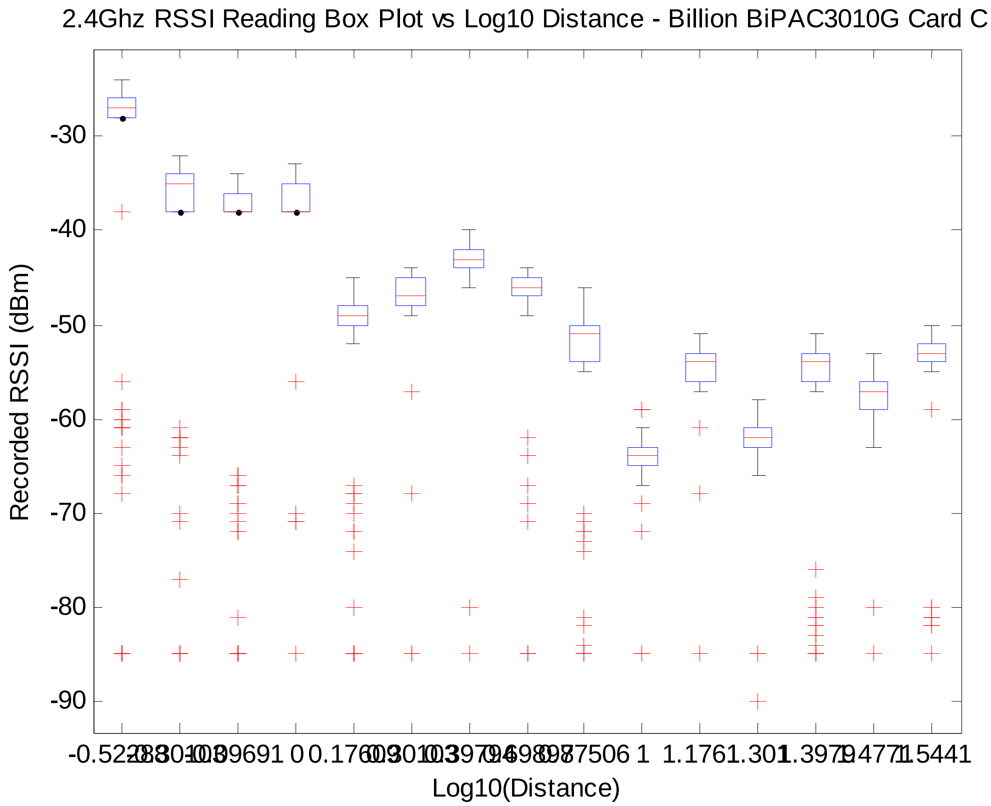


2.4Ghz RSSI Reading Scatter Plot vs Log10 Distance - Billion BiPAC3010G Card C




2.4Ghz RSSI Reading Box Plot vs Log10 Distance - Billion BiPAC3010G Card A
Recorded RSSI (dBm)
Log10(Distance)


2.4Ghz RSSI Reading Box Plot vs Log10 Distance - Billion BiPAC3010G Card B
Recorded RSSI (dBm)
Log10(Distance)

