Taste of Research
Gough Yumu LUI
Engineer's Log Book

Week 7

- Monday 10th January 2011

We had a meeting as usual for Monday. The results of the week's testing has been shown – some general trends were discussed but as of now, we are still relatively uncertain as to what the data itself may lead us to conclude. Indoor testing is to be finalized – it was planned for two devices today and two devices for tomorrow to round out the testing, and then head to outdoor testing. I had concerns about the village green itself – whether we would be allowed to use it, and how the trolley would track over such poor grassy ground. We came back to the initial suggestions of carpark or quad – in which case, I believe them to be much better alternatives since I don't want to lug my equipment all the way down to the green and back, and it provides better shelter in case of sudden rain. I will have to survey the areas later in the week to determine their dimensions – and if there is about 30m of space – I will follow the same testing regime as the indoor testing so it allows us to do better comparison of the data. There was also some concern about differences between signal level reports from wireless N and wireless A/G – in my opinion, the basic rate frames should show no differences as they are usually sent at the lowest rate in non-spatially multiplexed form and so they will probably not benefit from any MIMO enhancement.

I also discussed and decided to take Wednesday at home to code up the parsers for the data and do some basic analysis. Monday ended up being data collection day for the laptop, Belkin Play card and the Roving Networks Wi-Fi Tag. The tag was run from a 12v battery plugged through a DC converter and worked well, despite not having the banana sockets to connect it to the battery properly. Initially the tag froze and had problems connecting, but it held in just fine for the test.

- Tuesday 11th January 2011

I had came in today to finalize the indoor testing by capturing data from the Nokia N95 phone. The data was logged and downloaded by USB without an issue.

I had also, while at home, thought of a reason for the slightly different trends between each card – there could be possibilities that different cards behave differently when in presence of multipath and other interference. Even for non MIMO cards, some feature multiple antennas, whereas others feature only one – this antenna diversity on the receive is enough for an improvement in signal level. In essence, in the case of diversity – it is likely that you are looking at the best signal on the two or more antennas – and therefore, you are actually testing a few locations, not just one. MIMO based cards must have more than one antenna, and could do even more complex "maximum ratio combining" or something to improve signal. This thought was inspired by a Ralink mPCI-E card I have that was not tested, but when used with its own utility, shows up the signal strength for each of its antennas. Unfortunately, the reported value is only just one value – I sent e-mails to the technical support engineers at Realtek, Ralink, Intel, Atheros, Broadcom to try and get more details as to how the signal strength reading is determined. Marvell was not contacted as they require the signing of an NDA to get access to their information.

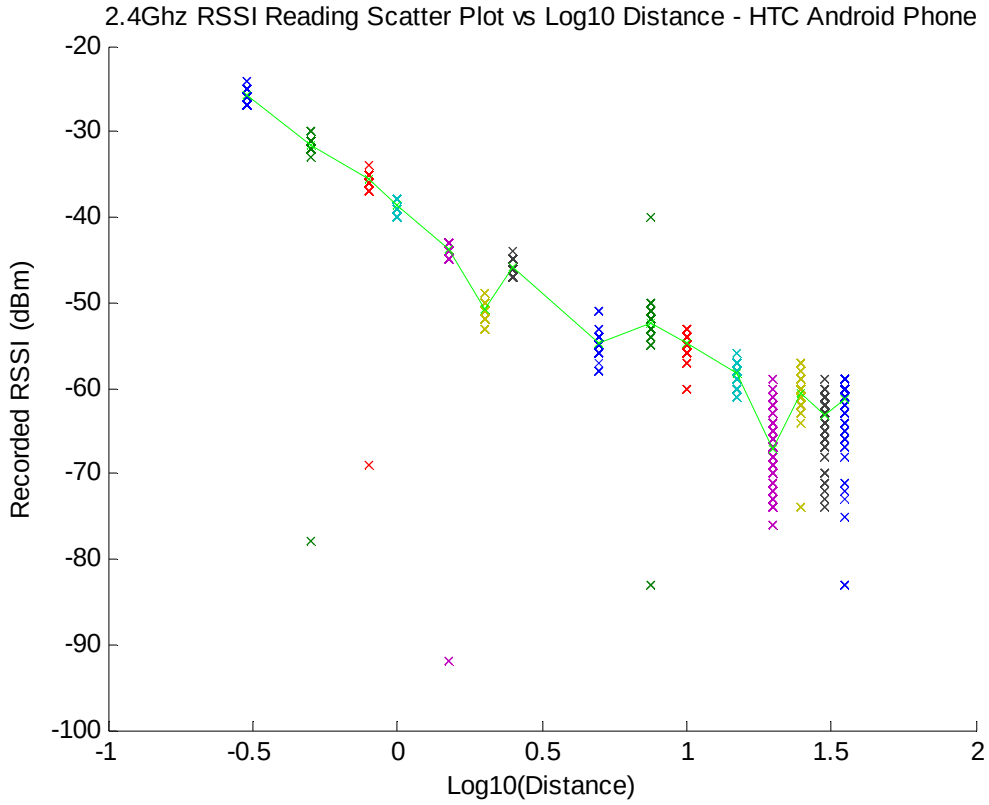
- Wednesday 12th January 2011

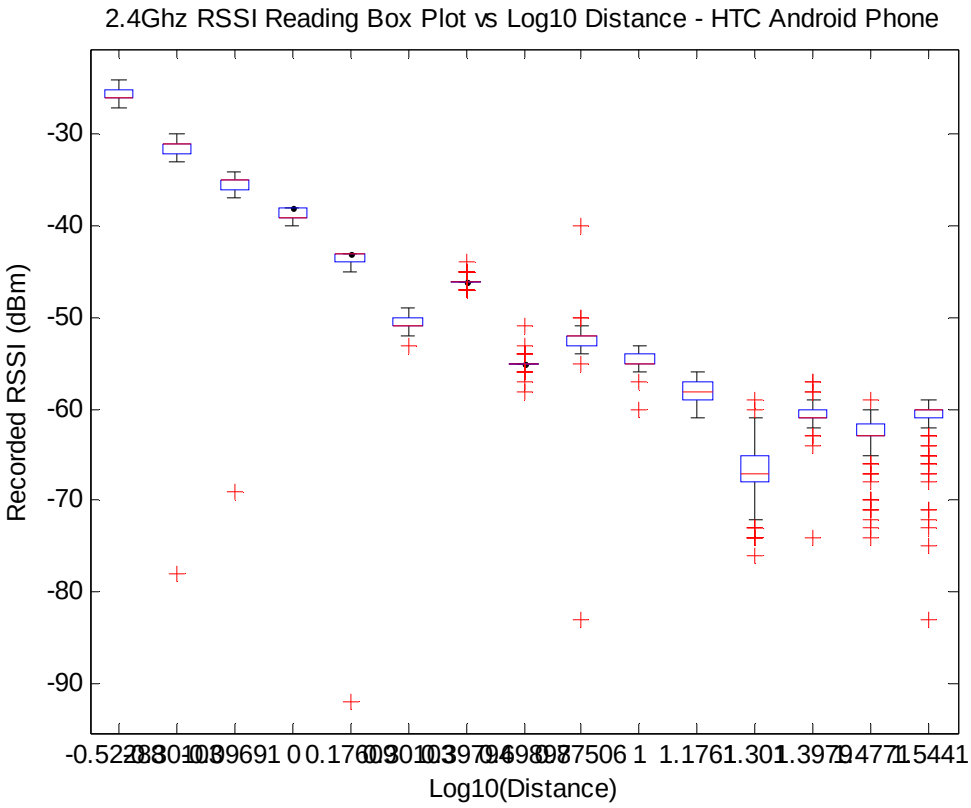
I wrote several parsers, in C as usual, to parse the data logs into matlab form for use with the plotting code. First up, the results for the HTC Android Phone – the easiest to parse as the logged data was already filtered and was in fixed spacing, comma separated form:

