International Journal of Business, Human and Social Sciences
ISSN: 2517-9411
Vol:12, No:10, 2018

A Geospatial Consumer Marketing Campaign Optimization Strategy: Case of Fuzzy Approach in Nigeria Mobile Market

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Abstract**—**Getting the consumer marketing strategy right is a crucial and complex task for firms with a large customer base such as mobile operators in a competitive mobile market. While empirical studies have made efforts to identify key constructs, no geospatial model has been developed to comprehensively assess the viability and interdependency of ground realities regarding the customer, competition, channel and the network quality of mobile operators. With this research, a geo-analytic framework is proposed for strategy formulation and allocation for mobile operators. Firstly, a fuzzy analytic network using a self-organizing feature map clustering technique based on inputs from managers and literature, which depicts the interrelationships amongst ground realities is developed. The model is tested with a mobile operator in the Nigeria mobile market. As a result, a customer-centric geospatial and visualization solution is developed. This provides a consolidated and integrated insight that serves as a transparent, logical and practical guide for strategic, tactical and operational decision making.

Keywords**—**Geospatial, geo-analytics, self-organizing map, customer-centric.

I. Introduction

THE integration of geographical intelligence and various geospatial dimensions into various aspect of marketing is referred to as geomarketing [66]. In general, geomarketing research uses geographical parameters in marketing research methodology. These include sampling, data collection, and presentation. Geomarketing impact on modern trade and the business strategy of the organization is significant, and a key factor in this discipline is location. For example, combining geographical locations of consumers with their demographics data can be used in geomarketing analysis to determine where the high-value segments of the customer base reside. Geomarketing leverages different parameters such as a good base map, reliable customer profiling, fine data layers and well-defined success or failed criteria [67].

Acquisition, retention, and ability to gain market share have become a challenging risk for businesses with a large consumer base because of the high level of competition. A typical example is the mobile telecommunication landscape in Nigeria. One of the differentiating factors in gaining market share is a firm's ability to apply the knowledge gained from hidden customer insights within the data available across the enterprise [11].

This paper discusses how firms with large customer base can leverage geomarketing to optimize the business revenue. The paper considers the various aspect of marketing strategy that can be influenced by a well-executed geomarketing analytics and focuses on the optimization of marketing campaign initiatives within the mobile market space. Section II details a review of the literature on the usage of Geographical Information System (GIS) in firms with a large customer base and power of geomarketing analytics in decision making. Clustering techniques comparison for different market segmentation is highlighted in Section III along the fuzzy clustering and algorithm. In Section IV, a fuzzy geomarketing clustering model is constructed through a Self-organizing map (SOM) with data analysis and model implementation using a mobile operator in Nigeria as a case study. Findings which include parameters and outcomes of the study are detailed in Section V with appropriate strategy formulation and allocation for easy and practical deployment of consumer marketing initiatives.

II. Literature Review

About 75% of all business data has been estimated to contains geographic information [17], [3]. Hence, the ability to leverage the consumer geographic information to optimize business revenue is essential for firms with the large customer base. Example of firm's strategy that is based on geographical information and geospatial data include, the decision of where shops will be located, where the base station needs to be deployed or where a dealer partner needs to be located. Also, how above-the-line (ATL) and below-the-line (BTL) marketing budget will be distributed can be determined by geospatial information [19]. Traditional methods such as charts and tables can be used to present geospatial data. However, unique relationships that are hidden in geospatial data can be shown through a geospatial visualization process. This is commonly referred to as geo-visualization [19].

According to [27], [46], [20], common tools for the search of information through visualization include Bing Maps and Google Maps, with which users can visualize and locate geo-referenced information such as customers, shops, businesses and even competition location. Specific examples as it relates to mobile network providers include the ability to determine network signal strength at street level, experience center location relative to competition and cluster of customers with similar characteristics and behavior. As mobile devices and terminals become increasingly networked with more sophisticated location capabilities, available data across

