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Towards the Deployment and Adoption of Location-Based Services for Optimal Mobile Communication Operations in Africa

Research Paper

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Abstract

Africa is the world's second largest and second most populous continent with about one billion people. Mobile phones are a major source of communication and means of taking information and technology to rural and remote areas of the continent. With low-cost and readily available mobile phones, underprivileged, low-income earners and rural dwellers can also participate in the Information and Communication Technology (ICT) revolution. Services are introduced by mobile operators and vendors to enhance and optimize this mobile evolution. One of such service is location-based services (LBS); LBS make available personalized services based on the geographical location of the subscriber's phone. LBS will be of great technological advantage in Africa optimizing operators' networks and bringing location information and services closer to the people. This paper offers some suggestions on effective deployment and adoption of LBS in Africa based on case studies from developed and developing countries.

Keywords

LBS, accuracy, Africa, ICT, developing countries, mobile phones

INTRODUCTION

Developing countries are caught up in the worldwide mobile technology evolution and Africa is no exception, though a bit slower. Until the year 2000, 50 of the 54 African countries had no mobile phone coverage; only South Africa, Egypt, Morocco and Senegal had mobile phone coverage (Mbiti and Aker,

2010). By 2008, 65 percent of the African population had access to mobile phone coverage even though barely a quarter of the African population have access to electricity (Mbiti and Aker, 2010; Bhavanani, Chiu, Janakiram and Silarszky, 2008), as shown in Figure 1. In Africa, mobile technology has not only been accepted, the mobile station(s) (MS) has become the ubiquitous form of communication. The penetration of mobile technology to rural Africa is particularly dramatic, where mobile phones are the first contact the populace had with modern telecommunication infrastructure (Bhavanani et al., 2008).

In Africa, especially in rural areas, the mobile network infrastructure is made up of mainly second wireless network generation (2G) networks and South Africa having the most advanced mobile network in Africa is a good indication of this. VODACOM South Africa with the largest network coverage in the country has about 99.7 percent 2G coverage and 54 percent 3G coverage. With a total urban coverage of 27,272 km^2 and total rural coverage of 1,191, 818 km^2, 2G rural coverage was 81.8 percent while 3G rural coverage was just about 7.3 percent (Vodacom, 2010). This might be because a large percentage of users only use voice and short messaging service (SMS) services. Consequently, rolling out a more advanced mobile network in most areas does not present economic importance. It might also be due to the low average revenue per user (ARPU) in most areas. Even though the major services presently offered are voice and SMS, the economic benefits currently enjoyed are enormous. Such benefits include, communication among social and business networks, job creation, and development projects using "m - development" (Mbiti and Aker, 2010; Bhavanani et al, 2008; Africa Partnership Forum, 2008).

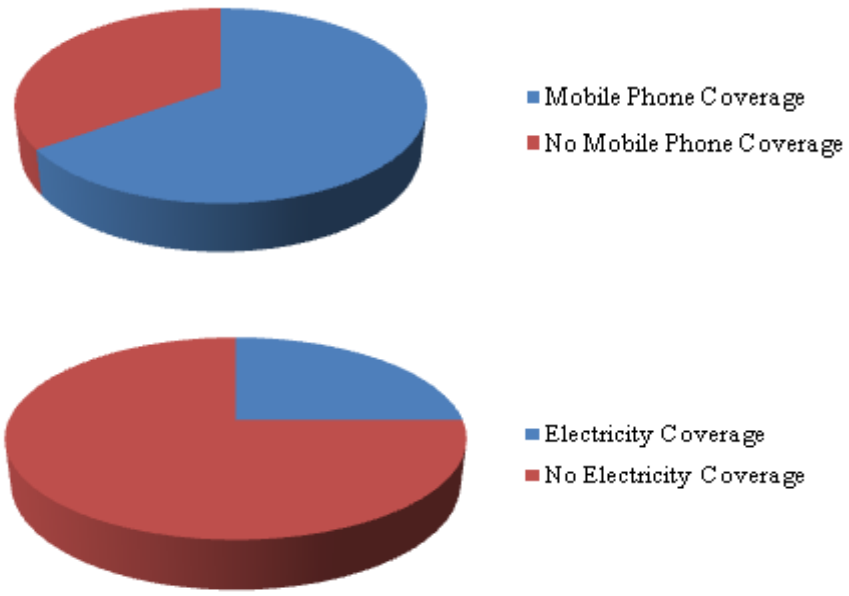

Figure 1. Mobile phone and electricity coverage in Africa in 2008

Even with the limitations presented by the mobile infrastructure, many other services can be introduced to the African populace to optimize the major communication technological penetration available to them: the mobile technology. Such new services include mobile money services; location based content services, menu driven information services, etc.

Location-Based Services

Location-based Services (LBS) are electronic service content that enable personalized services to the mobile cellular network subscribers based on their current geographical location (Dao, Rizos, and Wang, 2002; 3GPP TS 22.071 V 8.0.0, 2007). Some Mobile Station (MS) users have embraced LBS because of the important and significant relationship between mobility, geographical location and location dependent service. LBS in the United States represented about 15 percent of revenue made from downloadable applications in the second quarter of 2007 (Francica, 2007) and it is surprisingly almost non-existent in Africa. Even though the characteristics of each country and continent for the successful implementation of LBS are significantly different, LBS can improve the lives of people in Africa.

Global LBS platform revenue reached about US$510 million in 2010 and it is expected to reach a record high of about US$1.8 billion by 2015. After evaluating the importance of LBS, governments across the globe have not only embraced it, they are investing in network-based positioning which can assist in lawful interception of criminals, emergency services, and national security purposes. Governments are also taking the lead in network-based positioning because it is more reliable indoors and in covered areas than global positioning systems (GPS) (Mansfield, 2009.

LBS subscribers are provided with added services that enhance safety and provide peace of mind to users such as the emergency service and tracking services to track persons, assets, etc. Time and money is optimized by easy location of points of interest, location sensitive advertisement, and navigation. Tourists are immediately familiar with places with tourist guides, point of interest location, etc. There are always LBS available to meet diverse subscriber needs. Emergency location and other public safety related services can be regarded as the most important of the location-based applications especially important in situations where the caller cannot indicate his/her location due to his/her medical condition or unawareness of the right location (Juurakko and Backman, 2004).

Another reason for creating location-sensitive technologies is to create value added services. Such services include person locator, fleet management, affordable restaurant around, shortest route, etc. LBS provides new opportunities to mobile operators, application and content providers and other third party partners for the provision of innovative services and creation of new revenue sources (Turkyilmaz, Alagoz, Gur, and Tugcu, 2008; Lee and Rizos, 2003; Lakmali and Dias, 2008).