Distance	**2.4Ghz**
0.3m	510
0.5m	500
0.8m	498
1m	489
1.5m	492
2m	432

2.5m	495
5m	498
7.5m	506
10m	501
15m	492
20m	494
25m	491
30m	496
35m	455

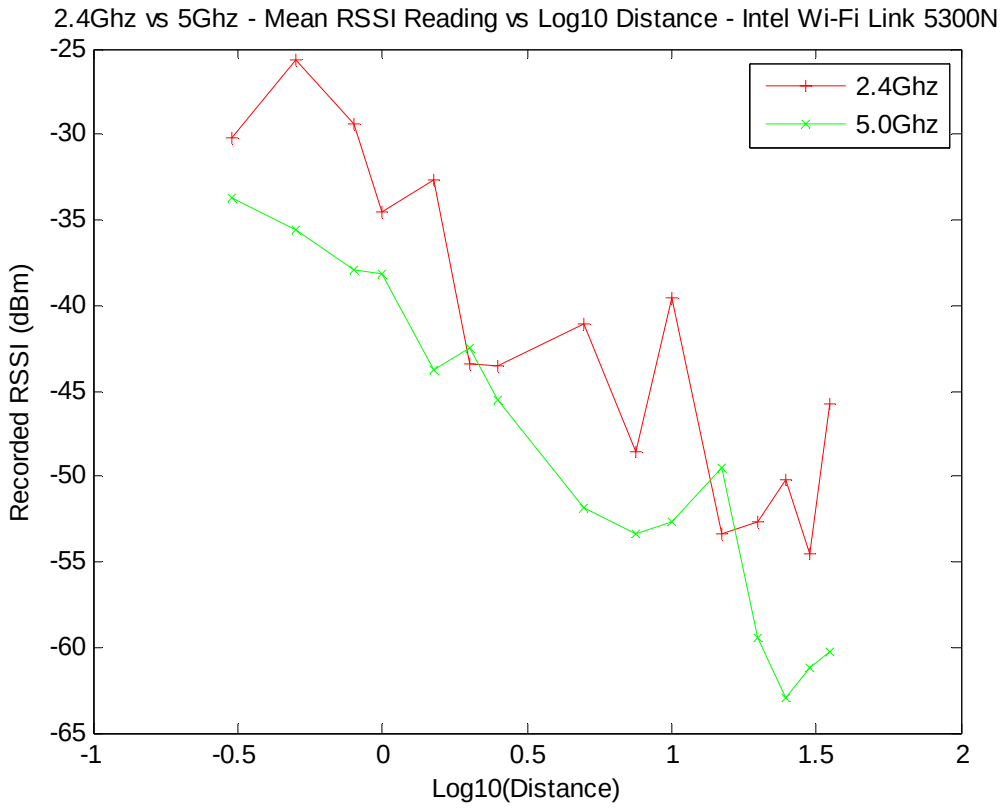
As you can see, this phone outputs a LOT of scan results for the time. We see many samples per second with a good healthy sized data set – twice as big if not more than what inSSIDer produces. The variance of the data is fairly controlled with this phone until we reach the larger distances where it gets much less stable.

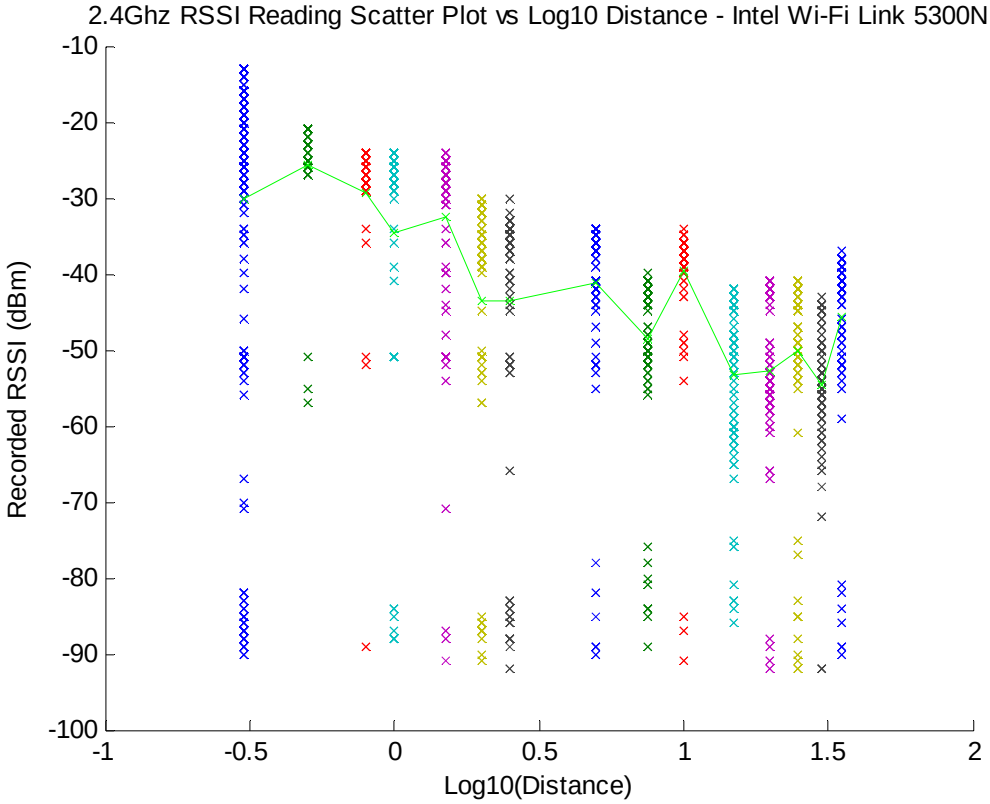


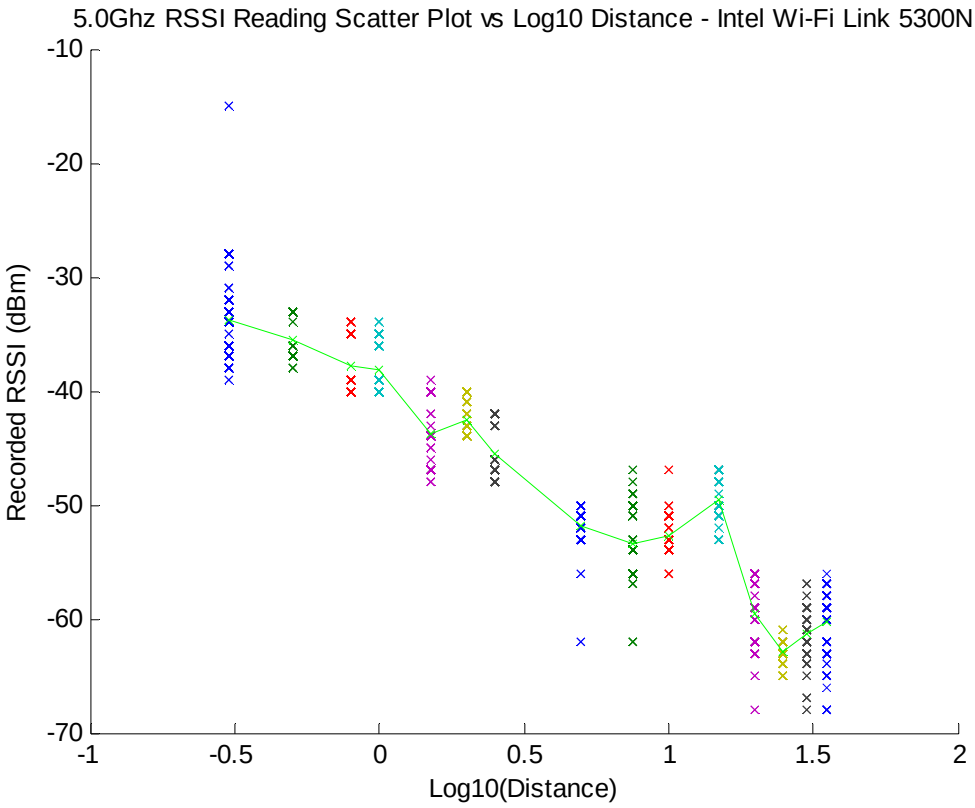


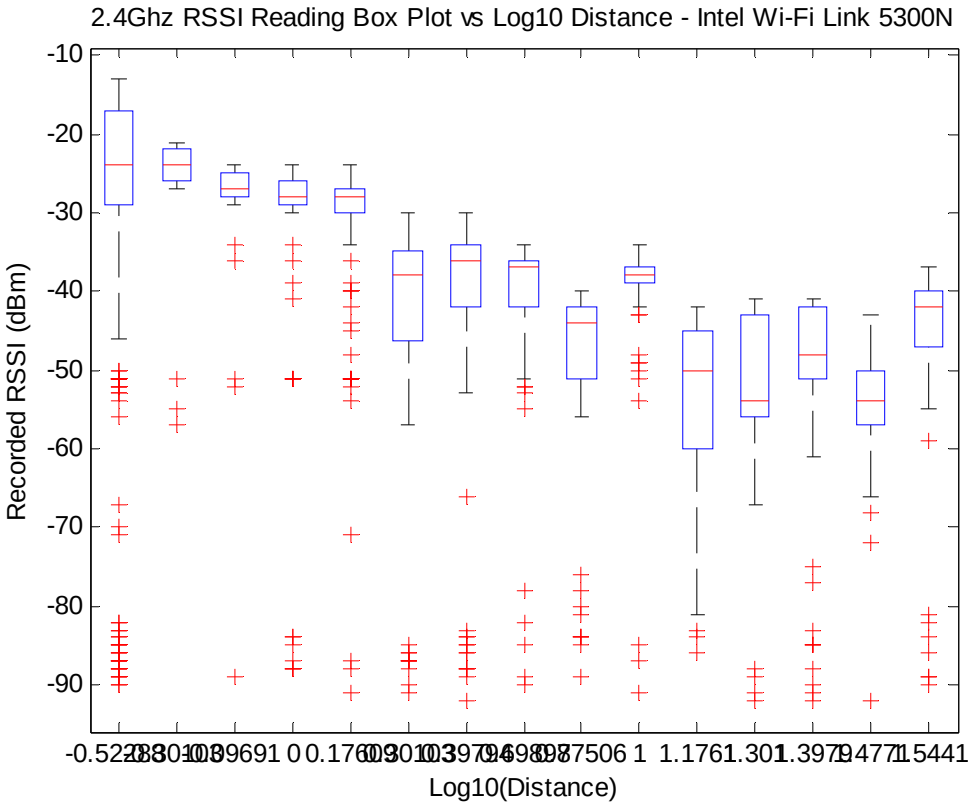
Next we come to the Intel Wi-Fi Link 5300 and we see a problem. I have checked the GPX file personally and this is not a problem with my parser, but that of the times recorded in the GPX by inSSIDer – it has grossly "redistributed" a lot of samples into the first 5 minutes for some unknown reason. To my dismay, we will have to do this one again for the second time! This also means that I won't compile a plotall.m until that is done. The noise on the data is quite strong as well, and some of the trends are a bit strange.

