Development of a web-based broadband mapping application

Jeremiah Tamarankuroemi Esite[1], Stella Ifeoma Orakwue[2], Hamza Mohammed Ridha Al-Khafaji[3], Olakunle Elijah[4]

[1] Nigerian Maritime University, Okerenkoko, Delta State, Nigeria
[2] Electrical/Electronic Engineering Department, University of Port Harcourt, P.M.B. 5323, Port Harcourt, Rivers State, Nigeria
[3] Biomedical Engineering Department, Al-Mustaqbal University College, 51001 Hillah, Babil, Iraq
[4] Wireless Communication Centre, School of Electrical Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, 81310 Johor Bahru, Malaysia

ABSTRACT

Broadband mapping plays an intricate part in broadband availability. With a variety of methods existing in achieving broadband mapping, a more compact approach that is both easy to use and cost effective is necessary. Exploring the software approach using a web application, it becomes plausible to carry out broadband mapping. A three-in-one web-based broadband mapping application (www.speedtester.com.ng) capable of detecting the mapping location and measuring the speed of the Internet Service Provider (ISP) was developed. It also provides a facility for data storage and display on a map. The developed application was tested against an existing software to confirm its accuracy. The developed application showed significant accuracy, flexibility of usage along with its cost-effective implementation. In addition, the performance of three different ISPs at selected locations were evaluated using the developed application. The result shows that the minimum broadband speed benchmark set by the National Broadband Committee has not been realized for some ISPs. Hence, for optimal internet services, users can make informed decisions on the ISP services to utilize.

Keywords: Internet service provider, broadband mapping, mapping application, web-based

Corresponding Author:

Stella Ifeoma Orakwue
Electrical/Electronic Engineering Department
University of Port Harcourt
P.M.B. 5323, Port Harcourt
Rivers State, Nigeria
E-mail: stella.orakwue@uniport.edu.ng

1.   Introduction

Broadband is defined based on user experience as Internet usage in which the users can browse the most demanding information in real time at a minimum speed of 1.5 Mbps. With broadband telecommunication, large amount of data can be carried through a single cable making it possible for the transmission of data at high speed [1]. Mapping in relation to broadband has to do with providing data on the current state of broadband quality using a Geographic Information System (GIS). GIS provides for the integration of location as part of an information system [2]. Data gotten from broadband mapping can be used to ascertain the broadband quality, coverage market availability in a given geographic region [3].

The broadband quality in a given location is of paramount importance as it affects the socio-economic situation of that area. According to a study carried out by Alliance for Affordable Internet in 2013, an estimate of only 33 % of Nigerians used the Internet while having Internet penetration level at a disappointingly low 6 %. Also, the 2019 Networked Readiness Index (NRI) placed Nigeria at 111 out of 121 countries [4]. In order to improve the broadband quality of a given place, broadband mapping has to be carried out.

There are existing broadband mapping solutions that have been identified in the literature [5-7]. In [5], MBPerf mobile broadband performance application that was developed was used to carry out coverage studies

within Akure and Ibadan metropolis, Nigeria. The main drawbacks of this approach are that broadband testing, data storage and map development required three separate platforms making mapping process tedious to perform. Complains were made by volunteers about storage space when installing the mobile application. In [6], two separate platforms were used for broadband measurement and broadband mapping. The system also only produces the network type and not the actual speed a SIGMAP for broadband measurement while the mapping is done at on a website (everyday.com.ng).

The authors in [7] made use of NetSurveyor with a host of accompanying tools for data collection, storage and display. The NetSurveyor tool reports the Service Set Identifier (SSID) for every wireless network it finds, together with Access Point channel. The recording of the signal strength is then done manually with paper records and Microsoft Excel. This poses a massive strain in carrying out tests as the tools do not allow for seamless testing and recording processes.

Other methods that have been identified is the use of hardware (probes). Using a hardware (Probes), broadband speed can also be measured as utilised by big companies such as Ofcom and SamKnows [8, 9]. This approach is very expensive hence why mostly companies with proper financial capital make use of this approach.

The identification of the limitations from the existing solutions motivated the need to develop a comprehensive and cost-effective and easy to use solution www.speedtester.com.ng. Here, a web-based tool is used capable of detecting the broadband speed using LibreSpeed and Google Maps API for mapping. One of the advantages of this application is that it does not require users to install any application to their mobile phones. It is easy to use, does not consume space on your mobile phone which is the testing device, distribution of links for individual testing in order to crowd source data is also efficiently done. In addition, it is simple to use both for individual and crowd-sourced data and economically affordable to set up.

The aim of this paper is to develop a three-in-one web-based broadband mapping application capable of detecting the mapping location and measuring the speed of the Internet Service Provider (ISP) and to evaluate the performance of the ISP providers (Globacom Limited, MTN Nigeria Communication Limited and Airtel Networks Limited) in South - South, Nigeria. The remainder of the paper is organized in the following manner. Section 2 describes the method used in the development of the proposed application, the procedure for ISP performance evaluation as well as the GUI of the test application. In section 3, the results and discussion of the performance of the ISP are presented. Section 4 concludes the paper.

