

## Development of an Automated Liquefied Petroleum Gas Station Detection Mechanism Using Haversine Principle and A\* Algorithm

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### Abstract

#### Keywords:

Location-based service,  
Liquefied petroleum gas,  
Haversine formula, A\*  
algorithm, Map reference,  
Texturing

Ever since the discovery of Liquefied Petroleum Gas (LPG), there has been a drastic increase in its usage both by home and industrial consumers. Meanwhile, as consumer migrates from one location to another, locating the nearest gas station particularly for rural and semi-urban dwellers has been a challenge. Therefore, in this work an automated liquefied petroleum gas station detection mechanism was developed using Haversine principle and A\* algorithm. The automated mechanism was based on a goggle geo-coding application programming interface in laravel structure, placing potential users and gas agencies on latitude and longitude of a particular geographic location. The Haversine principle was used to calculate the distance between the user location and the gas station to help consumer to choose the nearest gas station closer to them based on predefined radius, while A\* algorithm was employed to display the shortest path route on the goggle map between the user and closest gas station. The system was implemented using hypertext preprocessor, laravel python and java programming language all version 7 on android operating system. The mechanism when tested in the real world scenario performed well and suitably met its objective.

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### INTRODUCTION

Liquefied Petroleum Gas (LPG) is a gaseous flammable hydrocarbon fuel and is also referred to as natural gas liquids (NGL) (Hahn, 2019). The propane uses of LPG include residential cooking, heating, hot water and vehicle fuel. Propane-LPG (liquefied petroleum gas) uses for commercial purposes include LPG applications like petrochemical feedstock, aerosol propellant, air conditioning refrigerant and as fuel for power generators. Ever since the discovery of Liquefied Petroleum Gas (LPG), there has been a dire increase in its usage both by home and industrial consumers. However, as consumer migrates from one location to another, locating the nearest gas station particularly for rural and semi-urban dwellers has been a great challenge. Therefore, this work is aimed

at developing an automated liquefied petroleum gas station detection mechanism using haversine principle and A\* algorithm.

According to Ben et al, (2011), the haversine principle is an important model in navigation. It is perhaps the first model to consider when understanding how to calculate distances on a sphere. It has been adjudged an accurate way of computing distances between two points on the surface of a sphere using the latitude and longitude of two points. Haversine is very popular and frequently used formula when developing a Geographic Information System (GIS) application or analyzing path and fields. The word "Haversine" follow from the fact that they are customarily written in terms of the haversine function, given by:

$$Hav(\theta) = \sin^2(\theta/2) \dots \dots \dots \text{Equation 1}$$

The function names have a simple naming pattern, the "Ha" in "Haversine" stands for "half versed sine" i.e haversin(θ) = versin(θ)/2. The formulas could equally be written in terms of any multiple of the haversine, such as the older versine function (twice the haversine). Prior to the advent of computers, the elimination of division and multiplication by factors of two, proved convenient enough that tables of haversine values and logarithms were included in nineteenth and early twentieth century navigation and trigonometric texts (Goodwin, 1910). These days, the haversine form is also convenient in that it has no coefficient in front of the sin<sup>2</sup> function.

**Haversine Formula**

The central angle haversine can be computed, between two points with *r* as radius of earth, *d* as the distance between two points,  $\phi_1, \phi_2$  is the latitude of two points and  $\lambda_1, \lambda_2$  is longitude of two points respectively, the formula is represented as:

$$\text{haversin}\left(\frac{d}{r}\right) = \text{haversin}(\phi_2 - \phi_1) + \cos(\phi_1) \cos(\phi_2) \text{haversin}(\lambda_2 - \lambda_1)$$

.....Equation 2

For two points on a sphere (of radius R) with latitudes  $\phi_1$  and  $\phi_2$ , latitude separation  $\Delta\phi = \phi_1 - \phi_2$ , and longitude separation  $\Delta\lambda$ , where angles are in radians, the distance *d* between the two points (along a great circle of the sphere is related to their locations by the formula above:

A complimentary algorithm is the A\* (pronounced as "A-star"). It is a computer algorithm that is widely used in path finding and graph traversal, which is the process of finding a path between multiple points, called "nodes". It enjoys widespread use due to its performance and accuracy (Zeng and Church, 2009). However, in practical travel-routing systems, it is generally outperformed by algorithms which can pre-process the graph to attain better performance, (Delling et al, 2009).