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enterprise consists more of geographic or geo-referenced data. With this increase in the readily available geospatial data, it is crucial for service providers not only to understand the geospatial system but also to leverage their unique characteristics and build it into their overall business strategy for optimal business performance. For marketing campaign across channels to be strategically optimized within a multi-distribution system such as the mobile market space, four issues have been identified which marketers must confront [14]. Firstly, there must be synergy within the channel. Priorities confronting channel members must be understood, and the conflicts within channels must be resolved. Lastly, optimal channel mix must be identified. It has also been argued that choosing optimal distribution mix in multiple marketing and distribution channels is difficult as a result of the unique strength and weakness of each marketing and distribution channel [1], [13], [34]. When a firm leverages the available geospatial data, some of these channels challenges can be easily addressed. Also, several studies have shown that marketing costs play a key role in selecting a channel [14]. Reference [35] argues that firms can minimize costs in channels if the channel chosen properly matches its business. In evaluating several results such as [16], [59], there are indications that complexity of relationship interdependency exists among marketing channels. The evolution of technological advancement currently provides us with quality data in their rich format, and this is driving us fast to develop appropriate methods for dealing with them.

A. The Usage of Geographic Information System (GIS)

Several description and definition of decision support system (DSS) used by firms in making decisions are summarized by [51]. GIS is described as a computer-based spatial decision support tool that enables the input, management, analysis, output and dissemination of geo-referenced data and information [12], [49]. Spatial interactive models in GIS helps to understand and predict the location of activities and the movements of customers along with competition activities in calculating real distances between origins and destinations, store attribute information and individual location [25]. Robust studies exist with many perspectives on the impact of GIS application across various fields and industries. [51], demonstrates GIS as a decision-making tool in transportation and medical fields. As for [18], GIS was used to calculate the potential size of the market following the socio-economic profile of the trade area. Reference [22] shows that GIS can be integrated with other applications to provide timely insights for management. Moreover, the service industry has leveraged GIS and GPS in data collection, data storage with the visualization in airport management system [15], [53]. The idea of trade area analysis is becoming popular and appealing in the field of retail analytics because it helps to gain a much-needed understanding of the business potential and the competition with other retailers. Marketing managers use marketing DSS in their daily analysis and decision-making process [68], [58]. Reference [31] argues that the value of a consumer market is measured by its economic, demographic and geographical dimensions. This paper, therefore, focuses on the demographic, geographic and economic factors that exist within the geography of the business existence. This paper intends to provide marketers and the business at large with optimum strategy upon which campaign and infrastructure investment decisions can be made [2], [9]. In this study, our model is implemented using a case of a mobile operator in Nigeria mobile market where all external and internal data are integrated on GIS with enabled spatial visualization. Reference [43] presented the importance of technology when combined with marketing information systems model. Reference [62] classifies this into four major sub-systems. These are internal record systems, a marketing research system, a marketing intelligence system and a market DSS. For a mobile network service, the internal records systems house the information such as costs, sales and cash flows. The research system can be classified as relevant marketing research processes such as information gathered through a research agency in the form of a retail audit report, and reports of competition stores around a geographical location. As for market intelligence system, this is a typical business intelligence system which feeds on systems across the network elements. This system will be feeding on systems such as billing system, retail and shop application, call center applications, network applications and every other system within the network. These are all stored in the database. The marketing DSS is designed purposely for analyzing marketing campaign execution and campaign performance evaluation to enable executives to take an informed decision that is data-driven. This system typically consists of the decision and analytical models based on statistical techniques because mobile network operators have huge and rich amount of customer data. Several models such as churn prediction models, usage optimization model and other behavioral models can be integrated into these systems. With these four sub-systems, firms with large customer base may be more effective and efficient in marketing activities and marketing strategy development and planning [68].

The competition in the mobile industry in Africa is very fierce. One of the reasons for this is because most of the markets are predominantly prepaid market. The entry barrier is low, which is resulting in high churn rate. For an operator to be competitive, being aware of the activities of the competitions, customers, and the entire market are some of the main steps that can aid competitiveness. GIS is used in marketing information systems as a tool for the decision-making process. What marketers do is decision making. Decisions such as what offer to sell and to whom the offer should be targeted. What location to open a new store or close a store. Where are the clusters of the high net worth individuals and so on? The popularity of GIS is because of its powerful visual presentation capabilities and spatial relationship analysis [76].