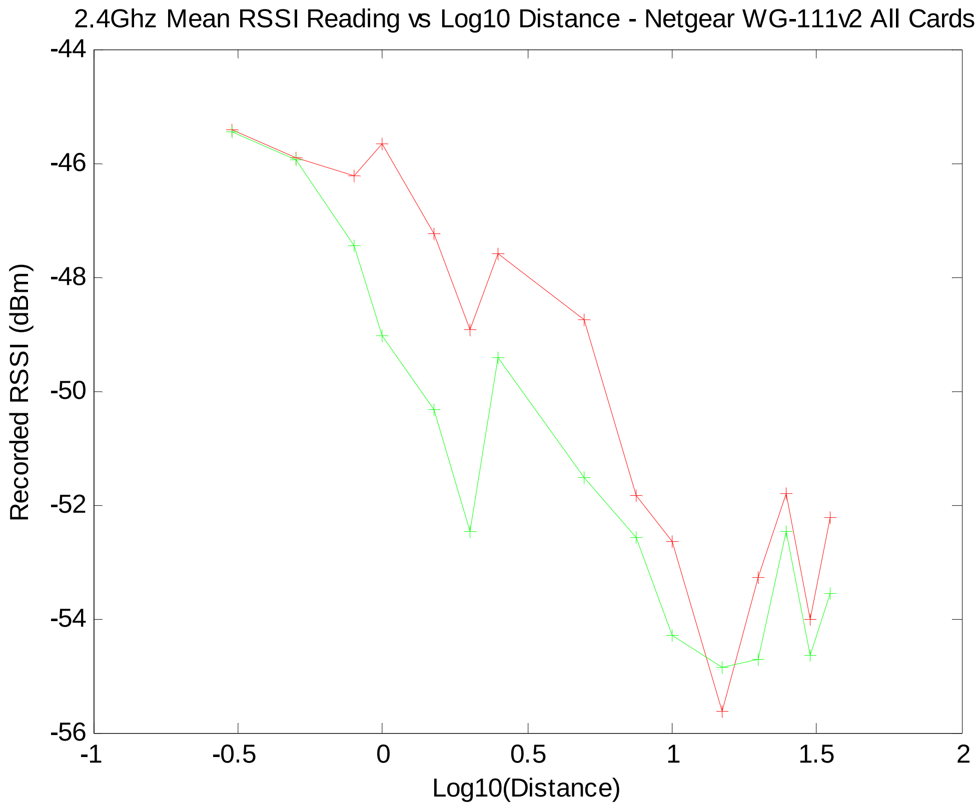


- Thursday 2nd December 2010

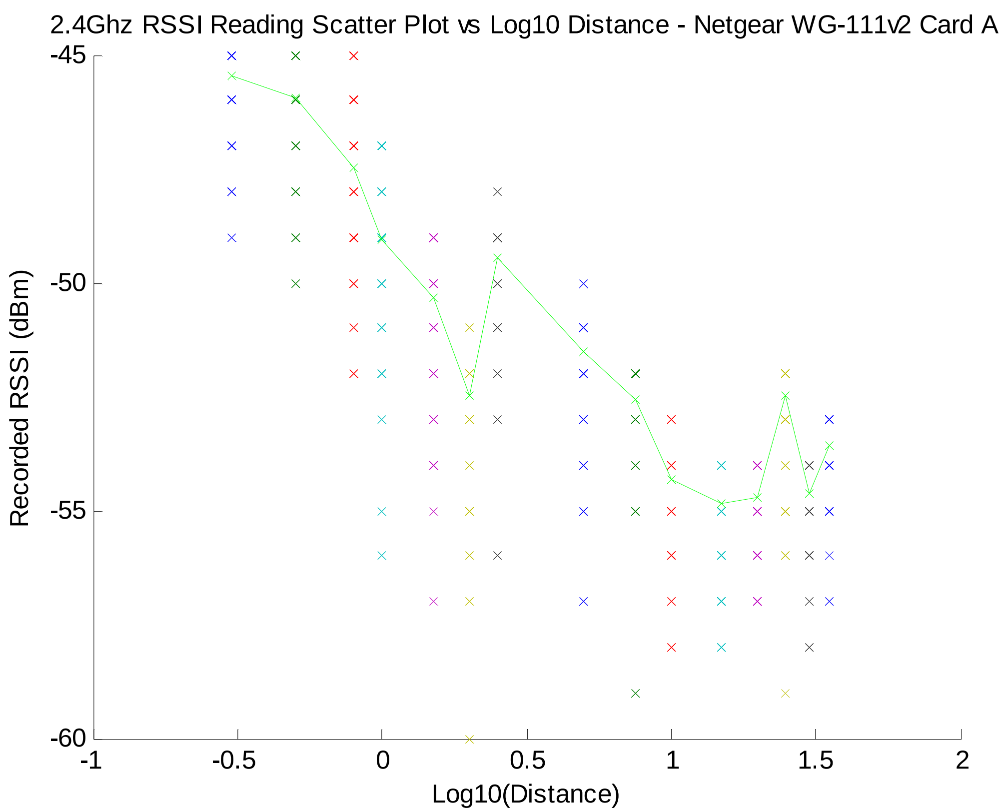
Testing continued today with the MSI Wind U100 testing two Netgear WG111v2's based on the Realtek RTL8187L chipsets. Similar trends in sample counts continued:

Distance	**RTL8187-A**	**RTL8187-B**
0.3m	214	212
0.5m	207	203
0.8m	200	191
1m	191	185
1.5m	186	171
2m	177	162
2.5m	170	161
5m	168	156
7.5m	160	143
10m	153	137
15m	152	138
20m	143	124
25m	138	126
30m	135	103
35m	132	115