The A\* Algorithm uses a best-first search and finds a least-cost path from a given initial node to one goal node (out of one or more possible goals). As A\* traverses a grid, it follows a path of the lowest expected total cost or distance, keeping a sorted priority queue of alternate path segments along the way.

Each time A\* enters a state, it calculates the cost, *f(n)* (n being the neighboring node), to travel to all of the neighboring nodes, and then enters the node with the lowest value of *f(n)*.

These values are calculated with the following formula:

$$f(n) = g(n) + h(n) \dots \dots \dots \text{Equation 3}$$

*g(n)* being the value of the shortest path from the start node to node *n*, and *h(n)* being a heuristic approximation of the node's value.

The efficiency of A\* is highly dependent on the heuristic value *h(n)*, and depending on the type of problem, we may need to use a different heuristic function for it to find the optimal solution. A requested route can be provided by using combination of A\* Algorithm and Haversine formula. Haversine Formula will give minimum distance between any two points on spherical body by using latitude and longitude. This minimum distance is then provided to A\* algorithm to calculate minimum cost for the distance.

In this paper, a platform for value-added location based services using haversine principle and A\* algorithm placing potential users and gas agencies on latitude and longitude of a particular geographic location to provide consumers of liquefied gas, who migrates from one location to another especially to rural and semi-urban areas, so as to easily locate the nearest gas stations and order for their liquefied gas refill online. Additionally, this is believe will also proffer solution to the dangers they may be exposed to, such as leakages that may leads to explosion, stress and other hazards in the course of transporting these products over a long distance as pointed out in Dhanya et al, (2015), Naik et al, (2016) and Sonawane et al, (2017).

The invention of the mobile technology has been revolutionary and advances in the technology have shaped the world in fundamental ways (Gazdecki, 2019). The global world is more connected than ever, giving more opportunities to the "disadvantaged" and creating businesses and market places where there were none due to its diverse functionalities. Mobile technology is a technology that is mostly used in cellular communication and other related facets. It is a field under information communication technology (ICT) classified by age of technology starting from first to fourth generation (Macwan, 2017). The technology uses a form of platform where many transmitters have the ability to send data simultaneously on a single channel. This platform is called Code-division multiple access (CDMA). It allows many users to make use of single frequencies and restricts the likelihood of interference of frequencies from two or more sources.

According to Macwan (2017), the diversity of mobile technology is due to the fact that many mobile operating systems are available for smart devices all of which have their own unique characteristics. Some of these operating systems are: the android, blackberry, webos, ios, symbian windows and bada

mobile. The importance of these mobile technologies in the global world cannot be over emphasized, especially in the business world. It has made it possible for one to easily locate places on the globe using the Global Positioning System (GPS). Bankers depend solely on mobile technology to manage their finances and stocks, providing many firms the platform to increase their earnings, and offer consumers easiness to patronize their customers' product through apps and websites.

Mobile technology methods include 1G wireless technology analog cell phones, 2G wireless technology which introduced data services for mobile, where phone conversations were digitally encrypted, 3G wireless technology with introduction of communication spectrum between 400MHz to 3GHz while 4G wireless technologies provide mobile ultra-broadband internet access (Jeya et al, 2017). Specific focus in this work is on 3<sup>rd</sup> generation (3G) mobile wireless technology where services such as mobile television, video on demand, video conferencing, telemedicine and location-based services were introduced. As a result of the development in technology, location-based service (LBS) was made popular which helps in solving problem related to getting user's real-time locations.

## LITERATURE REVIEW

### Location based services (LBS)

LBSs are services that can be offered through a mobile phone and take into account the device's geographical location. LBS typically provide information or entertainment. It can be used in a variety of contexts, such as health, indoor object search, entertainment, work, personal life, etc. (Guo et al, 2008; Guo et al.,2011; .Deuker, 2008).