Better planning, design and optimization of resources in the wireless network is also possible with location information by using the spatial distribution of wireless callers in a particular cell or location (Djuknic and Richton, 2001). Pre-emptive resource allocation can also be achieved through the use of location information. This will assist in the smooth operation of the anticipated multi-media communications in wireless networks, which require high bandwidth and quality of service (Mcguire, Plataniotis, and Venetsanopoulos, 2003).

A large number of handovers always consumes a lot of network resources and failures of handovers would lead to call-drops and data loss. Location information can also assist in preventing faulty registration caused of a MS into a distant cell instead of nearby cells due to multipath radio signal propagation (Hellebrandt and Mathar, 1999; Wang, Hoole, and Gunawan, 1999). This might reduce the number of handovers, thereby optimizing network resources.

Proving LBS to Mobile Phones with No Built-in GPS Receiver

The mobile network is not the only feature that has evolved over the years; the MS has also evolved in size, features and capabilities. In late 2007, the mobile phone manufacturing sphere entered into the GPS world and started making mobile phones with built-in GPS (Jurgensen, 2008). This was attributed to the need by the mobile network operators to achieve the mandate created by the U.S. government for E-911 services (Dan, 2006). GPS positioning being more accurate will enable network operators to achieve the E-911 mandate. A GPS receiver receives precise orbit and transmit signal information from the GPS satellite and uses triangulation to calculate the exact position of the user on earth (Kaplan, 1996). With a GPS enabled MS, mobile services and accurate LBS services can be offered. Unfortunately, not all mobile subscribers can afford an MS with built-in GPS receiver, therefore most users still use the basic MS.

Africa is one of the poorest continents in the world with more than 30 percent of the African populace living on less than $1 per day (R7.5 per day) and more than 40 percent of the people live in rural areas (Africa Development Bank, 2011). Consequently, most mobile subscribers in Africa can only afford and, therefore, only make use of the basic MS (Khalil and Kenny, 2008). Considering these facts, the positioning technique best suited for the provision of LBS in Africa is the network-based positioning technique that can be provided to basic MS without the need for an upgrade.

The handset pyramid shown in Figure 2 depicts this scenario better. About 75 to 87 percent of subscribers in Africa presently uses basic phones and about 3 to 5 percent use smart phones. It should also be noted that not all smart phones are GPS enabled, thereby reducing the percentage of users with GPS enabled smart phones.

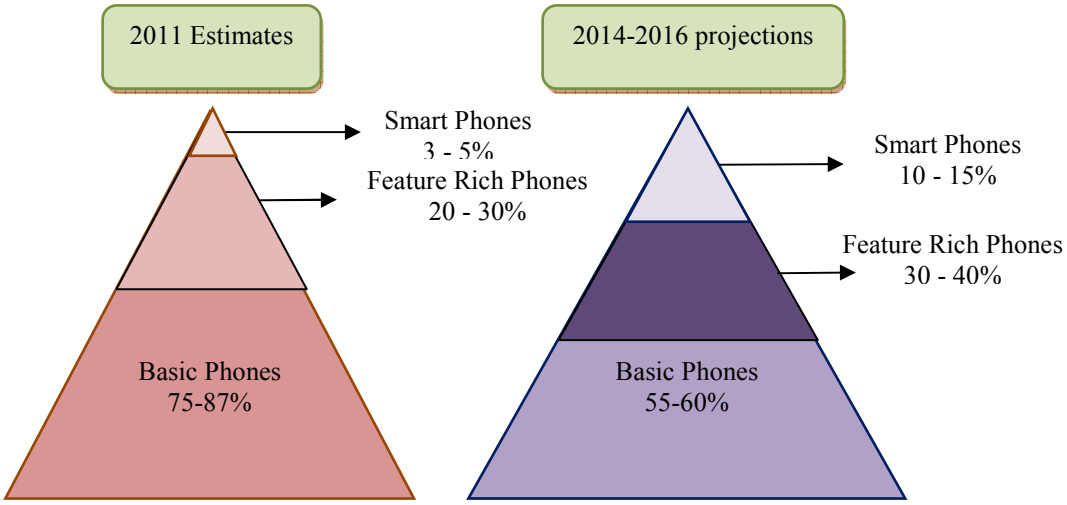

Figure 2. The handset pyramid (adapted from Hash, 2011)

The cost of the basic mobile phone is not the only issue to be considered; its low power consumption and battery life should also be considered. With only about a quarter of Africa having erratic electricity coverage (Mbiti and Aker, 2010), smart phones are quite difficult to maintain in Africa. In rural and even urban areas in Africa where there is no electricity coverage or erratic supply, MS users might only be able to charge their MS irregularly. Smart phones that are high ended devices consume much more electricity and their batteries drain faster than the basic phones. The basic mobile phone has a battery life

of about 400 hours while smart phone battery hours are highly dependent on the type of service they are used for as shown in Table 1.

Services	*Talk time on 3G*	*Talk time on 2G*	*GPS services*	*Stand by time*	*Media, games, surfing the web*
Battery life	5 hours	10 - 15 hours	5 hours	150 hours	< 5 hours

Table 1. Average battery life of a typical smart phone

With the obvious advantages of LBS, the African continent needs to address the provision of LBS in the continent particularly those living in rural areas, low income earners in slums and settlements and also to urban and suburban dwellers. There is no known written research on LBS in Africa especially analyzing its deployment and adaption to an African setting. An investigative research into the growth and deployment of LBS in Africa is presented in this paper. The investigative research was accomplished using a reference model and results presented indicate that Africa is indeed ready for LBS, and it will enhance the lives of many living in Africa since mobile technology has become the major means of information and communication to the African populace.

This paper presents the academic research carried out on two developed countries with already established LBS namely: the United States of America (USA) and the United Kingdom (UK). LBS in the developed countries were then compared to those obtainable from an African setting with the view to developing a roadmap for LBS deployment and/or adoption in Africa. Four African countries were investigated namely: South Africa, Nigeria, Kenya and Egypt. The primary objective of this paper is to examine the challenges posed to deploying LBS in Africa by analyzing other developed countries and looking at the peculiarities of the African mobile technology environment. Other issues considered include user satisfaction and profitability of mobile operators and their third party partners. This is an extended version of a paper presented in a conference (Dahunsi, Dwolatzky, Falaki, and Alese, 2011).

The rest of the paper is organized as follows: the next section introduces LBS as a convergence of various technologies and introduces a reference framework that will guide in the analysis of data collected. The last two sections present findings and the way forward in the deployment of LBS in Africa. A suggested direction for further work and conclusion is also provided.

