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Internet Technology

Group 1

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Assignment 1 - Wireless LAN coverage and network Throughput

PART 1 - Wireless LAN Coverage

Aim: To investigate and map the range and quality of the wireless network coverage provided by SIIT (More specifically focusing on the Ground Floor of the Main Sirindhralai Building)

Method:

All steps are carried using 2 different notebooks, for more precise results.

1. Take signal strength measurements in references to the marked areas on the map of the ground floor below
2. Since there are multiple wsiit networks available, record the signal strength of the network with the highest signal quality for each area.
3. Wait until the signal strength reaches a stable value, record the measurement, and move to the next designated area. If the measurement does not reach a stable, pick a value which occurs most frequently.

Equipment

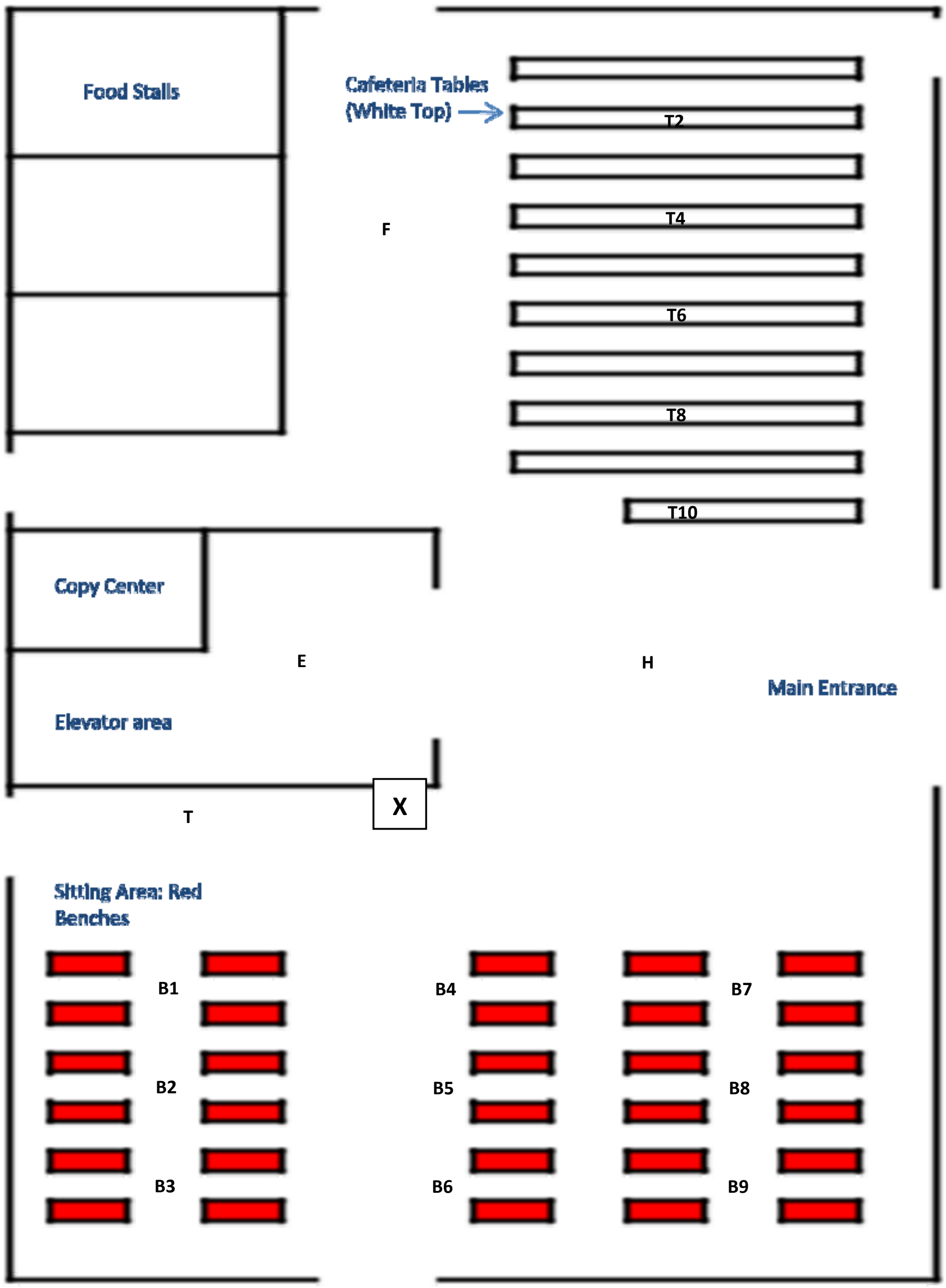
- Notebook1: using insider (Windows 7) – values in RSSI
- Notebook2: using Kismet (Ubuntu) – values in dBm
- Notebook3: using Kismet (Ubuntu) – values in dBm

T2

Network Coverage map

Note: the map of below outlines the area and indicates the points where the tests were taken.