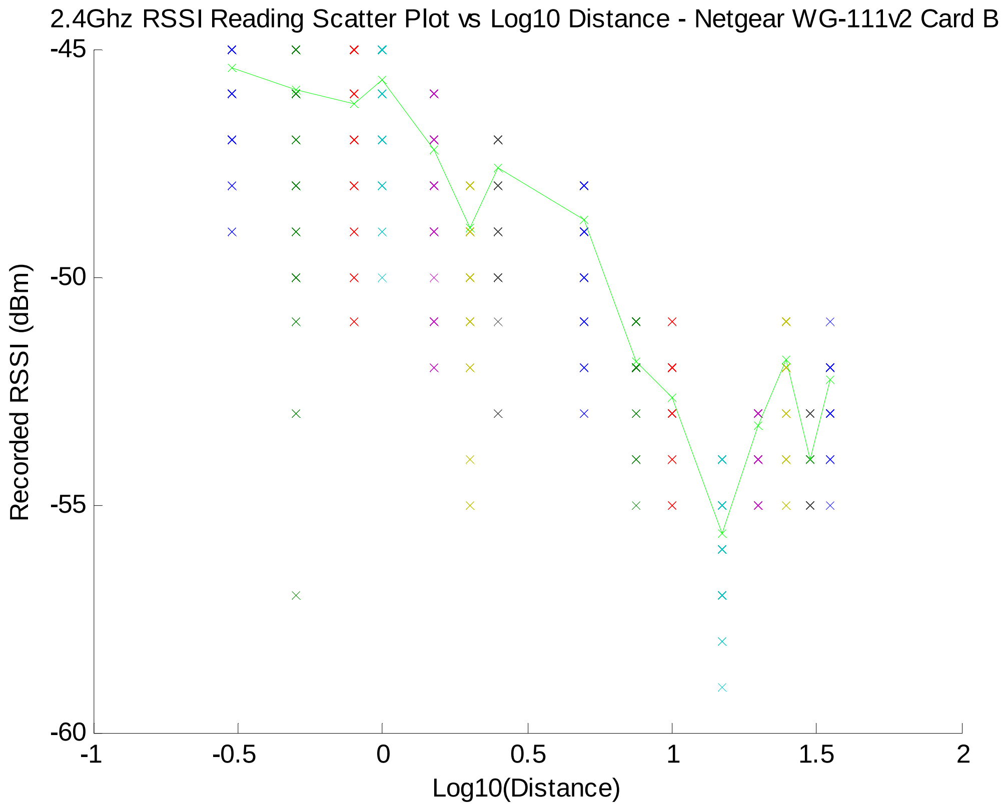
It can be seen that the number of spuriae in the rest results are lower than in the other cards, but the RSSI range is also smaller. This suggests that this card is radically different to the others in the way it reports RSSI. The combined graph seems to show some concerning variances in the trends as the Card A seems to report a lower signal level at 80cm onwards. This may have been due to changes in the environment, but I was careful to run these tests back to back to try and minimize it. Unfortunately since these tests take 1.5 hours to conduct, we cannot really do much about eliminating this error.