LBS also include applications that depend on the user location to provide a service/information that is relevant to the user at that location. It normally uses mobile devices with positioning ability to provide the service or information to the user. LBS can be used for personal or professional purposes although most of the services covered here are for personal use since professional services will be covered in other sections

Location based Services resulted from the convergence of 3 technologies in one device: mobile internet access, positioning and rich user interfaces as depicted in Figure 1.

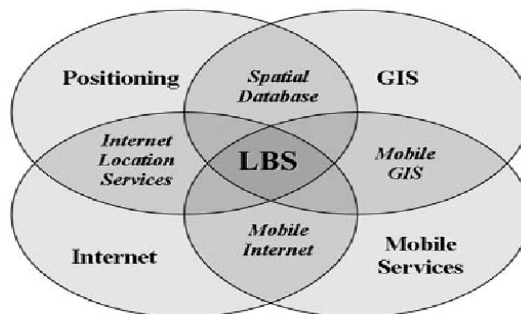


Figure 1: Convergence of technologies to create LBS  
Source: Pontikakos et al, (2010)

According to Quercia et al, (2010 and Shu, (2008), a location-based service (LBS) is the name for a general class of policies in software-level services that provide for accessing data, files, pipes, memory objects, streams and other or online services. Access policies are controlled by location data and/or time-of-day constraints, or a combination thereof. As such, an LBS is an information service and has a number of uses in social networking today as information, in entertainment or security, which is accessible with mobile devices through the mobile network and uses information on the geographical position of the mobile device.

The goal of LBS is to provide value-added services, such as social amenities and infrastructures to its users and it is described as a wireless internet protocol (IP) service that uses geographic information to provide location information to the user (Singhal and Shukla , 2012).

According to Pontikakos et al, (2010), Location-Based Services (LBSs) stands for the provision of information about the position of a device or a user, often offered as a service via various means of media. The position can be combined with spatial information so as to integrate an LBS system with Geographical Information Systems (GISs) or other location dependent information. The quality of the services provided by the LBSs depends on the utilized architecture that would support differentiated service levels, each of which guarantees a specific Quality of Service (QoS). Figure 2 showed a typical LBS architecture.

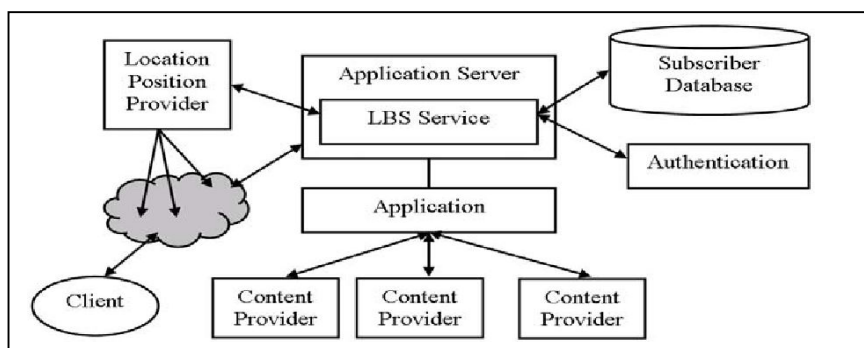


Figure 2: A Typical LBS Architecture  
Source: Pontikakos et al, (2010)

The most common architectures of mobile communication systems that their functionality can offer to the realization of LBS are: Cellular-based Mobile Communication, Wireless LANs, Internet-based Mobile Communication and Ad-hoc Networking. Until the late 1990's the available mobile devices mostly supported only voice and SMS and had few user interface capabilities. Although these technologies could theoretically already support very crude location based services (using SMS and cellular network based localization), but after the introduction of wireless application (WAP) and internet access in mobile phones, there is news of the first generally available location based services. LBS is critical to many businesses as well as government organizations to drive real insight from data tied to a specific location where activities take place. The spatial pattern that location-related data and services can provide is one of its most powerful and useful aspects where location is a common denominator in all of these activities and can be leveraged to better understand patterns and relationships. Banking, surveillance, on-line commerce, and many weapon systems are dependent on LBS. According to Mobile Location Apps Review in 2018, LBS include services to identify the location of a person or object, such as discovering the nearest cash machine (ATM) or the whereabouts of a friend or employee. LBS include parcel tracking and vehicle tracking services. LBS can include mobile commerce when taking the form of coupons or advertising directed at customers based on their current location. They include personalized weather services and even location-based games. They are an example of telecommunication convergence. These services of LBS can be classified into two types: Push and Pull. In a Push type of service, the user receives information from the service provider without requesting it at that instant, although the user may have originally subscribed to the service at an earlier time. The LBS advertisement mentioned earlier is an example of a Push service. In a Pull type, the user has to actively request for information. The restaurant query example belongs to this type. To specify a customer/user's location, one method

