ISSN 1512-1232

004.7 Computer communication. Computer networks

PERFORMANCE EVALUATION OF INTERNET SERVICE DELIVERY VIA SIM-ENABLED USB MODEMS

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Abstract

The telecommunications industry has grown rapidly from voice calls only to include data access as value added services. Subscribers have experimented with many connectivity solutions to the Internet without optimal satisfaction. The use of USB modems for Internet access was the most subscribed technology by Internet users prior to sale of data on mobile phones. Users of USB modems were however faced with quality of service problems such as low download speed in the morning or non-connectivity at night. This was unacceptable to users in terms of service delivery and cost. An objective evaluation of the Internet access delivered by the telecommunications service providers to users would provide quality assurance. In this work, the aim is to determine the Internet service delivery via USB modem for Internet access using speed and response time as performance metrics. Four USB Modems were tested at various times of the day using an online performance testing tool. The result was able to identify the most reliable and dependable Internet service provider when a USB Modem is used for Internet access.

Keywords: *QoS, Internet speed, performance, Telecommunications, SIM, Nigeria*

INTRODUCTION

The telecommunications industry has grown phenomenally since the introduction of the global system for mobile (GSM) communication in Nigeria. The data services provided by telecommunications companies allows Internet traffic which is composed of data exchanges between two end-points, such as web browsing or electronic mail. The additional communication opportunities created by the data services led to the adoption for personal and business purposes. [1], [2], and [3] developed applications that can be accessed through the mobile data services.

The rate of acquisition of telephone lines increased due to the value-added services available. The study of the mobile telephony services including value-added services have been carried out by [4]; [5] and [6]. Subscribers where initially excited to have their own communication facilities, however as the number of service providers increased the service delivered and quality of service (QoS) became an irritation factor for subscribers. User satisfaction became a competitive advantage for telecommunications companies.

Quality of Service (QoS) may be defined as the measured performance of a service to meet the satisfaction of users of the service, while service delivery is the measurement of the service received by the user. The Nigeria Communications Commission (NCC) as the regulatory body for telecommunications industry [7] has metrics such as error rates, bit rate, throughput, transmission delay, availability and jitter, to measure performance. The QoS may be measured for all users but service delivery is specific to a user. The metrics for service delivery such as download speed and upload speed are missing from reported statistics on the NCC website.

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USB modems, shown in Figure 1, became popular due to freedom of mobility given to users: by removing the constraints of physical connections initially required, and its compatibility with mobile devices such as laptop computers. The modems promoted individual use and selective deployment in organizations, campuses and hotels. USB modems provide 3G or 4G mobile broadband connectivity to any computer with a USB port. USB modems can work with Microsoft Windows, Linux systems and Mac OS operating systems. The USB modems are automatically installed from the devices themselves, thus making them quick and convenient to install and use. Internet service is provided by the Subscriber Identity Module (SIM) card that links to the radio signals of a specific telecommunication service provider.

Figure 1. USB Modem [8]

The delivery of Internet service is subject to a lot of factors that are not under the control of the subscriber. This does not however reduce the need of subscribers for good service at a reasonable cost. This work seeks to evaluate the performance of a subscriber's Internet access when using a USB modem connected to the radio signals of a specific telecommunication service provider. Three parameters, response time, download speed and upload speed will be used to determine Internet service delivery to the subscriber. The results are expected to guide subscribers in the acquisition of Internet services from telecommunication service providers.

RELATED WORKS

The issue of service quality and delivery has been investigated from the user perspective of customer satisfaction in the telecommunications industry using the SERVQUAL scale. The scale was designed to uncover areas of good or bad service quality and can be used to show service quality trends over time, especially when used with other service quality techniques [9]. The SERVQUAL scale measures the difference between customer expectations of a service and their perceptions after receiving the service. The following reviewed works used the scale or its modification to determine customer satisfaction with the services offered by telecommunications companies. In Nigeria, the works of [9], [10], [11], [12], [13], [14], [15] and [16] followed this trend. Literature by [17], [18] and [19], from other countries also followed the same trend.