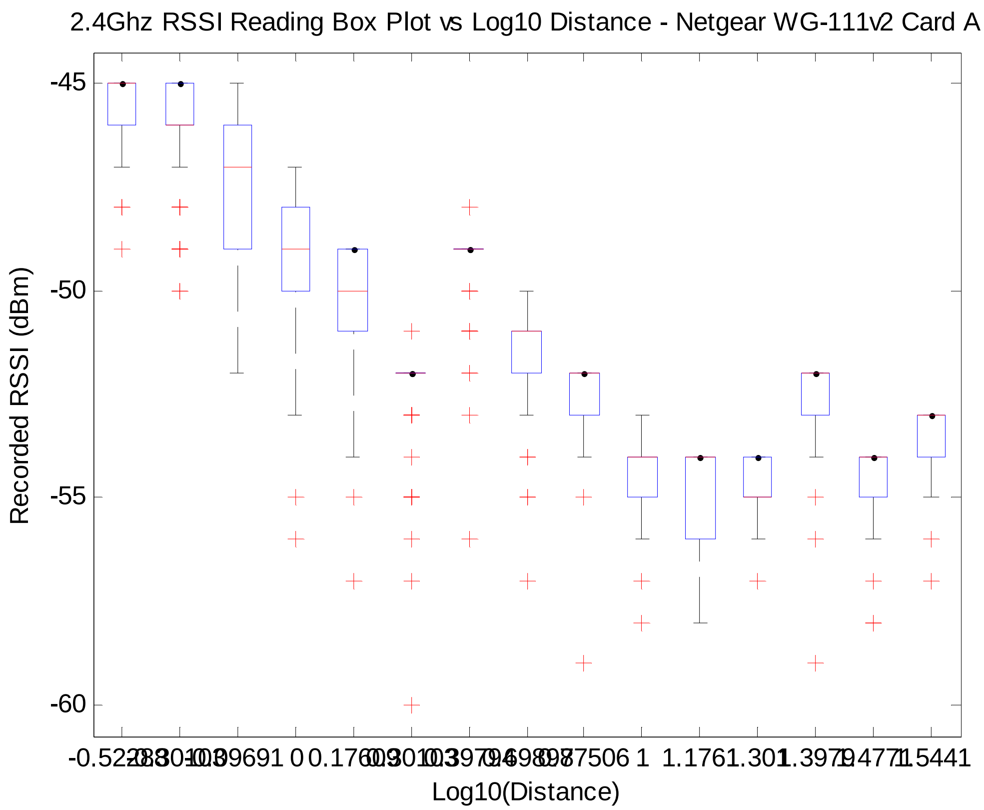


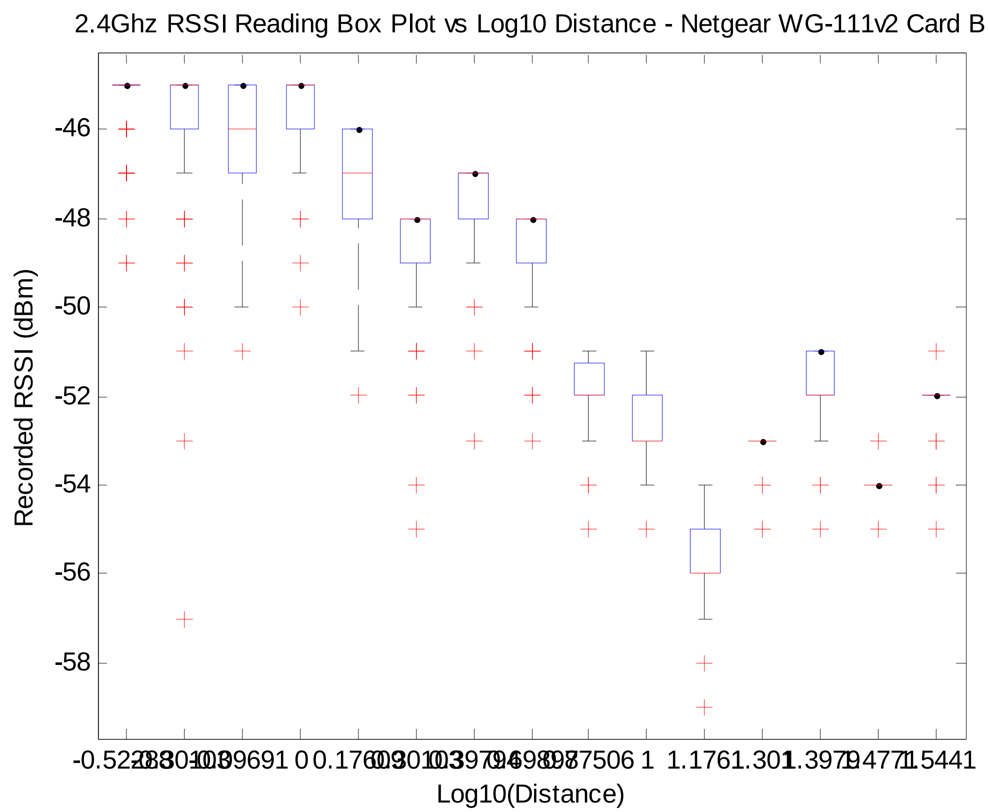
2.4Ghz Mean RSSI Reading vs Log10 Distance - Netgear WG-111v2 All Cards
Recorded RSSI (dBm)
-44
-46
-48
-50
-52
-54
-56
-1
-0.5
0
0.5
1
1.5
2
Log10(Distance)