BACKGROUND AND METHODOLOGY

Convergence of Technologies

Location-based Service is a convergence of four different technologies: the cellular network, Geographical Information System (GIS), Global Positioning System (GPS), devices and applications (Dao et al., 2002; Sadoun and Al-Bayari, 2007; Steiniger, Neun, and Edwardes, 2006). LBS are related to GPS, which enable location of people, objects and points of interest using satellite positioning technology. GIS is the management and analysis of spatial location data mapped to real world features such as places, roads, points of interest to geographical coordinates. The geographical information makes up the data and content given in response to the subscriber's request (Sadoun and Al-Bayari, 2007).

Methodology

Data collection was carried out through a survey of literature from different sources such as journal papers, conferences, mobile network operator's reports, newspaper articles, online publications and others. Data was collected for the aforementioned countries and areas. For the purpose of this research, a reference framework was adapted from Petrova and Wang (2010) to analyze the adoption and deployment of LBS in Africa.

Data collected were analyzed in five stages. Firstly, for each of the regions considered, the type of LBS deployed and location technologies used were examined. Secondly, the advancement of GIS and GPS were analyzed in the regions. Thirdly, the mobile network market that includes the mobile operators and the government regulations were considered. Fourthly, the average revenue per user (ARPU) of the countries under consideration was presented. Lastly, the outcomes of the findings were used to compare the case of Africa to the other regions. Finally, deployment and adoption of LBS in Africa was analyzed.

Reference Model

The author adapted and extended an earlier developed mobile commerce reference model given by Petrova and Wang (2010) to assist in data gathering and the data analyses carried out. There are five important factors that influence the development of new LBS applications; these are infrastructure, interface, business, customer satisfaction and experience, and the customer's bargaining power. The infrastructure includes the mobile/communication network and the MS. The positioning process is carried out by algorithms and applications to request and deliver the LBS request; GIS are used to provide data and content. A feedback is received by the mobile network operator from the subscriber through the ARPU. Figure 3 is the graphical representation of the reference model.

Infrastructure layer

The mobile network is a communication path; it transfers user data and service requests from MS to the service provider and gets the requested information back to the MS. Most smart phones today are designed to meet the needs of developed countries. Africa being home to the poorest citizens in the world has most subscribers using MS with restricted capabilities (ConnectWorld, 2009). It is predicted that Africa and the Middle East region will have the largest amount of mobile phone shipments with 166 million low cost phones to be sold by 2014, representing 24 percent of all sales for the year (ConnectWorld, 2009).

Interface layer

The interface layer comprises of the positioning component that is used to estimate the location of the MS. For LBS, locating the MS is of utmost importance. Methods of locating the MS can be grouped into three types, as previously highlighted: handset based, network-based and a hybrid of both. Most network-based methods are used for MS with basic features, where all measurements and calculations needed for positioning take place in an already existing mobile network (Steiniger et al., 2006; Kupper, 2005).

Business layer

There are many LBS offered by mobile service vendors in developed countries, which include locating a friend and locating a point of interest. Real world features such as roads, points of interest and companies are represented in databases and the location information is linked to location coordinates.

Consequently, a request is made to a spatial database about a specific location by the software application for the retrieval of location information. All these various aspects are handled at the business layer by mobile service vendors and third party partners.

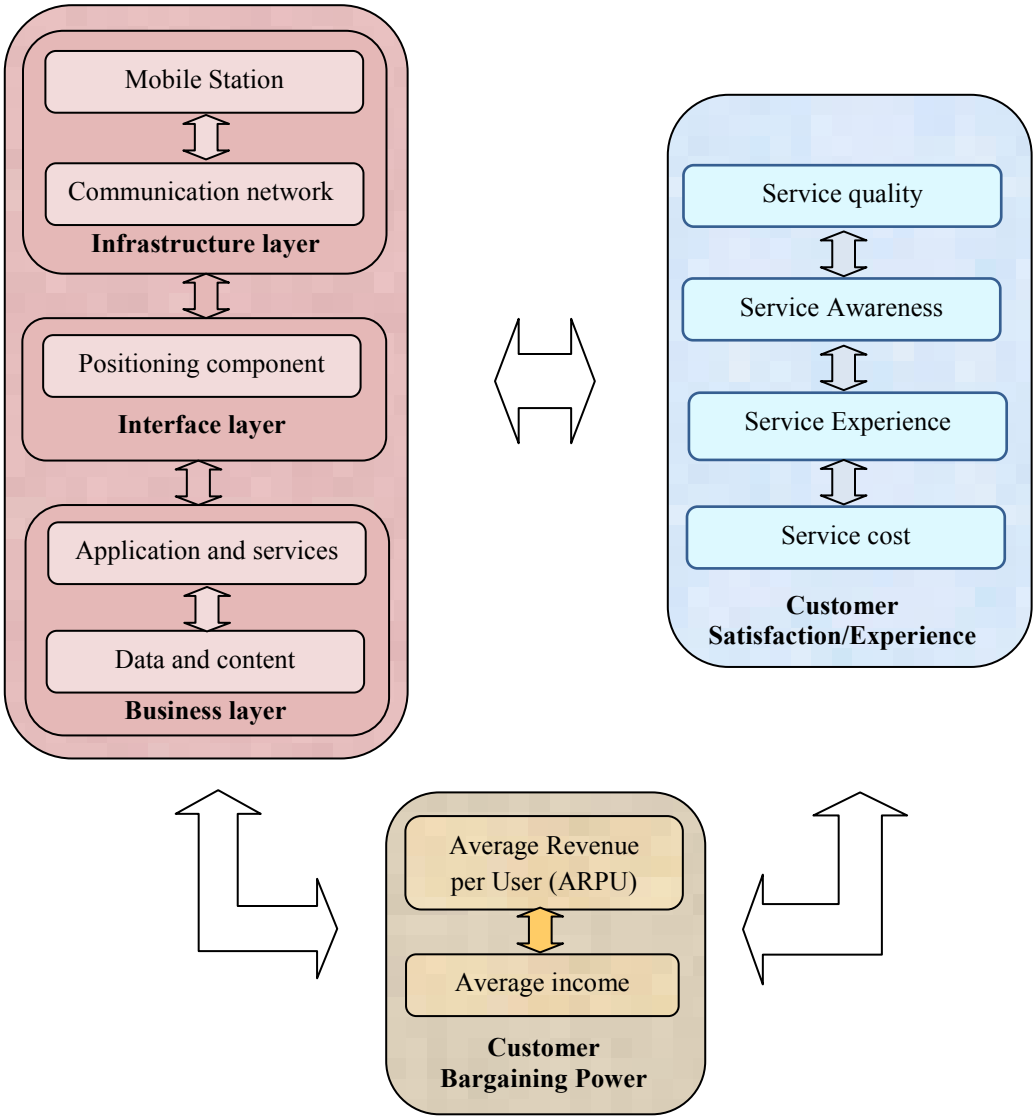

Figure 3. LBS reference framework (adapted from Petrova and Wang, 2010)

Customer Satisfaction and Experience

The ability to provide good service to the customer is a major pillar stone in any service oriented organization. Unfortunately, LBS developed and adapted to developed countries are transferred to Africa without undertaking adequate research and tailoring the services to the needs and preferences of the continent (ConnectWorld, 2009). This issue has led to customer dissatisfaction and an inability to optimize the opportunities for services presented by MSs.