[9] conducted a user satisfaction of services from four telecommunications companies. The services being evaluated were not stated, however voice calls and data services are presumed to be included. This survey work used subscriber perception for the analysis and not technical metrics. It

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also confirmed that retaining existing subscribers was a major strategy for profitability of the telecommunication company.

[17] looked at service delivery of six telecommunication service providers in Ghana. The survey indicated that quality of service did not improve as a result of competition for subscribers. Punitive measures were suggested for companies offering poor quality of service.

[10] examined customer satisfaction with services offered by telecommunication companies in Northern Nigeria. The survey work revealed subscribers were not satisfied with the customer care services provided. [15] analyzed data from a telecommunications company for service delivery in the south western part of Nigeria. The statistics used conformed to metrics provided by the Nigerian Communications Commission (NCC) on its website [20]. The findings indicated that infrastructure affected the quality of service delivery for voice calls.

[18] examined the relationship between service quality and customer satisfaction in a telecommunication company in Ghana. The analysis confirmed that all items related to service quality would likely affect customer satisfaction. Thus service quality items like download speed can increase customer satisfaction. The telecommunication company provided the data for this work, hence the reliability of the data is better than those obtained through survey.

[11] worked on quality of service with focus on voice call services. The poor quality of service was attributed to infrastructure based on survey data. [12] evaluated the quality of service delivery for a particular telecommunication company in Nigeria. The focus was on customer care and quality of the network.

The literature available examined service quality and service delivery from the customer satisfaction perspective. Customer satisfaction is subjective because so many factors affect and influence a user that are indicators of satisfaction. This work will however focus on the measurable technical i.e. quantitative, aspect of the service delivery.

METHODOLOGY

This experimental work was done using four laptop computer systems with the same configuration (Windows Operating System 7; Quad core processor with 4GB RAM) and USB modems from four Internet Service Providers (ISPs). The USB modems were branded by the Telecommunications Company and was the best modem available. All systems were placed on battery backup electricity supply (inverter) to provide electricity. The experiment was carried out in the Department of Computer Science, University of Ibadan, Ibadan, Oyo State, Nigeria

Table 1 provides information about the USB modems. The data service plan provided on all the modems allowed unlimited Internet access i.e. day and night browsing.

Table 1. Details of USB modems evaluated

Modem	Telecommunications Company	Services Provided
A	Smile	Data
B	Etisalat	Data and Voice
C	MTN	Data and Voice
D	Airtel	Data and Voice

The online measuring performance test tool, SpeedTest.net, was used to measure the parameters three times a day over a period of seven days. SpeedTest.net was developed by Ookla for free analysis of Internet access performance [21]. The parameters measured are response time in milliseconds (ms), upload speed and download speed in Megabits per second (Mbps). Response time is the time it takes a webpage to load on the browser when a request is sent to the web server;

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upload speed is the time it takes to send all the bytes of a file to a web server; and download speed is speed is the time it takes to receive all the bytes of a file to a client's device.

The measurements were collected at three times of the day. At 8.00am when the work day starts; at 2.00pm when lunch break is over; and at 8.00pm when users are settled at home after the day's work. The results were collated and analyzed using simple statistical analysis.

RESULTS AND DISCUSSION

The results obtained from the experimental setup are presented in four tables (Tables 2, 3, 4 and 5). The graphical comparison of the performances based on the three metrics of response time, download speed and upload are shown in Figures 1, 2 and 3.

Table 2. Results for Modem A

	Time	Response Time (ms)	Download Speed (Mbps)	Upload Speed (Mbps)
Monday	8.00am	80	1.29	1.36
	2.00pm	76	0.81	1.58
	8.00pm	50	1.07	1.16
Tuesday	8.00am	55	2.86	2.51
	2.00pm	48	0.04	0.16
	8.00pm	39	8.93	1.33
Wednesday	8.00am	39	10.51	8.70
	2.00pm	32	11.11	8.89
	8.00pm	34	16.71	6.87
Thursday	8.00am	40	13.80	5.37
	2.00pm	39	12.46	4.59
	8.00pm	50	2.45	1.65
Friday	8.00am	64	3.44	1.66
	2.00pm	55	10.22	4.28
	8.00pm	52	16.40	9.44
Saturday	8.00am	80	5.22	2.34
	2.00pm	75	7.32	3.88
	8.00pm	55	1.33	2.34
Sunday	8.00am	88	2.45	1.33
	2.00pm	40	13.44	8.40
	8.00pm	35	12.32	7.34
Average		**54**	**7.34**	**4.31**

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Table 2 shows contrasting download and upload speeds. The best download speed occurred on Wednesday by 8pm while the best upload speed was on Friday at 8pm. The range of response time was between 32 and 88 milliseconds.