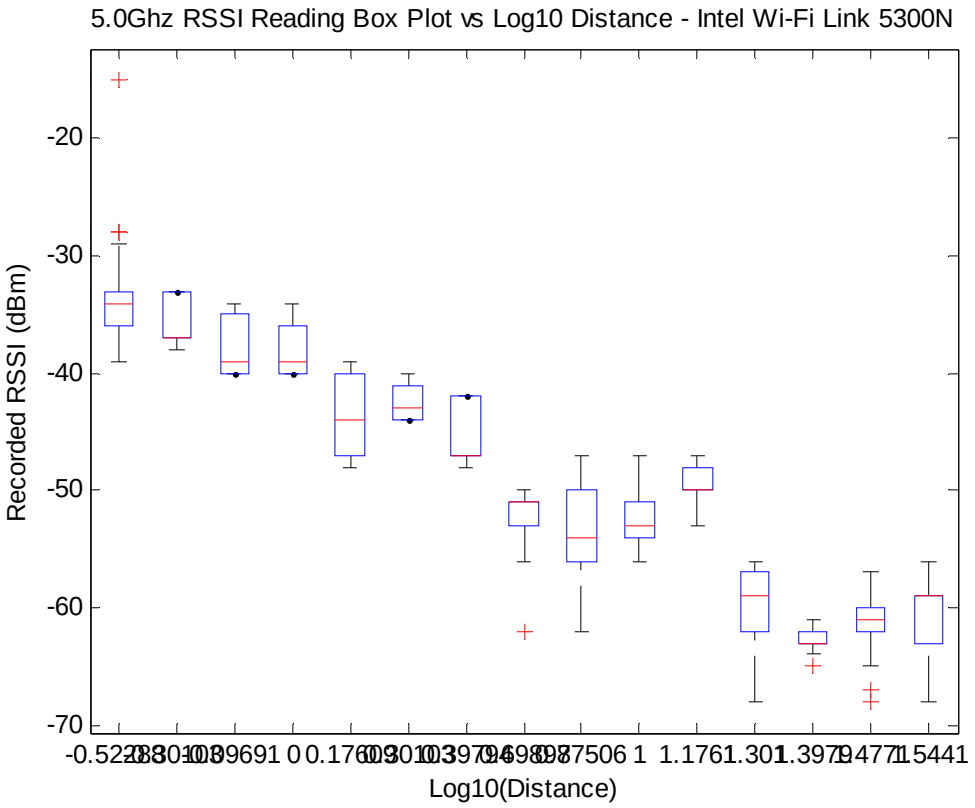
Distance	2.4Ghz	5Ghz
0.3m	659*	659*
0.5m	92*	92*
0.8m	93*	93*
1m	147*	147*
1.5m	225	225
2m	221	221
2.5m	219	219
5m	219	219
7.5m	236	236
10m	235	235
15m	235	235
20m	232	232
25m	228	228
30m	228	228
35m	223	223


2.4Ghz vs 5Ghz - Mean RSSI Reading vs Log10 Distance - Intel Wi-Fi Link 5300N
2.4Ghz
5.0Ghz
Recorded RSSI (dBm)
Log10(Distance)
-25
-30
-35
-40
-45
-50
-55
-60
-65
-1
-0.5
0
0.5
1
1.5
2


2.4Ghz RSSI Reading Scatter Plot vs Log10 Distance - Intel Wi-Fi Link 5300N
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 - Intel Wi-Fi Link 5300N
Recorded RSSI (dBm)
-10
-20
-30
-40
-50
-60
-70
-1
-0.5
0
0.5
1
1.5
2
Log10(Distance)

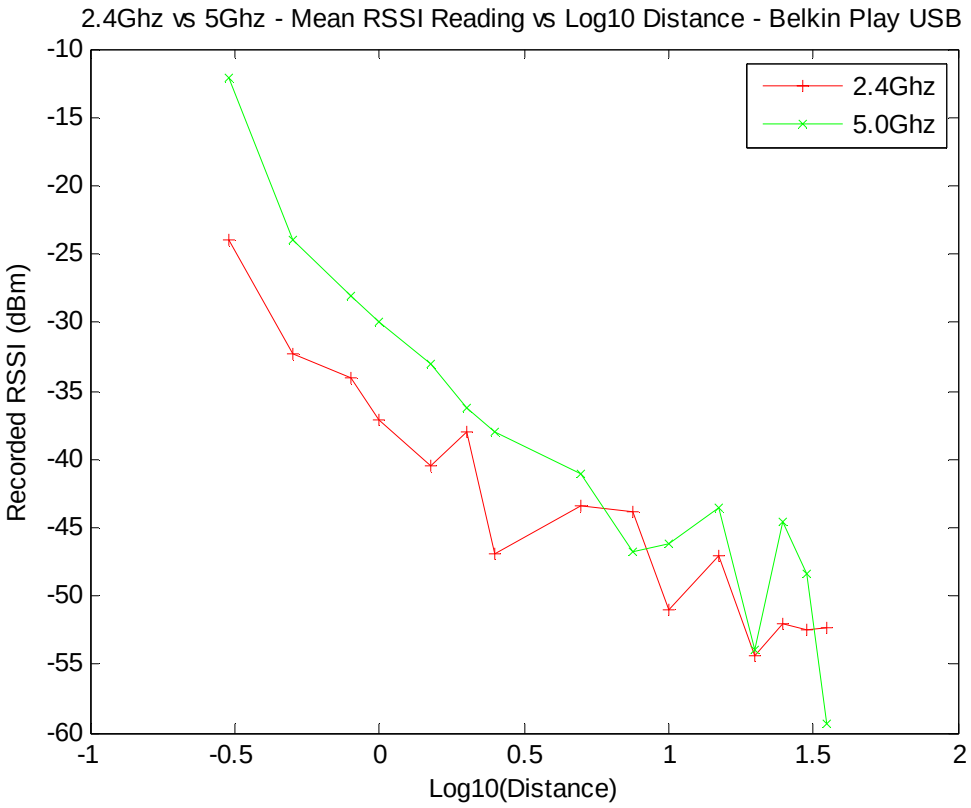

2.4Ghz RSSI Reading Box Plot vs Log10 Distance - Intel Wi-Fi Link 5300N
Recorded RSSI (dBm)
-10
-20
-30
-40
-50
-60
-70
-80
-90
-0.5228
-0.3010
-0.1549
-0.0969
1
0.1761
0.3010
1.1761
1.3010
1.3979
1.4771
1.5441
Log10(Distance)