2. Methodology

In solving the problem of broadband mapping, a web-based application was designed to test a user's broadband speed and display the data on a map. The design of this platform was divided into front-end and back-end. The front-end is the human interface of the system and was designed using Hypertext Markup Language (HTML), Cascading Style Sheets (CSS), JavaScript and jQuery library. The back-end was designed using Hypertext Preprocessor (PHP) which is a back-end language and a database management system using My Structured Query Language improved (MySQLi).

The method used in determining the upload/download speed was testing using injected traffic which is based on sending traffic (probing packets) between two destinations. Garbage data is uploaded/downloaded to/from the server in order to assess the quality of service (QoS). To calculate the amount of data transferred over a given internet connection per second (bits per second) while the latency was calculated as the time it takes for a connection to be successful.

$$\text{Upload/download speed} = \frac{\text{data transfered}}{\text{time duration of transfer}} \text{ (Mbps)} \tag{1}$$

This approach gives a close to accurate result since the speed is directly related to the rate of data transfer. This web-based software was used in collecting broadband data, storing this data and displaying it on a map as seen in the flow diagram in Figure 1.

Using a web-based approach, a web application (www.speedtester.com.ng) was designed and used in carrying out broadband tests. The tests were carried out simultaneously with (www.fast.com) and subsequently compared to ascertain accuracy (Figure 2).
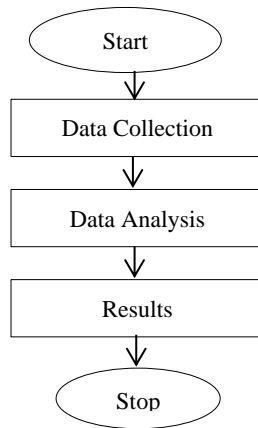
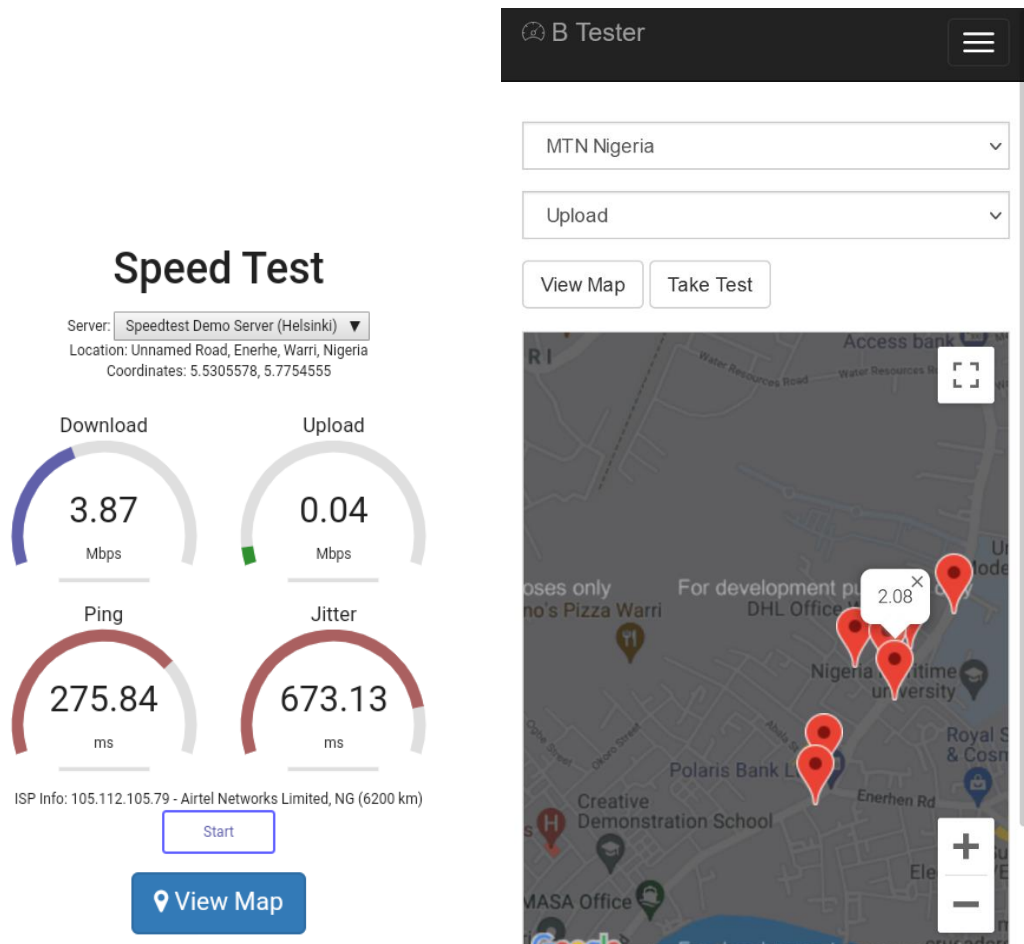Figure 1. Flow diagram of research procedure