Table 3. Results for Modem B

	Time	Response Time (ms)	Download Speed (Mbps)	Upload Speed (Mbps)
Monday	8.00am	85	2.65	0.90
	2.00pm	137	1.14	0.86
	8.00pm	70	1.60	0.79
Tuesday	8.00am	107	1.92	0.64
	2.00pm	129	0.64	0.89
	8.00pm	107	1.02	0.48
Wednesday	8.00am	98	0.81	0.59
	2.00pm	81	1.39	0.83
	8.00pm	132	0.90	0.22
Thursday	8.00am	97	0.89	0.37
	2.00pm	253	1.41	0.40
	8.00pm	55	1.81	1.00
Friday	8.00am	81	1.30	0.96
	2.00pm	99	2.19	0.81
	8.00pm	59	1.40	1.21
Saturday	8.00am	80	1.61	2.34
	2.00pm	75	7.32	0.97
	8.00pm	55	0.85	0.95
Sunday	8.00am	88	1.51	1.11
	2.00pm	80	1.66	2.00
	8.00pm	85	1.44	1.21
Average		98	1.69	0.93

Table 3 records fluctuations in the response time, download speed and upload speed. The best response time was on Thursday and Saturday at 8pm. The best download speed of 2.65Mbps was on Monday at 8am, while the worst upload speed was experienced on Wednesday at 8pm.

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Table 4. Results for Modem C

	Time	Response Time (ms)	Download Speed (Mbps)	Upload Speed (Mbps)
Monday	8.00am	62	3.25	0.03
	2.00pm	190	3.20	0.04
	8.00pm	78	3.05	0.05
Tuesday	8.00am	78	2.07	0.03
	2.00pm	297	2.82	0.03
	8.00pm	670	1.06	0.04
Wednesday	8.00am	971	1.00	0.01
	2.00pm	109	1.44	0.04
	8.00pm	432	1.87	0.03
Thursday	8.00am	302	1.90	0.05
	2.00pm	78	1.50	0.03
	8.00pm	282	2.11	0.04
Friday	8.00am	93	2.90	0.04
	2.00pm	78	2.43	0.05
	8.00pm	59	2.55	0.03
Saturday	8.00am	80	1.61	0.05
	2.00pm	75	2.32	0.03
	8.00pm	55	1.85	0.04
Sunday	8.00am	88	1.51	0.05
	2.00pm	80	1.66	0.03
	8.00pm	85	1.44	0.01
Average		**202**	**2.10**	**0.04**

Table 4 indicates that Modem C has very low upload speed on all days and times of the week. The download speed is averaged at 2.10Mbps. The response time varies greatly with values as low as 59ms and high as 971ms.

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Table 5. Results for Modem D

	Time	Response Time (ms)	Download Speed (Mbps)	Upload Speed (Mbps)
Monday	8.00am	258	1.77	0.69
	2.00pm	287	1.66	0.09
	8.00pm	237	2.24	0.79
Tuesday	8.00am	90	1.26	0.08
	2.00pm	355	1.00	0.10
	8.00pm	229	1.46	0.89
Wednesday	8.00am	70	1.78	0.06
	2.00pm	260	0.40	0.35
	8.00pm	279	1.37	0.41
Thursday	8.00am	310	1.23	1.40
	2.00pm	365	0.16	0.22
	8.00pm	258	1.46	0.41
Friday	8.00am	250	2.08	0.76
	2.00pm	259	1.81	0.92
	8.00pm	258	0.30	0.52
Saturday	8.00am	291	0.23	0.24
	2.00pm	269	1.45	0.51
	8.00pm	249	2.01	0.81
Sunday	8.00am	234	2.24	0.18
	2.00pm	289	0.29	0.20
	8.00pm	260	1.81	0.51
Average		**255**	**1.33**	**0.48**

Table 5 indicates consistency in the response time for Modem D. The maximum upload speed is 1.40Mbps, while the maximum download speed is 2.24Mbps.

