International Journal of Basic Science and Technology
April, Volume 10, Number 1, Pages 43 – 55 http://www.ijbst.fuotuoke.edu.ng/ 43
https://doi.org/10.5555/YXCZ4275 **ISSN 2488-8648**

Predictable Mobile Number Portability for Mobile Network Providers

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Article Information

Article # 10007
Received: 6th Jan. 2024
1st Revision:8h Feb. 2024
2nd Revision:14th Feb. 2024
Acceptance:11th March 2024
Available online:
25st March 2023.

Key Words
Portability, Fuzzy logic,
Call Quality Factor,
Tariff plans,
Customer care services,
Network coverage

Abstract

In this paper, predictable mobile number portability for mobile network providers is presented. The GSM networks studied were MTN and Glo. The actual measurements for this research were from various points of interest in Aba, (Abia State), Umuahia, (Abia State), and Mbaise, (Imo State). For each of the locations, measurements were taken at hourly intervals and the obtained data was aggregated and averaged into the following Key Performance Indicators (KPIs) namely; Call Drop Rate (CDR), Call Setup Success Rate (CSSR), Agent Utilization Rate (AUR), Handover Success Rate (HSR), Awaiting Time (AWT) and Call Quality Factor (CQF) via the existing Base Station Controller (BSC) areas. Practically tariff plans, call quality factors, customer care services and network coverage parameters are more important for a customer to switch their operator. These four parameters were used for MNP prediction decisions using fuzzy logic. The results showed that MTN NG ranked first with a prediction score of 78%, strongly followed by GLO NG with a prediction score of 77%. The research concludes that the prediction for mobile network providers could be of immense assistance should the Nigerian Communication Commission decide to revisit the mobile number portability as earlier promised from the available literature.

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Introduction

Mobile Number Portability (MNP) is an important component of mobile network providers. is the ability of cellular phone users to toggle among network providers while maintaining their cellular phone numbers (Smura, 2019). The switching cost will be minimal since the subscribers have the right to retain their numbers. As a result, the subscribers are challenged with migrating expenses that came with informing the public about changing their cellular phone numbers, redesigning their company -headed letters, and being unreachable to important calls from the populace that don't have their new cellular phone numbers, etc (Rajeev *et al.*, 2018).

Because of these factors, a lot of monitoring establishments have forced compulsory Mobile Number Portability (MNP) or at the verge of its beginning to bring subscribers' migrating costs to its barest minimum, and its effort to make cellular phone industries highly accommodating and competitive (Buehler and Haucap, 2018).

Some of the few studies that have made attempts in the direction of this study were the works of Hashim (2014), Adeiza (2010); Jibrin and Ahmad (2014). These works had methodological problems: some concentrated in only one State or institution, while some dealt with isolated variable indicators. They also used small sample sizes selected from narrowly defined populations and they failed to integrate the various independent variable sets. As a result, the findings and conclusions of the studies have limited relevance for broad generalizations.

Lee *et al.* (2016) conducted a study in South Korea about factors that attracted customers in porting their numbers. It was discovered that there was a willingness by customers to give a standard of 3.24% of their monthly cost for a mobile number portability choice. Willingness to pay (WTP) demonstrated a highly encouraging organization with proceeds, understanding of MNP, and aim to switch.

Contrary to these findings was a study by Haucap (2016), which found ambiguity about MNP in most European countries, the research results for this study indicated that MNP brought about 6% discount rates which was a benefit to consumers. The saturated market forced operators to bring prices of telecommunication down and quality of service was a determining factor in influencing customer choice more than prices. However, the two researches fail to provide a platform for the deployment of their ideas.

A study conducted by Smura (2019) looked at Finland, Italy, Singapore, and Germany on the implementation of MNP. His result shows that in Finland, MNP was only applicable to contract users who were 96% of the total users. Finland is among the countries that had a positive report on the effect of MNP on its consumers. This was attributed to the enforcement powers that the regulator had. Bundled services, SIM-lock, lock-in contracts, and long contracts were banned. But the research failed to take into consideration the Key Performance Index of the networks in question.

Igbal (2017) conducted a study in South Asia about the effect of MNP and highlighted measures for the success of MNP. First, he says that high porting numbers are indicative of the successes of MNP. He mentions several countries such as Hong Kong, South Korea, and Australia introduced low prices. MNP has interconnection rates. Complexities are associated with international interconnections rates which depend on a country's rates.

Interconnection is defined as a 'technical and business setting where network providers hook-up their infrastructure, services and network to allow users to access the networks and customer's services of their respective network providers'. Interconnection must be regulated where competition in telecommunications services exists. However, the research fails to prove that competition is not an end but a means to an end (lower prices, high rates of innovation and investment) etc.