Map 1 - Locations for Signal Strength



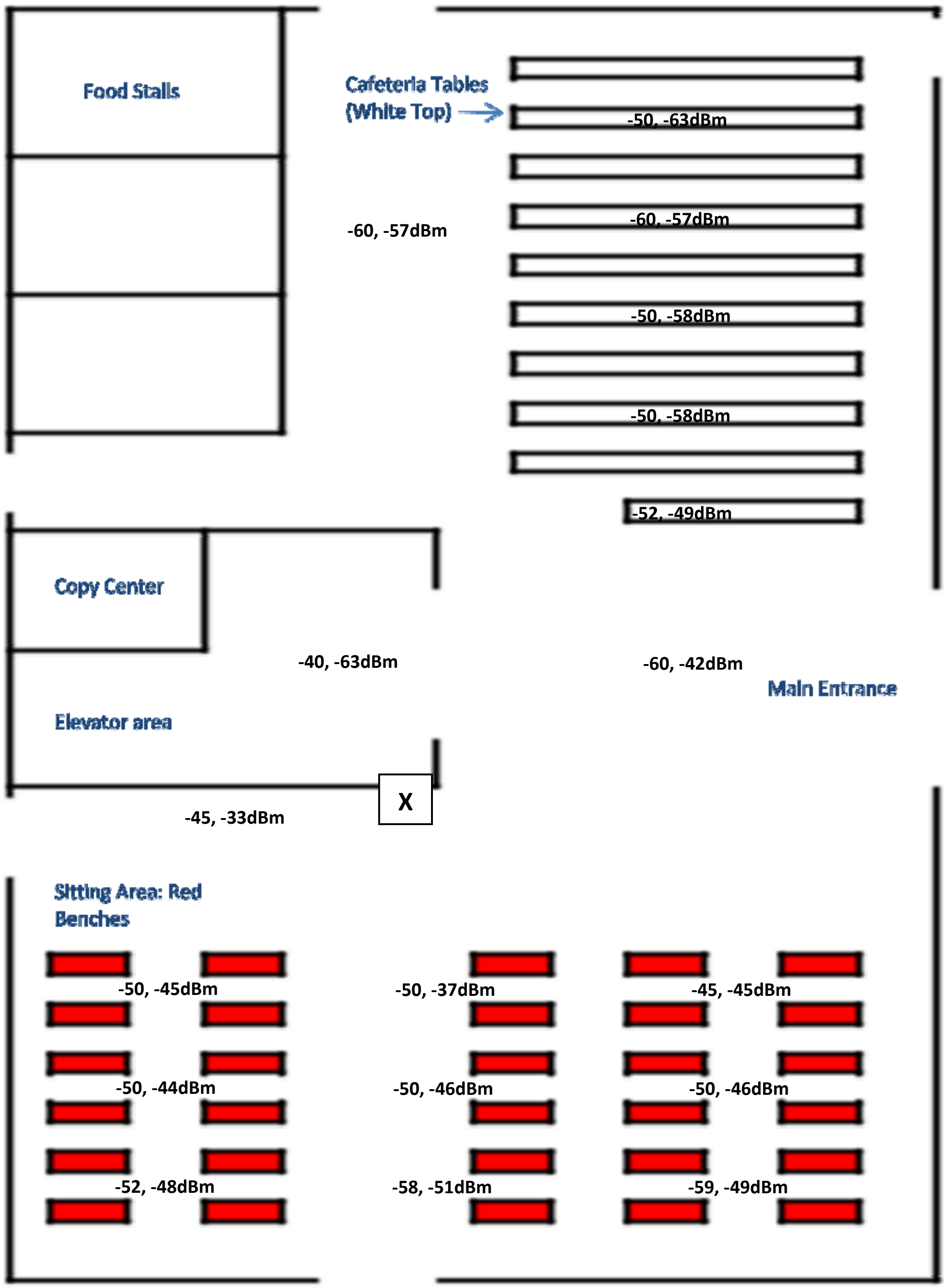
Results

Table 1.1 shows the signal strengths as taken all in the same locations by 3 separate notebooks, giving both RSSI and dBm readings.

