# Exercise #3: Raw Data Sheet
(Data Transmission over Bluetooth)

Part A Table 1. Data Throughput vs. Distance

Distance (m or ft)	Packet Type	Data Rate (kB/s)	Observations
10 ft	DH1	62	Mostly in 60s, some drops to 38-45 kB/s
	DH3	198	Some drops to 155-158 kB/s
	DH5	260	Some drops to 70-90, 120, and 170 kB/s
15 ft	DH1	60	More drops with lows of 42 or 43 kB/s
	DH3	180	Few drops to 52 or 78 kB/s
	DH5	265	Some drops to 90 and 150-160 kB/s
30 ft	DH1	40.22	Varies between 22-54 kB/s, with delay between packets
	DH3	99.3	Varies between 24-195 kB/s
	DH5	118.74	Varies between 56-177 kB/s

Part A Graph 1. Data Throughput vs. Distance
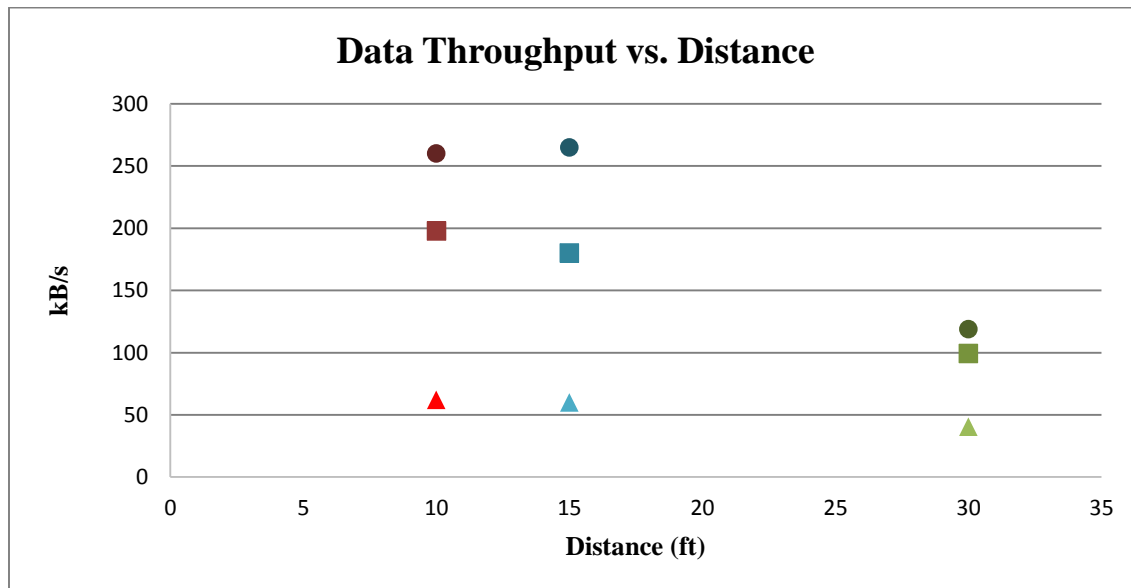

Key	
Symbol	Packet Type
▲	DH1
■	DH3
●	DH5

Part B Table 2. Data Throughput vs. # of Slaves
　　　　(Distance from master to slave nodes: 5 feet)

Number of Slaves	Packet Type	Data Rate (kB/s)	Observations
1	DH1	62.63	Data rate usually constant, occasionally falls
	DH3	197.54	Occasional large outliers
	DH5	260.24	Fluctuates between 170-260 kB/s
2	DH1	28.02	More variation than previous DH1; roughly constant
	DH3	86.94	More variation than previous DH3; smaller outliers
	DH5	131.17	Fluctuates around 70, 100, and 170 kB/s
3	DH1	17.57	Most fluctuation so far
	DH3	60.47	Greater variant but smaller outliers than DH3 with 3 slaves
	DH5	87.17	Occasional high outliers