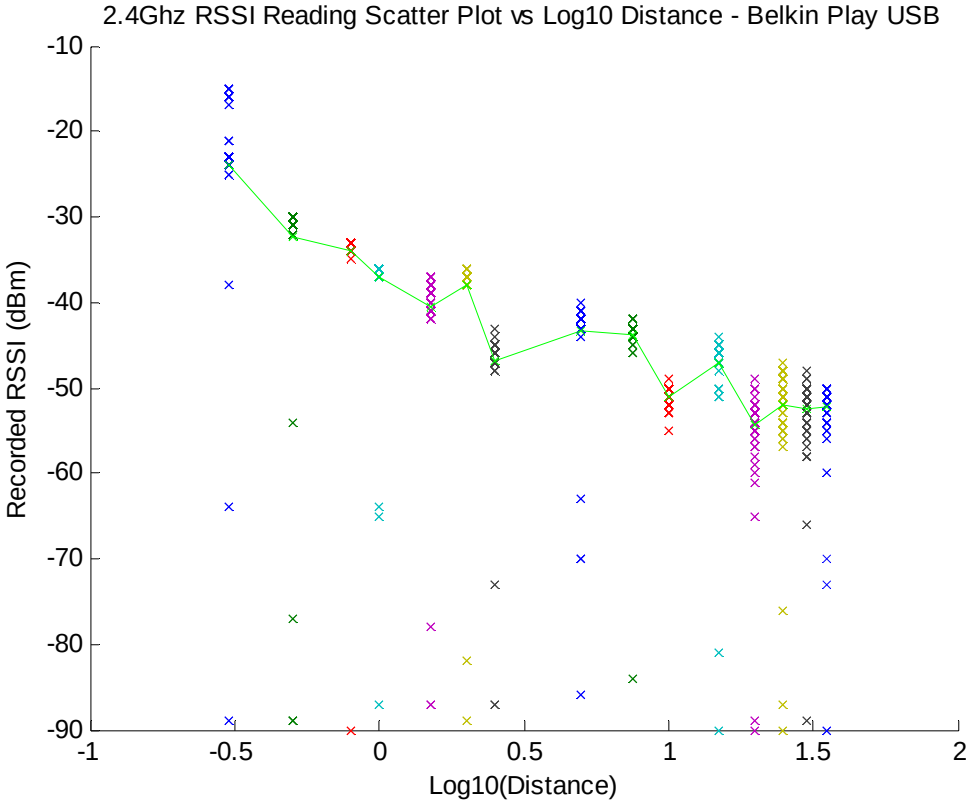


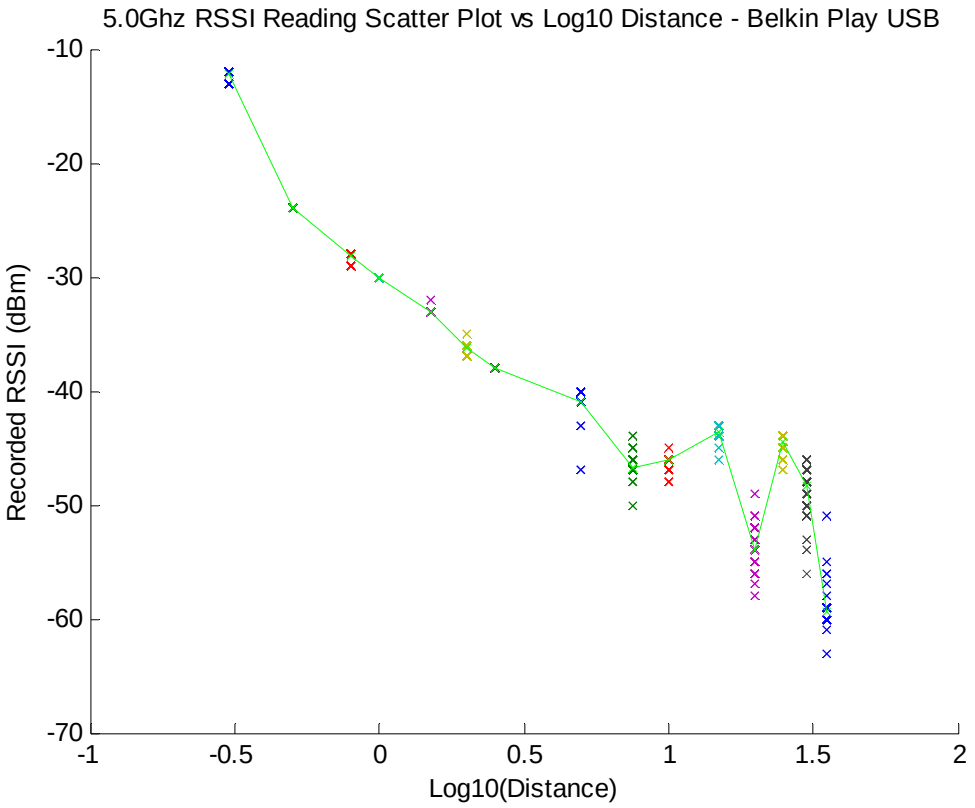
Now we come to the Belkin Play USB adapter – this needed to be retested due to a lack of data points when first tested due to the netbook CPU problem.

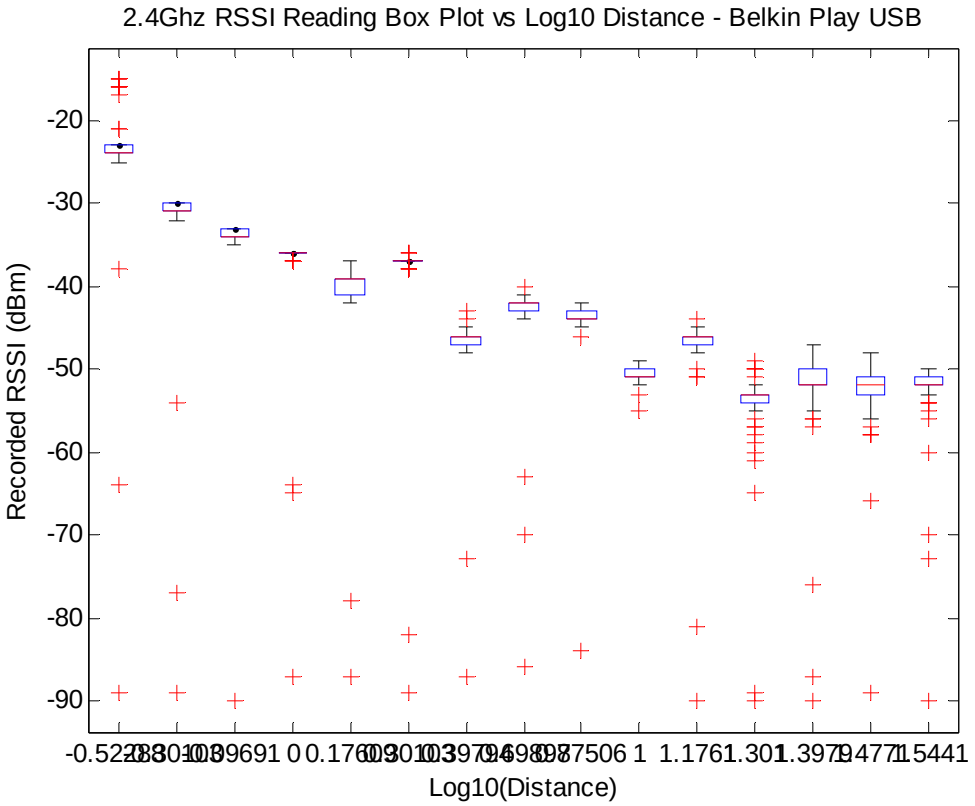
Distance	2.4Ghz	5Ghz
0.3m	229	229
0.5m	227	225
0.8m	227	227
1m	225	225
1.5m	223	223
2m	222	222
2.5m	223	223
5m	219	219
7.5m	231	231
10m	229	229
15m	229	229
20m	226	228
25m	223	225
30m	224	224
35m	221	219

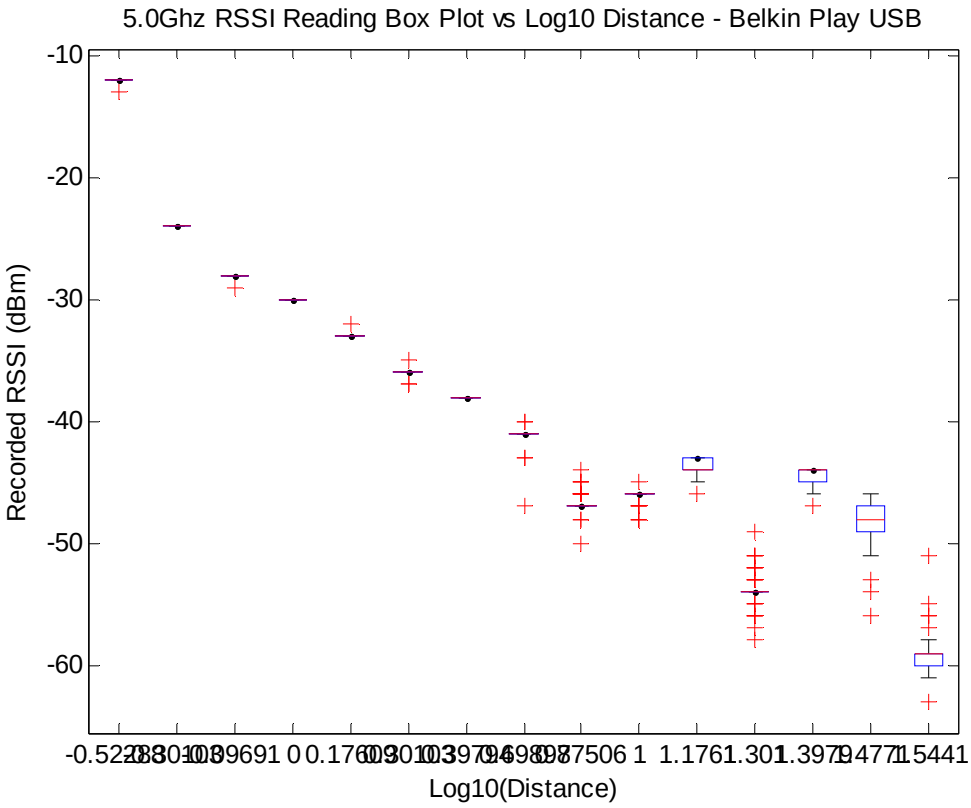
As you can see, the number of data points is now healthy. This card shows a reversal of what is normally seen – the 5Ghz signal is stronger than the 2.4Ghz signal for almost all points. This is not what usually happens and may be attributed to antenna design on this card, although nobody knows for sure.