Table 1.1 - Wireless Signal Strength on 1st Floor of Main Building					
			Notebook1 - InSSider	**Notebook2 - Kismet**	**Notebook3 - Kismet**
Area	**Location**	**SSID**	**Signal (RSSI)**	**Signal (dBm)**	**Signal (dBm)**
Caffeteria Tables	T2	wsiit	-50	-63	-63
	T4		-60	-58	-57
	T6		-50	-60	-58
	T8		-50	-58	-65
	T10		-52	-60	-49
Red Benches	B1		-50	-45	-46
	B2		-50	-44	-44
	B3		-52	-51	-48
	B4		-58	-51	-49
	B5		-50	-49	-37
	B6		-50	-46	-51
	B7		-59	-49	-60
	B8		-50	-46	-47
	B9		-45	-45	-45
White Table	T		-45	-32	-33
Hall Way	H		-60	-64	-42
Elevator	E		-40	-63	-63
Food Stalls	F		-60	-60	-57

Map2 below, (copy of the one above) provides a more detailed view of the signal strength readings in each location. Note: the map shows the standard RSSI reading followed by only the best power reading (dBm) from the collected results.

Map 2 - With Signal Strength Readings



Observations:

- The focus of the signal strength measurements were more towards areas with an available seating arrangement: as logically no one is expected to use the network In the middle of the hallways. But the measurements were still considered in the case of hand held devices.
- Generally throughout the ground floor the signal strength RSSI reading never dropped below -60 and -65, which shows a very good level of coverage: in a scale where 0 is the highest achievable.
- It was difficult to specify or distinguish each Access-point as their locations and MAC addresses were unknown, yet their manufacturer details are listed in the results table.
- The security for each Access-point appeared as “unsecured” but as know SIIT uses a radius server for authenticating and allowing users to access their network some of the access points however used WEP encryption.
- The access point constantly providing the best signal strength was always a Zyxell, although this may have no significance, because they may be different access points but the same brand.

Conclusion

As shown by the data collected, the wireless LAN coverage at the ground floor of SIITs main building is of a very high standard. All areas of the ground floor, regardless whether anyone would use a wireless device there, had a strong signal from at least one access-point. From the perspective of coverage or range alone, the current distribution of access-points is more than sufficient for providing individuals with access to the SIIT network.

PART 2 - Wireless LAN Throughput

Aim: To understand the difference between throughput and bandwidth and the factors that affects the throughput of the wireless LAN with different conditions

Method: -

Task 1: Understanding sending rate and throughputs using various transmission modes (b/g/mixed)

1. Connect a computer to the Access point with a wired connection in order to be able to configure the access point to use 802.11 b/g/mixed standards and use that computer to act as the server to listen for UDP packets
2. Set up a single computer to act as the client for sending UDP packets to measure the actual throughput achieved compared with the maximum sending rate (bandwidth)
3. To understand the maximum throughput achievable using, each of the wireless standards (b/g/mixed), gradually increase the sending rate and record the throughput.

Task 2: Understanding factors affecting the throughput

1. Use a single laptop to transfer UDP packets to the server/access point within a fixed distance
2. Increase the number of clients, simultaneously trying to send packets to the server and measure their throughputs. (All clients should send packets at the same time)
3. In this scenario each station is at a fixed distance and can clearly communicate with one another

Task 3: Affect on throughput while stations move apart from each other.

4. Use 2 clients, and gradually increase the clients distance from the access point in opposite direction. Increase in distance of client A, should equal increase in distance of client B
5. Sending rate should be constant and both clients should transmit simultaneously
6. Measure the throughput on each client every time the distance is increased, and explain how throughput is affected.

Note: Each member always had to be at a client, to ensure that clients tried to send packets to the server simultaneously: to ensure this aloud countdowns were enforced to remain synchronous.

Equipment:

- Iperf – Measuring the throughput achieved using various options (-b: bandwidth, -u:UDP protocol, -c: client mode, -s: server mode)
- Computers (client 1, client 2, client 3, server)
- Access point

Sub Task 1 - Measurements for sending rates against throughput:

Table 2.1 - Using Wireless B mode only				
Standar Test		**Specific Text**		
Sending Rate (Mbits/sec)	**Throughput (Mbits/sec)**	**Sending Rate (Mbits/sec)**	**Throughput (Mbits/sec)**	**Observations**
1	1	4	4	• Max data Rate did not exceed 6.85 Mbits/sec • although transmitting in this mode was possible there was no 802.11 b only device available to do this test with: throughput however shouldn't be effected
5	4.68	5	5	
10	6.41	6	6	
15	6.66	7	6.76	
20	6.76	8	6.7	
25	6.7	9	6.85	
30	6.3	10	6.71	
35				
40				
45				
50				
54	6.78			

Please Refer to Graph 2.11 - Attached to the end of the document

Table 2.2 - Using Wireless G mode only				
Standar Test		**Specific Text**		
Sending Rate (Mbits/sec)	**Throughput (Mbits/sec)**	**Sending Rate (Mbits/sec)**	**Throughput (Mbits/sec)**	**Observations**
1	1	26	26	• The maximum throughput value achievable is approximately from 28-28.5 Mbps at the sending rates between 28 – 54 Mbps
5	4.98	27	27	
10	10	28	28	
15	15	29	28.4	
20	20	30	28.3	
25	25	31	28.2	
30	28	32	28.3	
35	28.3			
40	28.5			
45				
50				
54	28.4			