According to Nilsson, (2017), MNP involves a series of complex internal and external application integration. MNP is an IT infrastructure that comprises several heterogeneous systems and customized applications, with a Web-based integration platform to support its important protocols which enables applications to communicate.

For MNP to be successful, it requires all the internal applications to be properly integrated with external applications identified as the central reference database of customers.

Therefore, this work was designed to overcome such deficiencies found in previous studies within the Nigerian context.

In this research, a predictable mobile number portability model for some selected mobile network providers was presented.

Materials and Methods

The actual measurements for this research were from various points of interest in Aba, (Abia State), Umuahia, (Abia State), and Mbaise, (Imo State). For each of the locations, measurements were taken at hourly intervals and the obtained data were aggregated and averaged into the following Key Performance Indicators (KPIs) namely; Call Drop Rate (CDR), Call Setup Success Rate (CSSR), Agent Utilization Rate (AUR), Handover Success Rate (HSR), Awaiting Time (AWT) and Call Quality Factor (CQF) via the existing Base Station Controller (BSC) areas. The selected parameters were perceived to have a direct impact on subscriber experiences on the network in the independent survey. The GSM networks studied were MTN and Glo.

MNP Decision Algorithm

In actuality, many parameters should determine why customers would switch their operator but practically tariff plans, call quality factors, customer care services and network coverage parameters are more important for a customer to switch their operator. In this section, these four parameters will be used for MNP decisions using fuzzy logic. Based on these four parameters, the decision on whether MNP is to be done or not is considered. The tariff plan, call quality factor, customer care services and network coverage are input parameters and MNP is output parameters. Input parameter tariff plan gives the information of call rate per naira. In this research, the tariff plan was taken from a minimum of 5 available tariff plans to a maximum of 15 available tariff plans. The whole range was distributed in three levels: small, medium and large.

Fig. 1 shows the input membership function of the tariff plan. Cheap, affordable and expensive are used in defining the tariff plan.

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https://doi.org/10.5555/YXCZ4275 **ISSN 2488-8648**

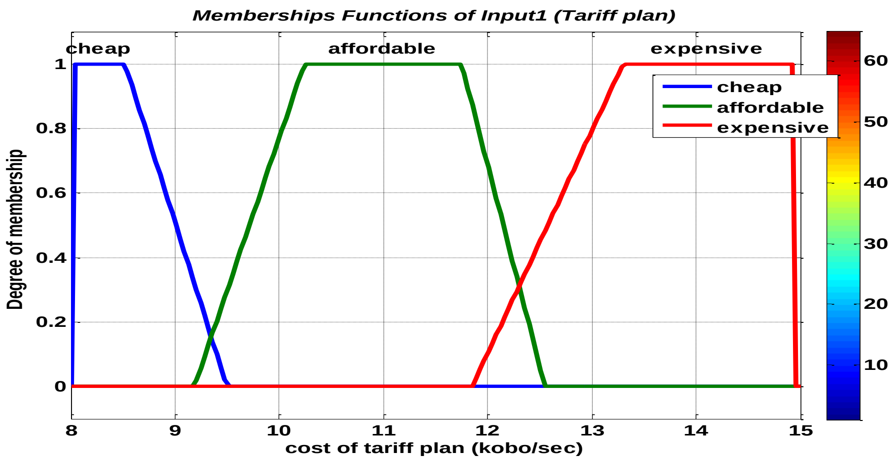

Fig. 1: Input membership function1 (tariff plan)

From Fig. 1, it was seen that the degree of membership function for the tariff plan isequal, but the cost of the plan (kobo/sec) differs. When the cost of the plan falls within 0 to 9.5 (kobo/sec), the tariff plan is said to be cheap. When it falls within 9.2 to 12.5 (kobo/sec), the tariff is said to be affordable. When it falls within 11.9 to 15(kobo/sec), the tariff is said to be expensive.

Fig.2 shows the input membership function of the network coverage. Poor, average and strong are used to define the network coverage.

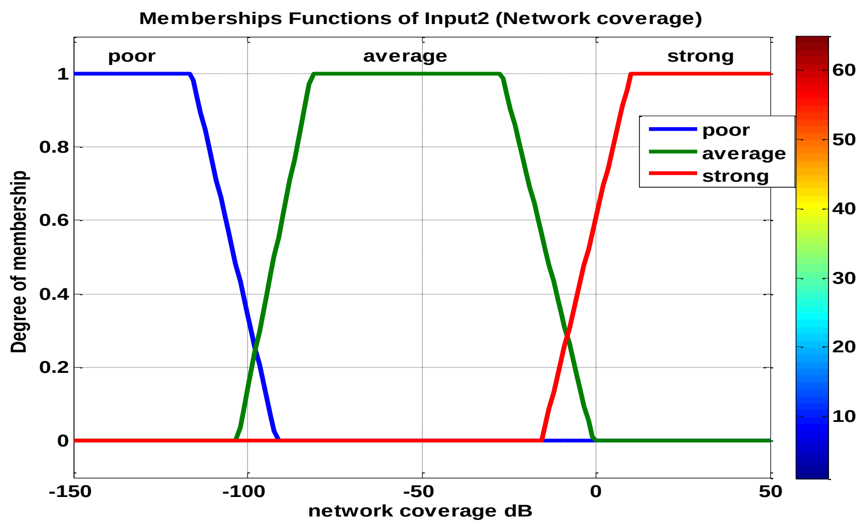

Fig.2: Input membership function 2 (network coverage)