Figure 2. Web based broadband mapping tool (www.speedtester.com.ng)

Outdoor broadband speed tests were carried out at Enerhen junction, Warri. The results of broadband speed tests carried at five bank locations at Enerhen junction as follows:

- Location 1 (L1) - Union Bank,
- Location 2 (L2) - First Bank,
- Location 3 (L3)- Unity Bank,
- Location 4 (L4)- Polaris Bank; and
- Location 5 (L5) – UBA.

The readings which were taken were for three different Internet Service Providers (ISP's) – Globacom Limited, MTN Nigeria Communication Limited and Airtel Networks Limited. The mobile phone device used in carrying out this test was an Itel A32F with 2G/3G broadband capability. The tests were carried out while setting the mobile phone internet service to 3G. Hence, the readings taken were an evaluation of the current 3G service of each service provider.

3. Results and discussion

At the end of the development of speedtester.com.ng, series of tests were carried out to test its workability as well as compare the results to those produced by fast.com.

3.1. Upload and download speed results for MTN Nigeria communication limited

The results of speed tests that carried out using speedtester.com.ng and fast.com for MTN Nigeria communication limited in Warri, Delta State are shown in Table 1.

Table 1. Broadband speed test for MTN Nigeria communication limited

| Location | speedtester.com.ng | | fast.com | |
	Upload (Mbps)	Download (Mbps)	Upload (Mbps)	Download (Mbps)
1	3.90	2.03	2.0	1.8
2	3.45	1.74	3.8	1.4
3	2.08	1.27	2.1	1.5
4	2.23	1.04	1.5	1.8
5	2.63	1.25	2.0	1.1
Average	2.258	1.466	2.28	1.52

The results of broadband speed tests recorded in Table 1 is represented graphically as shown in Figure 3 and Figure 4 as a means of comparing recorded values using both platforms.
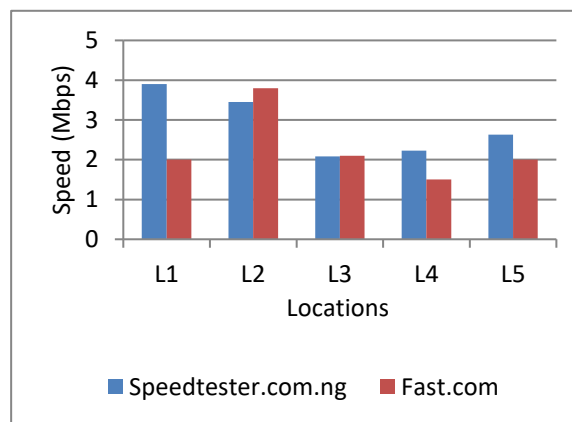

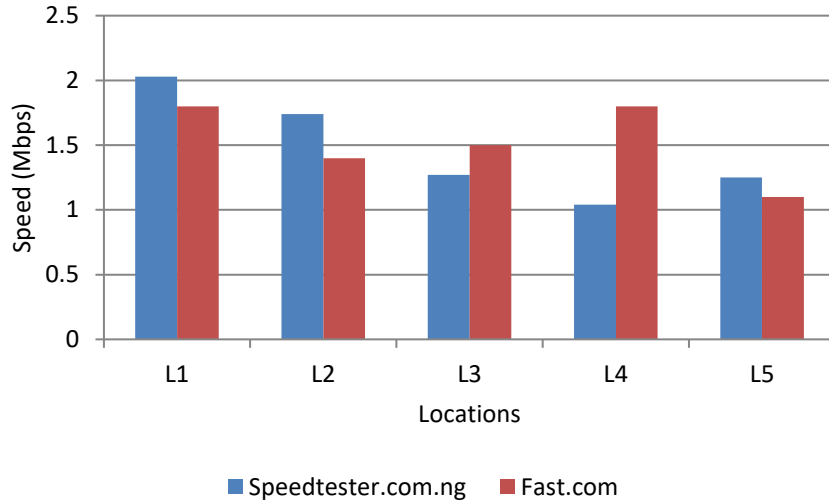Figure 3. Comparing upload speed values for MTN Nigeria communication fetion limited

Figure 4. Comparing download speed values for MTN Nigeria communication limited

From Figure 3, it was observed that at location 3 the upload speed was almost equal with a slight difference of 0.02 Mbps while at location 1, a maximum difference of 1.9 Mbps was observed. The average upload speed for speedtester.com.ng was 2.258 Mbps while that of fast.com being slightly higher by 0.022 Mbps. While Figure 4 shows that the download speed has slightly difference at location 5 with speedtester.com.ng being higher by 0.15Mbps while at location 4 there was a maximum difference of 0.76 Mbps with fast.com being higher. Overall, the average download speed for fast.com was slightly higher than that of speedtester.com.ng by 0.054 Mbps.

