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Research Paper

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ABSTRACT

Community Based Location Service (CBLS) provides information about services, based on the geographical location of subscriber's mobile phone, towards the development of the user's community.. With the increase in mobile phone penetration, citizens can participate actively in assisting the service provisions and infrastructure in the country by providing relevant information through their mobile devices. This paper proposes a framework for improving services and providing better infrastructure for developing countries. The framework hinges on four major technologies: location-based information, crowdsourcing, mobile communication devices and volunteerism. It also considers the importance of motivating the crowd to participate in the crowdsourcing platform. Therefore, the paper further investigates the willingness of the crowd to participate in the proposed CBLS crowdsourcing drive. The survey carried out indicates that 89% of the respondents want such location-based community services while 84% are willing to participate in CBLS, once deployed. The most important services to the respondents are electricity and education, while their major motivational factor is their ability to solve the problems and challenges in their community and to develop a sense of responsibility. Three prototype mobile applications for the proposed CBLS platform are also presented.

Keywords

Community based location service, information and communication technology, Nigeria, crowdsourcing, volunteers

INTRODUCTION

Infrastructural challenges in developing countries are numerous and these have severely hampered their growth and productivity which had inadvertently led to poor quality of life leave by most of their citizenry (Adi, 2015). Nigeria is definitely of no exception to these challenges, with a total land area of about 923,864 km^2 and a population of over 170 million (Bello and Ojigi, 2013). The teaming population needs to be adequately taken care of and they are scattered over a wide expanse of land. Some of these challenges include: security, water, agriculture, infrastructure, poverty, corruption, natural disasters and health issues. The road network (Foster, 2008), Agriculture (Manyong et al., 2005), power generation (Eberhard et al., 2008; Oyedepo, 2012), communication (Adi, 2015; International Telecommunication Union, 2014), mapping of the country (Bello and Ojigi, 2013), education (Kpolovie and Obilor, 2013), rural development (Akpomuvie, 2010), corruption and bribery (Nwaobi, 2006), security (Udama, 2013), health, just to mention a few are in need of dire attention.

The Government of Nigeria is already overwhelmed with the many needs and demands of the citizenry (Oyedepo, 2012); so it is important for citizens to participate actively, toward building the country. Citizens can contribute to the building of the country in many ways, such as offering community servicing and being responsible citizens of the country. With the increase in mobile phone usage in the country, citizens can also, through ICT, contribute in a significant way to the growth of the country. Further development can be enhanced with location-specific information regarding infrastructure and services needed by the citizenry.

Nigeria has the largest mobile phone market and it has the fastest growing internet penetration rate in Africa. Mobile penetration is high, at over 70%, though unique subscriber penetration basis is at around 30% and smartphone penetration is still between 10-15% (Sharma, Hatt, and Lucini, 2014). With the advent of relatively cheap and readily available smartphones, their penetration has also increased dramatically. This rapid growth of smartphone and feature phone usage in the country opens further opportunities for the citizenry's contribution to the country's growth country, because recent smartphones are embedded with multi-modal sensors, which are integrated to wireless communication technology and have complex processing capabilities (Restuccia, Dasja, and Payton, 2015).

This paper proposes a Community Based Location Service platform through which citizens can participate in providing relevant information to assist in the provision of services and infrastructure in the country. Specifically, the contributions of this paper:

- Provides a review of related works
- Gives a background of concept and presents the conceptual framework of proposed Community Based Location Service (CBLS) platform
- Presents the result of a survey which queried the perspective of respondents towards availability of CBLS and their interest in volunteering to provide geo-location information for the CBLS. Also investigated are the motivational factors which might encourage them to be involved in CBLS.

METHODOLOGY

A background concept of Community Based Location Service (CBLS) is discussed in details and a graphical prototype of relevant location-based information applications. Available ubiquitous smartphone crowdsourcing platforms and location-based sensor networks such as OpenStreetMap

(OSM), Noisetube, Foursquare, etc. are discussed. The CBLS conceptual framework is then presented in detail.

Due to the fact that the concept is a crowd dependent one, a survey was carried out to analyse the interest of Nigerians in participating in the proposed CBLS and the particular service they will prefer the CBLS to be deployed. The services considered include Education, Physical Infrastructure, Water Electricity, Security, Health, and Agriculture. The result of the analysis was calculated using weighted mean and presented in tabular and graphical forms. Some CBLS prototype applications that have been developed and deployed are also discussed.

