WIRELESS DATA COMMUNICATION

CSM117 LAB REPORT

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LAB SECTION: 1B

ABSTRACT

The main goals of lab 2 and 3 were to familiarize ourselves with wireless data communication methods through the IEEE 802.11n Wireless LAN and Bluetooth. Because both communication means have similarities, we tested their overall throughput with distance, and the general noise handling capabilities of both wireless communications.

Lab 2 focused on measuring the data rate of UDP and TCP with increasing distance, noting down the overall signal to noise ratio, and then measuring the same data throughput of both protocols with the presence of noise through the use of a microwave oven.

Lab 3 focused on measuring the data throughput of DH1, DH3 and DH5 packet types of Bluetooth with increasing distance. We also measured the change in data rate with an increasing number of slave nodes that feed off the master transmitter. We finally went onto directly comparing data throughput of Bluetooth against that of the TCP WLAN protocol by making their transmission paths cross and interfere with each other.

THEORETICAL BACKGROUND - Wifi

The IEEE 802.11n wireless uses Media Access Control with two well known modes of communication. If there exists a base station (such as a modem) connected to a wired network connection, the wifi utilizes this communication, else it falls back on an Ad Hoc networking. Wireless data communication tries to reduce interference through the Carrier Sense Multiple Access/Collision Avoidance protocol which makes it slow down transmission on a busy channel. This CSMA/CA operates under the Distributed Coordination Function, which means it can be unreliable in the presence of noise of the same frequency such as microwaves. As a result frames are sent in smaller packets that are fragmented with their own checksum so that they remain undamaged. The alternative to this DCF method is Point Coordinated Function which uses a base control to control the frame sending, thus avoiding collision altogether.

In the Transport layer of Wifi we have User Datagram Protocol and Transmission Control Protocol.

TCP – in conjunction with CSMA/CA effectively handles losses due to interference, fading and other factors. Because of its acknowledgement, congestion control and collision avoidance, TCP is expensive in retransmissions, but is extremely reliable, using byte streams to send the data.

UDP – is a connectionless protocol that requires no handshake for setting up a communication path. This then makes it extremely fast, and sends its data datagram packets. As a result there is the potential of losing datagrams or having datagrams overlap, which thus makes this protocol less reliable.

THEORETICAL BACKGROUND - Bluetooth

In contrast to Wifi, Bluetooth's MAC layer uses Frequency Hopping Spread Spectrum which involves switching across 79 different frequency channels to transmit radio signals in data bursts at around 1600 hops/second. Doing so reduces the interference. Because of this use of radio signals in bursts, Bluetooth is mainly used in creating an Ad Hoc Personal Area Network without line-of sight which is short range in contrast to Wifi's long range. Just like Wifi, Bluetooth transmits its data over the 2.4GHz frequency.

With Bluetooth, there is usually a master and slave connection that is set up. The master can pick up to 7 slaves to form a piconet with the master node as the central transmission point. The entire piconet then matches the master's frequency hopping and timing.

When it comes to external interference, Bluetooth employs interference suppression or interference avoidance. The transmission is done over links between these masters and slaves and they are either ACL at irregular intervals or SCO for real time data.

EXPERIMENTS – LAB 2 – Part A Results

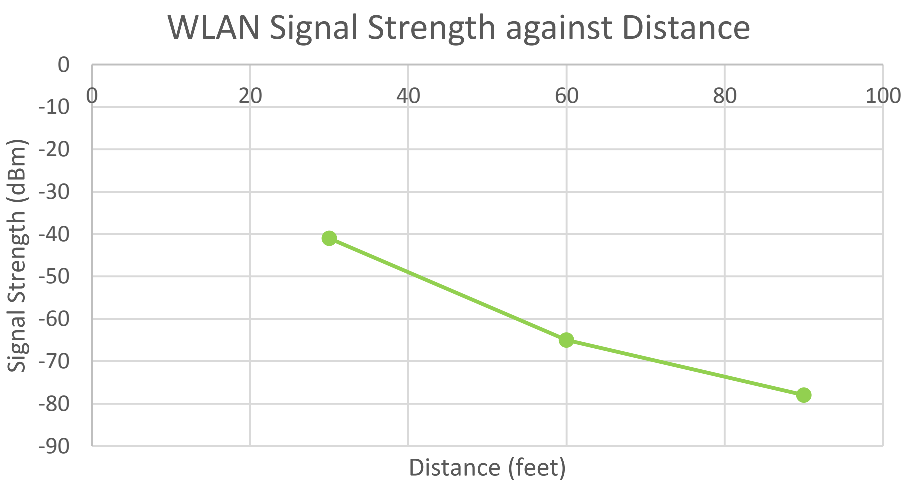

Figure 1: Graph representing how the signal strength of Wifi varied with increasing distance.

