

EXPLORATORY ANALYSIS OF MOBILE NETWORK TRAFFIC DATA: A CASE OF A MAJOR MOBILE NETWORK OPERATOR IN NIGERIA

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Abstract

The most effective and common method of assessing mobile network operator's (MNO) performance is through customer perception, usually gathered using mail, telephone, or internet-based surveys. However, previous studies have observed that the percentage of responses received from customers are extremely low, because customers do not return and complete the surveys at the stipulated time. To overcome the surveys' drawbacks, recent studies suggested the use of customer experience data obtained from the mobile network traffic. Therefore, this article explores the data collected from a major mobile network operator in Nigeria to determine whether the variables constituted in the dataset can be used in future to evaluate mobile network operator's performance. The dataset (data tariff, customer complaints and network quality (uplink and downlink throughput) used in this article was gathered from mobile network traffic. The study examined the gathered dataset in R Programming and the result shows that there is a relationship between data tariff and number of internet subscribers, as well as uplink and downlink throughput, which represents the network quality. Overall, the results from the study suggests the dataset can be used to evaluate the MNOs internet service performance to determine mobile internet customers' satisfaction.

Keywords: Internet; Data tariff; Internet Subscribers; Exploratory Data Analysis; Customers Satisfaction;

1.0 INTRODUCTION

In recent years, the proliferation in the usage of internet have experienced a remarkable growth and have changed the ways in which people communicate and obtain information through the wide usage of various applications and services delivered by the World Wide Web (WWW). At the same time, the rapid evolution of wireless mobile communication has increased internet user's requirement and expectations in terms of accessing a web-based service anytime, anywhere or on multiple devices (Barakovic & Skorin-Kapov, 2015). Equally, wide increase in the usage of the new mobile devices such as smartphones and tablets, as well as the internet-based applications used by the users have immensely enhanced the mobile internet used to browse new sites, read emails, and access social media sites (e.g., Facebook, Twitter, and Instagram). In 2017, Internet World Statistics (2017) reports

world internet users observed a tremendous growth between December 2000 (369 million users) to March 2017 (more than 3.7 billion). This growth facilitated the telecommunication (telecoms) industries in different part of the world to enhance their globalization, internalization, and effective coordination of economic activities.

Nonetheless, Africa countries are completely outstanding in the usage of mobile internet because of its contribution to the economic growth and development (Isabona & Ekpenyong, 2015). Specifically, telecoms industry has become the major driver of the economic growth in Nigeria. This is evident in the study of Ekwujuru and Ofili (2016) that claims the telecoms industry contributed 8.7% Gross Domestic Product (GDP) to the Nigerian economy. Previous studies and recent internet world statistics asserts Nigeria has the highest mobile internet users in Africa with 48.4 to 93.5 million users between 2012 and 2017 respectively (Internet World Statistics, 2017; Odudufa, 2012). This growth indicates that mobile devices have become the major medium for accessing internet in Nigeria (Kuliya, Abou, Aliyu, & Lele, 2015), which have instinctively reduced the stress associated with going to the cyber cafés (Ojo, 2011). In addition, the growth of the internet usage have enhanced the Nigeria economy through several channels such as providing effective delivery of public services through internet application used on mobile devices (GSMA, 2015). Equally, the widespread usage of the mobile internet has enhanced competitive advantage among the mobile network operators (MNOs) in Nigeria, by bringing down the tariffs or price of mobile internet data subscriptions (Akintaro, 2017). The idea of the data subscription tariffs crash in Nigerian telecoms industry was proposed by the Nigerian telecoms regulator that is Nigerian Communications Commission (NCC), to make cheap internet data rate available to many mobile internet users as much as possible. While the mobile internet customers were excited about the drop in the internet data tariffs, decline in the quality of service (QoS) has been observed as most internet subscribers complains bitterly about poor network services (Akintaro, 2017).

Mobile Internet data subscription tariffs is the amount of money exchanged for data bundles, that is the sum of values that the mobile internet exchange for the benefits of having access to mobile internet services. The data tariffs is commonly used as a competitive tool in most telecoms industry (Adebiyi, Shitta, & Olonad, 2016). For instance, the MNOs that offers lower data tariffs is most likely to attract more customers than those with higher data tariffs. Hence, in telecoms industry whereby it is difficult to perceive a significant difference in the QoS provided by the MNOs, data tariffs is used as a competitive strategy to attract new customers and retain the current customers (Adebiyi, et al., 2016; Chang & Wildt, 1994).