B. Geospatial Marketing and Power of Location

According to the United Nations initiatives on Global

Geospatial Information Management (UN GGIM), data that are generated every day is in the neighborhood of 2.5 quintillion bytes, and a considerable portion of the data is location-aware. Data that Google generates is about 25Pb with a sizable portion of the data in the space of spatiotemporal data [76], [71]. As the mobile smartphone penetration increases with increasing digital contents, we expect to see increasing growth in this trend [52].

According to [65], "location targeting is holy grail for marketers." Geomarketing analytics is an effective way to operationalize the power of location for the effectiveness of marketing activities. For example, a mobile operator can benefit from analyzing purchase or usage patterns of the regions designated by the location where a customer first joined the network [8]. According to [46], direct marketing can also benefit from the analysis of human mobility. This is supported by Tobler's first law of geography [70]; "*everything is related to everything else, but near things are more related than distant things.*" This means that for example, the retail outlet of a mobile service provider that is close to the current location of a user should be more effective than suggesting those that are far away. The embedded functionality of location has been combined with social networking, news, information and digital services [10]. Hence, businesses are willing to invest in the power of location with the aim to improving business revenues [46].

Combining geospatial methods with conventional marketing techniques enables marketers to visualize the spatial distribution of data on maps and spatial data in various statistical graphs and diagrams. This may clearly reveal more insights into customer relationship and other internal and external factors that may influence customer behavior with direct impact on revenue [56]. Businesses are aware of the importance of geographic location in planning and evaluating marketing strategy. For example, this knowledge can be used in determining the variations in product penetration, channel territories determination, store location, evaluation of campaign and promotional efforts, forecasting, and market potential analysis [75].

III. Clustering and Market Segmentation

According to [48], market clustering originated as a result of the need for segmentation and profiling of the market which [64] first defined conceptually as heterogenous. The underlying and driving strategy behind market segmentation is towards the development of a robust, targeted marketing campaign along with a customized offering across segment for effective profiling decisions and marketing development plans [7], [41], [42], [69]. Reference [24] submits that there are several targeted market characteristics that exist for segmentation. These include demographics or related socioeconomic factors, geographic location, product-related behavioral characteristics such as purchase and consumption behavior. The approach classification of market subsets and grouping them into specific but differentiated groups is one of the major aims of clustering [4]. The objective of these approaches is to identify and put the consumer in each subset into homogeneous groups for ease of marketing planning and provisioning [24]. (Table I) summarizes the various clustering methods along with their advantages and limitations.

TABLE I
Clustering Methods Evaluation

Methods	Advantages	Limitations
SOM [24], [45].	1. No prior assumption about the hidden distribution of data [73]. 2. Visualization advantages [24]. 3. Amount of data reduction. 4. Impact of missing data is minimum [73]. 5. Robust methodology [73]. 6. High accuracy [21].	1. Initial weight settings and the need for setting stop condition [37].
Extended SOM [36].	1. No overlapping [24]. 2. The same as SOM. 3. Dependency on sample size does not exist [24].	1. Lack of visualization and lack of difference from SOM [24].
K-means clustering [44].	1. Time of execution efficiency [6]. 2. High level of accuracy [21]. 3. Robust methodology [61].	1. Pre-defined cluster number is required [6], [61], [24]. 2. Lack of visualization [24]. 3. Dependency on the initial cluster centers [6], [61], [48]. 4. May fall in local optimal [48].
GA K-means [37].	1. Non-overlapping clustering [6], [24]. 2. GA is used to identify initial seed [6], [24].	1. The visualization is somewhat weak [24].
Automatic Interaction Detection [72].	1. Good for small sample size [48]. 2. Non-overlapping clustering [6].	1. No visualization 2. Optimization constraint within segment homogeneity [48].
Hierarchical clustering [21].	1. Appropriate for small sample size [28], [48]. 2. Non-overlapping	1. No visualization and low accuracy [48].
Simulated annealing [44].	1. Avoid local optima.	1. No visualization and show in reaching the optimal solution [32].
Fuzzy clustering [29].	1. Impact of missing data minimum 2. Initial assumption on the underlying distribution of data not required 3. Good for large sample data size [21].	1. No visualization and overlapping clustering [24]. 2. Difficult to decide clusters number 3. Determination of initial cluster centroids