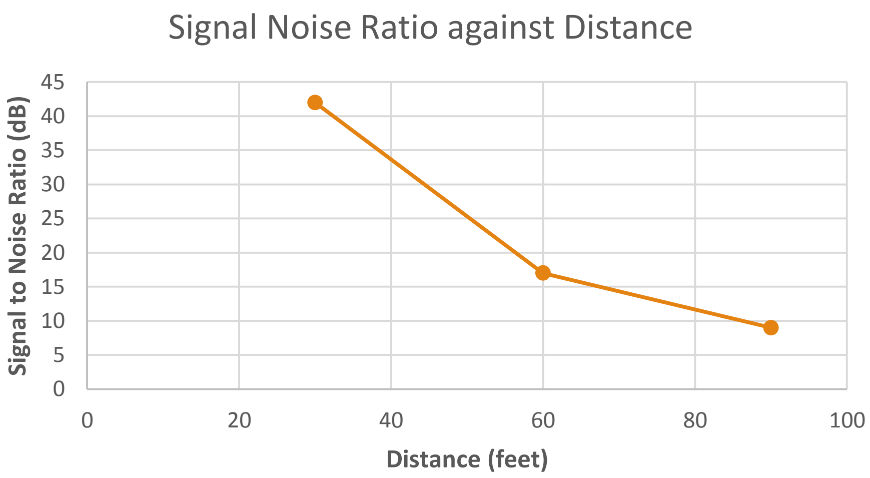

Figure 2: Graph representing how the signal to noise ratio of wifi varied with increasing distance.

Using a central server laptop, we measured the variation in signal strength and data throughput of UDP and TCP. From Figure 1 we notice a decreasing trend in that the signal strength of any wireless LAN signal decreasing with the increase in distance. This makes intuitive sense because as we get further away from the source, the interference levels increase and the data transmission gets lost more easily as it has to travel a further distance. Figure 2 shows us a following relationship that the signal to noise ratio (SNR) decreases as distance increases which essentially states that the noise levels increase as the distance increases. This is probably due to external noise from the third floor of Boelter Hall where the experiment was conducted. As we get further away from the transmission source we have more factors in the line of sight that could contribute to the noise and so SNR decreases.

EXPERIMENTS – LAB 2 – Part A Results

Building off of the previous section we notice that UDP and TCP are both reliant on the strength of the signal in that it relies on how effectively and how strongly the data communication link is. The stronger it is, the faster the data throughput for either of the transmission protocols will be. Figure 3 and 4 represent exactly this. As the SNR increases, that is the signal strength increases while the noise levels decrease, the throughput increases. This is a directly proportional linear relationship, and showcases the fact that the less interference there is, the stronger the data throughput is.

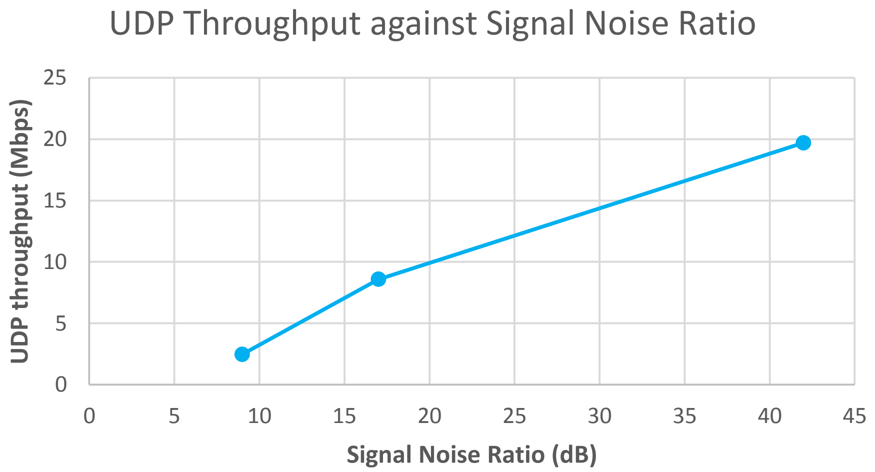

Figure 3: Graph representing how the data rate of UDP varies with increase SNR.