2.4Ghz vs 5Ghz - Mean RSSI Reading vs Log10 Distance - Belkin Play USB
2.4Ghz
5.0Ghz
Recorded RSSI (dBm)
Log10(Distance)
-10
-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)
-10
-20
-30
-40
-50
-60
-70
-80
-90
-1
-0.5
0
0.5
1
1.5
2

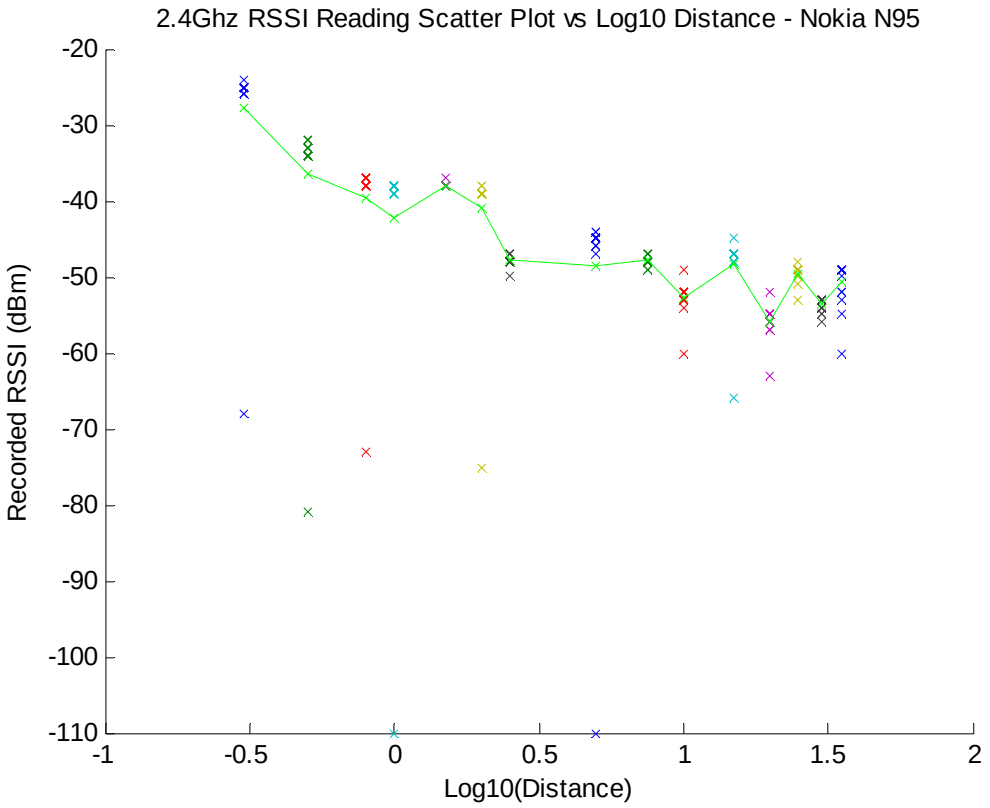

5.0Ghz RSSI Reading Scatter Plot vs Log10 Distance - Belkin Play USB
Recorded RSSI (dBm)
-10
-20
-30
-40
-50
-60
-70
-1
-0.5
0
0.5
1
1.5
2
Log10(Distance)

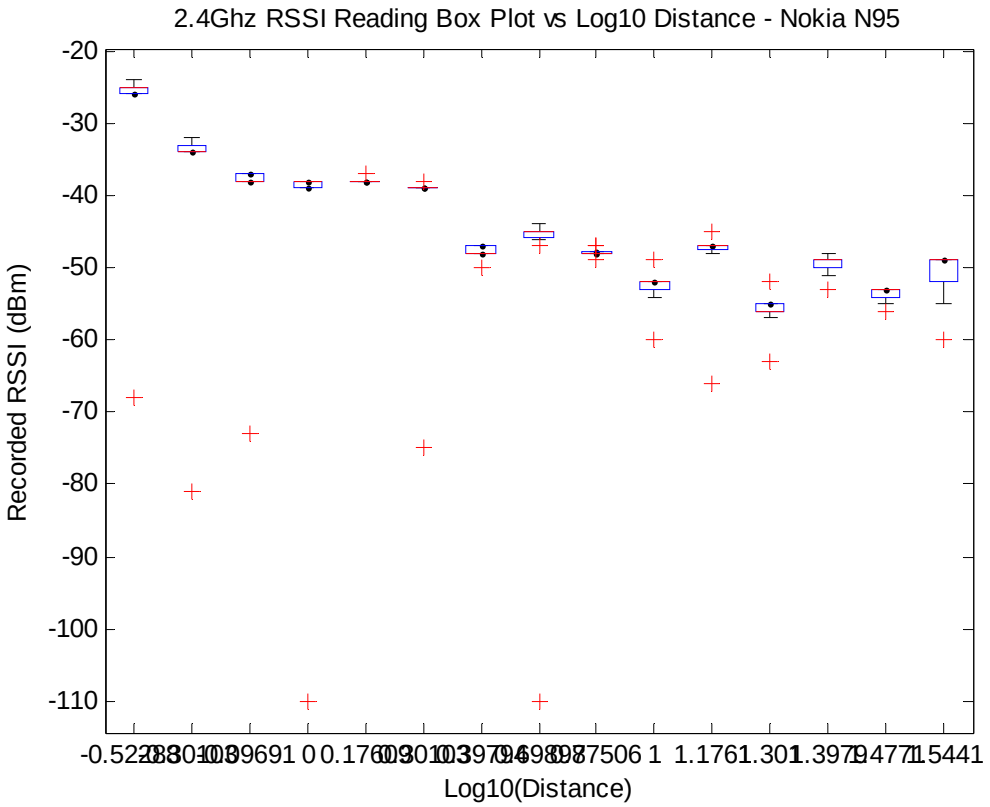

2.4Ghz RSSI Reading Box Plot vs Log10 Distance - Belkin Play USB
Recorded RSSI (dBm)
-20
-30
-40
-50
-60
-70
-80
-90
Log10(Distance)



Now, the Nokia N95 which was logged using Pynetmony – unfortunately this phone was slow at scanning and the number of data points received at each point is below 20. There are some spurious points - -110dBm seemed to be a very common "spurious" number which maybe a sign of the chipset design or the driver design. This data was in tab delimited form and was also fairly easy to process.

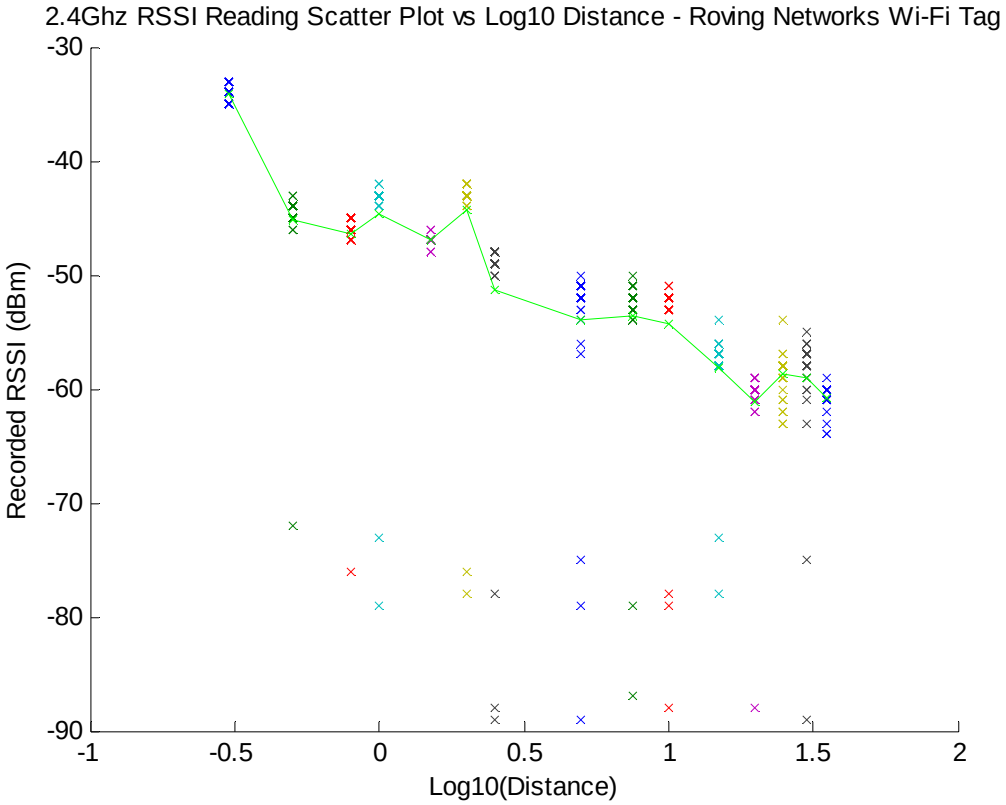
Distance	**2.4Ghz**
0.3m	16
0.5m	15
0.8m	17
1m	18
1.5m	18
2m	17
2.5m	17
5m	19
7.5m	17
10m	18
15m	16
20m	15
25m	16
30m	19
35m	17