From Fig.2, it was seen that the degree of membership function for the network coverage are equal to 1, but the network coverage in decibels (dB) varies. When the network falls within

-90 to -150 dB, the network coverage is said to be poor. When it falls within 0 to -110dB, the network coverage is said to be average. When it falls within -20 to 50dB, network coverage is said to be strong.

Fig. 3. shows the input membership function of the customer's services. Unsatisfaction, Medium and Satisfaction are used to define the customer's services.

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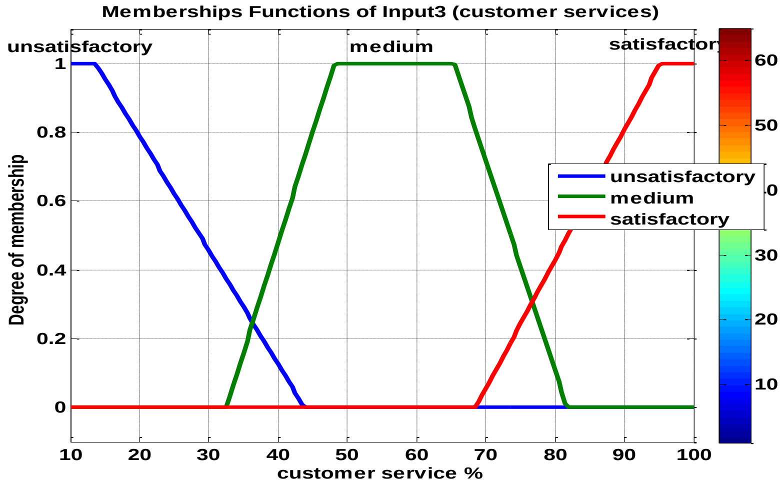

Fig.3: Input membership function 3 (customer service)

From Fig. 3, it was seen that the degree of membership function for the customer service are equal to 1, but the service rendered varies in percentage. When the service ranged between 10 to 45%, the customer's service is said to be unsatisfactory. When it varies between 33 to 82%, the customer's service is said to be medium. When it varies between 69 to 100%, the customer's service is said to be satisfactory.

If all the conditions as seen in Fig.1 to 3 are satisfied, then it gives the best MNP. If any one condition is low, or medium, then the result gives a moderate MNP. If any one condition is satisfied, but the remaining is low or medium, then it gives the result as a bad network.

Table 1: Table showing 27 fuzzy inference rules for making MNP decision

		RULE BLOCK	
	IF		THEN
Network coverage	Tariff	Customer care	MNP
POOR	CHEAP	UNSATISFACTORY	LOW
POOR	CHEAP	MODERATE	LOW
POOR	CHEAP	SATISFIED	HIGH
POOR	AFFORDABLE	UNSATISFACTORY	LOW
POOR	AFFORDABLE	MODERATE	LOW
POOR	AFFORDABLE	SATISFIED	MEDIUM
POOR	EXPENSIVE	UNSATISFACTORY	VERY_ LOW
POOR	EXPENSIVE	MODERATE	VERY_ LOW
POOR	EXPENSIVE	SATISFIED	LOW
AVERAGE	CHEAP	UNSATISFACTORY	MEDIUM

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AVERAGE	CHEAP	MODERATE	HIGH
AVERAGE	CHEAP	SATISFIED	HIGH
AVERAGE	AFFORDABLE	UNSATISFACTORY	MEDIUM
AVERAGE	AFFORDABLE	MODERATE	MEDIUM
AVERAGE	AFFORDABLE	SATISFIED	MEDIUM
AVERAGE	EXPENSIVE	UNSATISFACTORY	LOW
AVERAGE	EXPENSIVE	MODERATE	LOW
AVERAGE	EXPENSIVE	SATISFIED	MEDIUM
STRONG	CHEAP	UNSATISFACTORY	HIGH
STRONG	CHEAP	MODERATE	VERY_ HIGH
STRONG	CHEAP	SATISFIED	VERY_ HIGH
STRONG	AFFORDABLE	UNSATISFACTORY	MEDIUM
STRONG	AFFORDABLE	MODERATE	HIGH
STRONG	AFFORDABLE	SATISFIED	HIGH
STRONG	EXPENSIVE	UNSATISFACTORY	LOW
STRONG	EXPENSIVE	MODERATE	MEDIUM
STRONG	EXPENSIVE	SATISFIED	HIGH

Table 1 gives a rule block summary of the flow chart of the figure defining the fuzzy logic decision rule. The MNP decision was taken based on the combination and analysis of the three input membership functions. A high MNP was obtained when there was either moderate customer care or an affordable tariff plan combined with strong network coverage. A low MNP was obtained when any two of the inputs were on the low side and the third input on the high side. A very low MNP was obtained when all three inputs were on the low side or any input on the medium and the other two inputs on the low side. Table 1 gives an understanding of the fuzzy rule using if and then comments.