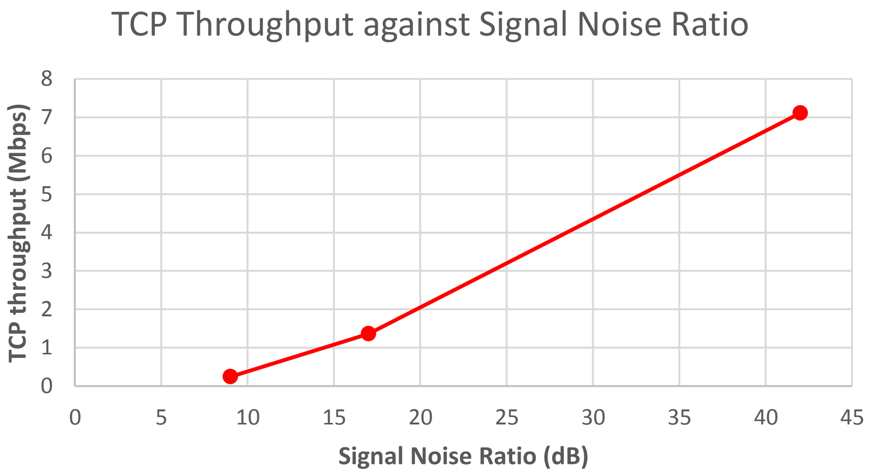

Figure 4: Graph representing how the data rate of TCP varies with increase in SNR.

EXPERIMENTS – LAB 2 – Part B Results

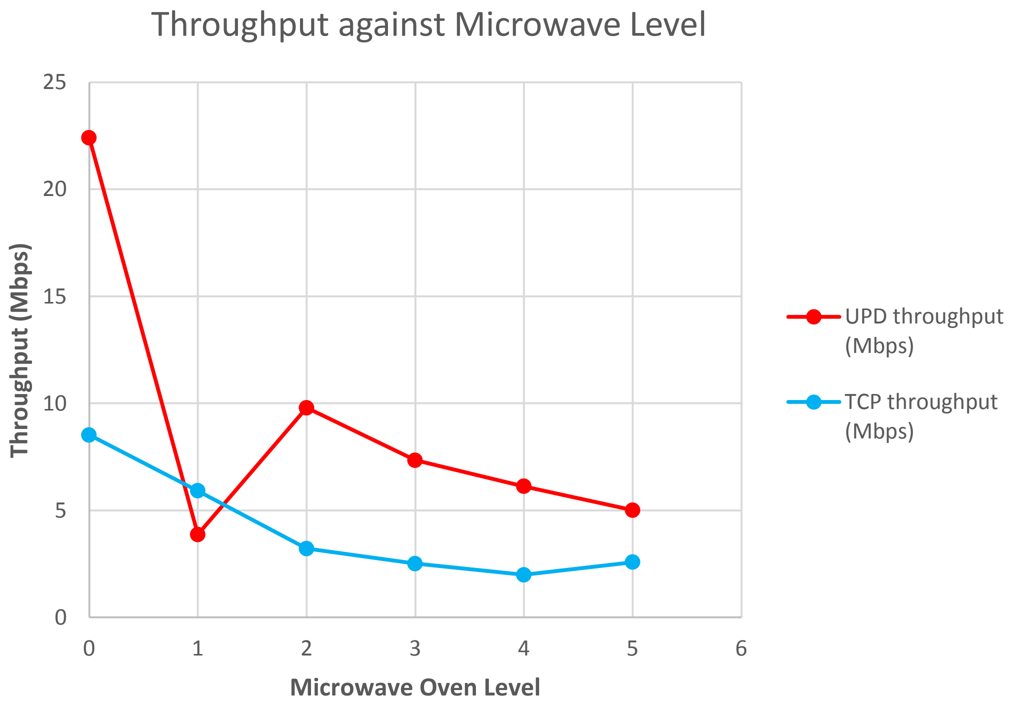

Figure 5: Graph representing the change in data throughput in both protocols with the introduction of noise in the form of microwave radiation.