Customer Bargaining Power

The inclusion of the customer bargaining power in the LBS mobile commerce reference model is one of the important contributions of this research work. It is a major addition to the model presented in Petrova and Wang (2010), which did not consider the effect the customer bargaining power has on customer experience and profitability of mobile operators and their third party partners. The customer bargaining power of the developing and developed countries will be compared using Gross Domestic Product (GDP) per capita, Gini coefficient and ARPU.

GDP is a basic measure of a country's economic output, while GDP per capita is the GDP divided by the population of the people in the country by midyear (Case and Fair, 1996). Individual purchasing power (GDP-per-capita) is a means to compare the strength of consumers. A country with customers with higher GDP per capita compared to another, has a higher purchasing power. A country with higher GDP per capita has customers who have higher income and better purchasing power than another with lower GDP per capita. The GDP per capita is taken as the average income of the country (Case and Fair, 1996).

The Gini coefficient is also an important economic indicator that measures the degree of inequality in the distribution of family income among an entire population or country (Central Intelligence Agency [CIA], 2011). A high Gini coefficient indicates that more of the income is distributed amongst a small group in the population and a low Gini coefficient indicates that the income is equally distributed among the majority of the people.

The amount mobile operators are ready to invest in research, development of services, applications, infrastructure and their deployment is dependent on the average income of the community of interest, which will in turn give an estimate of the expected ARPU. ARPU in a mobile network is used to express the income generated by a typical subscriber on the mobile network (Bedel, 2005). ARPU is dependent on the amount an average subscriber earns and the amount the user is willing to pay for the services that are offered. The customer bargaining power has a direct effect on all the other layers such as the infrastructure layer, interface layer, business layer and definitely the customer's satisfaction and experience.

GDP per capita, Gini coefficient and ARPU are metrics of customer's bargaining power employed in this research. They have various limitations. Some limitations of GDP per capita include firstly, computed economic statistics methods vary by country. Secondly, it excludes informal income and thirdly, exchange rate used for computation is rarely stable. Gini coefficient is limited because firstly, it cannot be used when the distribution is negative; secondly, tangible information might be lost in the process of computation. It is also limited when absolute national and personal incomes are considered. ARPU is not without some limitations too, such as subscribers having multiple accounts and generally the metric is skewed to and by certain services. The considered metrics are however widely used and accepted and hence appropriate for the investigation carried out.

CASE STUDY OF DEVELOPED COUNTRIES

Customer Purchasing Power

GDP per capita of USA and UK, as given by the CIA by the first quarter of 2011, are $47,400 and $35,100 respectively (2011). The ARPU of AT&T the largest mobile operator in the USA and Orange

in the UK is $61.89 for the first quarter of 2010 (AT&T, 2010) and $31.87 for the fourth quarter of 2010 (Orange and T-mobile, 2011) respectively. The ARPUs measured in the UK and USA was determined based on the mobile operator with the largest market share; that is, AT&T.

Infrastructure

In Europe, Global system for Mobile Communications (GSM) is a unified technology but this is not the case with USA, where there are both Code Division Multiple Access (CDMA) and GSM networks (Petrova and Wang, 2010).

LBS Deployment

The main driver of LBS in USA is the requirement by Federal Communications Commission (FCC) for locating Emergency 911 callers using MSs within a specified accuracy (Kerton and Kerton, 2003).

Among the top five wireless operators in the USA are Cingular, American Telephone and Telegraph Wireless Service (AT&TWS), T-Mobile, Sprint-Nextel and Verizon. Cingular, AT&TWS and T-Mobile are based on GSM infrastructure while Sprint-Nextel and Verizon operators have CDMA infrastructure (Petrova and Wang, 2010; Kerton and Kerton, 2003). The GSM infrastructure can easily locate both legacy MS and those with built-in GPS, while for the CDMA network it is more technically effective to locate only MSs with built-in GPS.

Cingular, AT&TWS, and T-Mobile adopted a network-based solution uplink time difference of arrival (U-TDOA) (Kerton and Kerton, 2003). Other mobile operators with CDMA technology adopted assisted GPS (AGPS), a handset based solution. U-TDOA technology requires an upgrade of the mobile network while the later requires an upgrade to the MS. The U-TDOA and the AGPS are the only ones that have met the performance requirement for emergency services location (Kerton and Kerton, 2003;Wilde, Saunders, Melcher, Sage, Curry, and Jones, 2004). U-TDOA supports many types of mobile phones.

Various types of LBS such as emergency, navigation, information and tracking location based services are offered in USA by mobile operators and other third party business partners (Wang, 2008). These LBS are monitored by regulatory bodies; therefore, they should meet the specifications of the FCC in accuracy and reliability.

Enhanced 112 (E112) a variant of E911 in USA was initiated by the European Commission as a directive in 2002 ("Directive 2002/22/EC", 2002) with the aim of providing emergency services to MS users. In Europe, GSM is a unified technology. As a result, it was easier to work on a technology for E-112 and enhance LBS deployment. The technologies proposed includes Cell-ID, Cell ID + TA, E - OTD, U-TDOA and A-GPS were all considered suitable for E112. The most probable ones due to accuracy are U-TDOA and A-GPS (Wilde et al., 2004). Various types of LBS such as emergency, navigation, information and tracking location based services are also offered in the UK (Koutsiouris, Polychronopoulos, and Vrechopoulos, 2007).

Data and Content of LBS

There are many GIS companies already operational in developed countries especially USA and UK; therefore, they have well managed up to date maps and spatial information available on most parts of the country. The data and content made available to LBS subscribers are reliable and up to date. With qualified and trained personnel working for LBS vendors, services and applications well suited for the

needs of subscribers are developed and deployed. This approach will effectively meet the expected requirements for LBS accuracy.

Regulatory Body

The FCC regulates E-911 in the USA and E-112 was commissioned by the European Commission; both are well established regulatory bodies. No implementation deadline or accuracy was specified by the European Commission (Kerton and Kerton, 2003; European Commission, 2003).