BACKGROUND OF CONCEPT

Community Based Location Service (CBLS) provides location-based information, supplied by volunteers with smart mobile communication devices, regarding important metrics such as services and infrastructure for electricity, water, drainage, road, railway, etc., in the communities where they reside. The government and relevant stakeholders then can use this information to make (informed) decisions concerning the services or infrastructure. Citizens participate by providing relevant location-based information to assist in the provision of relevant services and infrastructure in the country. Figure 1 shows a prototype of some CBLS which can be deployed to help give better services. Examples of CBLS presented are those in the agricultural, security, electricity and water sectors.

Some long term goals of proposed community-based and participatory LBS include:

- Providing relevant information about the weather, electricity, road infrastructure, corrupt officials, etc.
- Curtailing the spread of terrorist activities and give information to victims about places to get help (health services, shelter, food, etc.)
- Helping track patients and fighting the spread of diseases and epidemics in Africa i.e. tuberculosis, HIV/AIDS, malaria, Ebola, Lassa fever, etc. Location specific information can be sent to patients particularly relating to health issues. The application can also assist in locating patients who require follow-up.

CBLS is about citizens coming together to move the country forward and it hinges on four major technologies; location-based information, crowdsourcing, mobile communication devices and volunteerism.

Crowdsourcing in the context of CBLS is the process of obtaining needed information about services provided from a large group of people in an online community rather than the traditional way of providing information to service providers. Crowdsourcing could be participatory or opportunistic (Chatzimiliousdis, Konstantinidis, Laoudias, and Zeinalipour-Yazti, 2012; Satyanarayanan, 2010). CBLS is participatory when active participation by the users is required.

The location-based information is provided by volunteers who use the service and are willing to make available information on the services, based on their geographical location (Chatzimilioudis et al., 2012). The information is provided using smart mobile devices. Geographical Positioning System (GPS) which is the location sensor will be used to get the location of the mobile device and will be automatically tagged with the information provided using such device. The mobile device requires internet connection to provide and receive geo-tagged information.

Figure 1: Prototype of some community-based location services

Volunteerism is a way of giving back to the society. People, irrespective of their age or educational status, generally like to support community resources they use or that benefit people they care about. Volunteerism is the major glue which joins other technologies together to ensure the effectiveness of the crowdsourcing platform (Borst, 2010). Therefore a survey was carried out to investigate the willingness of people to participate in CBLS. The main objective of this research is to present a survey carried out about the investigation of the crowd's perspective towards the provision and volunteering for CBLS.

Contributions required from the crowd are dependent on the priority sector of the country that requires and has urgent need of locating information. It is also dependent on the preference of contributors. Intrinsic and extrinsic motivational methods (Petri and Govern, 2013; Restuccia, Dasja, and Payton, 2015; Brown, 2007) are also proposed in this part of the research work based on the target contributors. Citizens or community members contribute to provide location information on infrastructure, health or security depending on the priority challenge to be handled and the preference of the location information contributor.

In ubiquitous and smartphone crowdsourcing, contributed information is not only limited to information generated by the user due to his opinion or perspective but also passively-generated through sensors from the mobile device (Mashhadi and Capra, 2011). Some properties of ubiquitous computing include real-time events and dynamic crowds. Information collected is from dynamic events and crowd who keeps changing their location with time. OpenStreetMap (OSM)[1] is an example of such ubiquitous crowdsourcing which is highly successful. OSM enables citizens to participate in building and

[1] OpenStreetMap, January 2016, www.openstreetmap.org/

maintaining an accurate map of the changing world by providing geographic information. Waze[2] is another example and as described by the host website "is the world's largest community-based traffic and navigation app." It is a free social mobile application that uses real-time input from motorists to update traffic conditions for other users by using GPS-enabled smart phones with a data plan, unlike traditional GPS navigation software.

Noisetube uses mobile phones as noise sensors, and users participate in the creation of noise maps of their community (Maisonneuve, Stevens, and Ochab, 2010). Overeem et al. presented a system which urban air temperature using the battery temperatures of volounteers' smartphones (Overeem et al., 2013). An application to gather information on road and traffic condition using crowdsourcing was developed by Mohan, Padmanabhan, and Ramjee in 2008, and so many other applications have been developed since then, (Chatzimiliousdis et al., 2012).

A number of location-based services (LBS) have combined fundamental communication concepts to give rise to a new form of social networking (McKenzie, 2011). These are called location-based social networks (LBSN). A popular one is Foursquare[3]. Foursquare is a free application that enables users to share their location and make comments about the location which is visible to all registered users (Foursquare, 2015).