Figure 5 shows us how the different levels of microwave radiation affect the data rate achieved by both UDP and TCP. For reference the levels 0 – 5 represent the microwave levels from *off* to *high*. These were the settings on the microwave oven in the lab that was switched on at each respective level for a minute each time. The general trend we notice is that as we expect that with the introduction of more noise and interference from the microwave results in a significantly lower data throughput. The reason the effect is so high as well is due to the fact that the microwave frequency lies around the 2.4 GHz range which is the same frequency modern computers use for data communication.

Specifically with UDP we also noticed an increased amount of datagrams lost. We also note the interesting effect that the drop in UDP throughput is a lot higher relative to its original as compared to that of TCP, probably because of the fact that TCP is more reliable and has more checks in place to handle interference such as congestion control and acknowledgement.

EXPERIMENT – LAB 3 – Part A Results

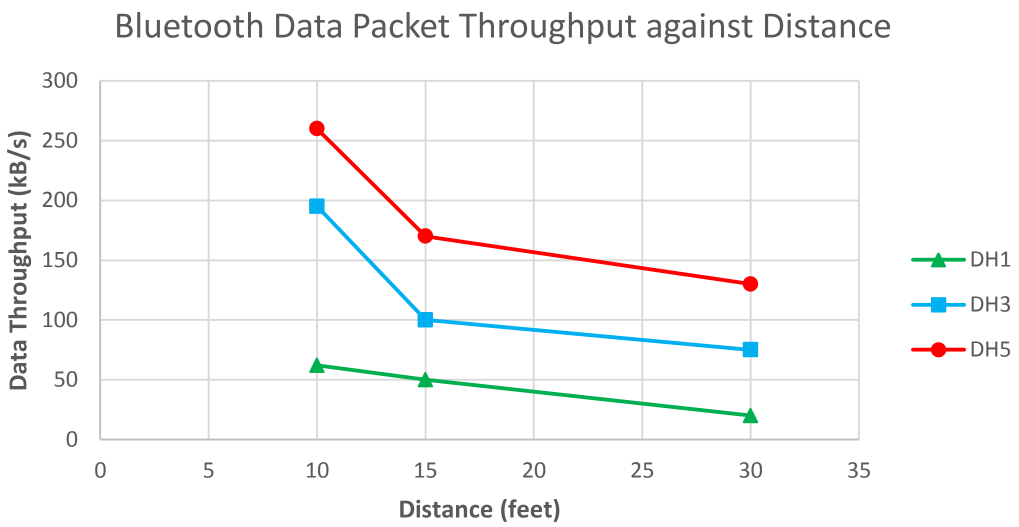

Figure 7: Graph representing the throughput of the different types of data packets in Bluetooth with varying distance

Just as noted with the wifi results, as the distance from the master central source increases the overall data throughput decreases significantly. The general trend is the same for all data packet types, though we notice that DH5 is clearly much faster than DH3 which is much faster than DH1.

The interesting thing to note is that the data throughput values with Bluetooth are much lower than that of both UDP and TCP WLAN protocols. These values exist in the KB/s range while with UDP and TCP exists in Mbps range which is almost 3 orders of magnitude greater!

This demonstrates that Bluetooth was built for smaller short range communication.