In 1996, the USA FCC adopted a report that enforced mobile operators in the USA to provide and deliver wireless emergency service (E911) (Zhao, 2002;FCC, 2000). The E911 became a major driver of LBS to enhance effective location based emergency service delivery sent from MS(s) to Public Safety Answering Points (PSAPs) (911 call centers) and to meet the deadline set by the FCC (FCC, 2000).

According to USA FCC regulations, MS-based positioning technique must ensure the accuracy of 50m for 67 percent of calls (150 m for 95 percent of calls) while network-based E911 service are to provide for an accuracy of 100 m for 67 percent of calls (300 m for 85 percent of calls) (Zhao, 2002; FCC, 2000). The mobile operators in a bid to obey the FCC rules invested much resource in their mobile network thereby paving the way for commercial LBS as well (Beinat and Dias, 2003), (Zhao, 2002). The European Union (EU) commission (EC) also issued a directive in 2002 ("Directive 2002/22/EC" 2002) enforcing the enhanced 112 (E112) a variant of the USA's E911 (Wilde et al., 2004).

CASE STUDY OF DEVELOPING COUNTRIES IN AFRICA

Customer Bargaining Power

GDP per capita of South Africa, Nigeria, Kenya and Egypt as provided by CIA for the first quarter of 2011 are $10,700, $4,400, $1,600 and $6,200 respectively (CIA, 2011). As can be seen in Figure 3, the GDP per capita of the USA is about 30 times more than that of Kenya. The ARPU of the largest mobile operators were also considered in South Africa it was $19 for first quarter of 2010 (VODACOM report, 2010), $11 for the fourth quarter of 2010 in Nigeria (Mobile Telecommunication Network (MTN), 2011), $7 in Kenya for the fourth quarter of 2010 (Safaricom, 2010), and $5.16 in Egypt for the third quarter of 2010 (Mobinil, 2010).

Figures 4 and 5 show a strong correlation between the GDP per capita and the ARPU of the countries considered except for Egypt, which offers the most cost effective mobile services in the world. The exchange rate of the Egyptian pound to the dollar is also affected by the turmoil that recently took place in the country (The New York Times, 2011). These data imply that a country that earns more will pay more or spend more on mobile applications and services.

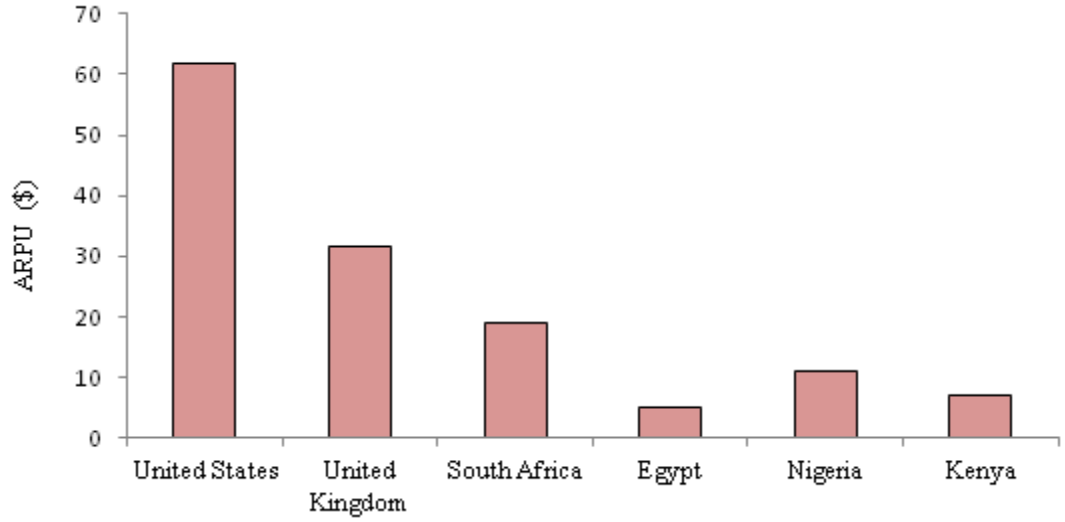

Figure 4. Average Revenue Per User (ARPU) of some selected countries

According to the CIA's "World Fact Book" (2011), the Gini coefficient of USA, UK, South Africa, Egypt, Nigeria and Kenya are 45 percent, 34 percent, 57.8 percent, 34.4 percent, 43.7 percent and 42.5 percent respectively. The Gini coefficient from the Human Development Report produced by the United Nations Development Programme is slightly different due to the method of data collection and analyses. According to the United Nations Development Program (2010), the Gini coefficient of USA, UK, South Africa, Egypt, Nigeria and Kenya are 40.8 percent, 38 percent, 65 percent, 32.1 percent, 42.9 percent and 47.7 percent respectively. These relationships are shown graphically in Figure 6.

Though income distribution inequality affects all countries, the worst affected countries are those with low GDP per capita, such as the African countries considered. Though the income in these countries is minimal it is unequally distributed and in the hands of a few of the entire population. From Figure 6, South Africa has the worst Gini index with a large amount of its family income taken by a small group of people, and Egypt has the best distribution according to the Gini coefficient.