3.2. Upload and download speed results for Globacom Nigeria limited

The results of speed tests that performed using speedtester.com.ng and fast.com for Globacom Nigeria limited in Warri, Delta State are shown in Table 2.

Table 2. Broadband speed test for Globacom limited

| Location | speedtester.com.ng | | fast.com | |
	Upload (Mbps)	Download (Mbps)	Upload (Mbps)	Download (Mbps)
1	0.64	1.56	0.52	0.85
2	2.17	1.66	1.8	2.7
3	1.77	6.19	1.8	3.5
4	2.2	2.4	2.0	2.6
5	1.8	3.5	1.9	3.2
Average	1.716	3.062	1.604	2.57

From the graphical representation of Figure 5, it was seen that at location 3, the upload speed was slightly different to an extent of 0.03 Mbps with the reading from fast.com being higher at 1.8 Mbps. The maximum difference was seen at location 2 which was 0.37 Mbps with the value from speedtester.com.ng being higher at 2.17 Mbps. The average upload speed was seen to be 0.47 Mbps for speedtester.com.ng while it was 0.3196 Mbps for fast.com.
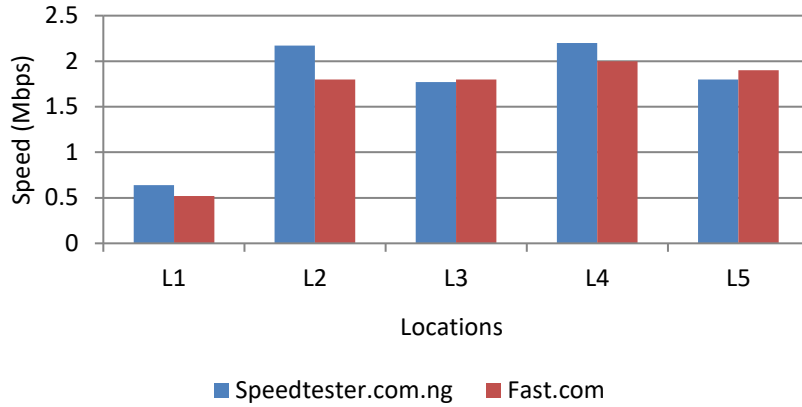
Figure 5. Comparing upload speed values for Globacom limited

For download speed as seen in Figure 6, the minimum difference between both platform readings was at location 4 (0.2 Mbps) with the higher value being 2.6 Mbps on fast.com. The maximum difference in download speed was at location 3 with fast.com recording a value of 3.5 Mbps while speedtester.com.ng recorded a value of 6.19 Mbps. On an average, the download speed as recorded by fast.com was 2.57 Mbps while that for speedtester.com.ng was 3.062 Mbps.
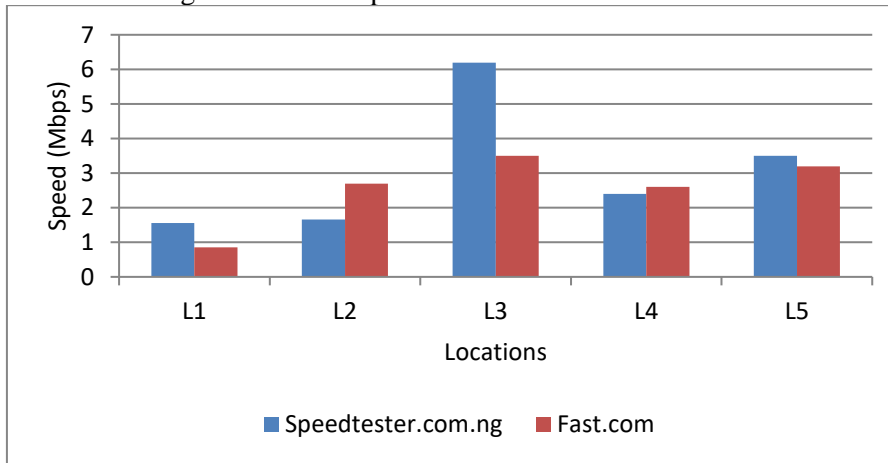

Figure 6. Comparing download speed values for Globacom limited

3.3. Upload and download speed results for Airtel networks limited

For Airtel Nigeria limited in Warri, Delta State, the results for broadband speed tests using both speedtester.com.ng and fast.com are shown on Table 3.