involves using the mobile phone network. For example, the current cell ID can be used for identifying the base transceiver station (BTS) that the phone is communicating with. Once that is determined, the only thing left is to pinpoint the location of the BTS. Other systems use GPS satellites. This method is much more accurate than the one previously mentioned and are now made easier by some smart phones that already have built-in GPS receivers. Another common method is the use of short-range positioning beacons. Such devices typically employ WiFi or Bluetooth technologies and are ideal for indoor LBS applications. Ryan (2013) posited that companies have found several ways to use a device's location, which include:

**Store locators:** Using location-based intelligence, retail customers can quickly find the nearest store location.

**Proximity-based marketing:** Local companies can push ads only to individuals within the same geographic location. Location-based mobile marketing delivers ads to potential customers within that city who might actually act on the information.

**Travel information:** LBS can deliver real-time information, such as traffic updates or weather reports, to the Smartphone so the user can plan accordingly.

**Roadside assistance:** In the event of a blown tire or accident, many roadside assistance companies provide an app that allows them to track your exact location without the need for giving directions.

**Mobile workforce management:** For logistics-dependent companies that employ individuals out in the field or at multiple locations, an LBS allows employees to check in at a location using their mobile device.

**Fraud prevention:** An LBS creates another level of security by matching a customer's location through the Smartphone to a credit card transaction. Tying the Smartphone's location to a credit card allows a user to flag transactions made across several geographic locations over a short time. Today, the number of LBS mobile users has steadily increased over the past several years (see the chart in Figure 3).

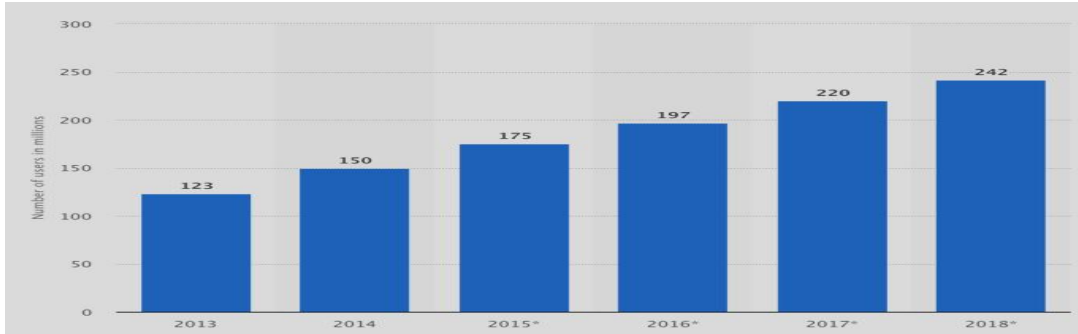


Figure 3: LBS users chart over the years

**RELATED WORKS**

Research on LBS has been approached from different disciplines and different perspectives. In this section, few of these approaches are presented: Marex (2002) presented a marine asset telemetry device for commercial sale was designed. The device was capable of transmitting location data and retrieving location based service data via both cellular and satellite based communications channels. Utilizing the Orbcomm satellite network, the device had multi level SOS features for marine assistance, vessel system condition and performance monitoring with remote notification. Based upon the device location, it was capable of providing detailed bearing, distance and communication information to the vessel operator in real time. Gugapriya et al. (2015) presented an Android mobile banking tool to aid electronic banking (e-electronic), the tool was developed with mobile technology and wireless media using global positioning system (GPS). The tool was able to provide opportunities for ubiquitous

access to the banking services anytime and from anywhere. Navneet (2016) introduced a nearby places displaying tool using Google places application programming interface (API) and Google maps API V2. The idea is to aid users in searching for a particular place such as restaurants, hospitals and schools in an environment nearest to the users' location.