On the other hand, mobile internet customer complaints is often managed by the customer care services. Customer care services is considered as a system of activities that constitutes customer support systems, complaint processing, speed of complaint processing, ease of reporting complaint and friendliness when reporting complaint (Adebiyi, et al., 2016; Kim, Park, & Jeong, 2004). Customer care services encompasses the series of packages designed to enhance the level of customer satisfaction by ensuring the feeling of a product or services has met the customer expectations (Adebiyi, et al., 2016). In particular, customer care services is provided as a support by different MNOs to enable their customers reports complaints on-site, over the phone, or through the internet about the services provided by the MNOs. Generally, data tariffs and customer complaints are considered as a basic components used by most customers for selecting their preferred MNOs and a competitive advantage used by the MNOs to retain customers for a longer period time.

Extensive studies have investigated the performance of the MNO through the customer perception often in the form of surveys and the result of most of the studies have shown that customer care services, network quality and data tariff have a strong correlation with the way the customer perceived the services offered to them by the MNOs (Adegoke & Babalola, 2011; Alabar, Egena, & Gbande, 2014; Isabona & Ekpenyong, 2015). However, there is limited studies that have investigated the performance of the MNOs by obtaining the data from the MNOs, especially in Nigeria. Therefore, this study presents an overview of the telecoms industry in Nigeria and obtain data generated by a

major MNO in Nigeria telecoms industry to investigate the relationship that exist between the network quality parameter, data tariffs and show a comparison between the number of internet subscribers and complaints received by the customer service care of the MNO. The remainder of this paper is structured as follow. Section 2 of the paper presents an overview of the Nigerian telecoms industry, followed by an extensive literature review of the mobile internet in Nigeria and the factors that influence the selection of a preferred mobile network operator in Nigerian telecoms. This resulted to the development of hypotheses that are presented in section 3, which is the methodology section. In addition, data collection, data analysis and findings are discussed in the methodology section. Followed by section 4, which discusses the findings of the study. Lastly, section 5 presents the conclusion and future work of the study.

2.0 LITERATURE REVIEW

2.1 Overview of Nigerian Telecoms Industry

History of Nigerian telecoms industry can be traced back to the deregulation of the telecoms sector that occurred in 2001. The deregulation have resulted in quantum of growth of various service delivery and regulatory advancement (Jawah, 2011). Reports obtained from National Bureau of Statistics (2015) and NCC (2017) shows that Nigerian telecoms industry observed an immensed increase in the aggregates of internet users between 2013 (127 million) and 2017 (154 million). The increase of internet usage enhanced the telecoms sector to contibutes 8.7% GDP to the Nigerian economy (Adi, 2015; Ekwujuru & Ofili, 2016; Juwah, 2011; NBS, 2015), thereby making the telecoms sector the most profitable in terms of revenue generation (Adekunle, 2015). Presently, Nigeria telecoms industry have four leading MNOs, which are Mobile Telephone Networks (MTN), Air Telecommunications (AIRTEL), Global Communication Limited (GLOBACOM) and Emirates Telecommunication (ETISALAT). The listed MNOs are managed and supervised by the Nigerian telecoms regulatory authority. Statistically, MTN has the largest pcentage of mobile internet subscribers (39.00%), followed by GLOBACOM (25.00 %), then AIRTEL (23.07%) and lastly ETISALAT (13.00%) (NCC, 2017).

The NCC is an independent national regulatory authority responsible for the provision of qualitative and efficient telecoms services throughout Nigeria (NCC, 2017). NCC was founded because of the poor performance of Nigerian Telecommunications (NITEL) (Adeleke & Aminu, 2012). Following the establishment of NCC, licensing of the Global System of Mobile Communication (GSM) was ensued to enable private sector participation in the telecoms industry and transform the telecoms industry from a monopolist industry to a competitive industry. Hassan (2011) affirmed that the competitive strategies introduced in the telecoms industry resulted to an unprecedented high mobile penetration with an increase of teledensity from 0.45 to 58.52 lines per 100 inhabitants with a relatively poor quality of service. Subsequently, the competitive advantage created through liberalization among the MNOs have led to the reduction in mobile tariffs, initiation of new and innovative products, advertising, and innovative customer care support (Adeleke & Aminu, 2012). The renovation of the Nigeria telecoms to a competitive industry have improved customer attraction and retainment of existing customers within the chosen MNOs, thereby increasing the revenue and profits generated by the MNOs.