CONCEPTUAL FRAMEWORK

Since citizens or community members contribute community-based location information through mobile applications, it is important to develop these applications to ensure participation is simple enough for the user, while it enables saving contributed information in a usable, readily transferrable format. Location information sent from the volunteer's mobile phone travels through the internet to the CBLS platform where it is processed and archived (Chatzimiliousdis, et al., 2012). The processed information can then be made available to the community through the CBLS platform, and to users requiring location-based information such as electricity pattern, security information, etc., or to relevant stakeholders for informed decision. The CBLS platform will be managed by an administrator or administrators. The conceptual framework of the proposed CBLS is shown in Figure 2.

Crowdsourced location information displays in various forms. For example, location information on security will help individuals and the Government to make informed decisions. While location information on water sources or electricity in the community will assist the Government and other organizations related to water provision or electricity, to plan, manage and make informed decisions.

Location information stored in the database can be accessed through the CBLS for specific location information and through a more secured means. Security is an essential and important consideration when information is required for a large area, especially security-related information which requires authentication of people who can have access to the information. The proposed CBLS platform will have two interfaces, one for contributors to the CBLS platform and the other is for accessing information from the CBLS platform.

The major task of the crowdsourcing system is receiving and giving information from and to the crowd. Users of the crowdsourcing system are classified as requesters and contributors. Contributors provide

[2] Waze Ltd., January 2016, https://www.waze.com/

[3] Foursquare, January, 2016, https://foursquare.com/about/

relevant information around their environment and requesters are relevant Government and Non-governmental Organization (NGO) managing the platform. Where $\{A_1, \ldots, A_M\}$ denotes action set by contributors $C_1, \ldots, C_M$ and I_M is the information given by contributor M at a location L_M. L_M is a point represented by the latitude and longitude of a location where contributor C_M volunteered/contributed information I_M. A radius R_M is created around location L_M. I_M is only valid when two conditions are met. First, if and only if there is information I_{M+1} given by another contributor same or similar to I_M given by a previous contributor C_M within a time frame t. Secondly, L_{M+1} has to be within a distance D_M to L_M.

The CBLS platform is characterized by four major mechanisms. These mechanisms are lifetime allocation to information, such as information about events that are most relevant when they are up-to-date. Therefore, the application automatically allocates lifetime-to-location information data acquired and deletes it from the interface the user accesses when the time elapses. Data deleted will be archived in the database. Secondly, the application will have the capability to handle more than one task at a time, thereby allowing for concurrent contribution to various tasks, though only one after the other. Thirdly, due to the multitask option that will be existing, there will be periodical announcements of priority tasks which contributors will be made aware of and encouraged to contribute to. Lastly, each use case or task-at-hand is independently executed and driven.