**MATERIALS AND METHODS**

**The System Architecture**

The system architecture as depicted in Figure 4 is composed of four (4) major components: the first component is the users registration/log in, the second component is the user interface (comprising of the gas station search, order/ payment and logistics), the third component is the gas agencies platform and the last component is the reference mapping and deployment of the Harvestine principle and A\* Algorithm.

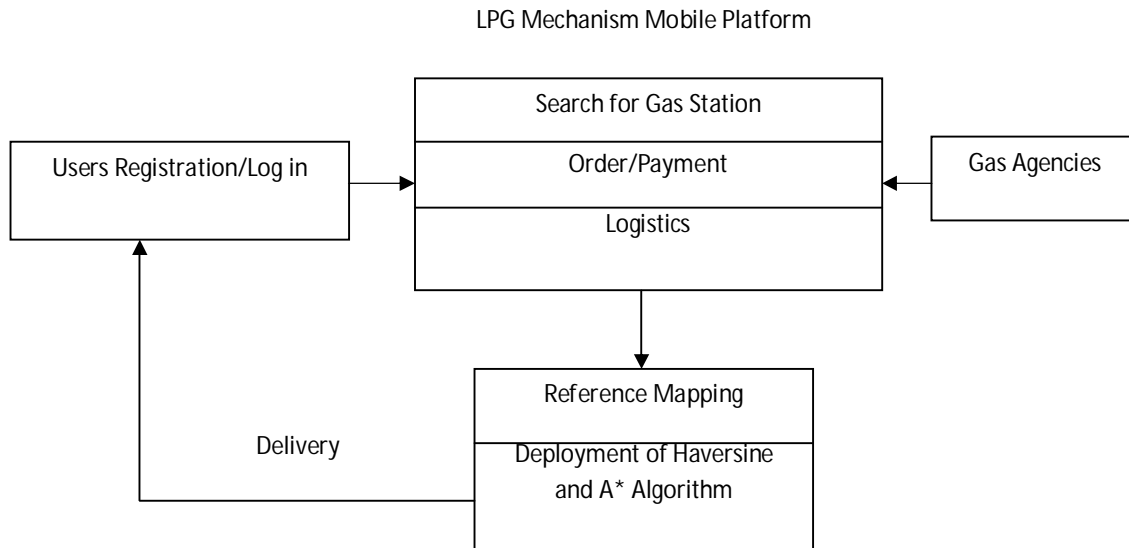


Figure 4: The System Architecture for the proposed LPG Detection Mechanism

The system development was implemented using hypertext preprocessor, laravel python and java programming language all version 7 to implement the haversine formula and A\* pathfinder algorithm, while MySQL database was used for all the data manipulations. The haversine formula calculates the distance between two points on the earth's surface, specified in longitude and latitude as presented in equation (4) and implemented in PHP laravel framework including user interaction module controllers.

$$haversine(d) = \arcsin\left(\sqrt{\sin^2\left(\frac{\Delta\phi}{2}\right) + \cos(\phi_1) \cos(\phi_2) \sin^2\left(\frac{\Delta\lambda}{2}\right)}\right) \dots\dots\dots \text{Equation 4}$$

From the equation,  
*d* = the distance between the two points (along a great circle of the sphere)

*r* = the radius of the sphere

*U*<sub>1</sub>, *U*<sub>2</sub> = latitude of point 1 and latitude of point 2

*V*<sub>1</sub>, *V*<sub>2</sub> = longitude of point 1 and longitude of point 2.

The value obtained from haversine formula was passed to A\* pathfinder algorithm to determine the shortest path route the user can take to select any gas station of interest as shown in equation (5).

$$f(n) = g(n) + h(n) \dots\dots\dots \text{Equation 5}$$

The *g*(*n*) is the cost of getting to a location from the start location and; *h*(*n*) is the straight line distance to target point. To incorporate this features in android mobile environment, a goggle map based application was developed on android platform.