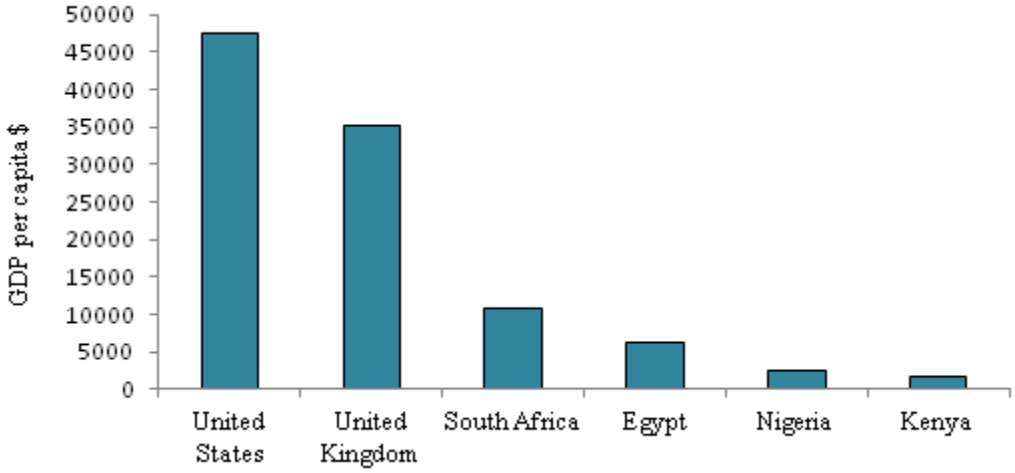

Figure 5. GDP per Capita of some selected countries

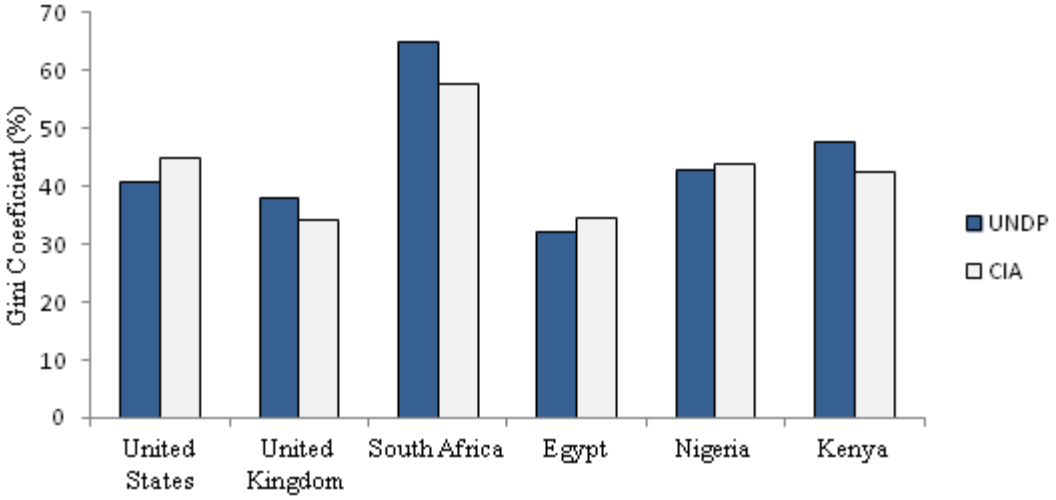

Figure 6. Gini coefficient of some selected countries

Infrastructure

South Africa has a population of about 50 million people and a mobile network penetration rate of 93 percent (International Telecommunication Union [ITU], 2009). The South African mobile market started in mid-1994 and by 2008 had about 45 million subscribers, or a 92 percent penetration rate. It was predicted that by the end of July 2009 there would be about 54 million mobile subscribers in South Africa, which is about 13 percent of the estimated 415 million mobile subscribers in Africa.

South Africa operates with a more advanced technology than other African countries. The mobile operators include Vodacom with about 26.3 million subscribers in the first quarter of 2010 (Vodacom Group, 2010), MTN with about 18.8 million subscribers in the third quarter of 2011 (MTN Group, 2011) and Cell C with about 8.2 million subscribers (Mansfield, 2009). Virgin Mobile is a mobile virtual network operator using Cell C network while Red Bull Mobile and 8.ta are roaming virtual mobile network operators using Cell C and MTN for coverage across South Africa respectively. All the mobile networks operate GSM, General Packet Radio Service (GPRS) and Enhanced Data Rates for GSM Evolution (EDGE) technologies. Vodacom and MTN both operate the Universal Mobile Telecommunication Systems (UMTS) technology. All mobile operators plan to roll out a higher package, High-Speed Packet Access Evolution (HSPA+) in the nearest future.

Kenya has 19.4 million subscribers in total and a 51 percent penetration rate (Communication Commission of Kenya, 2010). The mobile operators are Safaricom, Airtel, Orange Kenya and Yu- Essar Telecom Kenya with Safaricom being the largest subscriber base with about 18.1 million mobile subscribers in the third quarter of 2011 (BuddeComm and Chiltern Magazine Services Ltd, 2011). All mobile operators use GSM technology.

Egypt has about 66.3 million subscribers in total, or a 93.2 percent penetration rate by the end of 2010. Egypt is the second largest market in Africa with approximately 13 percent of the total mobile subscriber market (Telecoms Market Research, 2011). The mobile operators are Mobinil, Vodafone and Etisalat with 30.4 million, 31.8 million and 13.28 million subscribers respectively. All the networks operate with the GSM and UMTS technology (BuddeComm and Chiltern Magazine Services Ltd, 2011).

Nigeria has a population of about 153.2 million people with about 90 million active mobile line subscribers or a mobile line penetration rate of 60 percent. Nigeria is the largest single mobile market in Africa having grown from a no mobile phone country in early 1999 to 59 mobile subscribers per 100 inhabitants in 2010, an enormous growth for just about 10 years of mobile technology in the country. The country has over 120 million connected mobile subscribers (Nigerian Communications Commission, 2011a).

The GSM mobile operators in the country include MTN, GloMobile, Airtel-Zain, Etisalat, Mtel with about 40.54 million, 19.49 million, 15.97 million, 7.8 million and 0.2 million. The CDMA mobile operators have about 10% penetration and the CDMA operators are Multilinks-Telkom, Starcomms, Reliance telecoms, Intercellular Nigeria and Visafone (Nigerian Communications Commission, 2011b).

LBS Deployment

VODACOM and MTN are the only South African mobile operators offering LBS at the moment and they make use of enhanced Cell-ID method for locating the MS. Though they have the most advanced technology in Africa, they make use of the most basic positioning method to estimate the position of a MS for most commercial LBS.

VODACOM offers the following network-based LBS; Emergency call (911Alert), Distress call (Look4Help), Person tracking (Look4Me), and Points of interest (Look4it). MTN offers Emergency call (911Alert), Distress call (MTN2myAid), and Person tracking (WhereRU). Asset tracking is offered by MTN and VODACOM in conjunction with asset tracking companies.

Cell C offers only emergency calls (911Alert). VODACOM introduced a new trial of a location-based advertising service called the grid to be launched soon (SAinfo reporter, 2009). Look4Me for Business, Cellfind Assets, Cellfind Messaging Portal, 911 Alert, Look4Music and miTraffic are other types of LBS offered through third party business partner CELLFIND (Microsoft Dynamics ®, 2010). South Africa LBS market forecasts an increase in the LBS market to rise to $33.8 million in 2013 (SAinfo reporter, 2009).

Safaricom and Airtel-Zain are the only operators offering LBS in Kenya. Safaricom engages commercially in vehicle tracking and Airtel-Zain Emergency calls. Table 2 summarizes the LBS offered in the aforementioned developing countries in Africa.

Data and Content of LBS

South Africa is the most developed country in Africa and was the pilot for many technologies already existing in Europe and USA. ESRI, a major GIS company, has a subsidiary in South Africa; therefore, South Africa has relatively up to date maps and spatial information. Here data and content availability is more commendable than other African countries, and there are more qualified and trained personnel to develop and manage LBS.

Before now, Egypt had a ban on GPS and all GPS products. MS entering the country with built-in GPS had to be disabled before they could be sold. The ban was recently lifted in April 2009 (Privat, 2009). This might have a positive impact on the growth of LBS in this country.