2.4Ghz RSSI Reading Scatter Plot vs Log10 Distance - Netgear WG-111v2 Card A
Recorded RSSI (dBm)
-45
-50
-55
-60
-1
-0.5
0
0.5
1
1.5
2
Log10(Distance)


2.4Ghz RSSI Reading Scatter Plot vs Log10 Distance - Netgear WG-111v2 Card B
Recorded RSSI (dBm)
Log10(Distance)
-45
-50
-55
-60
-1
-0.5
0
0.5
1
1.5
2


2.4Ghz RSSI Reading Box Plot vs Log10 Distance - Netgear WG-111v2 Card A
Recorded RSSI (dBm)
Log10(Distance)
-45
-50
-55
-60

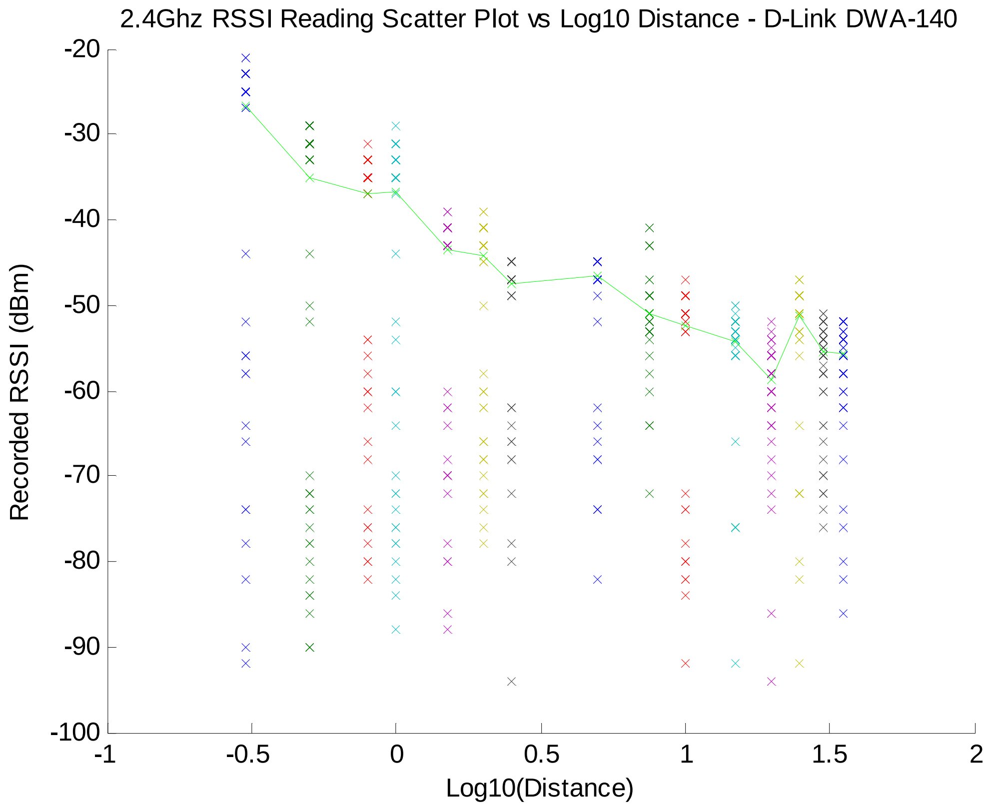


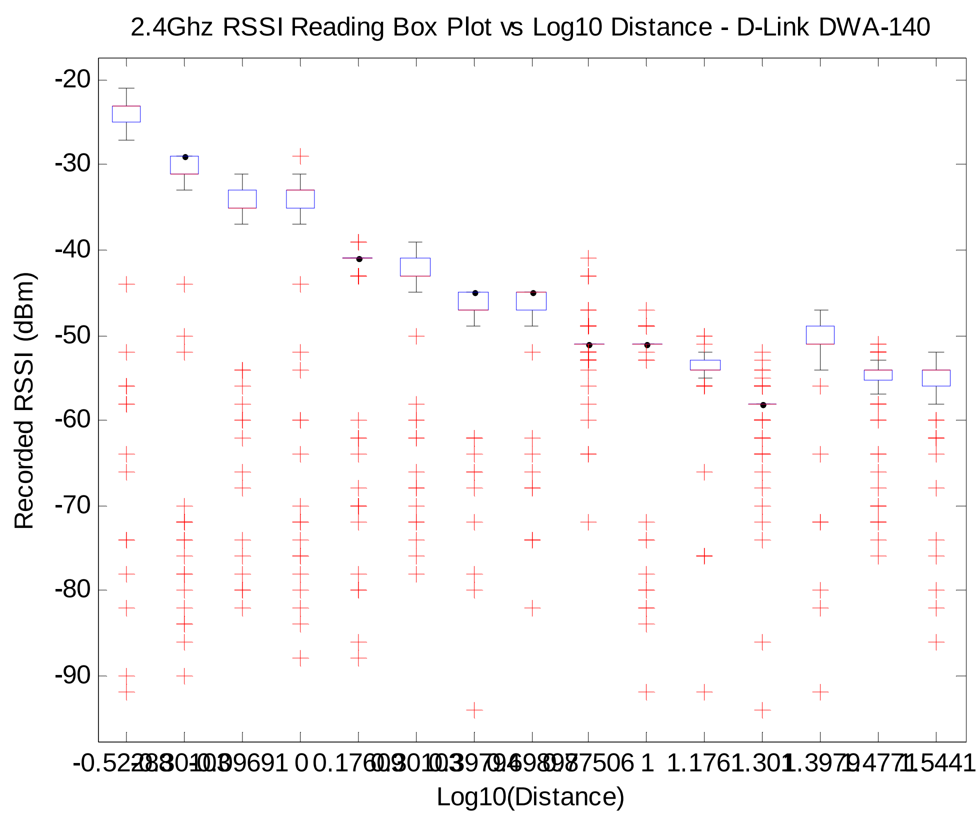
In addition, I bought in my BenQ R55UV10 T2300E Dual Core Centrino laptop which has slightly better battery life than Nonie's old laptop, thus letting us test two other cards as well. This is where it gets interesting – GPX files are doubled or tripled in size compared to tests with the MSI Wind U100. Initially I dismissed this as a faster scanning card – however – when this happened for both cards, I began to be suspicious. It may be the difference in CPU processing ability that causes variations in samples recorded.

First, the D-Link DWA-140 Wireless N Single Band Dongle:

Distance	**DWA-140**
0.3m	217
0.5m	213
0.8m	210
1m	206
1.5m	208
2m	200
2.5m	199
5m	195
7.5m	183
10m	194
15m	191
20m	188
25m	193
30m	189
35m	181

It can immediately be noticed that there is still a reduction in samples recorded over time – but this time, it is not a halving but a reduction of about 18 percent over the test run. This is still disappointing though. The card produced a lot of noisy data as well.

