

Location-based Services: A study on applications and services

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Abstract

The proliferation of location services and location determination in mobile devices had broaden the landscape for the development of heterogeneous Location-based Services (LBS). The correlation of LBS applications, mobile devices and facilitating technology is a complex issue due to its diversity, hence there are immense contextual definitions of LBS. This study, review the applications and services of LBS in order to provide a common classified LBS applications and services to date. The literature reviews of LBS definitions, standards and guidelines, LBS architecture, LBS components and the most common classification of LBS application and services were attained.

Keywords: Location-based Services; location services; mobile devices; literature review; LBS components, LBS architecture

1. Introduction

Location-Based Services (LBS) has revolutionized in location-based technologies and geospatial information during the recent decade and a large number of theoretical and empirical findings of LBS are already ubiquitously present in our everyday lives. The demand in LBS and geospatial information applications coupled with the advancement in Internet and cloud technology had open up new opportunities for service providers and application developers to leverage on [1, 2].

Although LBS is a mature field of research [2], the demand to bring location-specific and personalized services and information accessible with mobile devices to users is still huge. LBS is allowing users to receive up-to-date information about their surroundings, save time and money, and make better, informed real-time choices while enabling businesses to prosper with their customer relationships and profit generation [1]. In general, LBS is a tool for profit to a broad profit making organization and at the same time, it fits with the needs of all users regardless of their demographic profiles.

In this paper, we review the definitions, standards/guidelines, architecture, components and findings of the most common classification of LBS application and services.

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1. Background

LBS market are amassed and it continue to develop in parallel with the growth of end devices such high end smartphones, tablets, navigation and tracking devices, games and entertainment, digital cameras, personal locator beacons and other location determination devices [3]. Global Navigation Satellite System (GNSS) enable smartphones are reportedly reaching 3.1 billion units in 2014 and expected to go up to 5.2 billion by the end of 2017 and by 2019, LBS market will reach 43.3 billion dollars driven by context aware mobile services [4]. In this light, it is foreseen that LBS applications will also increase in demand towards the future technology.

Vast LBS applications developed for all types of purposes and usage such as for navigation, tracking, social network, traveling, fitness and sports, healthcare, entertainment, games which are mostly popular trend applications utilized by all ages in their everyday lives. In 2014, 2.8 billion application had been downloaded as reported on App figures, an analytic software[3] and 7.5 billion LBS data based applications projected to be downloaded by the year 2019 [3]. These numbers are signalling that the applications of LBS will be the niche towards the currently accepted as well as future technologies.

Definitely, it is still a broad way forward for LBS. There are many efforts towards classifying the LBS applications and functions since the last two decades, however the technology and applications of LBS have been evolving with the emerging technologies being introduced such as cloud computing, business analytics, location intelligent, augmented reality, the Internet of things, Internet of Vehicles and so on that depends of location determination functionality. The Gartner's emerging technologies hype cycle of 2016 and clearly many of the emerging technologies (Autonomous Vehicles, Machine Learning, Connected Home, and Internet of Things) in the listing overlaps the functionality needs of LBS.

Furthermore, the initiatives that is ongoing by various influenced parties had increase the enthusiasm to the pursuance of this research to improve the understanding of LBS applications and services towards the various body of knowledge and towards the space of requirement engineering of LBS. The National Institute of Standards and Technology (NIST) of US Department of Commerce provide a technical papers of LBS R&D [5] that focuses on the provision of LBS Application towards the public safety and divided their strategy towards three factors of software/applications, devices and networks. Similarly, in Malaysia, National Internet of Things (IoT) Strategic Roadmap in Malaysia launched and implemented by MIMOS a National R&D Centre in ICT under the Ministry of Sciences, Technology and Innovation (MOSTI) indirectly supports the implementation of LBS in Malaysia through their pilot projects such in healthcare, agriculture and smart villages. The IoT strategy call to three elements that are similar to LBS elements that are devices/things; applications, services and analytics; and connectivity and storage [6].

A brief overview of some of LBS applications and services in Malaysia includes, Malaysia Emergency Response Services (MERS999) integrate the usage of LBS in their 2D and 3D mapping, Global Information System (GIS) and City Cameras [7]. Maxis, a telecommunication company, also a service provider, invested in LBS through Friend Finders mobile application to provide location of other persons and further launched their location based advertising later in year 2013 [8]. As a business entity providing LBS is a value added services for their customers and the charges of short messaging services that is integrated to the LBS systems is one of the business perspective initiatives.

Other applications maintained by the government is the Geographic Information System (GIS) applications, mainly conducted by Malaysian Centre for Geospatial Data Infrastructure (MaCGDI) established under the Ministry of Natural Resources and Environment (NRE). Through MaCGDI websites, there are listings of GIS and Geospatial Data Infrastructure (GDI) and their initiatives [9]. LBS clearly had their forte from the government and businesses entities and worth investing of time and effort towards the aim of this research to provide better decision making, return on investment and sustainability of technology investment.