2.2 Mobile Internet in Nigeria

Nigeria is one of the countries with high usage of mobile internet in Africa (Adekunle, 2015; Olaposi, Binuyo, Oluwale & Ayanlade, 2013). According to recent Ericsson report documented in April 2015, 82% of mobile customers access internet through their mobile phones (Aginam, 2015). In addition, the report revealed that the common online activities performed by most internet customers are social media networking sites, sport news sites and mobile banking applications. In a follow-up study,

Aginam (2015) highlighted that 94% of mobile internet users' access social media sites, while 93% access mobile banking sites, sport news and Nigerian news sites on their respective mobile phones. The habit of using mobile phones to access internet is believed to enhance sharing of ideas and information among different groups of people, thereby strengthen the global technological revolution, empowering the social and economic development of the country (Ajanaku, 2014). As noted by Internet world statistics (2017) Nigeria was on the 8th ladder of the world internet users, with a total country population of 191.8 million, 93.6 million internet customers and 48.8% internet penetration rate (percentage of population with internet). Nigeria internet penetration rate and some developed countries internet penetration rate is displayed in Figure 1.

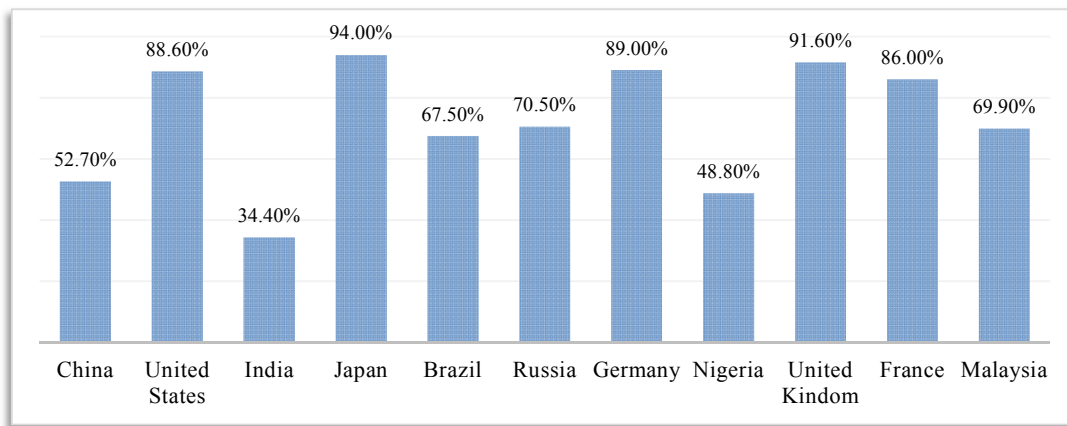


Figure 1 Internet Penetration rate of Nigeria and some developed countries
 Source: (Internet World Statistics, 2017)

Based on internet world statistics (2017) and internet live statistics (2017), it is observed that there is a growing increase in Nigeria population and internet customers as shown in Figure 2. This supported previous studies that claimed tremendous increase in internet customers' growth is responsible for the reason Nigeria telecoms is regarded as one of the fastest growing telecoms sector in Africa (Adeleke & Aminu, 2012; Nwaubani & Kapoulas, 2013).

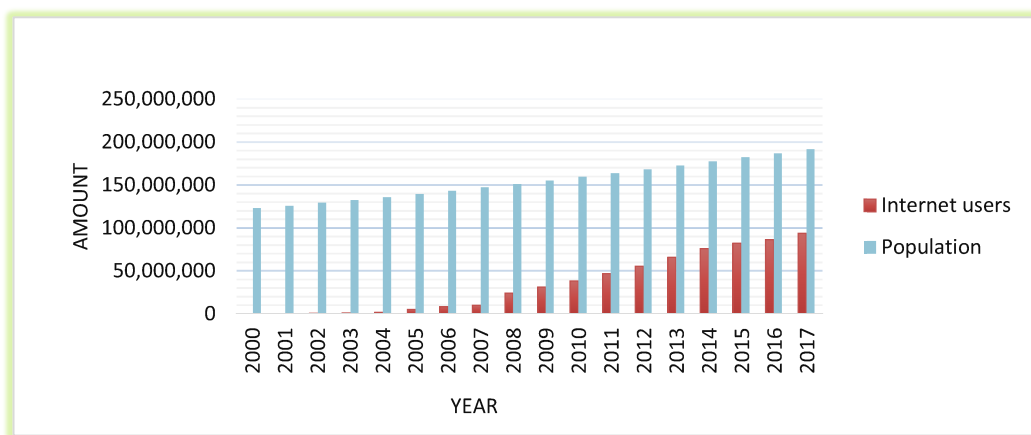


Figure 2 Nigeria Population and Internet Customers growth from 2000 - 2017
 Source: (Internet World Statistics, 2017; Internet Live Statistics, 2017)

However, comparing with some selected Africa countries, Nigeria has the highest country population, highest internet customers, but a low internet penetration rate when compared to South Africa, Kenya, Mauritius, Morocco, and Tunisia. These claims are presented in Figure 3, 4 and 5.