Fig. 4 describes the fuzzy inference system (FIS) showing the relationship among the three input membership functions cost tariff, network coverage, customer service and the output membership function. The FIS system was designed using the Mamdani decision system with 27 inference rules.

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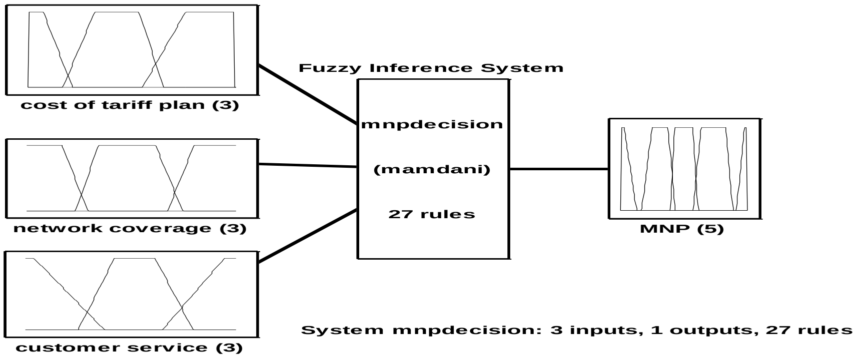

Fig.4: Fuzzy inference system model showing all input and output functions with 27 rules

Defuzzification

The method of obtaining a numerical result based on a defined fuzzy set and an output member function is called defuzzification. The output member function is shown in Figure 5. The center of gravity technique was considered to defuzzify the fuzzy result. Equation (1) describes the defuzzifier technique

.

$$fuzzycost = \frac{[\sum_{allrules} R_i \times \eta(R_i)]}{\sum_{allrules} \eta\,(k_i)} \qquad (1)$$

Where Fuzzy Cost represents the degree of deciding factor R_i denotes all fuzzy rules, $\eta(k_i)$ denotes all variables and $\eta(R_i)$ denotes its membership function. The output of the Fuzzy Cost function was changed to a numerical result based on the above-described defuzzification method.

Figure 5 shows the output of the Fuzzy Cost function. The MNP was divided into a set of k_i variables. The output parameter MNP gives information on the decision. In this, the MNP ranged from a minimum 0% to a maximum 100%. The whole range was distributed in five levels such as very low, low, medium, high, and very high

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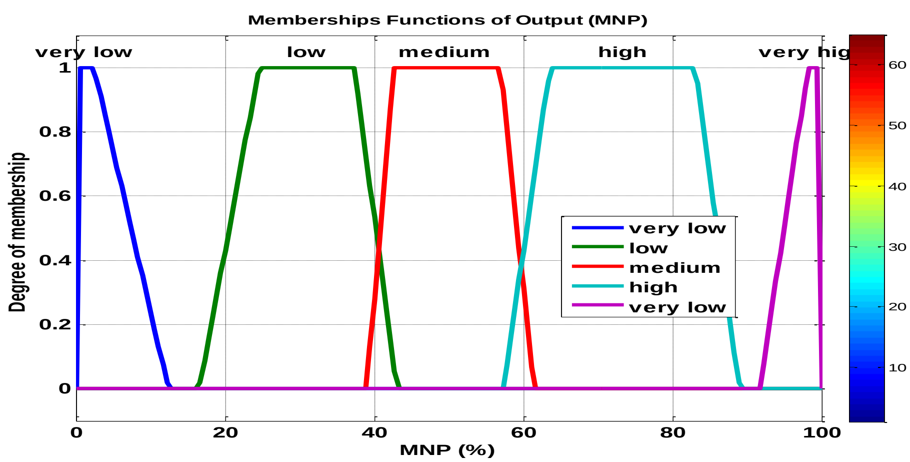

Fig.5: Output membership function of the MNP fuzzy inference system

From Fig.5, it was seen that the degree of membership for the output membership function of the MNP fuzzy inference system was the same at 1, but the output MNP in percentage (%) varies.

When the MNP output ranges from 0 to 20%, the MNP output is said to be VERY LOW. When it falls between 18 to 42%, the MNP output was said to be LOW. When it ranged between 39 to 62%, the MNP output is said to be MEDIUM. When it varied between

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58 to 90%, the MNP output was said to be HIGH, and when it ranged between 91 to 100%, the MNP output was said to be VERY HIGH.