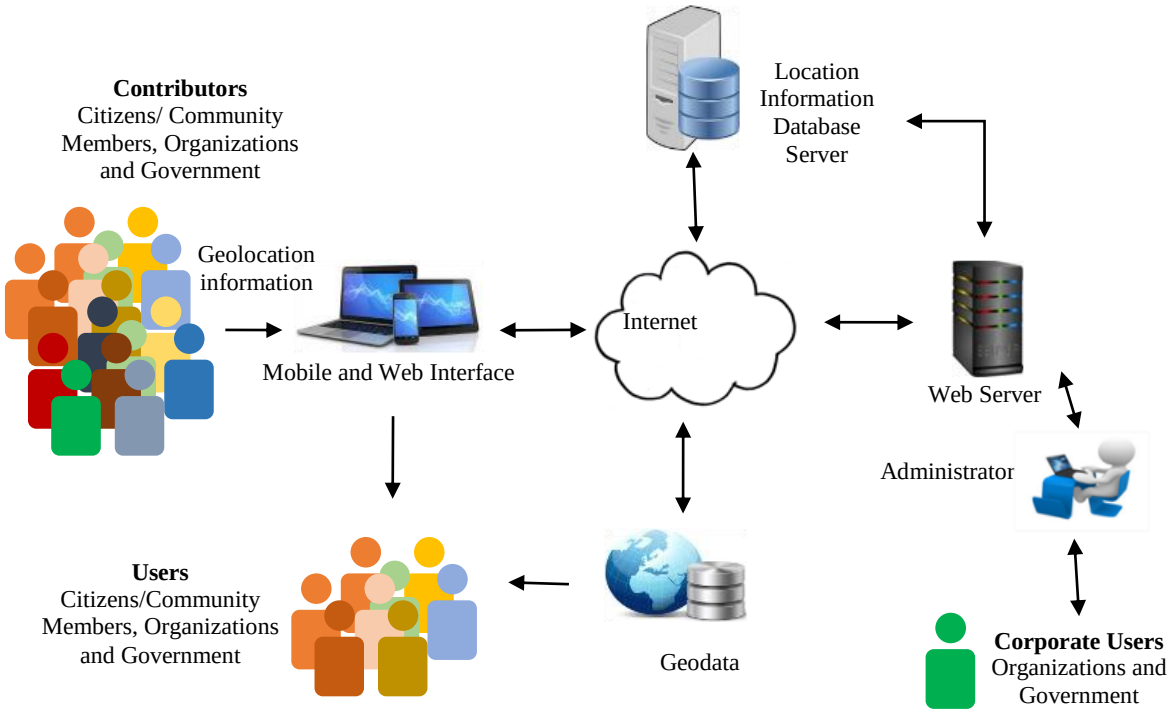


Figure 1: Conceptual framework of the Proposed Community Based Location Service

MOTIVATION OF THE CROWD

To ensure the success of CBLS, It is very important for the crowd to participate. Adequate motivation of contributors is fundamental to the success of this project which is participatory and people based. Motivation refers to the dynamics of one's direction to behavior, it explains the way in which our actions are initiated, sustained, directed, and terminated (Deckers, 2010; Petri and Govern, 2013; Ellliot

and Covington, 2001; Pardee, 1990). Motivation can be divided into two different theories known as Intrinsic (internal) motivation and Extrinsic (external) motivation. Intrinsic motivations are driven by an interest or enjoyment in the task itself rather than external pressure (extrinsic) or desire for a reward. The reward can be tangible (money and grades) or physiological (obligations, rewards and social approval) (Brown, 2007; Baard, Deci, and Ryan, 2004; Dennis and Mitterer, 2014).

The crowd also could be motivated by giving free access to the crowdsourced data. This is an extrinsic form of motivation which is based on the availability and open source nature of CBLS. It can be used by individuals, corporate organizations, and government for more informed decisions to create a better life for all. Also, communities, service providers, individuals and organization want to be acknowledged. Furthermore, there is a desire to want to be the best and a personal pride to be known that will hopefully lead to a healthy competition. People, irrespective of their age or educational status, generally like to support community resources they use or benefit from. To analyze the interest of Nigerians in participating and interest in CBLS, a survey was carried out and the result will be discussed in the next section.

SURVEY ANALYSIS

Study participants were staff and students of the Federal University of Technology, Akure. 103 people responded to the call but only 97 passed the credibility test for the survey. The credibility of the respondents' responses was tested by asking the age of the respondents at the beginning and end of the questionnaire. 79.8% of the respondents were male while 20.2% were female with 77.8% and their reported ages was between 16 – 35 years and 22.2% above 36 years of age. The data collected indicated 51.5% were undergraduate students, 44.4% had postgraduate qualification or were in the process of acquiring one, 3% were high school students. Therefore, it could be inferred that majority of the respondents were literate. All the respondents are familiar with the internet, 82 respondents use the internet very frequently, 10 responded using the internet frequently, 3 responded occasionally and 2 responded rarely, while no respondent has never used the internet.

The questionnaire was posted on Google docs and the Federal University of Technology, Akure's website. The survey was conducted for six (6) weeks (February and March, 2015) and participants were invited through e-mails and personal invites. The survey queried the interest of respondents towards availability of CBLS and their interest in volunteering to provide location information for the CBLS. Also investigated are the motivational factors which might encourage them to be involved in CBLS.

The 5-point Likert scale was used for the analysis and since the research is considering the preferred fun ways and game pattern to be utilized in the design of a gamification system, just checking the frequency and distributive analysis of the variables, such a bar chart or pie chart would not be adequate to point to the most appropriate game patterns to be implemented. Therefore, this research uses a weighted mean such that:

$$V_m = \left[\sum_{n=1}^{5} N_n W_n \right] \Big/ \sum_{n=1}^{5} N_n \qquad (1)$$

Where m is the dependent variable and V is the mean of the dependent variable m for a particular question answered by the respondents. The dependent variable m can be the gender thus m = 2; male and female or >35 years and < 35 years. W is the weight allocated to the measurements considered on the Likert scale, where for example for the scale Very Frequently = 5, Frequently = 4, Occasionally = 3,

Rarely = 2 and Never = 1. The aim of the research is to investigate the variable most preferred; therefore the Very Frequently scale gets the highest weight. N is the frequency which the respondents choose a rating on the Likert scale. For a Likert scale of 5, n = 1, …, 5. For example when 10 respondents choose occasionally for any of the questions under consideration, $N_3 = 5$.