Table 3. Results from broadband speed test for Airtel networks

| Location | speedtester.com.ng | | fast.com | |
	Upload (Mbps)	Download (Mbps)	Upload (Mbps)	Download (Mbps)
1	0.06	0.08	0.018	0.2
2	0.04	3.87	0.09	2.7
3	0.47	0.38	0.08	0.3
4	0.77	0.50	0.61	0.7
5	1.01	0.76	0.80	0.8
Average	0.47	1.118	0.3196	0.94

From Figure 7, it was observed that the minimum difference in upload speed was at location 2 with a difference in 0.05 Mbps while the maximum difference (0.21 Mbps) was at location 5 with speedtester.com.ng having a higher value.
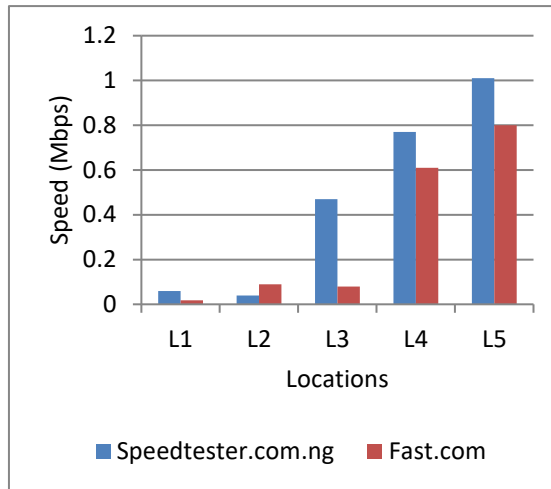

Figure 7. Comparing upload speed values for Airtel networks limited

For the download speed as seen in Figure 8, location 5 produces a minimum difference in readings from speedtester.com.ng (0.76 Mbps) and fast.com (0.8 Mbps) while a maximum difference in reading was observed at location 2 with fast.com recording a speed of 2.7 Mbps and speedtester.com.ng recording a speed of 3.87 Mbps.
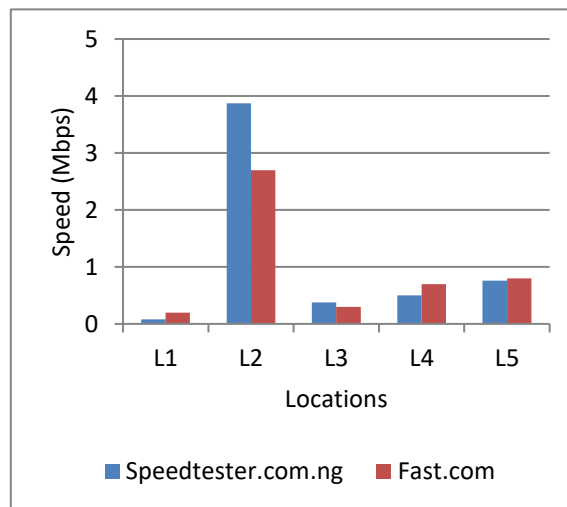

Figure 8. Comparing download speed values for Airtel networks limited

3.4. Latency values recorded by speedtester.com.ng and fast.com

The records for latency during the speed test was taken and recorded as seen in Tables 4 – 6 in Warri, Delta State. The latency values signify the delay before a connection is established with the server.

3.4.1 Latency results for MTN

For latency, Figure 9 shows a minimum value difference of 11.94 ms at location 1 with speedtester.com.ng having a higher value of 203.94 ms while at location 3, a maximum difference of 74.31 ms was observed with speedtester.com.ng having a value of 214.31 ms which is 74.31 ms higher than that of fast.com. The average latency value for speedtester.com.ng was 204.88 ms while that of fast.com was 147.4 ms according to Table 4.

Table 4. Latency results from broadband speed test for MTN Nigeria communication limited

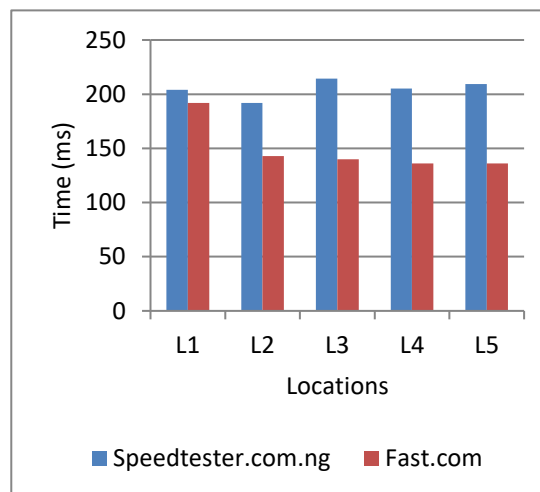|	Speedtester.com.ng	Fast.com
Location	Latency (ms)	Latency (ms)
1	203.94	192
2	192.01	143
3	214.31	140
4	205.24	136
5	209.44	136
Average	204.88	149.4

Figure 9. Comparing latency values for MTN Nigeria communication limited

3.4.2 Latency result for Globacom

From Figure 10, the maximum latency difference between readings from fast.com (268.26 ms) and speedtester.com.ng (105 ms) was observed at location 1 while at location 5, only a slight difference in values was observed. Speedtester.com.ng records a latency of 198.33 ms while test.com records a latency of 180ms. The average latency value recorded by fast.com (144.6 ms) was less than the average latency value recorded by speedtester.com.ng.