LBS were introduced in Nigeria in the year 2010 by Starcomms, which uses a CDMA network and covers less than 5% mobile penetration. The LBS launched called StarTrack allows subscribers to locate family and friends (ITNewsAfrica, 2010). At the time of this research, all the other mobile operators

were yet to launch any other LBS. With most subscribers on GSM networks, StarTrack on CDMA network is available to very few.

Country	*Company*	*Penetration Rate*	*Services*
Egypt		58.85% penetration rate	
	Mobinil,	(05/2008)	-
	Vodafone		-
	Etisalat		-
Kenya		51.2% penetration rate	
	Safaricom	(06/2010)	Vehicle tracking
	Airtel-Zain		Emergency calls
	Orange Kenya		-
	Yu- Essar Telecom Kenya		-
Nigeria		59.90% penetration rate	
	MTN	(10/2010)	-
	GoMobile		-
	Airtel-Zain		-
	Starcomms		Person tracking
	Mtel		-
	Etisalat		-
	Multilinks-Telkom		-
	Visafone		-
South Africa		92.15% penetration rate	
	Vodacom		Emergency calls
			Distress calls
			Person tracking
			Points of interest
			Asset tracking
	MTN		Emergency calls
			Distress calls
			Person tracking
			Asset tracking
	Cell C		Emergency calls
	8.ta		rMVNO[1]
	Virgin Mobile		MVNO[1]
	Red Bull Mobile		rMVNO[1]

[1]Roaming Mobile Virtual Network Operator

Table 2. Location-based services in 4 African countries

Regulatory Body

At present, as far as the author can ascertain, there is no legislation regarding emergency LBS or other LBS in any African country.

THE WAY FORWARD TO DEVELOPMENT AND DEPLOYMENT OF LBS IN AFRICA

All over the world, many LBS have been successfully launched, and to find new opportunities, mobile services providers are looking at Africa more closely. Unfortunately, this is not paying off well because providers try to push existing products and services deployed in developed countries to the African market instead of adapting the services and products to the needs and culture of the people (ConnectWorld, 2009; Entrepreneurial Programming and research on mobiles [EPROM], 2010).

Location information allows subscribers to access information that is pertinent to the location of the requesting user. Subscribers may initiate service requests on demand, or automatically when triggering conditions are met; for example, entering a particular cell or when a specific hot spot in the area is approached.

According to ITU, LBS can be classified as pull and push services (ITU, 2006). For broader analyses of LBS applications consult (Raper, Gartner, Karimi, and Rizos, 2007). With pull services, the user request for LBS and location information are sent based on user interaction and request (Steiniger et al., 2006), some examples of push services includes information, functional, interactive, emergency and mobility services (Steiniger et al., 2006; Beinat and Dias, 2003) .

While for push services, location information are pushed by the service providers to the end users not on request but based on the location of the user. Such services are activated when the mobile user gets to a particular location or area, and it might also be time dependent. Sometimes user needs and preferences have to be sensed by the push system (Steiniger et al., 2006). The LBS discussed here are those that have been adapted to the needs of Africa.

Short Term LBS Needs

These LBS will attend to the short term needs of subscribers.

People tracking

The LBS helps to pinpoint the geographical location of friends and family especially when they go missing, or for child tracking purposes. People tracking can also be of importance in fighting the spread of diseases and epidemics in Africa, such as tuberculosis. African countries face formidable challenges in public health such as the rapid spread of HIV/AIDS, persistence of malaria and related killer diseases such as tuberculosis.

Presently, Africa is facing the worst tuberculosis epidemic since the advent of the antibiotic era. This is driven by a generalized human immunodeficiency virus (HIV) epidemic, compounded by weak health care systems; the situation has gradually worsened (Ambali, Mugabe, and Mutero, 2009). More than two-thirds of the populations in 25 of the most affected African countries live in rural areas. Rural people are more prone to the disease because they are less likely to protect themselves and do not have adequate access to health services and information (Food and Agricultural Organization of the United States, nd). With LBS, location specific information can be sent, treating and locating patients to assist in management of these health challenges might be made easier.

Maintaining patients on pulmonary tuberculosis (TB) treatment is also critical to ensure its cure and the prevention of drug-resistant strains of tuberculosis. A contributing factor to high treatment interruption rate is the limited capability of the TB clinics to locate patients who interrupt their treatment (Dwolatzky, Trengove, Struthers, McIntyre, and Martinson, 2006). LBS can be used to trace and locate patients to ensure completion of TB treatment.

Health information services

There is a huge brain drain of health professionals in the rural areas to the urban areas (Clemens, 2006). Therefore, there is a need to make effective and adequate use of the services available. LBS can be used to provide information services to mobile subscribers such as nearby hospitals with health care workers,

health care centers with the required medication and health providers. Event reminders for community health education and immunization can also be broadcast to the people in a particular location.

Cell broadcast

The network automatically broadcasts information to mobile phones in a geographical area. The information can be sent to all mobile phones in the area or to a specific group/community. Health information, weather alerts and other important information can be sent to the people in the coverage area. In most African countries, the police do not always have the capacity to respond to and help victims of attack. Therefore, people resort to depending upon each other in a community and even employing security personnel if applicable. When there is an incident of robbery or assault, an emergency number can be sent to the police and selected members of a registered community or geographical area, like the Community Policing Forum (CPF).

Security alerts

Robbery, murder, rape and other forms of assault are prevalent in particular areas and locations. Warning information might be sent to all persons approaching or already in the location to make them aware of the dangers of that particular location and precautions to be taken. This information can also be enforced on beaches and unsafe natural habitats. Africa is a continent with many indigenous beliefs, culture and traditions. There are some rural and urban areas in Africa where visitors are not welcome at particular times of the year, on particular days and in particular hours, because some traditional rituals are being performed which might be harmful or embarrassing to visitors.

Emergency service and alert

Emergency calls and emergency alerts are probably the most important feature offered by LBS, especially in situations where the caller cannot indicate his/her location due to a medical condition or unawareness of his/her location. Emergency alerts are very useful when natural disasters occur, such as flooding, disease epidemics and fire outbreak, which could claim lives and destroy homes. Africa is known for the slow response of emergency personnel to alerts; mobile phones of passengers in any means of transportation can also be automatically linked to emergency alerts.

Commodity availability information

Poverty in Africa is predominantly in rural areas with more than 70 percent of the continent's poor people living in such areas. These rural dwellers still depend on agriculture for food and livelihood even though development assistance to agriculture is decreasing (International Fund for Agricultural Development [IFAD], 2010). The availability of LBS in rural areas will enhance the advertisement of commodities available in a particular environment or community and the location of such commodities or agricultural produce. This will improve people's access to commodities or agricultural produce before it perishes due to unavailability of adequate storage and preservation facilities in rural areas.