V_m, the mean value obtained will have a maximum of 5, where this indicates that all the respondents choose a rating of "Very frequently" making the independent variable the most preferred. With V_m tending to 1, indicates that most of the respondents choose "Never" on the Likert scale for the independent variable under consideration and therefore it's the least preferred.

SURVEY RESULT

Eighty-nine (86) respondents were interested in Community Based Location Services and expressed interest to get detailed location information while 11 respondents were not interested. Eighty-four (81) respondents were interested in participating in the CBLS while 16 respondents were not interested.

CBLS of Importance

Majority of respondents considered very important CBLS applications which will assist to improve already provided services. According to the order of preference, Electricity - 4.23, Security - 4.20, Health - 4.17, Education - 4.13, Physical Infrastructure - 4.12, Water - 3.96 and Agriculture - 3.67 are rated according to the order of importance when the mean value is considered. Table 1 and Figure 2 shows the responses of the people to what service they consider most important to be enhanced by CLBS. Electricity is considered as the most important service this might be because of its importance in relation to the economy and comfort of respondents. Agriculture has the least weighted mean because an average Nigerian is a farmer or has relationships with farmers and considers this not pertinent.

Services	Male	Female	<35 years	>35 years	Average
Electricity	4.16	4.41	4.24	4.10	4.23
Water	4.10	3.81	4.10	3.81	3.96
Security	4.19	4.36	4.30	3.95	4.20
Agriculture	3.83	3.41	3.74	3.71	3.67
Health	4.14	4.36	4.26	3.90	4.17
Infrastructure	4.12	4.23	4.20	3.95	4.12
Education	4.07	4.31	4.17	3.95	4.13

Table 1. Services to be enhanced by CLBS

Willingness to Participate in CBLS

The respondents are also willing to participate in (according to the order of preference) Education, Health, Security, water, Physical Infrastructure, Water and Agriculture are rated according to willingness of the respondents to participate in applications that might assist to improve services provided in the aforementioned sectors. Table 2 and Figure 3 shows the responses of respondents to services they will be willing to participate in, by providing and receiving geo-location information about.

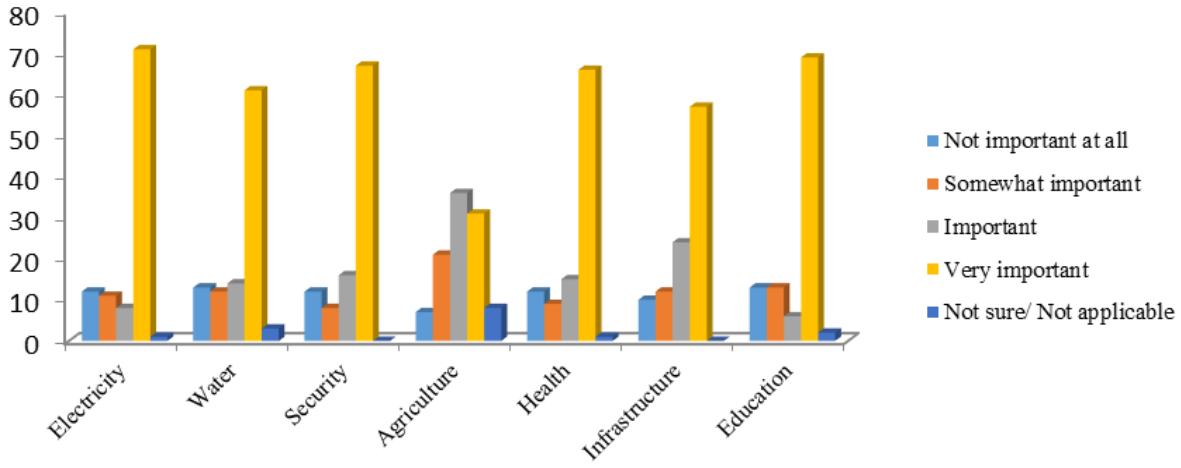


Figure 2. Importance of Services to be enhanced by CLBS

Services	Male	Female	<35 years	>35 years	Average
Electricity	4.15	4.54	4.22	4.28	4.30
Water	4.03	4.27	4.05	4.19	4.13
Security	4.10	4.41	4.13	4.29	4.23
Agriculture	3.72	3.68	3.67	3.86	3.73
Health	4.21	4.45	4.21	4.48	4.34
Infrastructure	4.04	4.05	4.06	3.95	4.02
Education	4.44	4.73	4.46	4.67	4.58