Please Refer to Graph 2.21 - Attached to the end of the document

Table 2.3 - Using Wireless Mixed Mode (b/g)				
Standard Test		**Specific Text**		
Sending Rate (Mbits/sec)	**Throughput (Mbits/sec)**	**Sending Rate (Mbits/sec)**	**Throughput (Mbits/sec)**	**Observations**
1	1	26	26	• The maximum throughput value is 28 – 28.6 Mbps from 28-54 Mbps sending rate • Almost same throughput values as G-only mode (refer to graph 2.4 to see similarity)
5	5	27	27	
10	10	28	28	
15	15	29	28.3	
20	20	30	28.4	
25	25	31	28.2	
30	28.6	32	28.3	
35	28.6	33	27.6	
40	28.2	34	28.2	
45	27.9	35	28.4	
50	28.3			
54	28			

Please Refer to Graph 2.31 - Attached to the end of the document

Discussions:

From the observations, the highest throughput achievable is approximately 28.6 Mbps in the G-only**,** even though the maximum possible bandwidth specified by the 802.11 standard is 54 Mbps, this may be due to the overheads like headers, errors and re-transmissions, control frames, interframe spaces and Backoffs which is performed by the MAC layer defined by the 802.11 standards. Since mixed modes functionality is to allow clients using 802.11 b or g to connect to the network therefore the maximum throughput would be that of a client using the 802.11 g standard.

The second observation is that the maximum throughput value given using a B-Only mode is lesser than that of G-only and mixed mode because the bandwidth supported by the B-only mode according to the 802.11b standard is 11Mbps which may be due to the modulation technique used. Unfortunately there was no 802.11 b client and therefore using mixed mode may have had little or no affect on the throughput; Graph 2.4 summarizes the maximum achievable throughput of all the transmitting modes (b/g/mixed).

Sub Task 2 - Multiple clients

This section focuses on the affect on throughput when multiple clients try to communicate with a server simultaneously. All notebooks were 1m apart from the access point, and the maximum sending rate (54 Mbits/sec, using Mixed Mode setting on the access point) was used for all tests.

Table 3.0 - Multiple clients communicating simultaneously						
	Constants		Throughput (Mbits/sec)			
Number of Clients	**Distance from AP (m)**	**Sending Rate (Mbits/sec)**	**Notebook 1**	**Notebook 2**	**Notebook 3**	**Average Throughput**
1			28.7			28.70
2			14.1	14.2		14.15
3	1	54	8.16	8.91	8.81	8.63
3			8.09	8.95	9.37	8.80
3			9.17	8.97	8.97	9.04

Discussion

It is clear from the data collected that the average throughput achieved by each client is greatly reduced as more clients try to communicate simultaneously with the server: the average data rate when only 1 client communicated was 28.7Mbits/sec and the average when 3 clients tried to communicate was 8.63 to 9.04 Mbits/sec. Overall the bandwidth is roughly equally divided amongst the number of clients and therefore so is the throughput. This is a real world problem and one which is harder to solve, but is safe to say that each client gets an equal opportunity to transfer data when other clients are simultaneously trying to communicate with the access point.

Note: It must be kept in mind that the clients were in range of each other, and within range of the access point further tests can be carried out to test the effects when each client is within range of the access point but not within range of each other.

Sub Task 3 - Clients moving apart

Table 4.0 - Two Clients moving apart				
		Throughput (Mbits/sec)		
Distance from Acess Point (m)	**Sending Rate (Mbits/sec)**	**Client 1**	**Client 2**	Average
1	54	14.1	14.2	14.15
2		13.3	13.8	13.55
3		14.2	13.5	13.85
4		13.2	13.8	13.5
5		12.4	12.2	12.3
6		12.7	12.5	12.6
7		8.5	8.96	8.73
8		7.35	7.46	7.405
9		4.68	4.79	4.735
10		4.32	4.44	4.38

Note: each client was moving in the opposite direction to each other with the access point in betweenPlease Refer to Graph 4.1 - Attached to the end of the document

Discussion

The results show that for the first few trials (0-5 meters away from the AP), the throughput seems to have been divided from the maximum achievable amongst the 2 clients, with an average of 14 Mbits/sec; presumably at this point both clients were still within range of each other as well as within the range of the access point. Beyond this point the graph slopes downwards, and the throughput decreases significantly, to as low as 4.38 Mbits/sec.

There are several assumption which can be made to explain this occurrence, the simple one being that the devices were further apart from the access point had lower signal strength, greater errors, and retransmissions rates which may have greatly hindered the throughput.