Route/ security information

With possible hijacking and accidents on African roads, this LBS service can give security and traffic information about a route to ensure safety and timely passage.

Hotspots alert

Africa had experienced and is still experiencing a lot of human-made disasters. Examples include xenophobic attacks in South Africa, religious crises in Northern Nigeria, ethnic cleansing in Sudan, and genocide in Rwanda. An effective warning system can be developed that sends out emergency alerts once there are natural or human-made disasters. This service will give information about what is happening and the best way to get to safety. Hotspot alerts locate crisis areas and provide information about the nearest safe spot, including police station, nearest military barrack and directions on how to get there safely. Disaster zones can also be mapped out quicker in the even to fires, outbreak of diseases, etc..

Weather alert

There have been many cases of flooding, drought and destruction of lives and properties due to lack of adequate weather warning. Weather alerts can be sent that might help people adequately prepare for such events, thereby saving life and property.

Long Term LBS Needs

These LBS suggestions are adapted to the long term needs of subscribers.

Directions/Navigation

This application guides a mobile phone user to his/her destination by providing navigational or directional information, linked to a geospatial information system. This service can also be provided to villagers travelling out of their zones for the first time.

Traffic monitoring and management

The infrastructure in place in most urban areas of Africa cannot cater to the population of people living in these urban areas. Traffic management can be a lot easier with traffic information sent with different routes. Traffic management can assists in decongesting roads and providing alternate routes.

Route planning, fleet and asset management

This service is very important to companies with fleet vehicles having scheduled deliveries. Routes are carefully planned to get the goods delivered no matter the eventualities. Asset management needed in rural communities may range from perishable agricultural goods to cultural artifacts and in urban areas: vehicles and goods. These LBS should be able to provide location and timestamp of the fleet/asset when registered to ensure safety and prompt delivery.

City guides

Tourism is an important alternative source of foreign exchange into the continent. A guide should provide information about points of interest such as historical sites, tourist attractions, restaurants, police stations, etc.

Location based voting

Electoral processes in many parts of Africa had been characterized by electoral crises; Zimbabwe, Nigeria, Democratic Republic of Congo and Kenya are a few examples of this (Mehlar, 2007). Location based voting will help monitor the movement of voters and the movement of election materials from different locations, which might assist in authenticating the fairness of the elections.

Personnel and workforce management

The workforce and personnel management LBS can be used to track employees and ensure that work-plans are completed. It could also offer the ability to enforce penalties to defaulters. This service can be used by both private and government sectors. It could also be used to communicate with field workers to improve their productivity in the field.

CHALLENGES ENVISAGED

Data and content

A good addressing system and adequate geocoding for Africa is important for the deployment of LBS due to the use of geographical information system used to map real points of interest and streets to geographical coordinates. Considering the fact that Africa is a developing continent, the spatial database are not well populated, low in accuracy and not up-to-date. Also, due to inadequate town planning, houses and street addressing and not well marked streets (Dahunsi and Dwolatzky, 2011) consequently, Africa needs to invest more in GIS to provide adequate and accurate LBS.

Services and Application

Most of the services currently in Africa were brought in from developed countries and rolled out; therefore, they have not been adapted to the needs of African users (ConnectWorld, 2009). This might be due to the unavailability of trained local staff and personnel to develop the services and applications. Acceptance of such services will be slow if not impossible by most subscribers because the needs of the intended subscribers might not be met.

Quality of service

Cell density affects most network-based positioning methods. The present challenges with voice services such as high drop call rates in some areas in Africa might translate into reliability challenges with LBS.

Regulatory body

There is presently no regulatory body looking into LBS services in Africa. Without good regulation in place the quality of service provided cannot be ensured.

LBS Infrastructure

Many location estimation devices such as location measurement unit (LMU) and smart devices are not readily available in developing countries because of huge investment involved. Therefore, some location estimation technologies using these devices have low applicability in Africa. It is important to explore other methods to further enhance the accuracy of network-based location estimation techniques.

Accurate positioning

The most applicable positioning methods in Africa are those that need little or no modification to the mobile network and no modification to the MS for its implementation. These can be summarized as network-based positioning techniques. These are generally dependent on many factors such as cell size, multipath, propagation channel, wireless environment and geometry of BSs.

Error models, multipath propagation models and non-line-of-sight (NLOS) propagation models are highly dependent on the geometry of BSs and the wireless environment (Dahunsi and Dwolatzky, 2011). Consequently, various location estimation algorithms are affected in varying ways by different topology and wireless environments especially in network-based positioning (Sun, Chen, Guo, and Liu, 2005).

Different methods should be adapted to different areas depending on the topography of the area and topology of the network. There should be no one general solution for all the areas.

RELATED WORK

From the research conducted and presented in Latif et al. and by Indicus, it was suggested that Africa is not the only continent with a need to explore the full potential of LBS (Latif, Memon, Khan, and Shahzad, 2008; Indicus for IAMAI, 2008). Latif et al. proposed some location based services that can be deployed in Pakistan such as e-marketing, parental eye, cellular cab services, location based voting, etc. The researchers did not access the infrastructural facilities available and a roadmap to the successful implementation of LBS in Pakistan. The services suggested would only serve urban subscribers adequately (Latif et al., 2008).

The Indicus white paper gave a detailed roadmap to a proposed deployment of mobile LBS in India. It gave the challenges envisaged and the way forward in the implementation of LBS in India. Current LBS provided in India are fleet management, person locator, mobile yellow pages and tourist information. It also suggested some LBS that might be adapted for use in India (Indicus for IAMAI, 2008), such as emergency LBS, LBS navigation, weather alerts, person location based search, location-based gaming and other types of location information.

Petrova and Wang (2010) compared LBS in developed countries with LBS in New Zealand by using an LBS reference model. They claim that though New Zealand is a developed country, the country is not enjoying the full potential of LBS like some other developed countries such as USA, Japan and Europe. They suggested that the possible boosters of LBS could be public safety demand, which will lead to legislative laws guiding the provision of LBS as obtained in USA and industry demand for navigation and routing.

CONCLUSION

This paper presents a novel investigative research about LBS in Africa. The contribution to knowledge presented in this paper includes the extension of an LBS reference model to incorporate customer satisfaction, comparing LBS in Africa with developed countries, the adaptation of some LBS to the African setting, highlighting the challenges that might be encountered with deploying LBS in Africa.

With the analyses and evaluation presented, it can be concluded that Africa needs LBS adapted to its needs. LBS that are reliable, dependable and their location information that can be used for the required purpose is of optimal importance. Consequently, there is a need to provide accurate location information (data content), which is highly dependent on accurate network-based positioning techniques.

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