Table 2. Services Considered Most Important for implementation Using CLBS

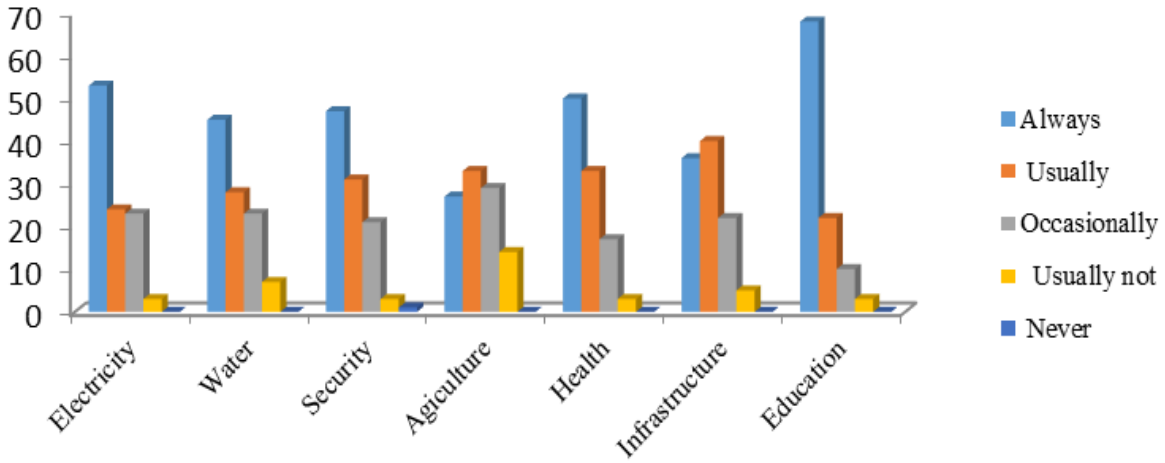


Figure 3. Frequency Response of Services Considered Most Important for implementation

Motivating Factor of Participation in CBLS

Majority of respondents indicate that what will make them most willing to participate is if the application is problem solving and challenging with an average of 4.36, secondly comes their sense of responsibility to the community with 4.21. Thirdly, if it offers a good business opportunity, then they can consider the application too. Fourthly respondents are willing to be volunteers if the CBLS application will provide financial incentive when they participate. Fifthly, they will participate due to the respondent's desire to be the best then; sixthly if they are participating with friends. Introduction of game elements in the CBLS application was the least motivational element which the respondents indicated with weighted average of 3.79. Table 3 and Figure 4 show the factors motivating respondents to participate in CBLS.

Motivational Factors	Male	Female	<35 years	>35 years	Average
Community responsibility (M1)	4.17	4.23	4.16	4.29	4.21
Financial incentives (M2)	4.02	4.23	4.09	4.04	4.10
Game elements in the application (M3)	3.73	4.09	3.90	3.43	3.79
Business opportunities (M4)	4.19	4.36	4.32	3.86	4.18
Problem solving and challenging (M5)	4.36	4.32	4.33	4.43	4.36
Participating together with friends (M6)	4.11	4.18	4.24	3.67	4.05
Ability to be the best (M7)	4.20	3.95	4.22	3.86	4.06