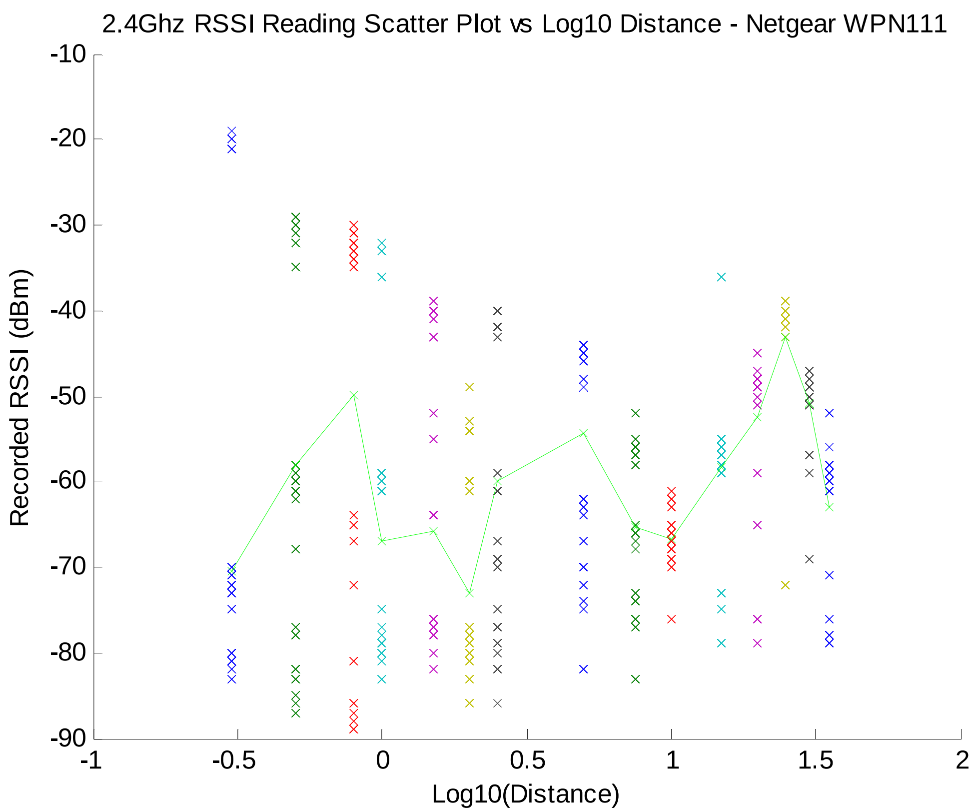

2.4Ghz RSSI Reading Scatter Plot vs Log10 Distance - D-Link DWA-140
Recorded RSSI (dBm)
Log10(Distance)
-20
-30
-40
-50
-60
-70
-80
-90
-100
-1
-0.5
0
0.5
1
1.5
2

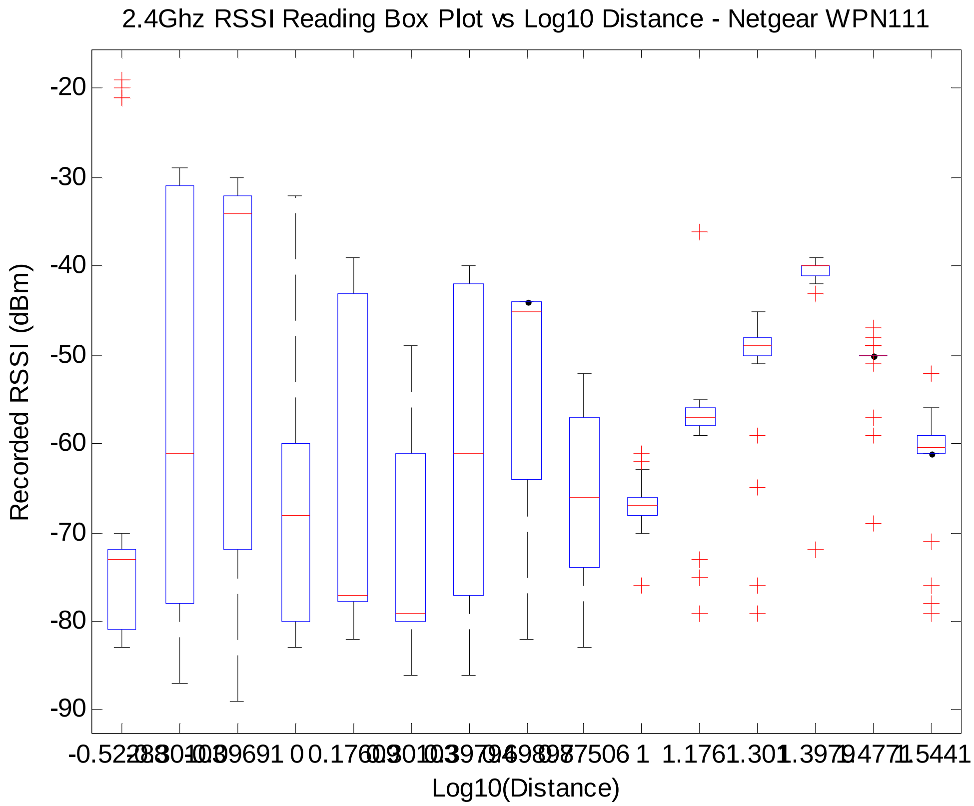

2.4Ghz RSSI Reading Box Plot vs Log10 Distance - D-Link DWA-140
Recorded RSSI (dBm)
Log10(Distance)
-20
-30
-40
-50
-60
-70
-80
-90

Finally, the Netgear WPN111 single band Super G card was tested on the BenQ laptop. This card was most interesting as its results were completely useless. It has been noted that other people have had issues with signal strength readings on the card, and I have noticed that it does not always seem to associate to a stronger access point – I think this provides us a good reason as to why this might be the case. A lot of points show high variance in signal strength figures, and if we analyze the peak readings, they somewhat show the trend we are expecting, however, most recorded readings were actually quite far away from this expected value. First of all, the number of data samples were:

Distance	WPN111
0.3m	225
0.5m	220
0.8m	219
1m	218
1.5m	215
2m	214
2.5m	212
5m	213
7.5m	214
10m	211
15m	207
20m	206
25m	202
30m	204
35m	196

Again, the decreasing trend in data samples collected continues.