EXPERIMENT – LAB 3 – Part B Results

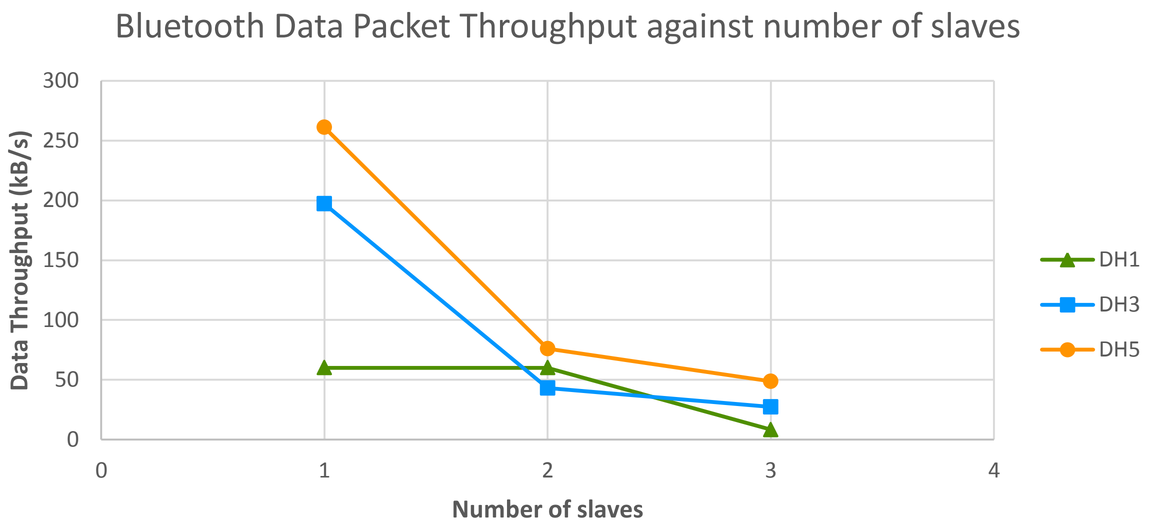

Figure 8: The variation of the different Bluetooth data packets data rates with varying number of slaves in the piconet.

Just as noted with the wifi results, as the distance from the master central source increases the overall data throughput decreases significantly. The general trend is the same for all data packet types, though we notice that DH5 is clearly much faster than DH3 which is much faster than DH1. We measured this data while being 5 feet away from the master.

The interesting thing to note is that the data throughput values with Bluetooth are much lower than that of both UDP and TCP WLAN protocols. These values exist in the KB/s range while with UDP and TCP exists in Mbps range which is almost 3 orders of magnitude greater!

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EXPERIMENT – LAB 3 – Part C Results

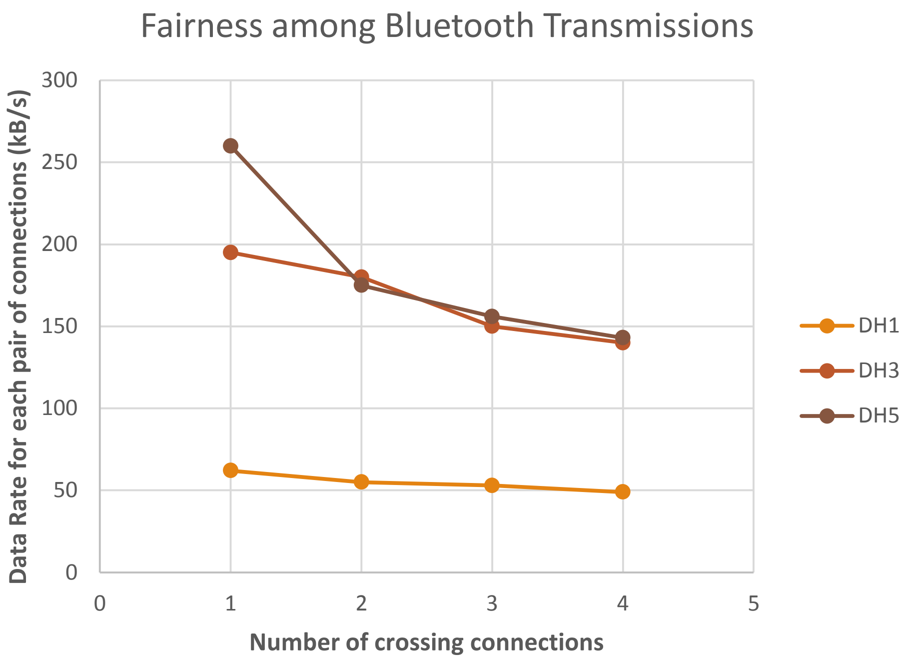

Figure 9: A graph representing the data throughput for the different Bluetooth packet types with varying intercrossing connections.

We notice from Figure 9 that when the data transmission paths for Bluetooth cross each other, we have effective interference that results in significantly lower data throughput. We notice however that both DH3 and DH5 fall down to approximately the same value which suggests that the throughputs are pretty fair.