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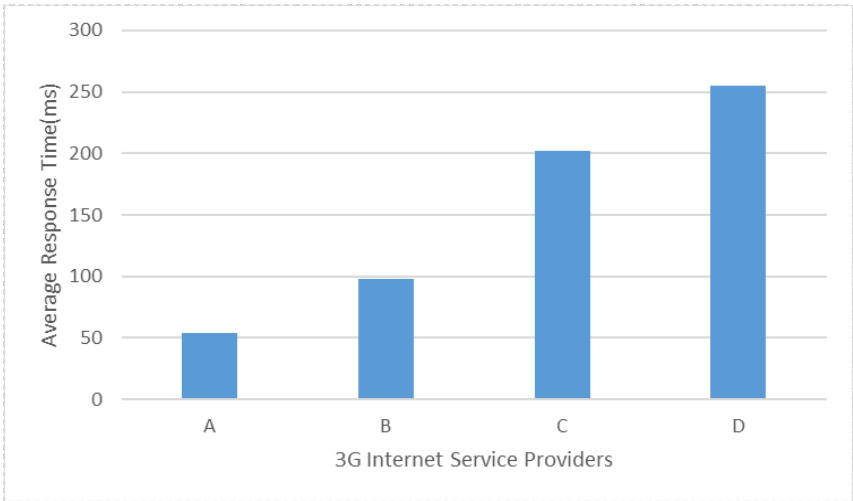

Figure 2. Bar Chart showing the average Response Time of different Internet Modem

Figure 2 shows that Modem A has the lowest average response time. This implies that users are able to start browsing the Internet before other modems respond.

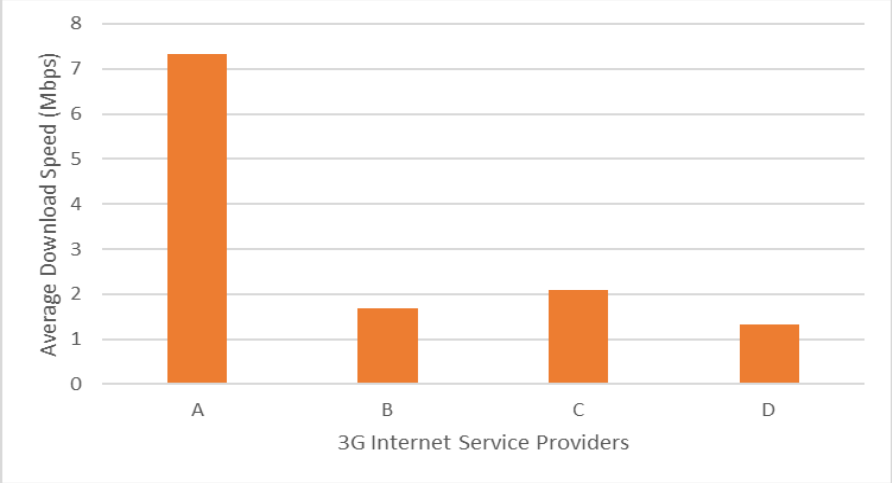

Figure 3. Bar Chart showing the average download speed for the USB Modems

In Figure 3, Modem A has the best average download speed followed by Modem C.