A. Techniques of Fuzzy Clustering and Algorithms

What defines the fuzzy clustering techniques are the data segmentation, and the way data is clustered and mapped by grouping related attributes in uniquely defined clusters [50]. In fuzzy clustering, an identity is given to a data point within the sample space, and it is assigned only to one cluster. Following the data partitioning, data points are fixed while the cluster centers are fixed [23]. There is a self-iterative process that exists in this clustering which helps in defining better cluster centers at each iteration level. K-means algorithm remains the most well-known methods and commonly used portioning method [50]. In this method, k represents the number of cluster seeds initially provided for this algorithm. Therefore, the input parameter is represented as k, and it partitions set of m objects into k clusters. According to [77], this technique computes the Euclidian distance that exists between a data point and the cluster center to add the item into one of the clusters. This results in high intracluster similarity and low intercluster similarity. Euclidian distance is calculated by the sum of squared differences as follows [47]:

$$d_k = \sum_n \| X_j^k - C_j^i \|^2 \quad (1)$$

where d_k is the distance of the k_{th} data point; n is the number of attributes in a cluster; X_j^k is j^{th} value of the k^{th} data point; C_j^i is the j^{th} value of the i^{th} cluster center;

Initialization occurs randomly within the centers which are cluster t and a data point x_i to a cluster for which distance is the least distance for new cluster centers. For new cluster centers, the calculation is done after all these data points are assigned to various clusters by calculating the weighted average for all data points in a cluster. Due to this calculation of the center of clusters, there is a movement towards the center of cluster set. The repetition of this process continues until the change in cluster centers is nil [50].

While the real world does not appear in a defined boundary, they also have the several shortcomings [39], [30]. Data in the real world is unclear and not definite. Real world data is also doubtful because it does not contain all the information. Sometimes, real-world data is vulnerable to change and ambiguous because of many results that can be derived from it. The parameter which can change in real-world data is not dependable [50]. Reference [39] classifies the above categories of limitations into vagueness and uncertainty. Using fuzzy sets, the knowledge of quality and certainty can be addressed.

Membership is assigned to clusters in fuzzy clustering. Algorithms which are fuzzy in nature allow clusters to grow. In some cases, membership value is very low which indicates that some data points may be outliers with respect to the cluster. In the case of crisp techniques, it may be difficult to address outliers, but these outliers are assigned a small degree of membership in case of fuzzy techniques. Membership degree shows the degree to which the data point represents a cluster. Hence, fuzzy logic handles data which is vague or which is not certain [50].

B. Fuzzy C-Means and GK Clustering Algorithm

The Fuzzy C-Means algorithm involves an iterative process in which cluster centers are calculated, and points are assigned to these centers using the well-known Euclidian distance formula. It is iterative because this process is kept repeating itself until the cluster centers are stabilized (see Table I). Membership value is assigned by the algorithm of data items for the clusters within a range of 0 to 1 [5].

The fuzzification parameter determines the degree of fuzziness in these clusters. This parameter m is in the range [1, η]. The algorithm works just like a crisp, positioning as the value of m equals one. The membership value μ is also calculated by the algorithm [50].

For powerful clustering techniques which involves various domain applications Gustafson-Kessel (GK) clustering algorithm is commonly used. One of the advantages of GK algorithm is that it adapts the clusters according to the real shape of the cluster. However, GK algorithm shortcomings are due to advance made regarding the number of clusters by a scheme which is iterative optimization (see Table I) [50].

IV. A Case Study of an Operator in Nigeria Mobile Market

A. Customer-Centric Geospatial Solution

The motivation for this research came because of the need to provide consolidated and integrated insights that can be used for strategic, tactical and operational decision making by a mobile operator in Nigeria. The mobile industry landscape in Nigeria is being reshaped because of so many factors. Some of the factors are the unfavorable regulation, the decline in voice revenue due to unregulated over-the-top (OTT) and fierce competition for the battle of a share of wallet. Also, recent regulations on SIM card registration have also impacted so much on acquisitions of new customers which has resulted in the erosion of value of the industry, in which every operator takes its share. At this point, one of the operators was compelled to leverage both the internal and external data to develop and establish strategic guidelines for the immediate and future strategic decisions.