Results and Discussion

Predictable Mobile Number Portability for Studied Case KPI's

By considering the studied KPI's, the fuzzy controller can be varied by modeling the average value of the KPI's for the period under study. This is to determine a predictable mobile number portability for the period under study. Figure 6 shows the rule-viewer adjustable knob of the fuzzy inference system which can be used to obtain a predictable MNP for the studied network operators using the given KPI's.

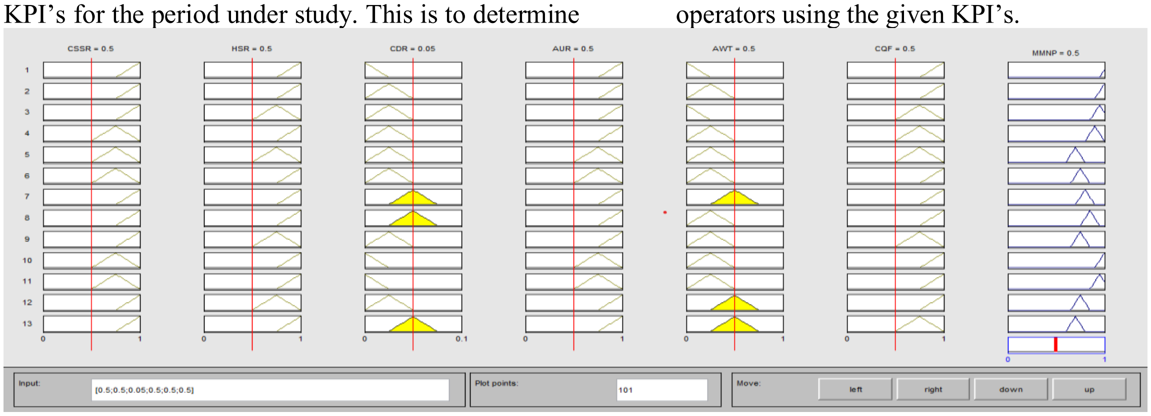

Figure 6: Rule viewer adjustable table for predicting MNP

Table 2: The predictable MNP for the months of June to November 2023

MNP (%)			
MONTHS	NCC	MTN NG	GLO NIG
JUNE	0.8	0.75	0.75
JULY	0.8	0.811	0.821
AUGUST	0.8	0.721	0.791
SEPTEMBER	0.8	0.813	0.748
OCTOBER	0.8	0.721	0.70
NOVEMBER	0.8	0.861	0.80

Using the predictable MNP for June 2022 in Table 2, a bar plot of Figure 7 was generated.

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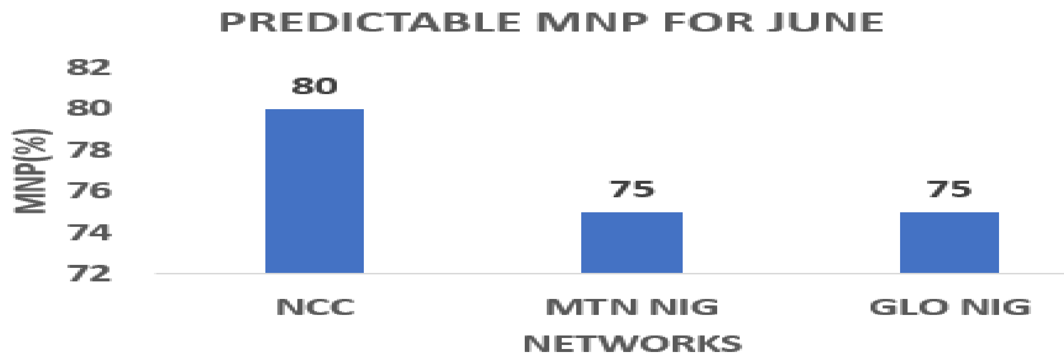

Figure 7: Plot of predictable MNP against network operators in June 2023.

From the plot of Figure 7, the standard predictable MNP for NCC was 80% (0.8). It can also be seen that for a user wishing to port to a better network, MTN NG and GLO NG were not able to meet the standard predictable MNP for NCC at 80%. Their MNP score was 75% each.

Using the predictable MNP for July 2023 in Table 2, a bar plot of Figure 8 was generated.