In addition, although the RTS-Threshold is unknown, if the clients were out of range from each other (Hidden Stations: indicating they were both within the range of the Access point but not within the range of each other) and were using Basic Access transmission trying to transmit simultaneously then they would have a much greater chance of data collision at the AP, which includes waiting for ACK timeouts followed by long back off periods prior to retransmission (which could further lead to even more collisions) may have caused the massive drop in throughput.

On the other hand if the packet size sent was larger than the RTS-Threshold value then the RTS/CTS transmission must be used, although this is useful for hidden stations, establishing that the medium is available (sending a RTS frame and waiting for a CTS reply) is also time consuming, and requires greater over heads contributing to the lower throughput rates.

In any case whether Basic access was used, RTS/CTS, or if the signal was just poor the combining factors decrease the throughput of 2 clients trying to communicate with each other vastly.

Discussion of Possible Errors

- The use of 3 different notebooks may have produced slightly different results as they may have had different antenna specifications.
- Although sending packets of different sizes each time to test throughput should not change the final results, many times packet sizes sent by different clients varied largely which may have caused unfair tests.
- The antenna of the access point is not perfectly Omni-directional and may have favored a client
- Interference from other devices (wireless keyboard, other nearby Access points, may have caused interference hindering the results)

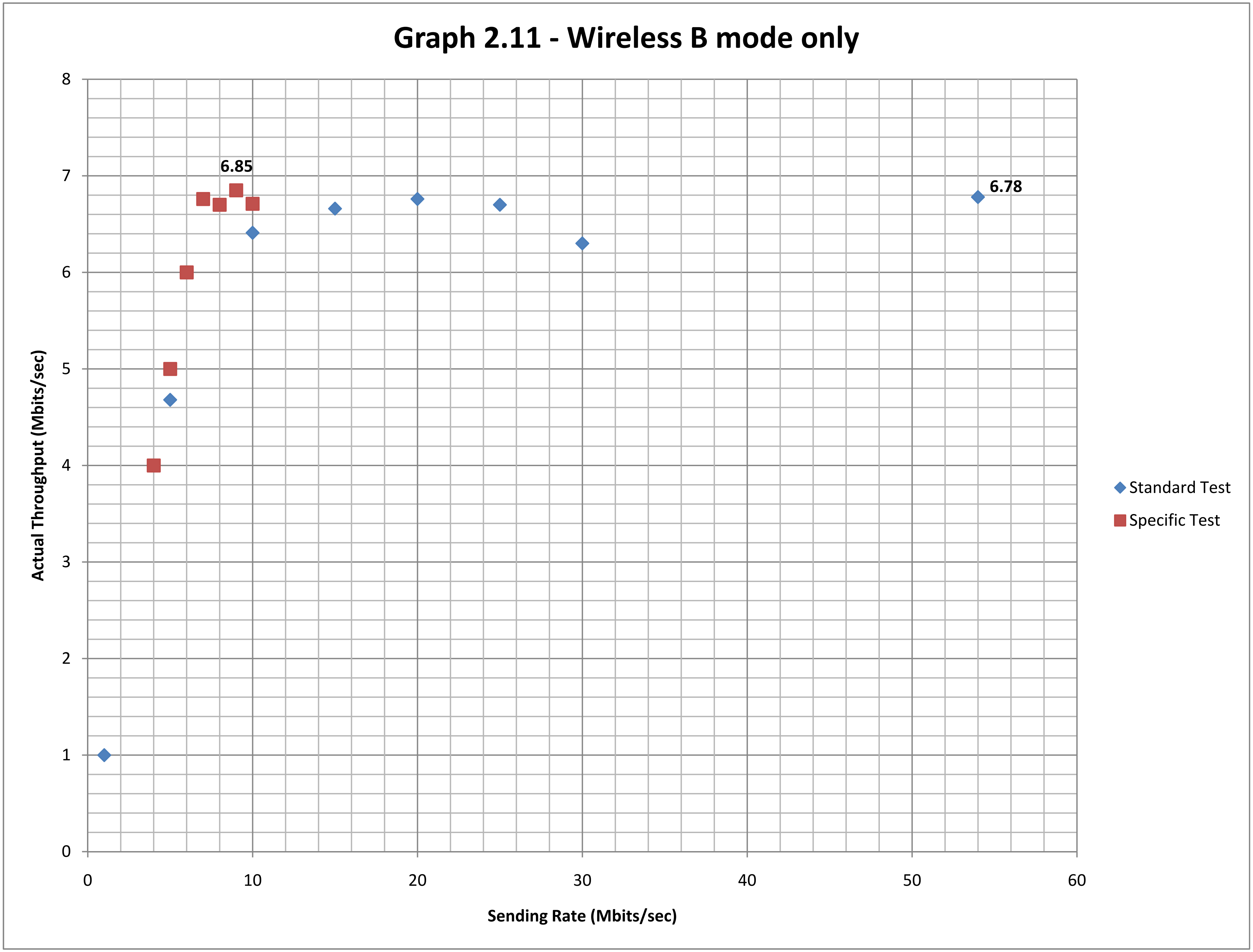
Conclusion

It is clear that many different variables can affect the throughput of wireless transmissions; Specifications or the mode which the access point is transmitting at (b/g/mixed), can have a large impact but remaining at mixed mode allows the greatest flexibility to users, it remains compatible with older devices and sacrifices throughput very slightly if at all. nonetheless, it would be interesting to test the throughput of 2 different devices simultaneously one with B only, and the other with G only to tests its affect on throughput.

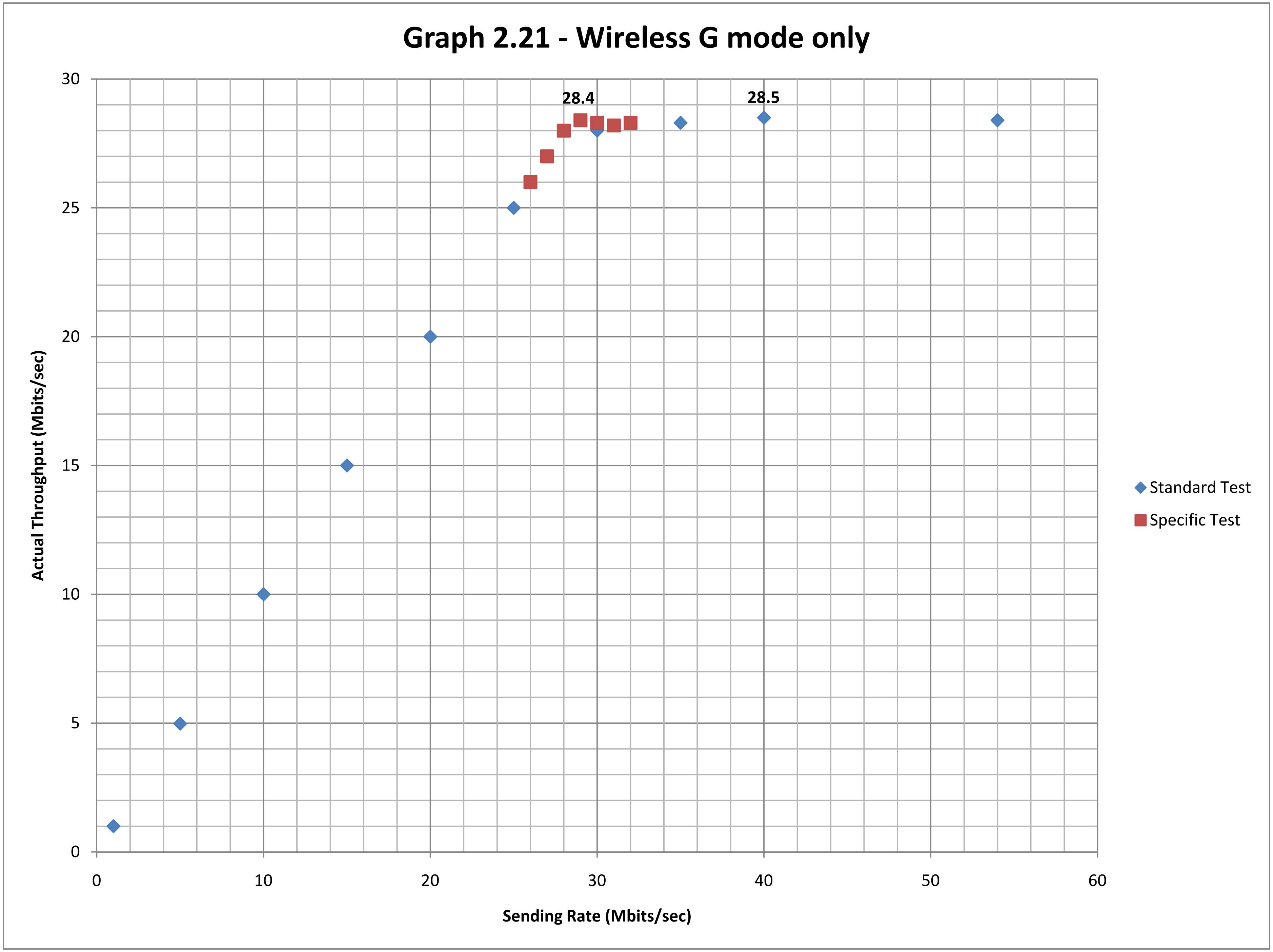
On the other hand having multiple clients decreases throughput as the bandwidth is shared roughly equally amongst the number of clients, off course considering all the clients are within range of each other. Furthermore if the clients move apart from each other they make furthers drawbacks in throughputs either due to the distance, the high chance of collisions and retransmissions using the basic access method or because of large overheads imposed by the use of RTS/CTS.