The executives of the mobile operator including the marketing leadership requested for a geomarketing solution with a focus on three things:

1) A customized tool that would provide insights into the ground realities regarding customer, competition, channel and network.
2) Insights that will provide areas (states and districts) for expansion, growth, and protection.
3) A tool to track performance and implementation of strategic initiatives over a period.

Firstly, we conducted interviews with the managers of the mobile network which include experts from Marketing, Sales, Distribution and some other functions in the organization to understand the needs and business strategy focus of each of these business streams. Upon these discussions, we found there are about five areas we need to focus on. They are communication, sales, channel, network and marketing campaigns and actions (see Table II)

B. Self-Organizing Maps (SOM)

SOM was introduced in 1981 as a neural network architecture algorithm for the first time and was practically used in 1984 for voice recognition [40]. SOM uses unsupervised and competitive learning to produce low dimensional and discretized representation that present high dimensional data and at the same time preserve similarity relationship within the data items. This type of low dimensional representation is referred to as a feature map [54]. A SOM is a single layer neutral network with units set along an n-dimensional grid [40]. SOM is not only frequently used in data mining but also in image processing, complex spaces display, financial analysis, medical diagnoses and industrial detection [74]. The fundamental of SOM is to map spaces with several high dimensions into two-or-three-dimension space in a way that minimum information is lost and the hidden information in relations among the data can be discovered and showed. This method may show the correlation between data, information and their mutual effects on each other [24]. There are typically two layers of nodes in SOM network – the input layer and the map layer. SOM as a neutral architecture can learn without supervision (unsupervised) from the training data without specified input/output pairs [54].

The SOM is the appropriate method for geomarket clustering due to the combination of its capability of taking into consideration the location of the markets and its conceptual and geographical visualization [38], [60].

TABLE II
A STRATEGIC PILLAR FOR GEOMARKETING SOLUTION IMPLEMENTATION IN MOBILE INDUSTRY

Strategic Pillar	Example of Use
Communication	Optimized the deployment of ATL communication based on in-depth understanding of customers in a district.
Sales	Identification of states, districts where SIM cards sale and /or top-up is underperforming and then appropriately create remedial action plans.
Channels	Identify ideal location and format for own-shops / outlets based on customer profile in the district
Network	Understand Network QoS based on KPIs in relation to the customer base it is serving
Marketing Campaigns	Tailored regional offerings can be devised based on the “Ground Realities.”

C. Research Methodology

Apart from the strategic needs for this research which has been highlighted in the previous section, Table III shows the three stages in which this research is presented along with the approach of [24].

TABLE III
STAGES OF RESEARCH METHOD AND DEVELOPMENT

Stages	Descriptions
Stage 1 Model development, data set and variables construction	1. Problem definition with research goals, scope and methodology. 2. Identification and gathering of a list of demographics, behavioral and geographical variables used for segmentation in marketing literature with the view of selecting most appropriate variables.
Stage 2 Geomarket cluster construction (SOM network development)	1. Model construction, network development and parameter configuration. 2. Finalization of the data set obtained from the mobile operator business intelligence data warehouse and other network element across the operator enterprise. 3. Processing of the data which includes standardizing and dataset normalization. 4. Setting initial weights and training the network using data set. 5. Tagging of segments and subsegments.
Stage 3 Result Interpretation and implementation - Analysis	1. Selection of a sample customer set from each segment across the district and clusters. 2. Investigating and modeling the value of each sample customer to the operator products and services. 3. Analysis of segments behavior.

D. Model Development

Fuzzy Delphi method has been previously used to identify critical factors in the mobile industry context. Rand Corporation originated Delphi method in series of their studies in the 1950s [57]. The idea was to construct a technique to obtain most reliable information from external expert sources, such as key trade partners in the channel, frontline agents in the stores and various industry experts as in this case. The traditional Delphi method has always suffered from low convergence expert opinion [24], high execution cost and the possibility of filtering out important expert opinion. Hence, [55] proposed the idea of constructing the Delphi method and the fuzzy theory to improve vagueness and ambiguity of Delphi method. [26] leverage triangular fuzzy number to support expert opinions and establish the Fuzzy Delphi method. This revealed the advantage and simplicity which can encompass all expert opinion in one investigation.

The question in the fuzzy Delphi questionnaire contains a list of variables frequently mentioned in clustering and segmentation literature and distributed to commercial strategy experts of the mobile operator. A five-point Likert scale was used to ask respondents on the influence of each variable on several customer behaviors.