Table 5. Latency results from broadband speed test for Globacom limited

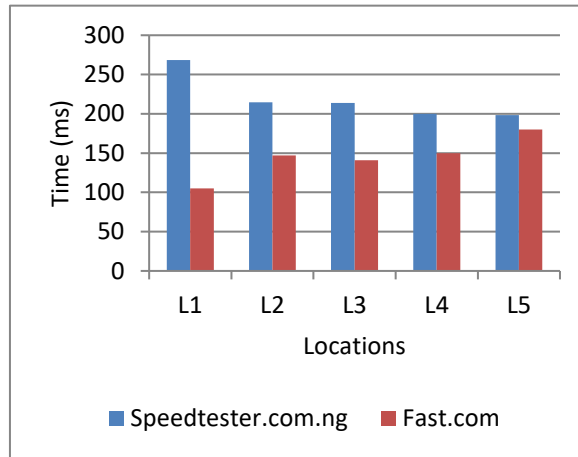|	speedtester.com.ng	fast.com
Location	Latency (ms)	Latency (ms)
1	268.26	105
2	214.60	147
3	213.72	141
4	200.03	150
5	198.33	180
Average	218.988	144.6

Figure 10. Comparing latency values for Globacom limited

3.4.3 Latency results for Airtel

For the latency measurement as seen in Fig. 11, location 5 has very similar values for speedtester.com.ng (243.65ms) and fast.com (240ms) while at location 1 it was observed that fast.com (229ms) records a lower latency compared to speedtester.com.ng (295.3ms).

Table 6. Latency results from broadband speed test for Airtel Networks limited

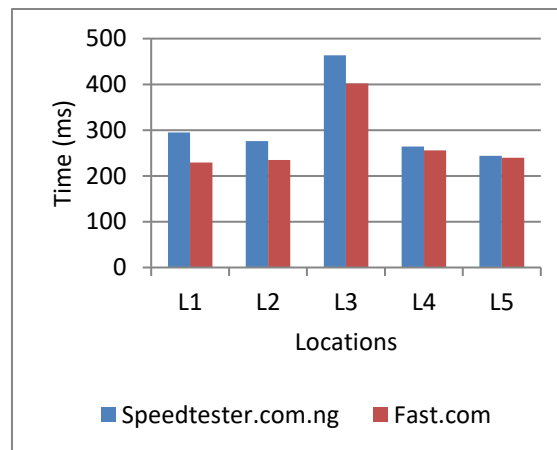|	speedtester.com.ng	fast.com
Location	Latency (ms)	Latency (ms)
1	295.30	229
2	275.84	235
3	463.66	402
4	264.34	256
5	243.65	240
Average	308.558	272.4

Figure 11. Comparing latency values for Airtel networks limited

Comparing the three networks, it can be seen that MTN has the highest peak upload speed at 3.9Mbps while Airtel has the least upload speed of 0.06Mbps. For downloads, GLO has the highest download speed at 6.19Mbps as seen in Figure 13 while Airtel has the least download speed at 0.08Mbps. From Figure 14, it can be seen that MTN has the least latency (192.01ms) while Airtel has the most latency (463.66ms)
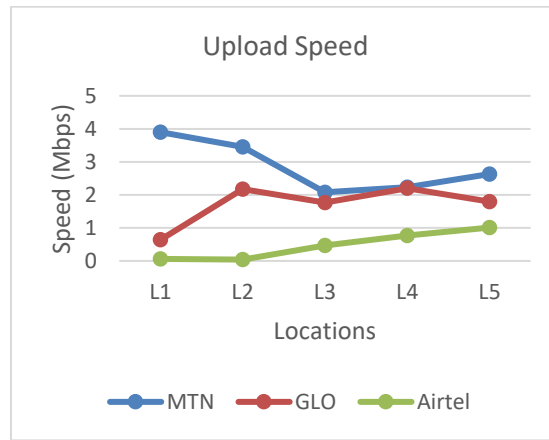

Figure 12. Comparing upload speed of the three networks
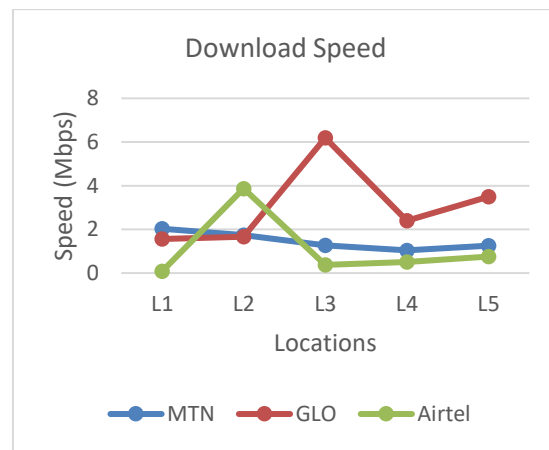