Table 3. Factors Motivating Respondents to participate in CLBS

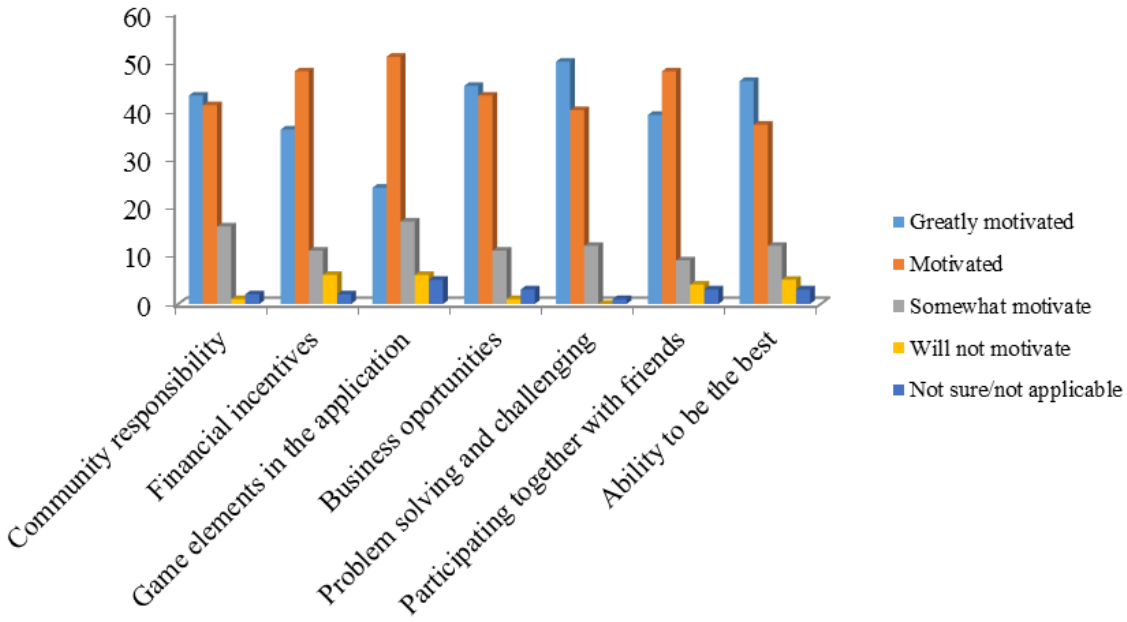


Figure 4. Factors Motivating Respondents to participate in CLBS

CBLS APP PROTOTYPES

In the following sections, three CBLS applications to assist in the provision of better services in the areas of security, electricity and voice services provided by mobile operators are presented. The prototype applications for security, electricity and voice services provided by mobile operators are presented in Dahunsi and Obembe 2015; Dahunsi and Ayinde, 2015 and Dahunsi and Kolawole, 2015 respectively.

Crime Alert System (CAS) acquires and disseminates needful security-related information. The system utilizes crowdsourcing, gamification and location-based techniques to receive security information from volunteers, verify such and disseminate to subscribers. The home page and the crime list page of the developed application are shown in Figure 5.

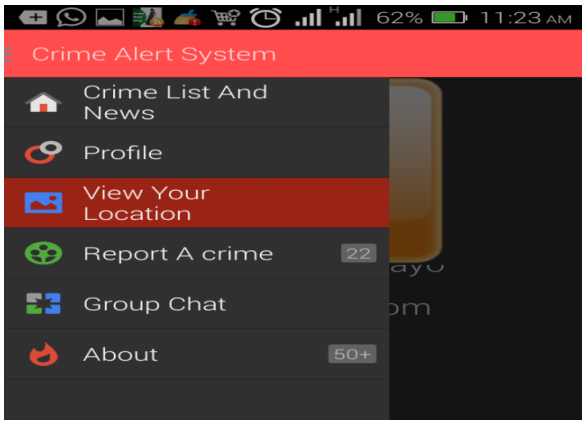
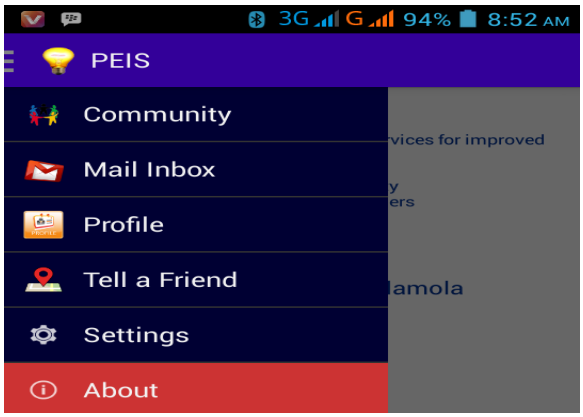


Figure 5a. The home page

Figure 5b. Crime List Page

Further work can be carried out on CAS to improve verification of the information provided. It is also recommended that the application should be multi-lingual, as Nigeria is made up of various ethnic groups and tribes with three major languages, Hausa, Yoruba and Ibo.

Participatory Electricity Information System (PEIS) utilizes mobile devices to enhance improved power supply to customers. Subscribers give and receive relevant information relating to electricity in their geographical location by using crowdsourcing; faults and complaints also can be made more conveniently by subscribers to the Power Distribution Company. Snapshots of the system are shown in Figure 6.



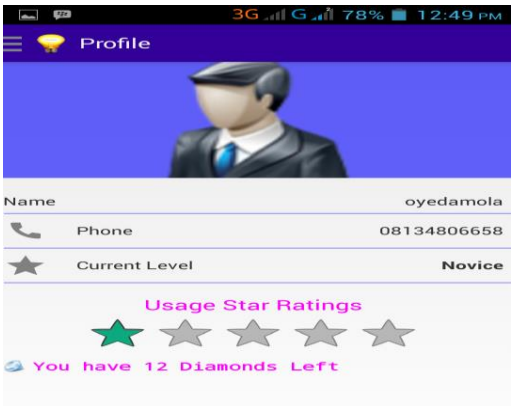


Figure 6a: Menus List **Figure 6b: Profile of a registered user**

In future work, a central control department for controlling and validating user report is considered for ensuring prompt responses to users' complaints or faults. Predictive analysis can also be carried out on collected data to ensure even better informed decisions.