E. Geomarketing Cluster Construction – SOM Development

Several data items were collected through a survey sent to the mobile operator customers via email. The questionnaire was pre-tested by interviewing a few customers to avoid probable misunderstanding. Three dimensions were included in the questionnaire – geographical, demographics and psychographics. A neuronal grid that structurally represents the overall territory is produced.

The first step in dataset preparation is the selection of the target geomarkets. In this study, we focused on the PAN Nigeria as a country. We classified the data dimension layers into four groups; the demographic layer, network layer, sales, and distribution layer (see Fig. 1). In the demographic layer, the Nigeria 37 states including the Federal Capital Territory were bifurcated into 826 districts for the mobile operator. We refer to this as operator district (OD). Each district is created based on its unique characteristics such as residential, commercial and concentration of high-value customers [63]. Also, population and market share data are provided by the operator and from other sources such as the regulator website. Another key task is the development of a reference data set to sustain this study. Market clustering supposed to be data-driven and the selection of a set of segregation variables to be used for the clustering analysis [38].

The network layer is complex. A customer is attached to a base station when the majority of the customer mobile usage is generated on the base transceiver station (BTS). Home location is taken via a visitor location register (VLR) snapshot over a period. Utility for the mobile operator such as minutes of use (MOU) and revenue is an aggregation of the BTS within a specific district. The figure of Merit (FOM) is defined as the weighted score based on individual BTS while key performance indicator utilization levels are based on peak hour.

For sales and distribution layer, operator distribution points were mapped. Also, competition stores were obtained from the website and mapped. In the customer layer, customer data was taken from various sources across the enterprise. Analytical models were created and serve as input data. These analytical models were created via scripting and data transformation [33].

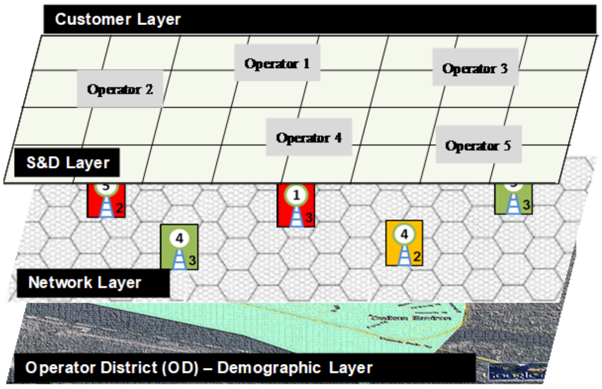

Fig. 1 Layers and complex interdependencies of parameters

V. Findings

A. Parameters and Outcome of the Study

Five key parameters become the drivers and outcome of this study (see Table V) below.

TABLE IV
DISTILLATION AND INTERPRETATION OF INFORMATION – ACTIONABLE AND TRACKABLE OUTCOMES

Parameter	Possible Outcome	Definition
Penetration	High (H) or Low (L)	When penetration level of the state or district is below that of natural average, then penetration is "L" otherwise it is "H."
Network	Good or bad	When the over utilization level of the state or district is lower than that of the national average, the network is "G" otherwise "B."
Sales and Distribution (S&D)	Good or bad	When OD has first and second highest number of location in the state or district, then S&D is "G" otherwise "B."
Fair share	Yes or No	When operator market share is higher than national share or OD share is higher than the state then fair share is "Y" otherwise it is "N."
Customer value	High or Low	When the operator average revenue per user (ARPU) in the state is higher than the national ARPU or OD ARPU is higher than the state ARPU then customer value is "H" otherwise it is "L."