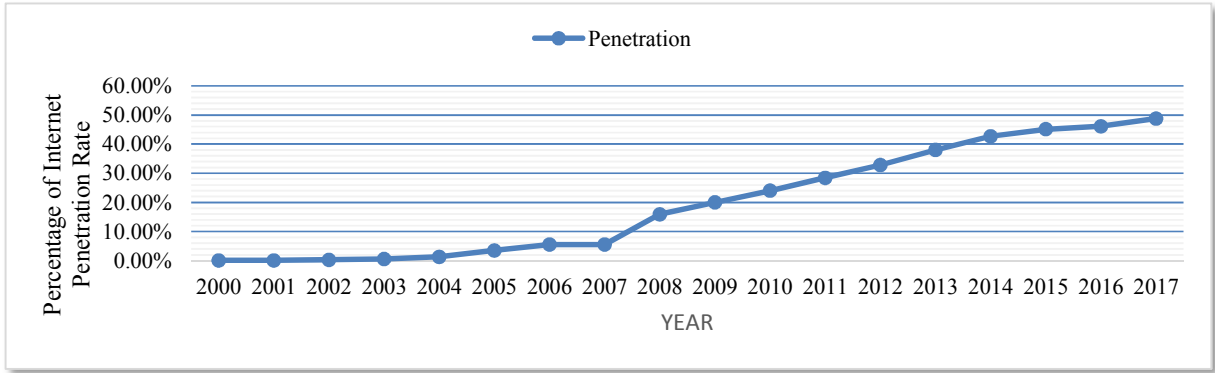


Figure 3 Nigeria Internet Penetration rate
 Source: (Internet World Statistics, 2017; Internet Live Statistics, 2017)

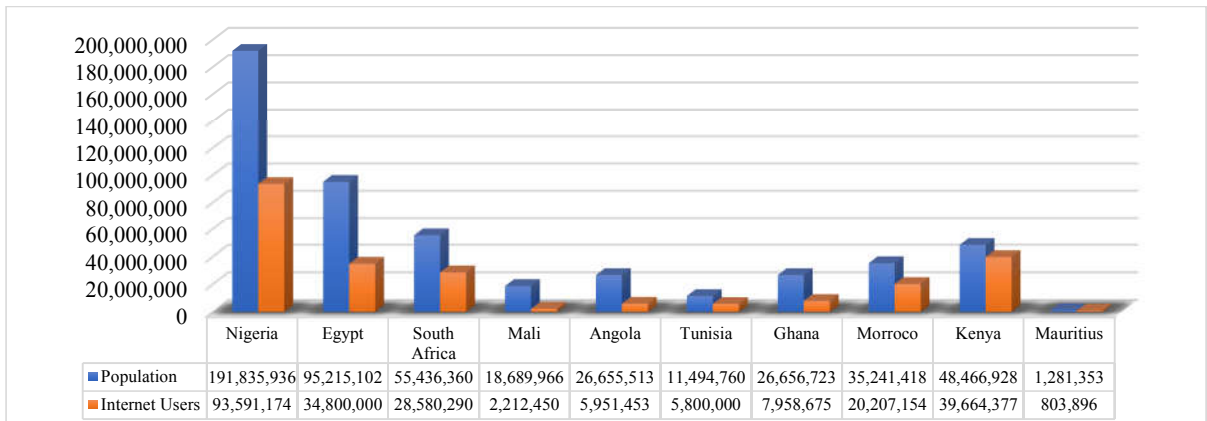


Figure 4 Nigeria and Some Selected Africa Countries Population and Internet Usage
 Source: (Internet World Statistics, 2017; Internet Live Statistics, 2017)