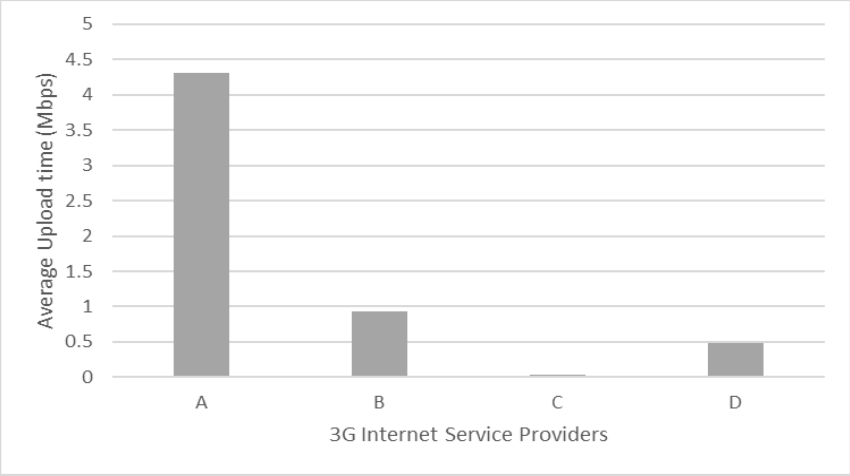

Figure 4. Bar Chart showing the average Upload speed

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Modem C has the lowest average upload speed, while Modem A has the best upload speed as shown in Figure 4.

Tables 6, 7 and 8 give the average performance of the USB modems at the three selected times of the day.

Table 6. Average Performance of USB Modems at 8.00am

8.00am	Response Time (ms)	Download Speed (Mbps)	Upload Speed (Mbps)
Modem A	64	5.65	3.32
Modem B	91	1.53	0.99
Modem C	239	2.03	0.04
Modem D	215	1.51	0.49

Modem A has the best average performance at 8.00am. The response time is low, with the download and upload speed at the best.

Table 7. Average Performance of USB Modems at 2.00pm

2.00pm	Response Time (ms)	Download Speed (Mbps)	Upload Speed (Mbps)
Modem A	52	7.91	4.54
Modem B	122	2.25	0.97
Modem C	130	2.20	0.04
Modem D	298	0.97	0.34

Modem A has the best average performance at 2.00pm. The response time is low, with the download and upload speed at the best.

Table 8. Average Performance of USB Modems at 8.00pm

8.00pm	Response Time (ms)	Download Speed (Mbps)	Upload Speed (Mbps)
Modem A	45	8.46	4.30
Modem B	80	1.29	0.84
Modem C	237	1.99	0.03
Modem D	253	1.52	0.62

Modem A has the best average performance at 8.00pm. The response time is low, with the download and upload speed at the best.

The four USB modems evaluated are sold under the brand name of each telecommunication service provider. The data plan (Internet service) used on each modem allowed 24 hours access to the Internet.

The response time of the modem is an indication of internal configuration and network connectivity. The modems showed better response time at 8.00pm than at other times. This may be attributed to low volume of calls at that time. Modem A had 71% of its response time less than a second, while modem D did not have any response time less than a second. The inconsistency of the response time for all the days of measurement imply that the quality of service is not consistent for all the telecommunications service providers.

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The rate of information retrieval by the subscriber is measured as the download speed. The higher the value of the download speed, the better the user experience. Modem C had all download speeds above 1Mbps, while modems A, B and D recorded download speeds less than 1Mbps. The average download speed for each modem at 8.00am, 2.00pm and 8.00pm are above 1Mbps except modem D at 2.00pm. Most subscribers are affected by the download speed because their activities on the Internet require the download speed.

Subscribers engaged in activities such as file or image attachment or upload are affected by the upload speed. Modem C has a very low upload speed for all days and time. This may be a deliberate configuration by the telecommunications company based on user profile and survey. Modem A provided the best upload speed at 2.00pm, Modem B had its best upload speed at 8.00am, Modem C gave the lowest average speed at 8.00pm and modem D had its best average upload speed at 8.00pm.

A comparison of the **average** performance of the four modems based on response time, download speed and upload speed indicate that modem A gives the best performance. This may be attributed to the data only service being offered by the telecommunications company.

CONCLUSION

Internet service delivery is determined by the response time and download speed received by the subscribers USB modem. Network performance is the most important parameter for measurement of quality of service. Poor performance of a USB modem for accessing the Internet may induce customer complaints and faults, thereby leading to customer dissatisfaction towards the telecommunications service provider. This work evaluated the quality of service delivery of Internet USB Modems for internet access using response time, download speed and upload speed as performance indicators. Based on the results of the test performed on the four USB modems the most reliable and effective is Modem A because of low response time and good download/upload speed. The performance of USB modems at multiple locations can be investigated.

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Article received: 2018-03-18