B. Strategy Formulation

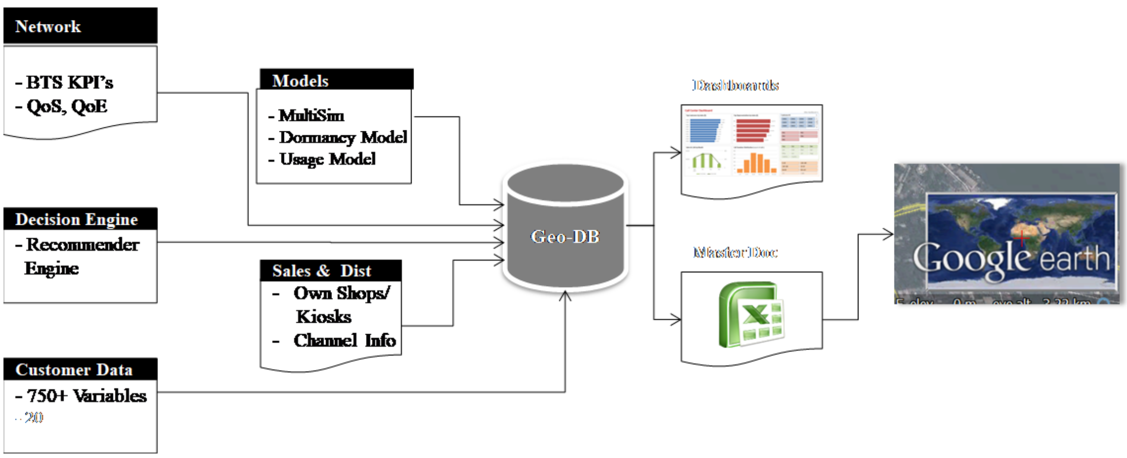

Fig. 2 Solution architecture of various data sources

TABLE V
SNAPSHOT OF A TYPICAL GEOMARKETING STRATEGY ALLOCATION

Market Strategy	Sub-strategy	No. of States	No. of Districts	Rationale
Expand	Acquisition	13	308	Under penetrated, either network or S&D is in place to acquire.
	Churn	2	32	Penetrated district, all resources to acquire from competition available.
Grow	Invest in S&D and Network	1	32	Under penetrated but lacking a component to properly expand.
	Farm the base	10	200	Penetrated market, resources in place maximize.
Protect	High-Value Customer (HVC)	3	72	High % of HVC, revenue is skewed to them.
	Invest in S&D and Network	8	100	Need to invest in resources to protect the customers
Low Priority			83	Deprioritize based on market potential

VI. DISCUSSION

This study is focused on geo-marketing analytics and how GIS can be used as a tool in the information of marketing and commercial strategy of a firm with large customer base. In this study, a mobile network operator is used as a case study. A customer-centric geospatial solution that provides consolidated and integrated insights that can be used for strategic, tactical and operational decision making is developed. The outcome of this study exposes us to the ground realities regarding customer, competition, channel and the network quality of the mobile operator.

This research answers a series of tough questions which a mobile operator asks daily. Questions such as where do we have high-value customers? Which areas do we need to prioritize our marketing activities to achieve most benefits? Do we have more shops than competitions in these regions? Is there an opportunity to grow adoption of service in these districts? Where are our high-value markets and where do we have good network quality? This study provides to the operator a tool to track performance and implement strategic initiatives based on the ground realities for expansion, growth and protection over a period.

VII. CONCLUDING REMARKS

This study is one of the few types of research that empirically demonstrates the importance of geomarketing analytics and visualization in the strategic decision making of mobile operators within the mobile market. The main research findings and strategic outcomes are summarized in Tables IV and V. The outcome of this study presents a mobile operator with the ground realities upon which critical strategic and tactical decisions can be taken to improve business performance and customer experience. The results provide visualized and insightful output for the operation mangers that are saddled with various responsibilities across Marketing, Sales and Technical departments for immediate deployment of consumer initiatives across the network. With the outcomes of this study, the mobile operator is well positioned competitively to visualize complex interdependencies of various parameters across the regions, states, and districts for effective consumer initiative and campaign deployment.

VIII. SCOPE FOR FUTURE RESEARCH

This research has some limitations that should be highlighted and provide avenues for future research. For the scope of this research and the implementation of this study, we relied on the experience of the senior executives that are involved in the day to day operational activities in Marketing, Sales, Engineering and Technical departments of the mobile operator in Nigeria. This research has been validated empirically. However, availability of historical trends on performance on the visualization could have improved the graphical trend analysis of performance. About 32 different combinations are used in this study to show the base station (BTS) information. Increasing the combinations will show more precise information on the BTS. On the key performance indicator (KPI) of the customer events such as data revenue and device types, we are constrained to use tri-monthly data in this study.

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