Extension

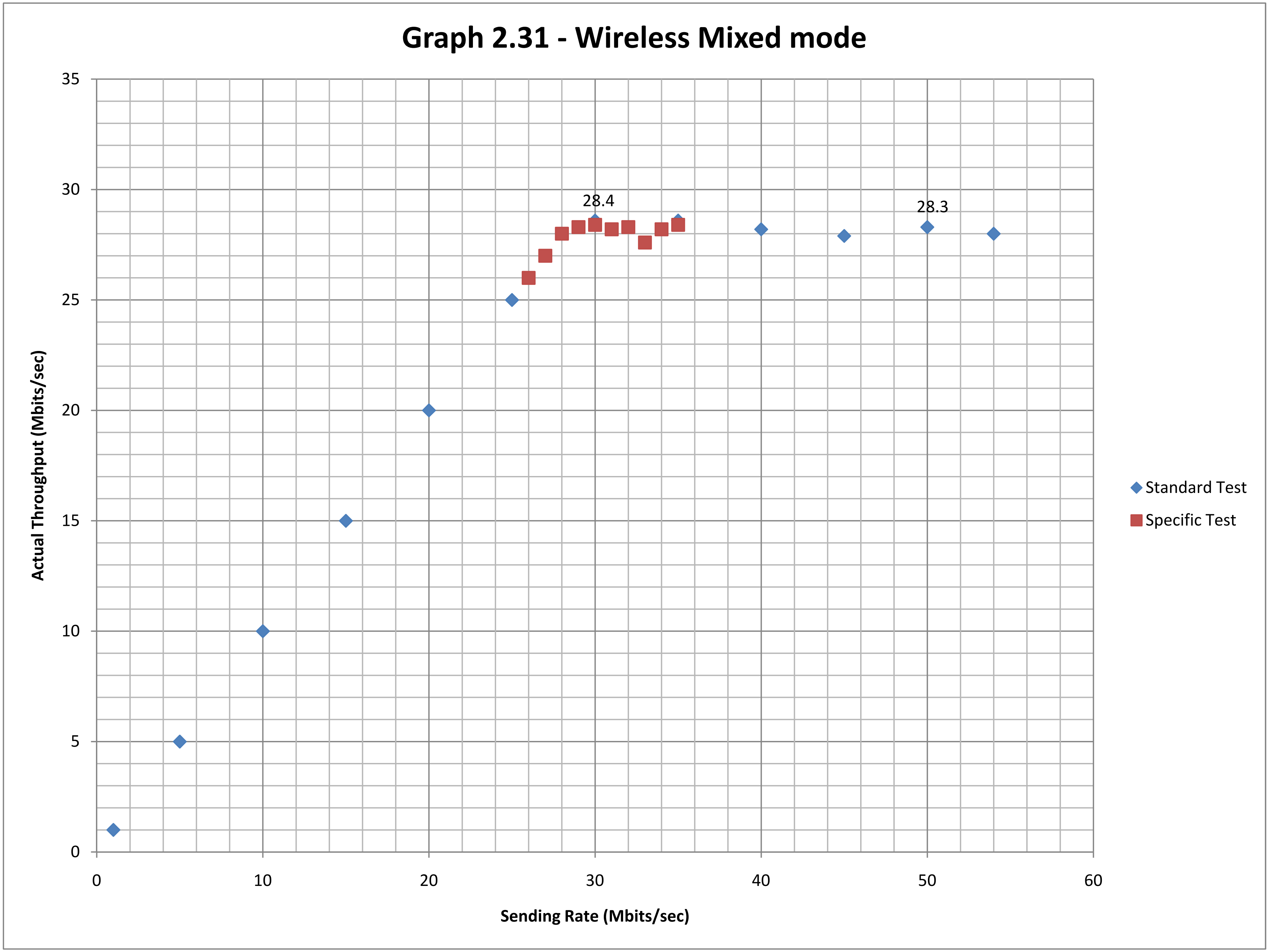
As an extension to the tests , ruining the same tests in a controlled environment with minimum interference, and larger number of clients, which have the same hardware specifications may help further support the conclusions reached by reducing the errors.