EXPERIMENT – LAB 3 – Part D Results

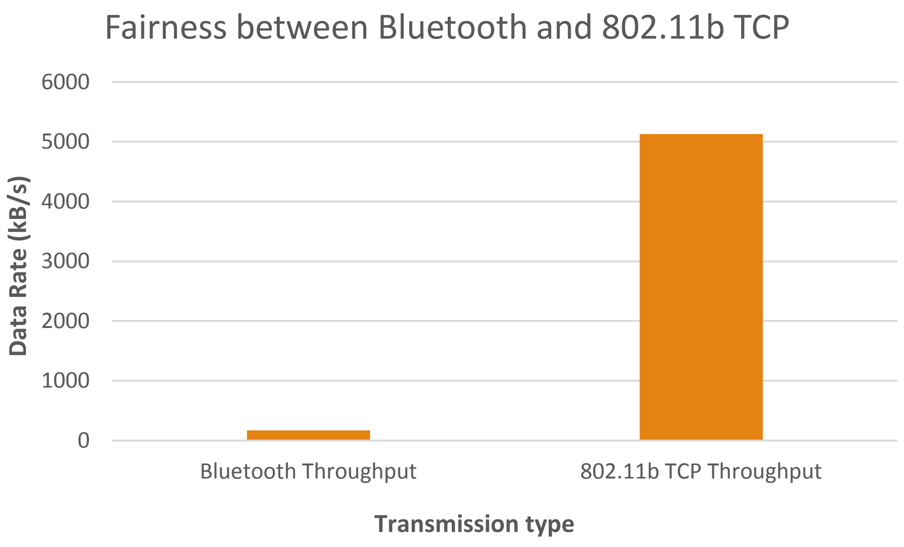

Figure 10: Measuring the difference between Bluetooth and TCP WLAN throughput.

In the final portion of the lab we connected two laptops separated by 5 feet and tried to receive data using bluetooth and using Wifi at the same time from a common master source. The data from Figure 10 shows us that the fairness in data transfer is highly skewed as Wifi got most of the data transfer while Bluetooth suffered during the intercrossed communication.

DISCUSSION

Through the experiments in Lab 2 and Lab 3, we notice that both Wifi and Bluetooth are susceptible to factors such as distance away from source and interference through external noise and path interference. We also notice how wifi has significantly higher bandwidth, with UDP at about 20Mbps and TCP at around 8Mbps when close to the source, while Bluetooth DH5 which is the fastest data packet only reaches about 260KBps. This makes sense in that Wifi was built to have higher bandwidth, but Bluetooth was meant to be cheaper while maintaining slow bandwidth. We have to realize though that the lab manual expects us to use the 802.11b wifi protocol, but all the experiments utilized the 802.11n which is much faster. Bluetooth is additionally susceptible to increasing number of slaves in the piconet up to a max limit of 7 slaves; while on the other hand Wifi is shared amongst multiple computers and maintains a relatively good bandwidth.

However, the distance variation affects both methods equally in that they decrease in their data throughput as we get further away from the source. We notice errors in our experiment with interference with microwaves and wifi, where we notice a sharp decrease and increase in UDP throughput when the Microwave intensity increases. The trend follows that the throughput has a general decrease as the amount of microwave intensity increases, which is why the UDP result for level 1 was an anomaly. We notice that both Bluetooth and Wifi communicate on the global 2.4GHz ISM, along with external devices such as microwaves, which is why the interference makes such a big difference.

Finally we notice the interaction between Wifi and Bluetooth given interference. As expected Wifi has a much higher bandwidth and thus steals a lot more data than Bluetooth does. Bluetooth fluctuates slightly but TCP doesn’t have room to fluctuate.

CONCLUSION

This lab overall taught us about the various benefits and downfalls of the two wireless data communication methods. We notice that Wifi is extremely good for high bandwidth and transmission, but is more expensive and very succeptible to noise interference. Within Wifi, UDP has the higher data throughput that TCP, but is a lot less reliable as interference and distance makes datagrams overlap and get lost in transmission. Bluetooth on the other hand, while communicating on the same frequency is meant for shorter range communication, with DH5 packet being relatively higher. It still faces losses in data throughput given the same conditions as Wifi, but is much cheaper to use. When discussing the combination of both Wifi and Bluetooth, we notice that Wifi is able to grab a significantly larger portion of the data.

While we had anomalies and errors in our data, for the most part the results from Lab 2 and 3 agree with the theories and expectations behind IEEE 802.11 WLAN and Bluetooth.