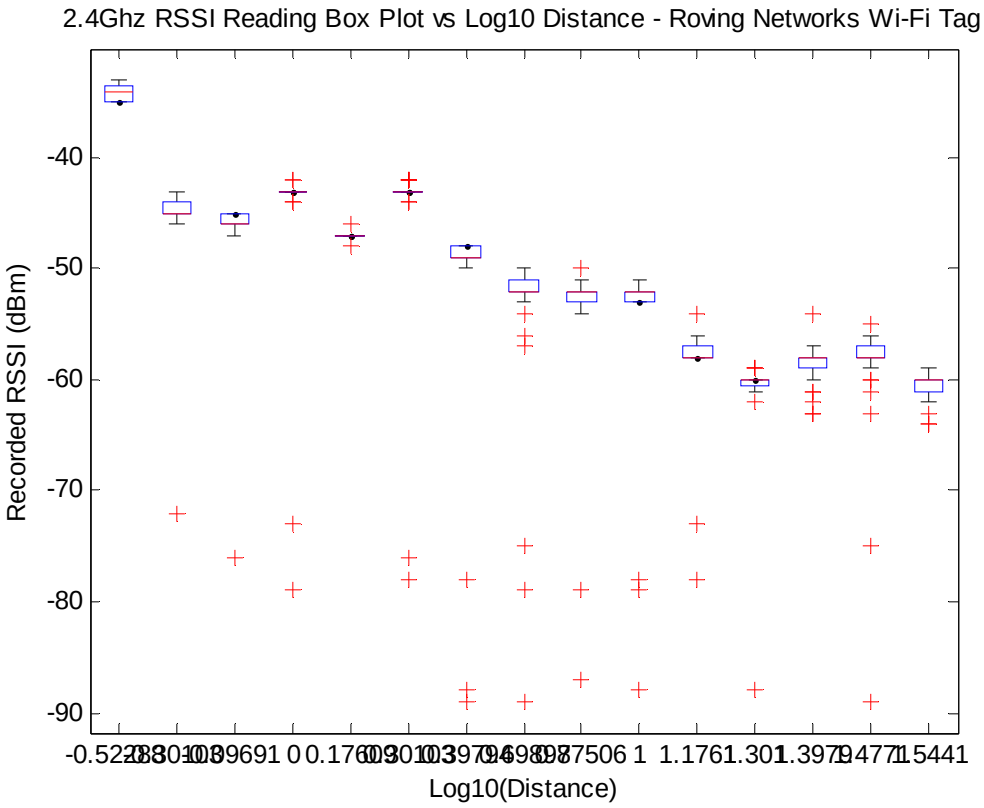

2.4Ghz RSSI Reading Scatter Plot vs Log10 Distance - Nokia N95
Recorded RSSI (dBm)
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-1
-0.5
0
0.5
1
1.5
2
Log10(Distance)


2.4Ghz RSSI Reading Box Plot vs Log10 Distance - Nokia N95
Recorded RSSI (dBm)
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
Log10(Distance)

Finally, we get to the Roving Networks Wi-Fi Tag. This was the most troublesome of all to parse as the data was right aligned by spacing and was not really designed with tabular format in mind. With a few tricks and rigid assumptions, a parser was written and the data was extracted. It does seem that the tag does not output data at a very regular interval – samples range from 27 samples for a point all the way up to 55. A check of the log file does confirm that it does not seem to be an issue with my parser, but more with the way the tag waits a "near random" amount of time after being commanded to scan. The number of data points is also small in comparison to the inSSIDer results, but at least we do get some data. There is some spurious noise as well with this tag, which shows up as a cluster towards the bottom.

Distance	**2.4Ghz**
0.3m	36
0.5m	44
0.8m	46
1m	42
1.5m	55
2m	48
2.5m	42
5m	44
7.5m	44
10m	43
15m	42
20m	28
25m	33
30m	40
35m	27



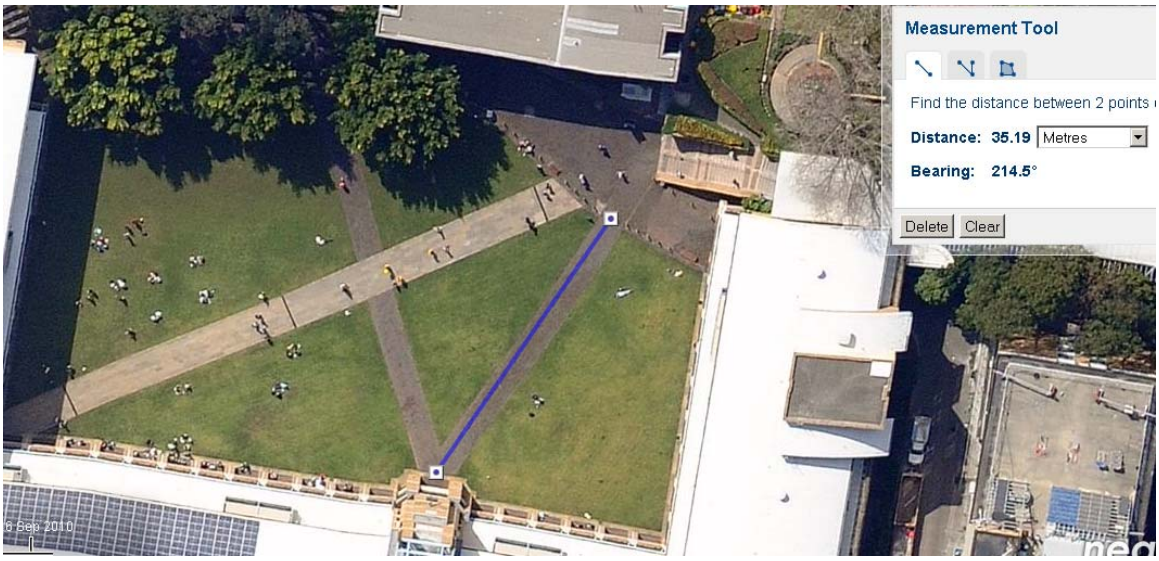


- Thursday 13th January 2011

Seeing the problems with the Intel Wi-Fi Link 5300 card's results, we have to set up for an indoor test for the last time. Unfortunately Binghao was a bit busy, so I could not immediately gain access to the laptop.

The first thing that I did was to survey suitable locations for outdoor testing. Of the two locations, the carpark was quickly ruled out, as access to the top level of the carpark was by stairs only. It would be very difficult to get all the test gear up to the top level that way. Also, while there was a nice stretch of unused spaces, it would be hard to guarantee that that row of spaces would remain available for weeks of testing. Furthermore, metal cars parked nearby could even influence the test results, depending on their size, shape and where they parked. So overall, my decision is not to test in the carpark.

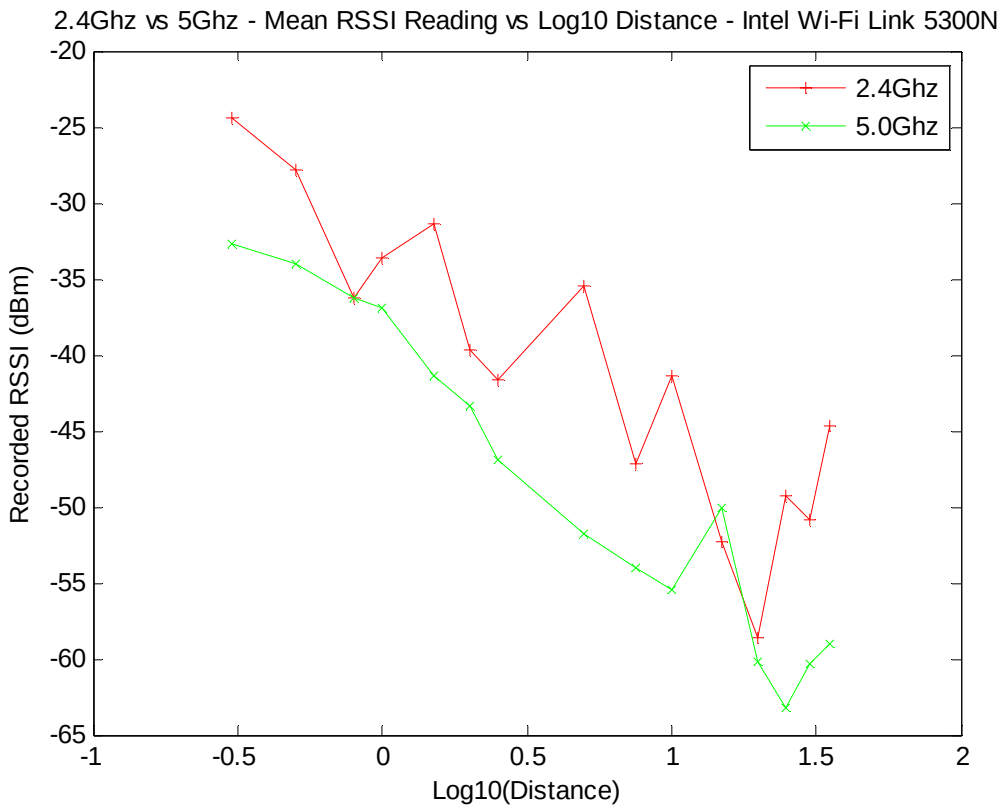
The quad was surveyed, and despite it being summer session (which is uni break for most people), there were still a fair amount of people walking around the quad, especially through the wide path that traverses the length of the quadrangle diagonally. With that in mind, that path was ruled out as the human traffic would cause a large level of interference. There were two shorter paths, the shortest path was the chosen one. The reason was that: it is 35m – of the same length as the hallway as required for keeping the same distances and producing comparable data. It is also standalone and has no intersection, and therefore, will have less chance of someone walking through the beam. Thirdly, we can cordon it off, and people have a (slightly longer) alternative path to their destination – therefore minimizing disruption and maximizing our ability to get good results. Thomas was concerned that we should be doing a larger distance – but unfortunately, I haven't seen a good place to do it. The paving in the quad will definitely help the trolley move – and prevent damage to grassed areas. The village green is definitely too far away.