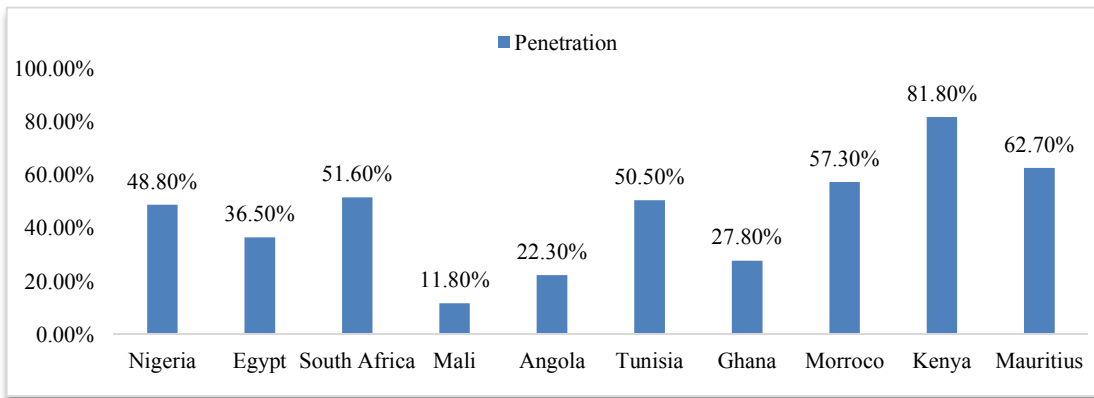


Figure 5 Penetration Rate of Selected African countries
 Source: (Internet World Statistics, 2017)

Figure 2, 3 and 4 has demonstrated that the number of internet customers is enormous in Nigeria. Still, the usage of mobile internet in Nigeria is faced with the challenges of QoS perceived and fluctuations in mobile internet customers' satisfaction (Adegoke & Babalola, 2011; Azeez, 2015; NCC, 2012; Isabona & Ekpenyong, 2015; Nnochiri, 2015; Oduh & Oduh, 2012). International

Telecommunication Union (ITU), describes QoS as “totality of characteristics of a telecoms service that bear on its ability to satisfy stated and implied needs of the user of the service” (ITU-T Recommendation E.800, 2008). QoS is considered as an important criterion in determining mobile internet customer satisfaction and loyalty in telecoms sector in Nigeria (Adeleke & Aminu, 2012; Adegoke & Babalola, 2011). However, based on the challenges shown in Table 1, previous studies have reported that numerous customers are dissatisfied with the QoS provided by the MNOs in Nigeria (Adegoke & Babalola, 2011; Isabona & Ekpenyong, 2015; Longe, 2011). This is evident in the study of Olaposi, Binuyo, Oluwale and Ayanlade (2013) that highlighted customers who access internet on mobile devices are less satisfied than those who access internet through internet modems. Subsequently, other studies point out that there is a strong interrelationship between the services delivered to the internet customers and customer satisfaction (Alabar, et al., 2014; Ogunlade, Joshua & Ogunlade, 2013). Overall, these studies support the view that QoS have a strong effect on the level of customer satisfaction, which means that an increase in service performance will increase the level of customer satisfaction.

Table 1 Challenges facing the usage of Mobile Internet Services in Nigerian Telecoms Industry

No	Authors	Challenges
1	Mawoli (2009)	Weak Infrastructure base. Regulator incompetency in enabling law and regulation. Inadequate tariff regulations. Improper management of customer expectation. Inadequate power supply. Spectrum planning and allocation problems.
2	Elebeke (2016) Oghojafor, Mesike, Omoera and Bakare (2012)	Inadequate management of radio frequency among subscribers resulting in poor services by the MNOs and difficulties in satisfying mobile network subscribers.
3	Ekpenyong (2011) Hassan (2011)	QoS problem because of vandalism of infrastructure, network failure due to network congestion, slow download, and connection drops.
4	Longe (2011)	Dissatisfaction with the provided QoS such as call drop during telephony, low voice quality, poor interconnectivity, and poor reception on network. High billing system on mobile network service. Problems of teledensity (network congestion) in the areas covered by the MNOs.
5	Iwuagwu (2014)	Rise of churn and attrition rate.
6	Kuboye, Alese, Fajuyigbe and Adewale (2011)	Delay in securing approval for sites for new base stations. Harassment by some government agencies especially at the state and local government levels.
7	Isabona and Ekpenyong, (2015)	Fair network performance and a fluctuating rate of the customer satisfaction.
8	Kuboye B. M. (2010)	Long delay in obtaining permit. Multiple and illegal regulations. Taxation at federal, state, and local government levels. Damage of fiber infrastructure during road works. Lack of green energy initiatives and support.