From all those literatures about LBS applications and services, in the myriad of diverse classifications of LBS applications and services, has neither common nor unified classification. Therefore different classification of applications and services may require different technology to be effectively, commercially and sustainably viable. This also as a vital factor for many parties, including developers, content and network providers and users to invest on the specific solutions to achieve economies of efficiency and to avoid the risk of obsolesces.

2. Method

This research is performed as a literature review within IEEEExplore database and sources of LBS from google search to maintain current in the informatics advancement. Due to the extensive results obtained, we filtered the results to the following several criteria: (1) English as language; (2) Articles with the most relevant to the keyword of LBS definition, architecture, standard and guidelines, components and LBS application and services; (3) Articles from 2003 till 2016 and (4) A attentively review to filter of the contents to exclude articles that is irrelevant or outdated.

The search strategy is done systematically and described in details in the following:

- Searching the combination of phrases “location-based services” AND “definition”; “location-based services” AND “architecture”; “location-based services” AND “standard”; “location-based services” AND “guideline”; “location-based services” AND “classification” OR “type” OR “categor” (categor is used to cover the range of searches for the case of singular and plural results).

- Relevant literatures are selected iteratively and reviewed according to the subtopic in the result and discussion.

3. Result and Discussion

In this section, we first review the relevant definitions of LBS provided by the literatures. Kupper [10] has mentioned that there are different terminologies possible to the reason of that the character and appearance of LBS have been adapted and specified by different communities and domains, especially the telecommunications sectors and the ubiquitous computing are for vast different area of applications. Aloudat and Michael [11], further mentioned that so many terms such location services, location-dependent services, location related services, location enabled services, location sensitive services have been used to describe LBS. These terms were used in different literatures before year 2007. Later literatures have been using the term LBS quite consistent and some are still using Location services (LCS) even after 2007. Now the term LBS is being used widely and almost all applications and mobile services openly using LBS as a common terms to embody any location based function or services even some incorporate just a little part of location information services from generic open APIs or Mapping plug-ins. Table 1 below are some of the famous definition of LBS that have been accepted widely throughout many literatures:

Table 1. LBS Definitions

Literature	Definition
[12]	<i>"LBSs are information services accessible with mobile devices through the mobile network and utilizing the ability to make use of the location of the mobile device"</i>
[13]	<i>"Location-based service (LBS) means a service that can be found easily on the basis of its described location with the aid of different kinds of indexing and guidance services. In connection with personal navigation, location-based services form the kernel content and they can be found using the location data of a mobile phone as the search criterion. Location service (LCS) (i.e. mobile location service) generally means determining a location and, in connection with personal navigation, especially determining the location of a mobile phone supported by a mobile telecommunications network"</i>
[10]	<i>"Location-based Services are IT services for providing information that has been created, compiled, selected, or filtered taking into consideration the current locations of the users or those of other persons or mobile objects."</i>
[14]	<i>"Location-based services (LBS) are the delivery of data and information services where the content of those services is tailored to the current or some projected location and context of a mobile user."</i>

Literature	Definition
[11]	<i>“Location-based services can be broadly defined as any service that provides information pertinent to the current location of an active mobile handset at a specific window of time, regardless of the underlying delivery technology used to convey its information”</i>
[15]	<i>“Location Based Services are information services accessible with mobile devices through the mobile network and utilizing the ability to make use of the location of the mobile device.”</i>
[16]	<i>“Location Based Services (LBS) is and information or entertainment service, accessible with mobile devices through the mobile network and utilizing the ability to make use of the geographical position of the mobile device.”</i>
[17]	<i>“Services based on the location of a mobile user as determined by using network and/or mobile-device-based technology.”</i>

All of the above definitions were deliberated towards the perspective of locating mobile devices to assist the supported LBS applications and services, inclusive of the perspectives in the various domains that deliberated the functionality of LBS. This concluded a similar definition for this research that LBS can be defined in various perspectives. As long as the use of location information or in the capability of performing location determination services, in any application, the system/application/services are classified as LBS. Location-based services is a technology dependent services that derive location and/or positioning sense though physical and/or previous positioning/location determinant method to a device/person. The location data/information/knowledge is achievable from the device capability as a receiver to satellite (GNSS), database (GIS/Location Aware/Cloud Services) through Internet, Cellular Network, or Device Sensors towards the needs of various applications.