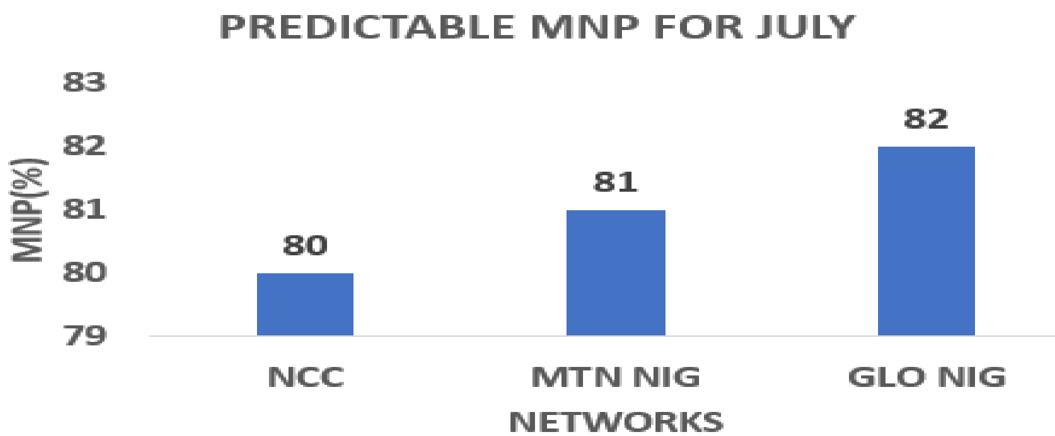

Figure 8: plot of predictable MNP against network operators in July 2023

From the plot of Figure 8, the standard predictable MNP for NCC is 80%. It can also be seen that for a user wishing to port to a better network, GLO NG is the best network operator to port into with MNP score of 82%. All networks predicted exceeded the NCC standard.

Using the predictable MNP for August 2023 in Table 2, a bar plot of Figure 9 was generated.

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https://doi.org/10.5555/YXCZ4275 **ISSN 2488-8648**

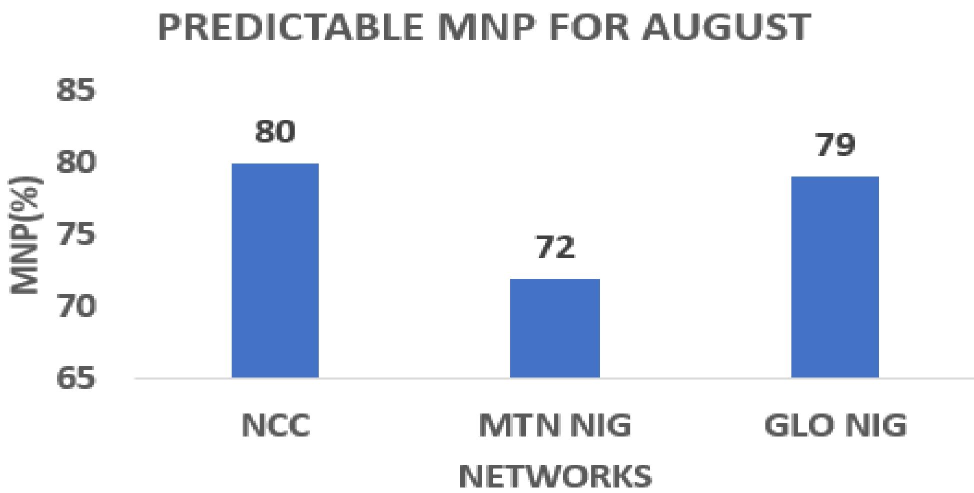

Figure 9: Plot of predictable MNP against network operators in the month of August 2023

From the plot of Figure 9, the standard predictable MNP for NCC was 80% (0.8). It can also be seen that for a user wishing to port to a better network, GLO NG is the best network operator to port into with MNP score of 79 %.

Using the predictable MNP for September 2023 in Table 2, a bar plot of Figure 10 was generated.

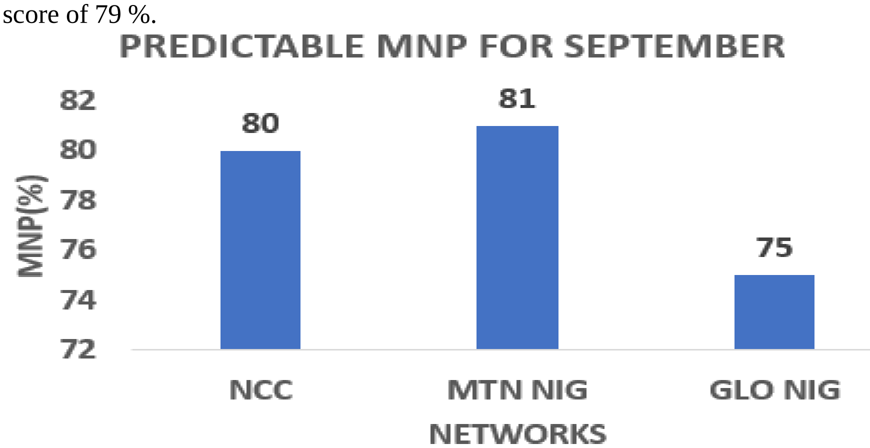

Figure 10: Plot of predictable MNP against network operators in September 2023

From the plot of Figure 10, the standard predictable MNP for NCC is 80% (0.8). It can also be seen that for a user wishing to port to a better network, MTN NG is the best network operator to port into with MNP score of 81%.