9	Kuliya, Abou, Aliyu and Lele (2015)	Instability of power supply. Security of infrastructure. Inter-network connectivity problems (such as call drops, call set up failure and call retention). Network congestion. General poor QoS in mobile networks.
10	Dahunsi and Kolawole (2015) Nnochiri (2015)	Poor network coverage. Unsatisfactory customer care support. Increase in number of dissatisfied customers because of poor QoS.
11	Adegoke and Babalola (2011) Osunade and Oyesanya (2016)	Traffic channel congestion below NCC recommendations and services provided below customer expectation.

2.3 Factors that Influence the Preferred Selection of Mobile Network Operator in Nigeria

Based on the challenges facing the usage of mobile internet services in Nigerian telecoms industry highlighted in Table 1, the challenges highlighted ranges from the issues of network performance (Isabona & Ekpenyong, 2015), high billing system on mobile network service (Longe, 2011), to unsatisfactory customer care support (Dahunsi & Kolawole, 2015). Chong, Teoh and Qi (2015) considers these challenges as the factors that influence competitive advantage among MNO and customer satisfaction. These factors can further be classified as customer service, data tariff (Price) and network quality. Previous studies have extensively shown that these three factors commonly affect the satisfaction of the mobile internet services and in turn enhance the competitive advantage of MNOs in the Telecoms industry in Nigeria (Adebiyi, Shitta, & Olonad, 2016; Bakare, Ekanem, & Allen, 2017; Chong, et al., 2015; Ekejiuba & Adebayo, 2016; Kuliya, et al., 2015). Customer service is a key driver used by the MNOs to add value to mobile internet services provided to their customers (Chong, et al., 2015). Customer services have received a research attention in customers satisfaction literatures, because if customer complaints are not properly handled by the MNOs, customers may switch to other MNOs that effectively handles customers complaints (Malhotra & Malhotra, 2013). On the other hand, customer complaints is commonly used by the MNOs to rectify network traffic issues hindering the customers from deriving values of their mobile internet subscriptions (Ibarrola, Saiz, Zabala, & Cristobo, 2014). Employing customers complaints to rectify network traffic issues will enable the MNO to know the numbers of mobile internet subscribers having problems with the provided mobile internet services. It is therefore believed that comparison of number of internet subscribers and number of complaints received by the MNOs will assist the MNOs to provide an efficient mobile internet service. Moreover, efficient handling of customer complaints by the customer care services will enhance the provision of better internet services that may likely increase the competitive advantage of such MNOs.

Mobile internet tariff or price is the amount of money charged for data bundles purchased from the MNOs (Kotler & Armstrong, 2016). Generally, mobile internet tariff fairness is very crucial in relation to customer perception and MNOs revenue generation. In the case of customers, most internet subscribers are much more interested in “you get what you pay for” (Chong, et al., 2015). In otherwords, mobile internet customers are often happy when the internet tariff they pay for is equal or more than the data bundles offered to them by the MNOs (Chakraborty & Sengupta, 2014; Santouridis & Trivellas, 2010). Previous studies on telecoms industry in Nigeria assert that the internet tariff is high due to lack of telecoms infrastructures (Bakare, Ekanem, & Allen, 2017; Longe, 2011). However, recent intervention by NCC initiated a competitive strategy by ensuring the mobile internet tariffs is as cheap as possible (Akintaro, 2017). The recent development of offering the

customers a cheap mobile internet tariff challenged most MNOs in providing efficient mobile internet services and at the same time increasing the revenue generated by the MNOs.

Network quality is an influencing factors of meeting competitive advantage in telecoms industry as the mobile internet data bundles subscribed by the customers rally round the type of network quality provided by the MNOs. According to Chong et al. (2015), network quality is a relevant factor when evaluating service quality to determine the overall customer perception. However, most studies does not usually captures the MNOs perceptible, that is the network traffic while examining the service quality, because the most common method used is the survey method. The survey method is a standard and reliable method (Barakovic & Skorin-Kapov, 2013; Demirbilek & Gregoire, 2016; Falk & Chan, 2006). However, several studies has shown that the survey method is expensive, time consuming, lacks usability and repeatability in real time (Alreshoodi & Woods, 2013; Baraković, et al., 2010; Demirbilek & Gregoire, 2016; Falk & Chan, 2006; Gates & Youngja, 2010; ITU-T Recommendation G.1011, 2016). In this case, recent studies have suggested the use of obtaining the data from the MNOs to have insight about the services provided to the mobile internet customers (Ibarrola, Saiz, Zabala, & Cristobo, 2014; Spiess, T'Joens, Dragnea, Spencer, & Philippart, 2014). The network quality consists of QoS parameters such as jitter, packet loss, packet delay, throughput, and bandwidth (de Gouveia & Magedanz, 2009; Gilski & Stefański, 2015). Throughput is the most important QoS parameters because it describes the data transmission speed used to evaluate the mobile internet service (Ibarrola, Xiao, Liberal, & Ferro, 2011). Analysing the mobile internet services provided by gathering throughput data from the mobile network will enable the appropriate evaluation of the services provided by MNOs to the mobile internet subscribers.