The NETWORKQoS app aim is to address the gap between the reported technical capabilities of the telecoms infrastructure and the QoS experienced by the user. The analysis is based on sets of location-specific network measurements obtained from mobile devices of volunteer users within the network. A crowdsourcing platform was designed to gather a sufficiently large dataset of measurements obtained from the volunteer mobile devices. Figure 7 shows the app snapshots. Crowdsourced data, when it was collated, evaluated and analyzed, can be compared against the key performance indicators (KPI) benchmarks set by the Nigerian Communications Commission. The collated, crowdsourced data is analyzed at the remote server and the results are made available through the web to interested users and subscribers.

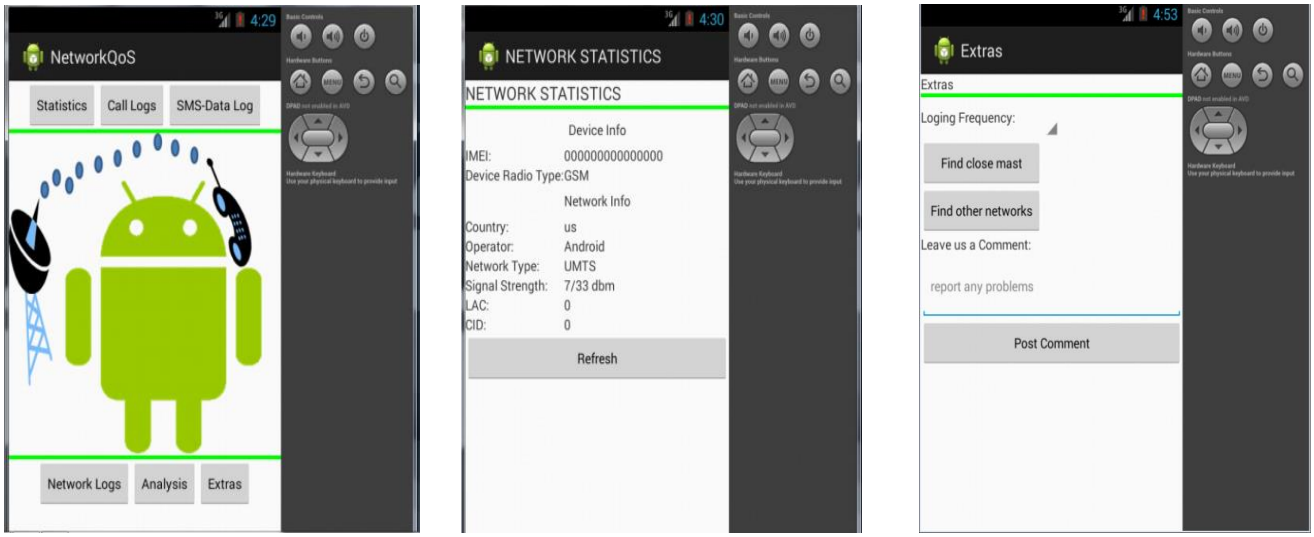


Figure 7: App snapshot

CONCLUSION

In this paper, Community Based Location Services (CBLS) was presented, it is expected that this platform will enhance services and infrastructure provided in Nigeria. CBLS combines location-based information, crowdsourcing, mobile devices and participation by the citizenry of Nigeria to move the country forward in order to achieve our various developmental goals. Location-based unique data generated from mobile phone sensors and information volunteered by the crowd as they constantly move around will ensure a huge pool of information which will assist stakeholders and the Government of Nigeria in making informed decisions. This might lead to improved quality of life to her citizenry. The survey carried out also indicated that 89% of the respondents want such location-based community services while 84% are willing to participate in CBLS once deployed. Services of great importance to the respondents are electricity and education, while the major motivational factor for them will be ability to solve the problems and challenges in their community, and also a sense of responsibility.

From the performance evaluation carried out on the prototype apps: CAS, PIES and NETWORKQoS the CBLS applications are well accepted and received high scores on metrics used, such as ease of use, latency, accuracy, quality of response and the ability of the gamification system to motivate volunteers to participate. The focus of future effort in this research lies in developing the CBLS platform and properly integrating the proposed mechanism for its implementation which are lifetime of data, announcement of priority task, presentation of multi-tasks option and use case driven analysis. Authenticity and security of information provided has to be ensured and proper performance evaluation to ensure quality of experience (QoE) has to be properly put in place. Crowd motivation is also a very critical area which has to be appropriately designed and put in place to ensure optimal participation.

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