Figure 13. Comparing download speed of the three networks
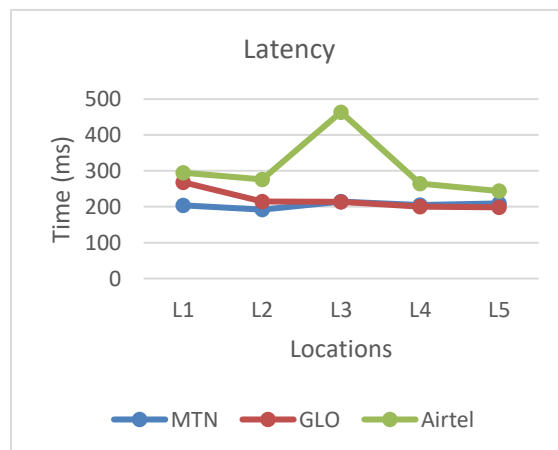

Figure 14. Comparing latency of the three networks

According to the National Broadband Plan [10], the definition of broadband by virtue of user experience is based on real time access of on demand content at a minimum speed of 1.5 Mbps. With this, the upload/download speed results can be compared to the 1.5 Mbps benchmark to further explain the QoS of the three service providers that were examined. In Figure 15, none of the readings in the five locations were able to meet the minimum broadband speed benchmark signifying a poor upload speed quality. For Globacom Limited, only one reading falls below the benchmark while MTN was the only service provider to significantly surpass the minimum benchmark set by the National Broadband committee in Nigeria.
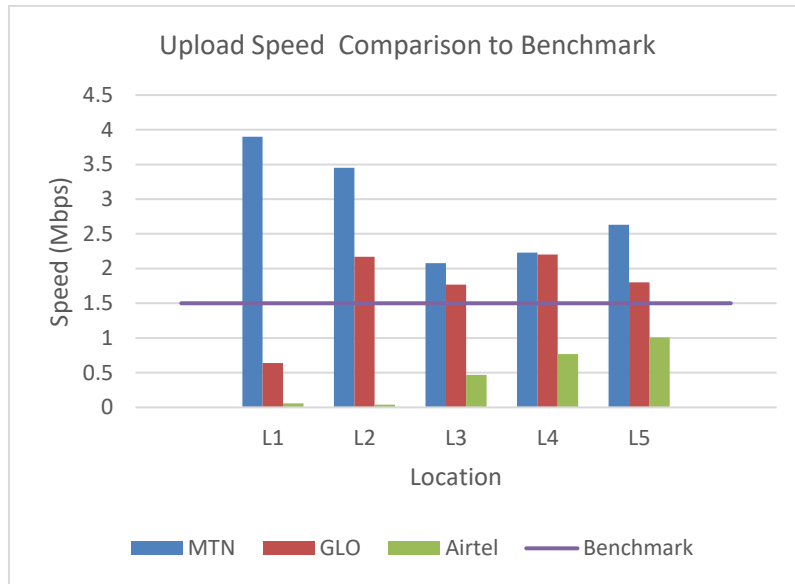

Figure 15. Comparison of upload speed with respect to national broadband benchmark

From Figure 16, only Globacom limited surpassed the benchmark in all readings taken. MTN Nigeria had just two readings meeting the minimum benchmark while just one reading for Airtel exceeded the benchmark. Overall, in terms of meeting the minimum benchmark broadband speed, Globacom Limited performed best for downloads while MTN performed best for uploads.
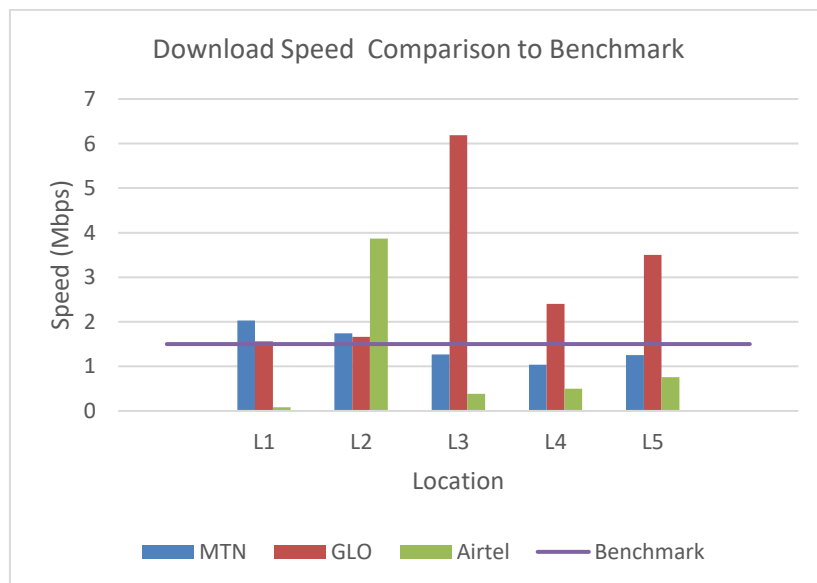

Figure 16. Comparison of download speed with respect to national broadband benchmark

4. Conclusions

In this paper, a web-based approach to broadband mapping was explored. A website capable of measuring broadband quality, recording the data gotten from the measurement and displaying on a map was developed.