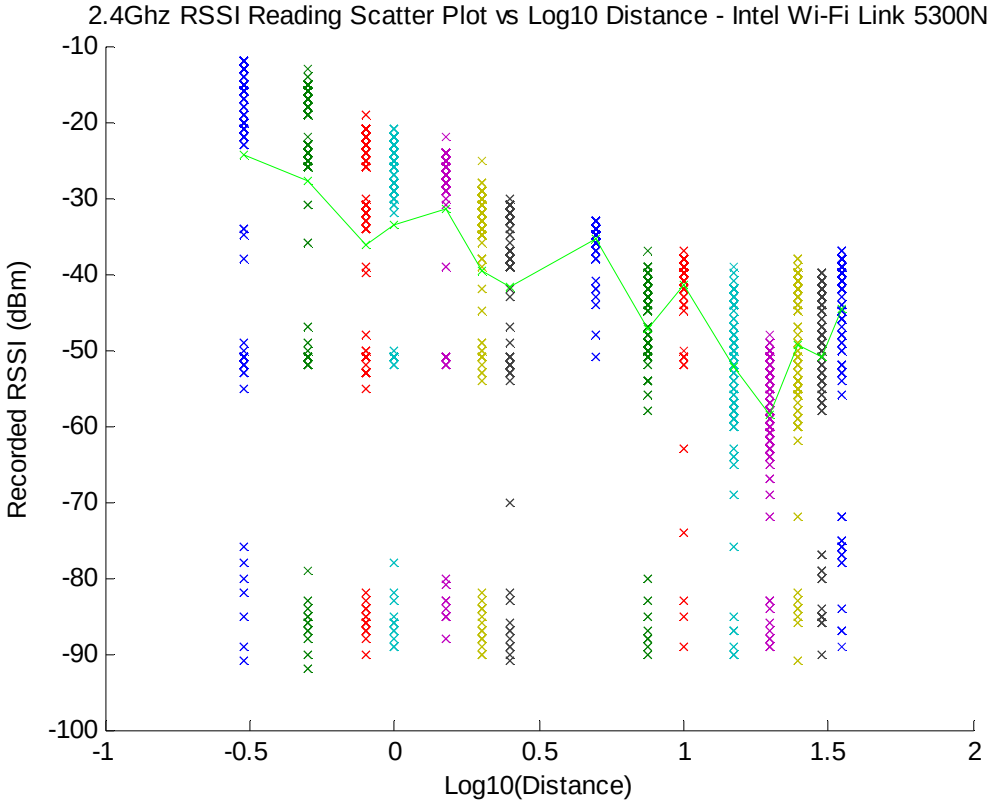


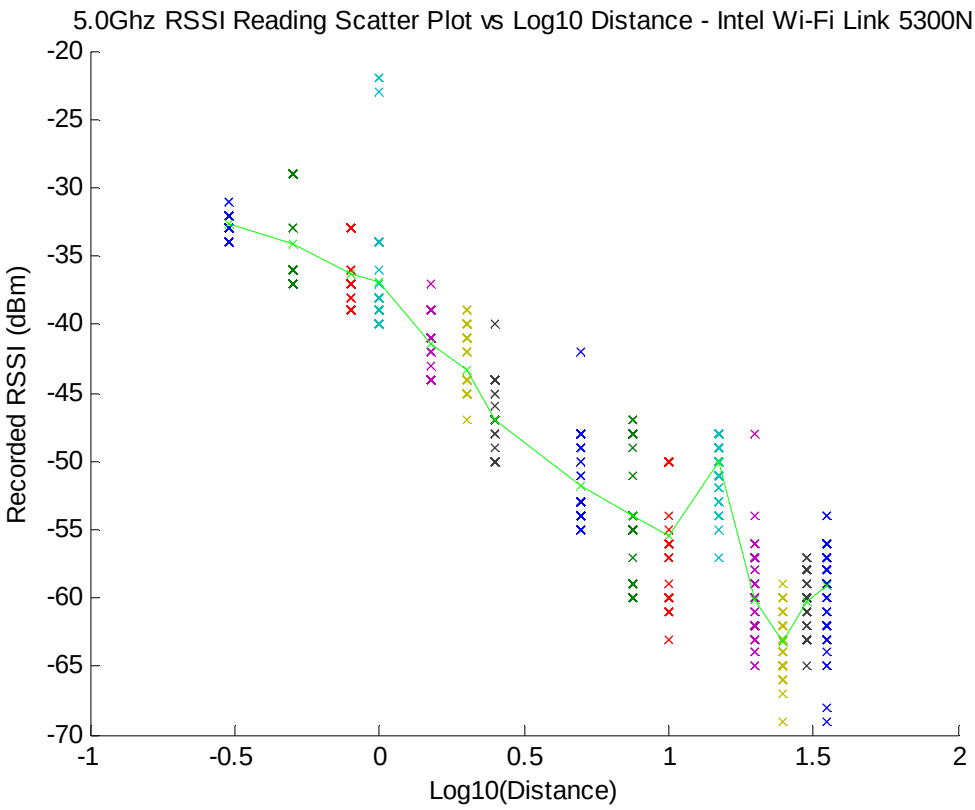
Additional witches hats and inverter were sourced to ensure that we could have smooth testing when outdoors. Testing the Intel card resumed as soon as access was gained to the laptop. The same method as used before was used in a rerun to collect the data from 30cm to 5m, however, it resulted in strange jumps and falls in the number of data samples, despite using the same software version, same GPS as the other experiments, this laptop still refused to co-operate.

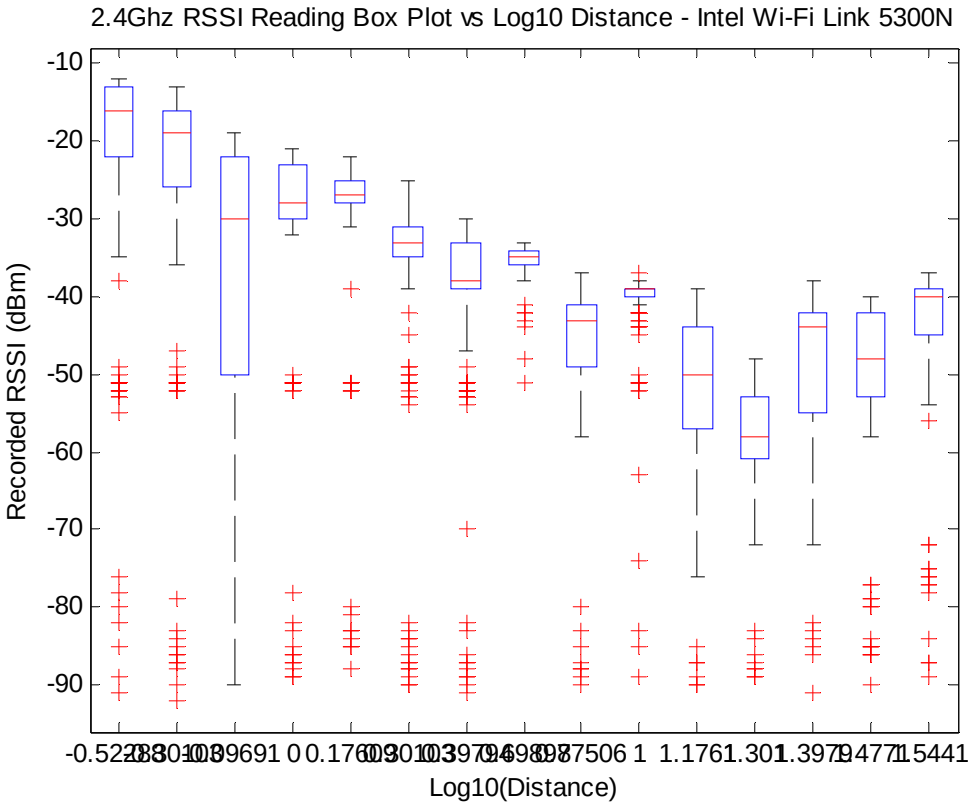
Upon discussing with Binghao, he suggested that we do it manually. I reluctantly agreed, and with some more tending than usual, and test intervals of 5 minutes (plus or minus about 3 seconds), we managed some good data, although the strange trends and high level of noise are still visible for some reason:

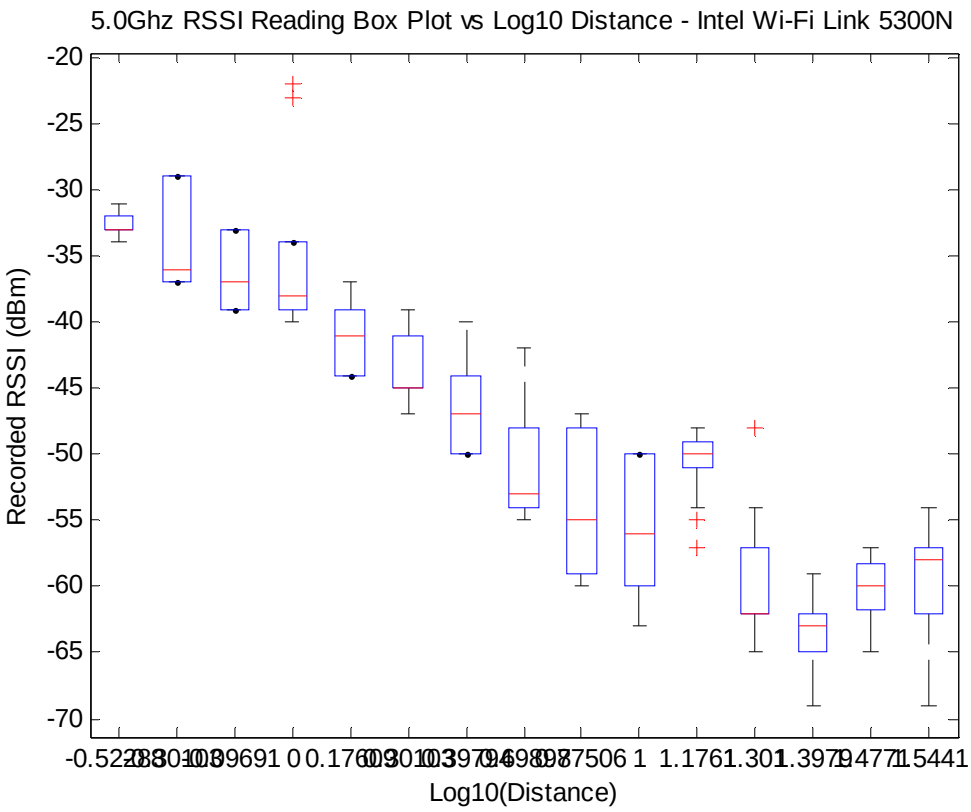
Distance	**2.4Ghz**	**5Ghz**
0.3m	296	296
0.5m	300	300
0.8m	298	298
1m	295	295
1.5m	297	297
2m	298	298
2.5m	296	296
5m	298	298
7.5m	298	298
10m	297	297
15m	296	296
20m	299	299
25m	299	299
30m	299	299
35m	302	302


2.4Ghz vs 5Ghz - Mean RSSI Reading vs Log10 Distance - Intel Wi-Fi Link 5300N
2.4Ghz
5.0Ghz
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 Scatter Plot vs Log10 Distance - Intel Wi-Fi Link 5300N
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 - Intel Wi-Fi Link 5300N
Recorded RSSI (dBm)
-20
-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 - Intel Wi-Fi Link 5300N
Recorded RSSI (dBm)
-10
-20
-30
-40
-50
-60
-70
-80
-90
Log10(Distance)



Outdoor testing was not attempted today owing to a lack of time and the fact that rain had fallen around lunchtime, making the grounds wet. The preferred location in the quadrangle also had gardeners who were maintaining the lawn, which I did not want to disturb. However, all indoor testing has finished, with a sigh of relief. I will update plotall.m with the new results shortly.

Unfortunately, there still is no response from the manufacturers in regards to the way signal level is calculated for their cards with feature receive diversity and or MIMO.

- Friday 14h January 2011

Today begins the first run of outdoor testing. The aim is to test laptops today, as it is slightly easier as there is no need to carry two batteries and inverters – just the one for the access point is enough. Initially, I intended to test four laptops, however, since one of the laptops was being used by me to communicate with Thomas and keep myself occupied, I could only test three.

The HP Elitebook with the Intel 5300N card was first tested as it is the fussiest of the lot, requiring manual attention. It was only as we were setting up that I realized there were a few additional unforeseen challenges to outdoor testing.

Firstly, the path chosen at the quad is on a slight grade initially, meaning that the trolley has a tendency to roll away from the access point. Initially, I fashioned up some duct tape chocks, but they require additional time and care to position properly. Thomas then was able to source me two doorstops which were better, but still don't avoid the issues entirely.

Secondly, the sun causes the measuring tape to expand as it heats up. This, combined with the wind, means that the measuring tape may be laid down flat, but then turns into arcs over time. Furthermore, the wind causes the tape to flutter and make annoying sounds. It appears that I will have to put more duct tape onto the measuring tape to keep it better tied down. It was also discovered that the paving was not entirely

straight as well, meaning positioning accuracy is a bit poor. It was also not level in certain areas. The duct tape itself had a tendency to become goopy when heated by the sun, resulting in a sticky residue being left on my measuring tape.

Thirdly, the wind itself is pretty powerful at times. It had a propensity to cause the cart to move on its own even on level ground – thus requiring the cart be chocked at all times. Furthermore, it was able to blow my netbook off the cart, and tear the bin off the cart despite two duct tape straps which were holding it down. This meant that I had to revise the trolley layout such that the bin is permanently taped to the trolley with a full loop of duct tape. This had the disadvantage of reducing the available area of the cart which could be used to cart things around. Furthermore, it was discovered that the access point needed to be duct taped to the box (as it was blown over), and the bin the access point rests on had to be duct taped to the floor as well as it twisted in the wind.

The strong sun made it extremely difficult to see and read any information off the LCD screen. I often had to struggle to try and shade the screen enough to try and determine whether it's in scanning mode or stopped mode.

Despite the layout of the witches hats, people still felt the need to walk into the test area and use the path which I tried to close off. Maybe it's because they don't see any danger to themselves, that they choose to do such a thing. Unfortunately, this sort of thing can only degrade my test data's quality – and personally – I would love it if we could exclude people permanently. At least the majority of people seem to take the cones seriously – others tend to walk on the grass, with some even crossing the beam of the Wi-Fi access point. Overall, I'm quite disappointed at the lack of co-operation from people. It cannot seriously be that hard to take a detour around the closed off area – only 35m long.

There was also a danger of "runaway cart" – especially since the weight of the batteries and cones are fairly significant, when rolling the cart down even a mild grade, it has a tendency to roll away. Let's just hope the string holds tight.

Despite these challenges, the one expected problem (rain) was not encountered today. The day remained sunny, and I was hesitant to leave the laptops out there. The black bin and the laptops were all heating up to uncomfortably hot temperatures – but I guess we must persist in the name of science.

Testing was also performed for the Intel Centrino Wireless 3945ABG card in my BenQ R55UV10, and the Broadcom BCM4312 inside the MSI Wind U100 netbook. The data would be analysed later, but the method was pretty much still the same.

I had e-mailed Thomas to help me collect the laptops after testing to reduce the load needed to be taken back. I was also visited by Chris Rizos and Binghao for a discussion about the poster presentation – they were concerned about available time, however, I think I will be able to complete the poster in less than a week's time. I am, however, concerned about the remaining time in this project – if we are to collect as much data as we had originally envisaged, everything will have to go well from now on – this means the weather, and inSSIDer has to be kind to us. Somehow, I don't think this will be the case. Furthermore, as I saw Thomas before I left, I reasoned that we should probably skip the Monday meeting and just go straight into testing because we had so much work ahead of us. He agreed that we should probably just go straight to testing – I neglected to tell Binghao this before I left, but Thomas agreed to let him know on my behalf.

As of today, there have still been no replies from any manufacturers in regards to signal strength calculations – however – a quick experiment with the Ralink Technology 1T2R m-PCIe card in my HP 2133 Netbook reveals that it sends only the signal strength of Antenna 1 to the operating system. This means that my initial hunch about the way diversity may affect signal strength readings doesn't really hold for the Ralink Technology cards.