3.0 METHODOLOGY

The literature suggests that datasets from the network traffic can be used to provide information about the service that is offered by the MNO (Ibarrola, et al., 2014; Spiess, et al., 2014). Therefore, this study aims to find the relationship between the collected dataset to investigate if the dataset from the MNOs can actually be used to evaluate the MNO's performance. Based on the literature review in section two and the data obtained from the MNO used as a case study, the following hypotheses was developed.

H1: There is a relationship between the data tariff and number of internet subscribers.

H2: There is a relationship between uplink throughput and downlink throughput.

3.1 Data Collection

The study collected three months traffic data from a major MNO in Nigeria. The data collected consists of mobile internet customer complaints, mobile internet tariff data and network quality data. Customer complaint comprises of number of internet issues reported to the customer service desk of the MNO. The mobile internet tariff data includes the data bundles, data tariffs and number of subscribers. Lastly, the network quality data comprises of throughput data consisting of uplink throughput (data transmission from the customer mobile phones to the base station) and downlink throughput (is the data transmission from the base station to the customer mobile phones).

3.2 Data Analysis and Findings

This study investigated the relationships between the network quality parameters, data tariffs and show a comparison between the number of internet subscribers and complaints received by the customer service care of the MNO. This study analyzed the collected data using R Programming, which is a free and open- source integrated development environment for data analytics. R programming provides various functionalities for data pre-processing, statistical computing and graphics visualization. The analysis started by performing a correlation analysis between the data

tariffs and number of subscribers for three months. The result from the correlation analysis shows $r = -0.64$ (first month), $r = -0.65$ (Second month), $r = -0.63$ (Third month). The result indicates a negative relationship between the data tariff and the number of internet subscribers. The correlation result means the number of internet subscribers increases as the data tariff decreases. In addition, a regression analysis was performed and the result is depicted in Table 2.

Table 2 P-value and T-value result for the Regression of Data tariff for three months

	t-value	p-value
First Month	-1.359	0.197
Second month	-1.355	0.198
Third Month	-0.911	0.377

Then, a correlation analysis was performed on the network data quality obtained from the MNO consisting of upload throughput and download throughput. The result from the correlation analysis shows $r = 0.96$. The result indicates a strong positive relationship between uplink throughput (data transmission from the customer mobile phones to the base station) and downlink throughput (is the data transmission from the base station to the customer mobile phones). This means as the uplink throughput increases the downlink throughput also increases or vice versa. In addition, a regression analysis was carried out and the result is depicted in Table 3.

Table 3 P-Value and T-value for the Regression of Uplink and Downlink Throughput

	t-value	p-value
Uplink	33.517	<2e-16
Downlink	33.517	<2e-16

The results shown in Table 3 described that the Internet data are synchronously transmitted between upload and download activities. The subscriber who subscribed for internet data bundles was compared with the total number of complaints received by the customer care service for three months as depicted in Figure 5.