Tests were carried out using this platform (speedtester.com.ng) at specific locations while comparing the results to that produced by fast.com (a Netflix platform). The results gotten were recorded and analysed to ascertain the accuracy of speedtester.com.ng.

At the end of the data collection with both speedtester.com.ng and fast.com, comparisons were made through graphical means. The result of the analysis showed that at very few instances, the readings were slightly different on both platforms. For a larger number of tests, the measured values were very similar for all internet service providers tested.

The difference was caused by distance and location of the speed test server. Latency variation is due to the network congestion and bandwidth availability [11]. Another factor that causes variations in speed test results is the request-handling capability of the server and how many users are connected to the server. For speedtester.com.ng, the server is at Helsinki, Finland which was the reason for higher latency measurements compared to fast.com which uses a server at Lagos, Nigeria.

From the comprehensive data collected, it could be seen that Airtel Networks Limited had the least average upload and download speed quality, MTN Nigeria Limited had the best average upload speed quality and Globacom Limited has the best average download speed quality. It can also be seen that the broadband prediction of the Nigerian National Broadband Plan [10], all three major service providers are behind in providing broadband service of the expected quality. Service providers were expected to have at minimum of 1.5Mbps as at 2018 for 3G services.

When compared to the minimum broadband speed benchmark, for uploads, MTN Nigeria exceeded the benchmark significantly while Airtel upload speed was not able to meet the minimum benchmark. For the downloads, Globacom Limited had the best speed, surpassing the minimum broadband benchmark. MTN Nigeria could not meet the minimum benchmark optimally while Airtel had just one reading surpassing the benchmark. Overall, MTN Nigeria emerged the best service provider for upload/download user experience which corroborates the findings of [12].

In conclusion, compared to other existing broadband mapping systems, speedtester.com.ng provided a more concise tool which combines location detection, broadband speed and a GIS on one platform. The platform was used in testing of broadband speed of the three biggest broadband service providers, comparing them with each other as well as comparing to the minimum benchmark of broadband speed in Nigeria.

Acknowledgements

References

[1] P. Christensson, "Broadband Definition" *TechTerms*. Sharpened Productions, 2006.

[2] D. Farkas, B. Hilton, J. Pick, H. Ramakrishna, A. Sarkar, and N. Shin, "A Tutorial on Geographic Information Systems: A Ten-year Update" *Communications of the Association for Information Systems*, vol. 38, no. 1, Article 9, 2016.

[3] G. Bernadi, D. Fenacci, and M. K. Marina, "BSense: A Flexible and Open-Source Broadband Mapping Framework" *Mobile Netw Appl*, vol. 19, no. 6, pp. 772-789, 2014.

[4] A. Dutta, and B. Lanvin, The Network Readiness Index 2019: Towards a Future-Ready Society, *Portulans Institute*, 2019.

[5] F. M. Dahunsi, and A. A. Akinlabi, "Measuring Mobile Broadband Performance in Nigeria: 2G and 3G" *Nigerian Journal of Technology*, vol. 38, no. 2, pp. 422-436, 2019.

[6] I. O. Dibie, and B. O. Omijeh, "Development of a Mobile Application for Mapping of Mobile Broadband Network Signal" *International Journal of Engineering Science and Computing*, vol. 9 no. 5, Corpus ID: 212533086, 2019.

[7]   C. Kalu, S. Ozuomba, and K. Udofia, "Web-based mashup application for participatory wireless network signal strength mapping and customer support services" *European Journal of Engineering and Technology*, vol. 3, no. 8, pp. 30-43, 2015.

[8]   Ofcom, Independent regulator and competition authority for the United Kingdom communications industries. (n.d.). http://www.ofcom.org.uk/

[9]   Global Leaders in Broadband Measurement. (n.d.). http://www.samknows.com/broadband/index.php

[10]   Nigeria's National Broadband Plan 2013-2018. A submission by the Presidential Committee on Broadband.
https://www.researchictafrica.net/countries/nigeria/Nigeria_National_Broadband_Plan_2013-2018.pdf

[11]   S. Bauer, D. D. Clark, and W. Lehr, "Understanding Broadband Speed Measurements" *TPRC*, 2010.

[12]   B. M. Kuboye, "Evaluation of Broadband Network Performance in Nigeria" *Int. J. Communications, Network and System Sciences*, vol. 10, no. 9, pp. 199-207, 2017.