Part B Graph 2. Data Throughput vs. # of Slaves
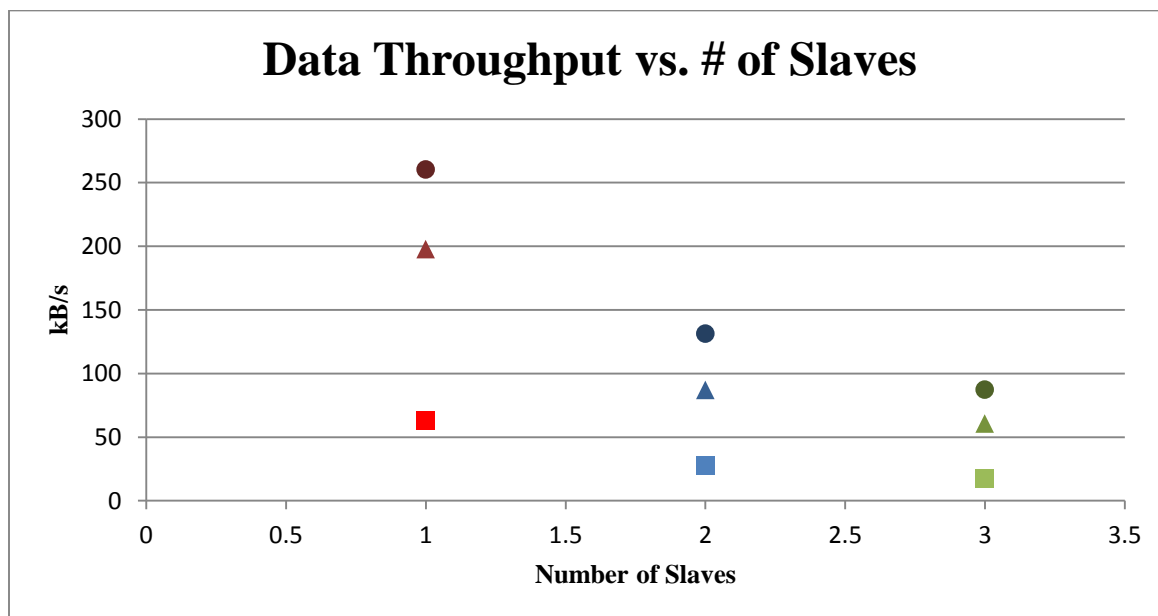
Key	
Symbol	Packet Type
■	DH1
▲	DH3
●	DH5

Part C Table 3. Fairness among Bluetooth transmissions
  (Distance from master to slave nodes: 5 feet)

Measurement Case	Data Rate for each pair of connections (kB/s)	Other Observations
Before interference	262.41	Fluctuation between 170-260 kB/s
3 connections crossing	176.85	Mostly around 170 kB/s but some fluctuating
	178.17	1 rare low spike at about 90 kB/s
	176.15	Fluctuations around 70, 100, 200 and 260 kB/s

Part D Table 4. Fairness between Bluetooth transmission and 802.11b TCP transmission
  (Distance from master to slave nodes: 12 feet)

	Data Rate (kB/s)	Other Observations
Bluetooth Throughput	174.67 kB/s	Also fluctuates between 260-282 kB/s
802.11b TCP Throughput	931 kB/s	Single connection, so no fluctuations

Data Transmission over Bluetooth

CS M117 Laboratory Exercise 3

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Observation

Experiment 3 is similar to the previous experiment we looked at, but focuses this time on the data throughput of Bluetooth when faced with different factors. This exercise determines the effect of distance, bit error rate (BER), and the one-to-many phenomenon (that is, one master node connected to multiple slave nodes) on the data transmission rate of Bluetooth and its various packet types (DH1, DH3, and DH5). We also explore interference between Bluetooth devices and between 802.11 devices as well. To run these tests, we'll be using the l2test tool to start data transmissions.

As usual, our results aligned with our expectations. Overall, as expected, we see that DH5 is faster than DH3, which is faster than DH1 in turn. Even when throughput drops, DH5>DH3>DH1 is maintained in terms of transmission rate. Part A demonstrates an inverse relationship between distance and Bluetooth data rate. Similar to wireless data throughput, the data rate of Bluetooth drops at higher distances between nodes and fluctuates more and more. In Part B, adding more and more slaves to the pool decreases the data rate drastically as well. Part C shows us that throughput drops when Bluetooth connections between different nodes cross. The difference doesn't seem as large as with distance or number of slaves, but data rate still takes a substantial hit. Finally, in Part D, we try crossing a Bluetooth connection with a wireless LAN connection. When both are transmitting, we see that WiFi is actually more "favored" with a slightly higher data rate.

All in all, we see that Bluetooth is affected by many factors that also affect wireless LAN. But when these different types of wireless connections are set to interfere with each other, the data throughput is not necessarily "fair" or equal.

Goals and Results

#	Main Goals	Results with error
1	Effect of distance and Bit Error Rate (BER) on data transmission	Distance is inversely related to Bluetooth data rate. Data rates at 30 feet away are about only half of what they were at 10 feet away. While we didn't seem to get any packet errors, larger distances seemed to produce more fluctuations in throughput, which may imply an increased BER at even farther distances.
2	Effect of one-to-many connection on Bluetooth data transmission	Connecting more slaves to the same group of nodes also decreases the Bluetooth data rate. When a master communicates with 3 slaves, throughput is around 1/3 of what it was with only 1 slave. As before, we also observe the most fluctuations and some outliers.
3	Interference among Bluetooth devices	Crossing devices that are communicating with each other by Bluetooth decreases the data rate by a respectable amount (although not as drastic of a change as the distance or number of slaves affects). Before interference, we have 262 kB/s, but after crossing 3 connections, each one is at about 177 kB/s.
4	Interference and fairness between Bluetooth and IEEE 802.11 devices	There is not very much fairness between interference of Bluetooth and 802.11n wireless LAN connections. Crossing these produces a Bluetooth data rate of 175 kB/s, whereas wireless TCP gets a whopping 931 kB/s.