As diverse and varying as the definitions of LBS being defined, the standards used by LBS is no different. OpenLS standards is a known LBS standards to be able to provide interoperability between various interest group of the Location Services over the Internet, web and wireless environment. Open Geospatial Consortium (OGC) are the single entity responsible for providing OpenLS by working closely with various contributors such Location Interoperability Forum (LIF), MAGIC, ISO TC211, TC/204, WAP Forum, IETF, AMI-C and W3C. Specifications of these groups must be consistent with specifications of the groups such as Parlay, Third Generation Partnership Project (3GPP), GPP2, European Telecommunications. Standards Institute (ETSI), and the Telecommunications Industry Association (TIA). OGC collaborates with interested organizations as sponsors or participants to join the OpenLS Initiative. Standards Framework creates the OpenLS Standards [18] which is given in Figure 1.

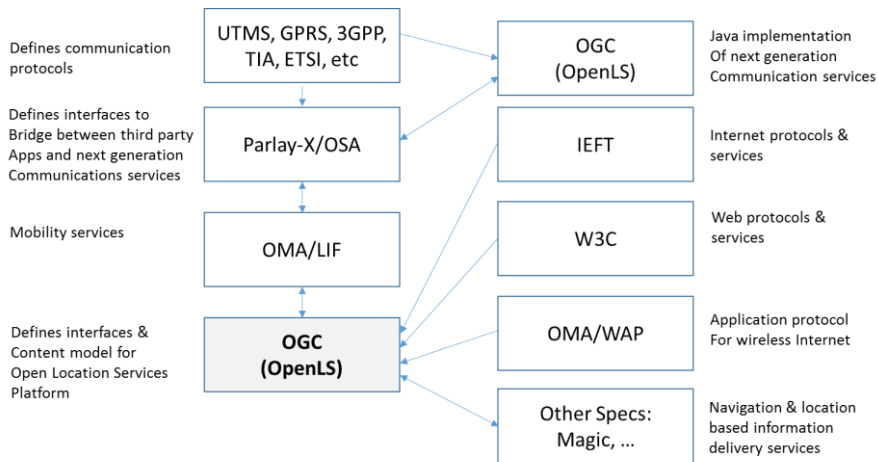


Figure 1 : OGC OpenLS Standard Framework [18]

Sanglyne [19], explained the architecture in a simpler way, which consist of five easy to understand components: (1) LBS Application that represents applications (mobile apps, software, services) in the smart devices or access through server (cloud or simply a client server access); (2) LBS Middleware to provide interoperability between devices or different protocol of services in consistency between the various of applications; (3) Location Tracking (location Information/data history) as a processed information that contains data that allow location information to be meaningful for user; (4) GIS Provider as the supplier of data requested or need to be pushed to users, information such map information, map visualization and directory services. Google Maps API can be a source of GIS provider; (5) Location Collection Services can interact back with LBS Application to provide mobile devices with the needed location information or via middleware that had been specified. Figure 2, shown the general architecture of LBS applications and services.

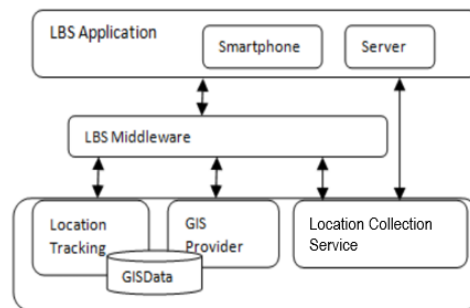


Figure 2 : Simple LBS Architecture [19]

LBS requires several components. Buczkowski [20] proposed to a model of six components (Figure 3), in which five are technological components and one human related components. The five technological components are Positioning System, Communication Network, Service and Application Provider, Data and Content Provider and Mobile Devices while the human related component is the user itself.

- Positioning systems (how the raw data or the source of location information performed) – permit geographically localizing the mobile device both located outdoor and indoor. Systems includes satellite-based systems, Cell-ID, RFID, Bluetooth, WiMax, LTE, Wireless LANs.
- Communication Network (how the location data being transmitted or by relying to network communication facility can also derive the raw data) – the communication or transfer of data between the user from its mobile device to its service provider via its server through wireless network. This includes currently wireless internet (e.g. GPRS, 3G, 4G, Wireless LANs)
- Service and Application Provider (who are the players of the LBS application/services) – the LBS provider, that response to the query of the user. Includes the software (e.g. GIS) and other distributed services and components.
- Data and Content Provider (who are the providers of the LBS raw data, and exploiters that give more meaningful information to users) – service providers that maintain and store information, which can be requested by users. Geographic base data and location information data will be usually requested from the maintaining custodian (e.g. mapping companies or mapping government agencies) or business and industry partners (e.g. google maps, traffic companies such highway consortium).
- Mobile Devices (what are the devices depended to provide and receive LBS information, processor, receiver, transmitter) – devices that are portable and having the other components of LBS as to be able to provide/receive information or services by data or content providers.
- User – the person that utilizes the mobile device, requesting and receiving or experiencing the services that is pushed/pulled to/from their mobile devices.