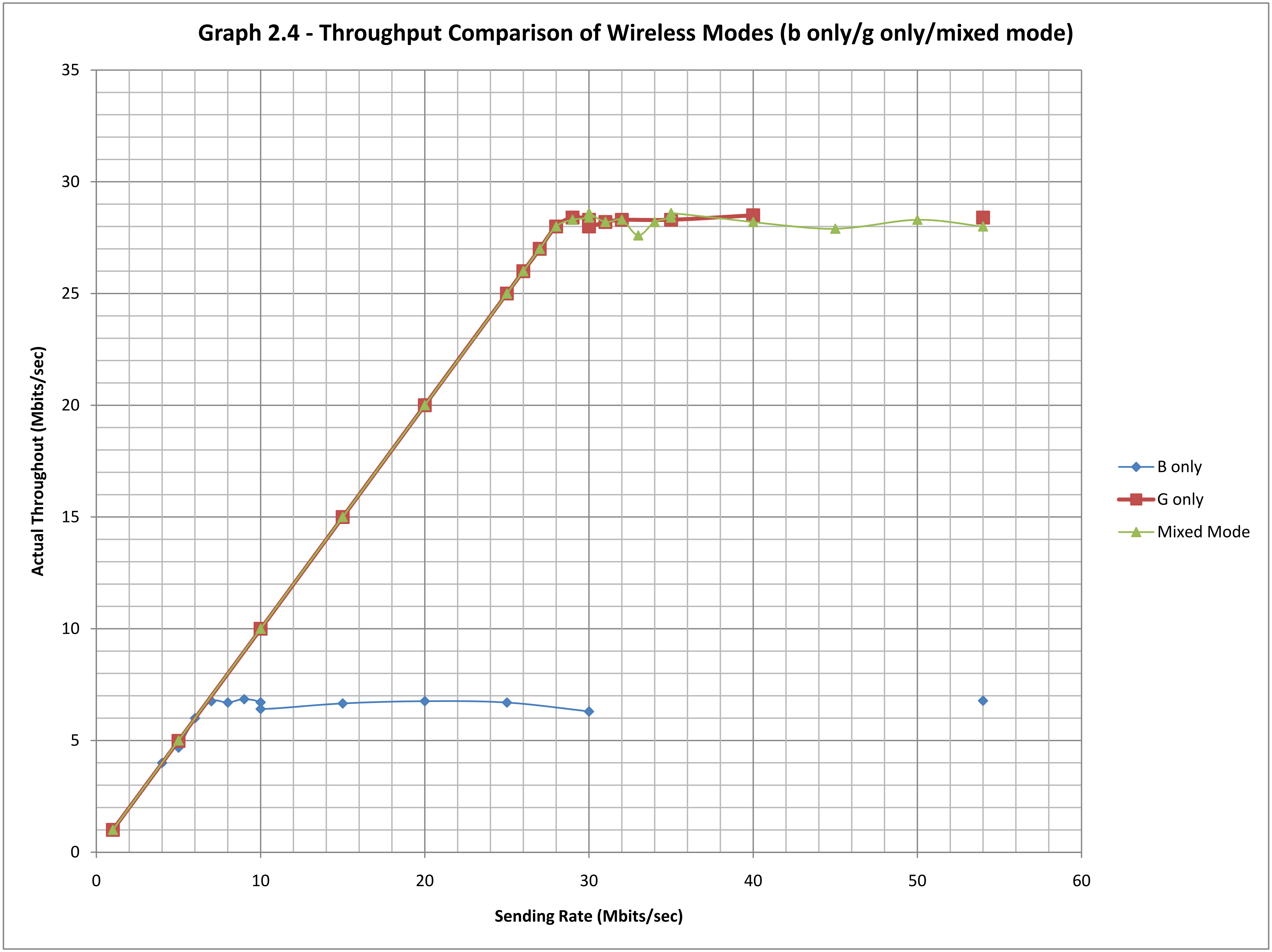


Graph 2.11 - Wireless B mode only
Actual Throughput (Mbits/sec)
Sending Rate (Mbits/sec)
0
1
2
3
4
5
6
7
8
0
10
20
30
40
50
60
6.85
6.78
Standard Test
Specific Test



Graph 2.21 - Wireless G mode only
Actual Throughput (Mbits/sec)
Sending Rate (Mbits/sec)
28.4
28.5
Standard Test
Specific Test


Graph 2.31 - Wireless Mixed mode
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
28.4
28.3
Actual Throughput (Mbits/sec)
Sending Rate (Mbits/sec)
Standard Test
Specific Test



Graph 2.4 - Throughput Comparison of Wireless Modes (b only/g only/mixed mode)
Actual Throughout (Mbits/sec)
Sending Rate (Mbits/sec)
0
5
10
15
20
25
30
35
0
10
20
30
40
50
60
B only
G only
Mixed Mode


Graph 4.1 - Average Throughput, while Clients Move Apart
Distance from Access Pont (meters)
Average Throughput (Mbits/sec)
14.15
4.38
0
2
4
6
8
10
12
14
16
Series2
Series1
Poly. (Series1)