Using the predictable MNP for October 2023 in Table 2, a bar plot of Figure 10 was generated.

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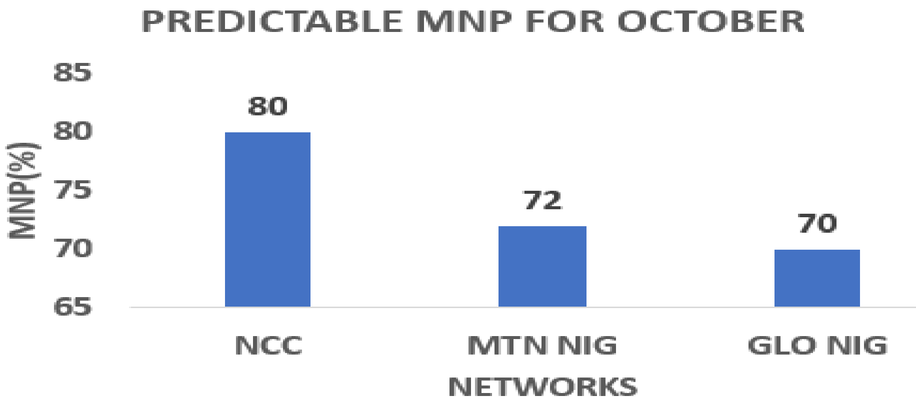

Figure 11: Plot of predictable MNP against network operators in October 2023

From the plot of Figure 11, the standard predictable MNP for NCC was 80%. None of the networks was able to meet the NCC predictable benchmark. MTN NG had MNP score of 72%, strongly followed by the Glo with a predictable MNP of 70%.

Using the predictable MNP for November 2023 in Table 2, a bar plot of Figure 11 was generated.

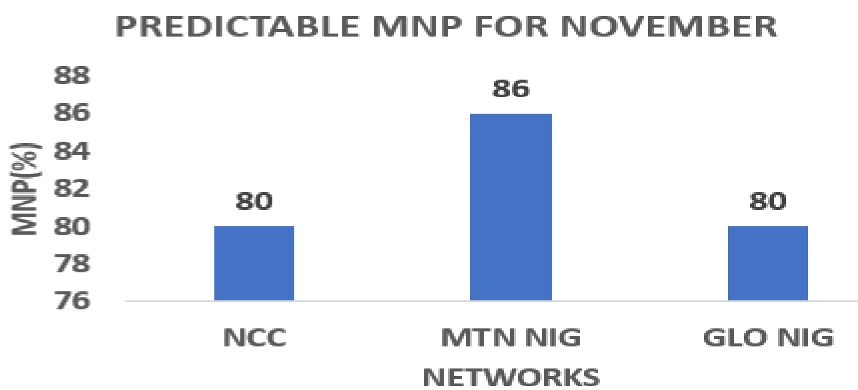

Figure 12: Plot of predictable MNP against network operators in November 2023

From the plot of Figure 12, the standard predictable MNP for NCC was 80%. It can also be seen that for a user wishing to port to a better network, MTN NG is the best operator to port into with MNP score of 86%, 6% better than the NCC target, strongly followed by GLO NG, with an MNP score of 80%.

Average Predictable Mnp for the Studied Period

To obtain the best predictable MNP of the considered network operators, the average of the MNP's for the six months under study was obtained and the results are shown in Table 3.

Table 3: Average predictable MNP score for the studied period

NETWORKS	NCC	MTN NIG	GLO
MNP	80	78	77

Using the Average predictable MNP score for the studied period in Table 3, a bar plot of Figure 13 was generated.