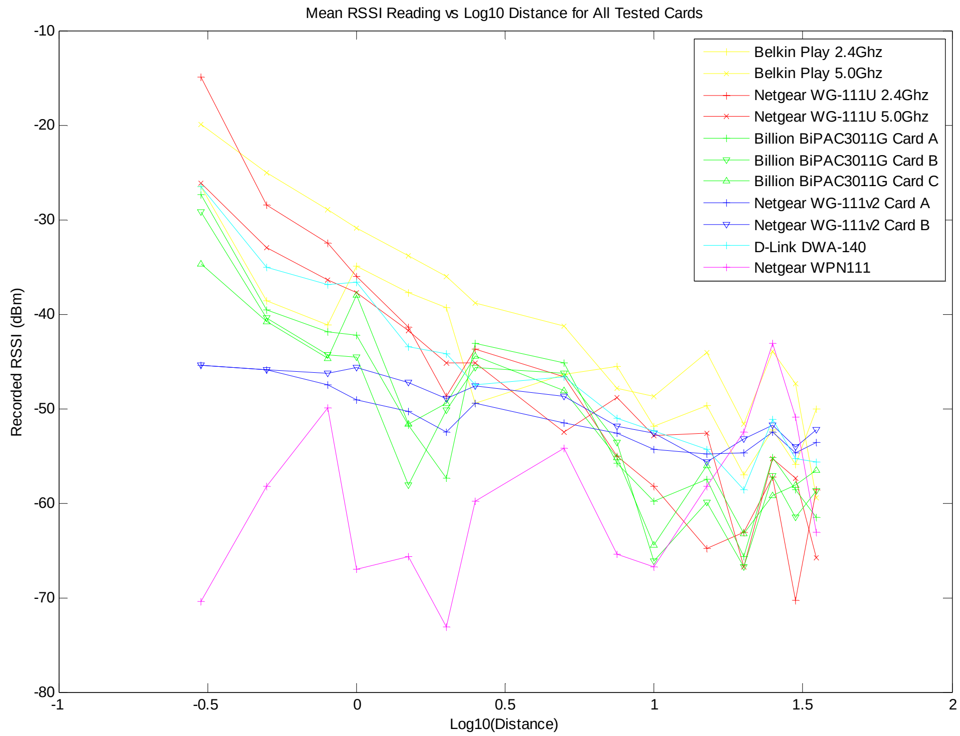
- <u>Friday 3rd December 2010</u>

Up till now, I had not had the time to update this diary log. I thought I would do it all at once at the end of the week – sort of a good idea, sort of not. As I reflect back on the test results, it is clear that there was something wrong. And through trawling through the data – I think we could have caught this more early on if I was of the mindset to properly document it rather than just going on and doing the tests. Lesson learned, I hope.

Regardless, there is another research team which requires the use of the hallway to perform a similar type of experiment. They were quite relieved to hear that I would be vacating the hallway on this day – as I would be doing some work from home. That being, updating this diary and fixing up all the graphs in order to be somewhat presentable. I realize my testing is quite disruptive to the users of the hallway in general, but in order to get the data I need, I have little choice.

Throughout the week, I have been working fairly hard – getting in fairly early and leaving late. I think that I've done more than my fair share of work for the week, and that this task is a bit more difficult than I first imagined. I think I may have to forego my other test objective of quantifying differences between MIMO and SISO RSSI measurements in order to be able to finish this experiment in time and produce a report.

In order to get a graphical sense of the data, I've decided to plot all the cards together on one plot. All the lines of the same colour indicate results from the same chipset of card, each line represents a discrete set of test data. The trend is visible in all the data, but as usual, different cards react differently to the humps and bumps and have a slightly different gradient. It's very difficult to draw conclusions from this as the testing situation results in many multipath components, which result in unusual shapes as well as the ever-changing indoor environment which can result in test to test variations.



The question is, given that the sampling problem exists and has been detected – what can we do about this problem which solves the problem elegantly, and does not require too much intervention and effort. I suggest we use the more powerful laptop to do as many tests as possible, however, even this is not immune to sampling rate issues.