**RESULTS AND DISCUSSIONS**

Figure 5 and Figure 6 presents the user's interface and the arial view of a city considered in this work using Goggle map respectively.

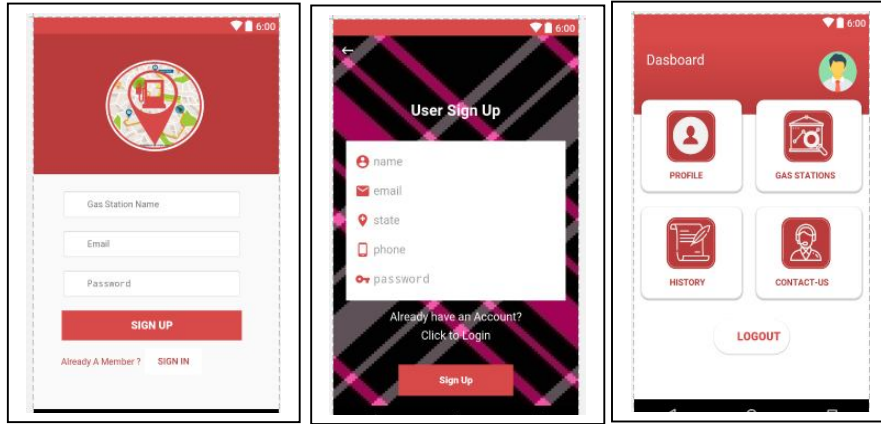


Figure 5: Sign-Up, Dashboard and Sign-In User-Interface

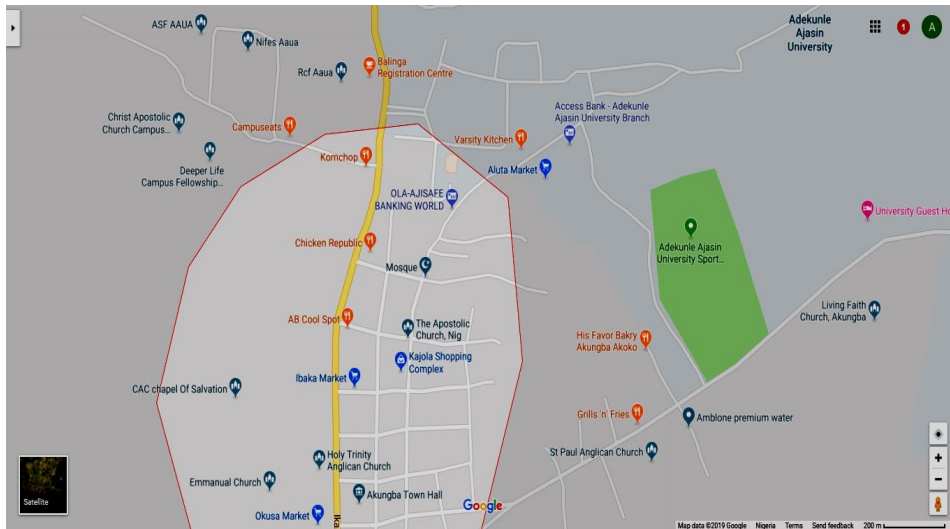


Figure 6: Arial View of Akungba Using Google Map



Figure 7 shows the gas ordering operation on an Android phone when testing the API. The figure showed the location of the gas agencies and

selected user's location on a latitude of 7.488226666666675 and longitude of 5.741100999999999 respectively.