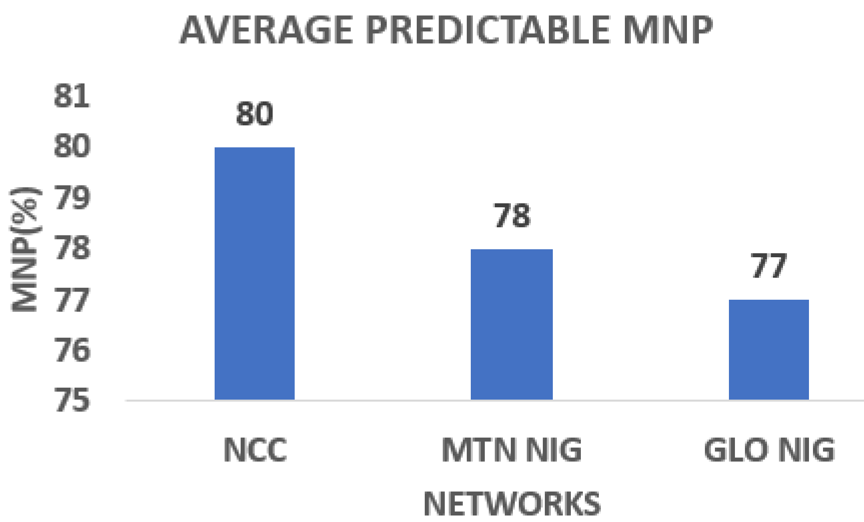

Figure 13: Plot showing average predictable MNP for the 6 months of study

From the plot of Fgure 13, it can be observed that taking an average of the MNP for the various networks under study, MTN NG ranked first with an average score of 78%, strongly followed by GLO NG with an MNP score of 77%.

Conclusion
In this research, predictable mobile number portability for mobile network provider's decisions using a Fuzzy framework was developed. The customers' parameters while focusing its evaluation based on a set of benchmarks which are considered as crucial for deployment while taking cognizance of user's requirements of mobile devices was shown.
By considering the studied KPI's, the fuzzy controller was varied by modeling the average value of the KPI's for the period studied.
The prediction for mobile network providers could be of immense assistance should the Nigerian Communication Commission decide to revisit the mobile number portability as earlier promised from the available literature.

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Appendix 1: The KPI raw data

JUNE

	ABA		UMUAHIA		MBAISE	
KPI	MTN	GLO	MTN	GLO	MTN	GLO
CSSR	0.9	0.85	0.92	0.9	0.87	0.84
HSR	0.7	0.9	0.8	0.9	0.9	0.91
CDR	0.04	0.05	0.04	0.06	0.05	0.05
AUR	0.9	0.8	0.9	0.84	0.91	0.81
AWT	0.65	0.68	0.64	0.67	0.65	0.69
CQF	0.9	0.75	0.91	0.76	0.9	0.74

JULY

	ABA		UMUAHIA		MBAISE	
KPI	MTN	GLO	MTN	GLO	MTN	GLO
CSSR	0.87	0.9	0.86	0.91	0.88	0.9
HSR	0.78	0.91	0.81	0.90	0.77	0.92
CDR	0.038	0.06	0.034	0.05	0.037	0.061
AUR	0.95	0.85	0.93	0.80	0.91	0.89
AWT	0.522	0.351	0.491	0.241	0.531	0.371
CQF	0.93	0.8912	0.94	0.911	0.931	0.8721

AUGUST

	ABA		UMUAHIA		MBAISE	
KPI	MTN	GLO	MTN	GLO	MTN	GLO
CSSR	0.9212	0.9	0.91	0.91	0.9210	0.9
HSR	0.81	0.89	0.78	0.90	0.76	0.90
CDR	0.03	0.033	0.041	0.031	0.03	0.034
AUR	0.94	0.83	0.92	0.86	0.95	0.81
AWT	0.52	0.61	0.51	0.59	0.60	0.63
CQF	0.92	0.95	0.88	0.91	0.872	0.871

SEPTEMBER

	ABA		UMUAHIA		MBAISE	
KPI	MTN	GLO	MTN	GLO	MTN	GLO
CSSR	0.95	0.9	0.94	0.91	0.96	0.89
HSR	0.83	0.94	0.84	0.93	0.87	0.92
CDR	0.05	0.01	0.06	0.02	0.04	0.01
AUR	0.92	0.83	0.91	0.84	0.93	0.82
AWT	0.5	0.3	0.49	0.4	0.51	0.3
CQF	0.9	0.9	0.92	0.9	0.9	0.92

OCTOBER

	ABA		UMUAHIA		MBAISE	
KPI	MTN	GLO	MTN	GLO	MTN	GLO
CSSR	0.9	0.8712	0.91	0.881	0.89	0.870
HSR	0.8921	0.92	0.8811	0.91	0.891	0.90
CDR	0.033	0.03	0.034	0.031	0.033	0.03
AUR	0.9	0.89	0.91	0.88	0.89	0.87
AWT	0.25	0.41	0.30	0.42	0.21	0.39
CQF	0.98	0.82	0.97	0.84	0.97	0.83

https://doi.org/10.5555/YXCZ4275 ISSN 2488-8648

NOVEMBER

	ABA		UMUAHIA		MBAISE	
KPI	MTN	GLO	MTN	GLO	MTN	GLO
CSSR	0.93	0.92	0.92	0.91	0.93	0.90
HSR	0.78	0.9	0.82	0.89	0.79	0.91
CDR	0.013	0.0332	0.014	0.032	0.013	0.033
AUR	0.9	0.8	0.92	0.81	0.93	0.9
AWT	0.367	0.24	0.371	0.30	0.381	0.252
CQF	0.95	0.93	0.96	0.91	0.94	0.92