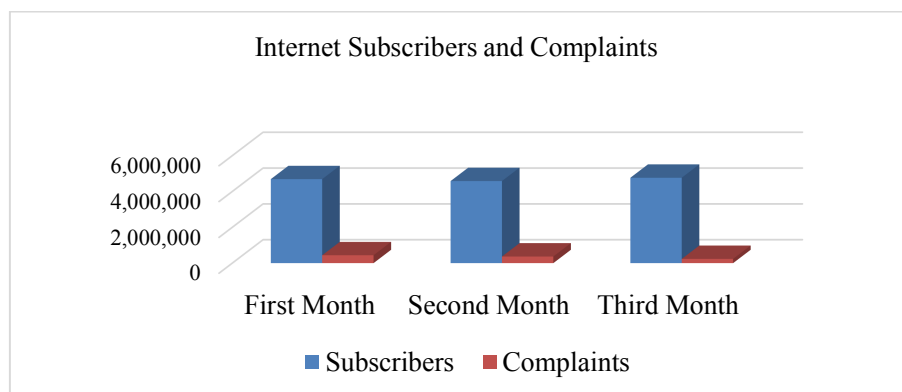


Figure 5 Three months internet subscribers and complaints

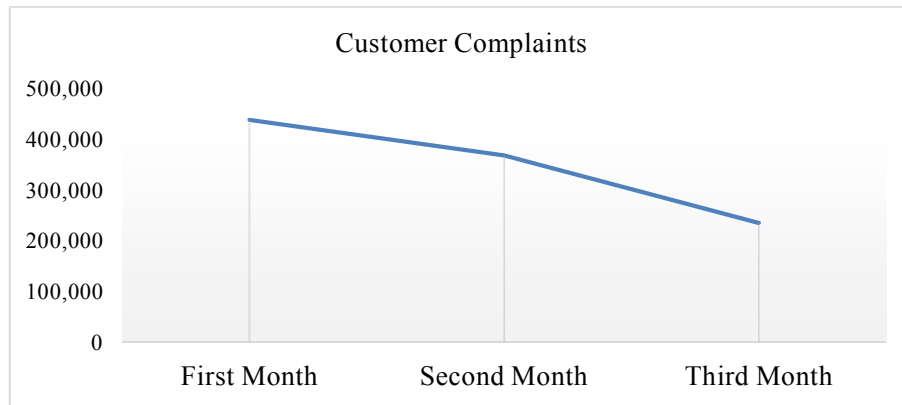


Figure 6 Line Graph Showing Three Months Customer Complaints

4.0 DISCUSSION

The result of the p-value in Table 2 shows the evidence that internet data tariff determines the number of mobile internet subscribers. This means that the internet shows preference of tariff in a preferred MNO. This result support the view of the survey method that has been used in previous studies to investigate price or data tariff as an antecedent of customer perception (Chong, et al., 2015; Hassan, 2011; Longe, 2011). There is a strong relationship between the data tariff and number of mobile internet subscribers, the p-value of 0.1 is greater than 0.05, which seems not significant. However, result obtained from the correlation indicates the data obtained from MNO can be used to evaluate the performance services offered by the MNO because there is a relationship between the data tariff and the number of internet subscribers.

In case of network quality represented by downlink and uplink throughput, the p-value result in Table 3 shows that the level of p-value suggest that the alternative hypothesis is accepted and therefore, there is evidence that there is a strong relationship between the uplink and downlink throughput that can be employed to evaluate the network quality of the MNO. In addition, the results shows that there is a relationship between the subscribers mobile phones and the base transmission station of the MNO. This result support previous studies that considers network quality as a factor for choosing a preferred MNO as well as providing an insight about the services offered to the mobile internet subscribers (Ibarrola, et al., 2014; Spiess, et al., 2014). Overall, the result obtained supported the stated hypothesis, but it does not really represents the performance of the MNO, except if the MNO are giving a reliable and consistent service. However, the expectation of higher uplink throughput comensurating with higher downlink throughput or vice versa was verified.

Figure 5 shows the numbers of mobile internet subscriber and the number of complaints received within a period of three months. Evidently, Figure 5 shows there is limited number of complaints received by the MNO when compared with the number of mobile internet subscribers. Figure 5 supports the study of Diaz-Aviles et al. (2015) that indicted not all internet subscribers that experience issue with the internet service will report to the customer care services. Therefore, comparing the customer complaints and number of internet subscribers may not clearly indicate the performance of the MNO. However, the line graph in Figure 6 indicates the MNOs observed a decreasing trend in the rate of customer complaints. Thus, to the MNO this could mean they are providing a better mobile internet service since the complaints is following a decreasing trend.

5.0 CONCLUSION

This study presented an overview of mobile internet in Nigeria telecoms and collected three months network traffic data from a major MNO in Nigeria to investigate the relationship that exist between the variables constituted in the data. The results obtained from the study indicated that data tariffs determine the number of mobile internet subscribers of the MNO. In addition, the study showed that there is a relationship between the uplink and downlink throughput, which can be used to evaluate the network quality provided by the MNO. Equally, the study showed that customer complaints on related internet data issues is limited when compared to the number of mobile internet subscribers, hence may not clearly indicate the performance of the MNO. However, a decreasing trend was observed in three months customer complaints dataset obtained from the MNO. Overall, this study suggests the use of mobile network traffic data for the evaluation of MNO performance to overcome the drawbacks usually observed in evaluating MNO's performance through customer's perception. It should be noted that this study is a preliminary study conducted with a limited dataset. Hence, the results presented should be treated with caution, until adequate and sufficient data can be gathered from the MNO to produce more and accurate prediction model that can be formulated to measure the mobile internet QoS and customer satisfaction. In this case study, the future work would investigate mobile internet customer satisfaction through the mobile network traffic data.

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