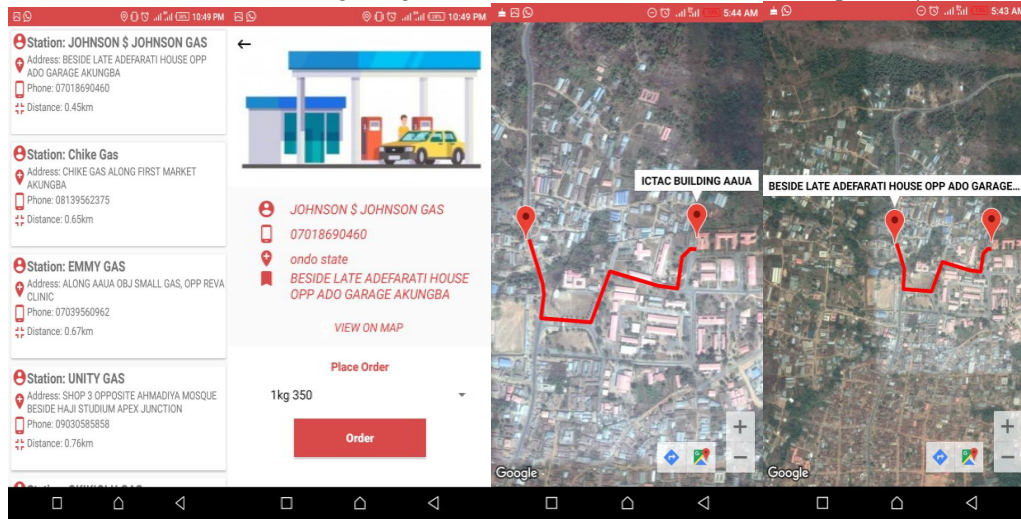


Figure 7: Gas Ordering Operation on Android Phone

Figure 8 showing the demographics representation of the distance between the user current location and all gas station. The y-axis represents the

distance in range of 0.2km and the x-axis representing the gas stations distance to the user's current location.

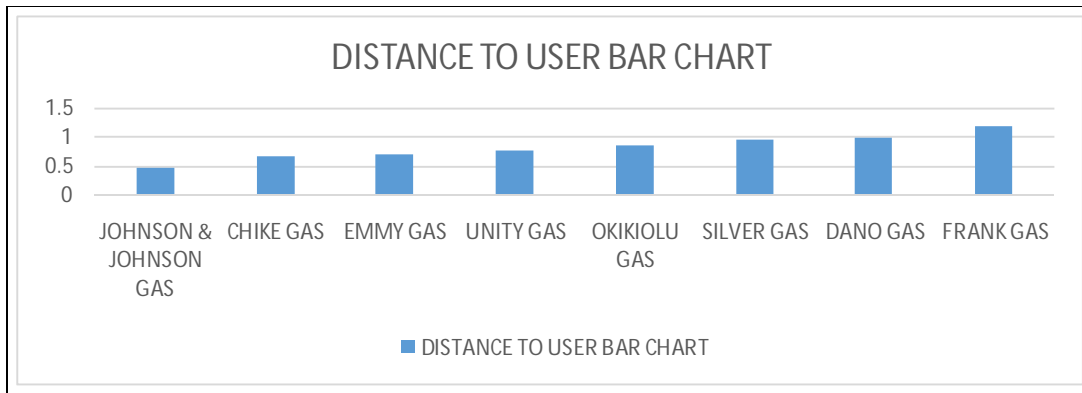


Figure 8: Distance between User Current Location and Gas Station

### Devices Performance Evaluation

Table 1 depicts the analysis carried out to check the performance of the system prototype on different version of android devices. The application works

better with the specifications of Android version 4.0 and above.

Table 1: Performance test with different devices

Application Properties/Device specifications	5.5-inch android Version 6.0 dual Core 1.4ghz	6-inch android Version 5.0 Dual Core 1.7ghz	6-inch android Version 4.0 dual Core 1.0ghz
Application Compatibility	Yes	Yes	Yes
Graphics Performance	Excellent	Excellent	Low
Screen Interaction Performance	Excellent	Excellent	Fair

## CONCLUSION

In this work, a platform for value-added services was developed based on LBS to provide consumers of liquefied gas, who are migrating from one location to another especially to the rural and semi-urban areas, an automated detection mechanism to easily locate the nearest gas stations and order for their liquefied gas refill online. The automated gas station detection mechanism was developed based on a goggle geo-coding application programming interface in laravel structure using haversine principle and A\* algorithm placing potential users and gas agencies on latitude and longitude of a particular geographic location. The application developed was tested on android devices on a selected city and worked satisfactorily.

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