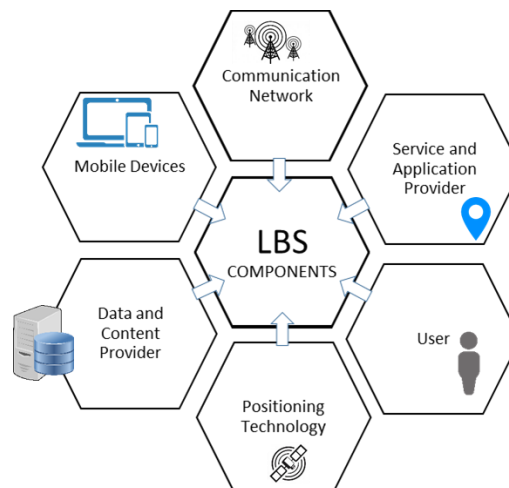


Figure 3: LBS Components

In the diversity of LBS applications and services, one can only attempt to group or classify LBS applications and services based on some common or shared characteristics, functions or requirements. Many researchers had try to provide a classification/ categorization and grouping LBS towards various way.

a. Emergency Application and Services (derived from a Public Safety Domain):

This first classification of LBS application and services appears to be the most common and fundamental application of LBS found in most literatures. There have been several studies observed to have proposed LBS as means for possible solutions to deliver location-based emergency information and warning notifications. In most countries, this application is made available to all mobile users 24/7, and is considered to be the most prevalent LBS application [21].

b. Tracking/Management Applications and Services:

Tracking management is one of the first and most successful application of LBS where it is also utilized in asset tracking and fleet management both in consumer and corporate market [15, 21]. Tracking management are applied to various services such as postal services in tracking parcels and packages, vehicle tracking for locating and dispatching vehicles such as the ambulance, locating the nearest engineer or field personnel to the customer's premise, etc. LBS has also made it possible for mobile supply chain management (m-SCM) applications as providing more accurate product tracking as opposed to the traditional supply chain management [15].

c. Map/Navigation Applications and Services:

This classification of LBS application and services has been implemented even in the earlier days where a printed map is used to navigate ways from a point of presence to the point of the desired destination. The advancement of technology has seen dedicated navigation devices installed and operated in cars to assist navigation, before everything is operated on the mobile phones. Today, this application is very much diversified in its utilization, expanding to be applied in not only navigation, but for entertainment as well. Smartphone map and navigation applications that can be used in either vehicle or pedestrian mode were made available to almost all mobile devices to assist users in finding their way.

d. Social Applications and Services:

Social networks like Myspace, Facebook and Twitter is fast becoming an everyday communication tool necessary for people to communicate and maintain relationships with each other. The development and ubiquity of LBS has given these platform the possibility to integrate location with content created users [20]. Chen stated that there are three types of social LBSs, also known as current position-based social networks (LBSNs) or geosocial networks [21]. The first are the social networks that were developed exclusively current position-centric features such as FourSquare, Google Latitude, or Find My Friends. Social LBS also includes Facebook, Twitter, LinkedIn, or Instagram, having recently featuring location-based features like "check-ins" and geotagging a photo or other post. The second type of social LBS users are given the option to turn off location based features when they do not wish to share their current location and the third of social LBS include those applications that aim to aggregate geotagged information from one or more different social networks.

e. Information Applications and Services

This classification of LBS application and services works as in firstly identifying the user's location and henceforth providing information based on person's location. Information relevant to the request or the need of users at the moment such as the nearest information booth, taxi's station or a list of restaurants nearby is very useful especially for tourists. Location-based information also available in another form which is called location-sensitive information services. It refers to the distribution of proper information based on device location, user's behaviour and time [22].

f. Gaming/Entertainment Application and Services

In the gaming and entertainment classification, Mobile Location Based Gaming (MLBG) is a growing trend among LBS. With the proliferation of new technologies such as positioning technologies, wireless fast speed internet, image recognition and augmented reality, among others that are available in mobile devices, MLBG is providing a location-based game that can run on a mobile device and by using a communication channel to the exchange game information with a game server or other players [20].

g. Advertising/Promotion Services

LBS had revolutionized the way advertising works in so many ways. The potential to broaden the market as well as to personalize advertising and to earn profit has achieved significant attention due to its advantages and features such as personalization. This has enable advertisers to put efficient and effective promotions to target consumers on mobile platform more broadly and cost effective. Common forms of mobile advertising include broadcasting short messages, mobile banners and proximity-triggered advertisements [22].

The discussed of seven LBS applications and services applications derived from the summarized in table 2.

4. Limitation

There are number of limitations in this review. The studies review used keywords to retrieve the existing literatures; therefore those studies without the main keywords that have been used for this review may not be included. Furthermore, the database selected are from the most studied area of LBS which is the IEEE Explore database and cross-checked with the current issues of LBS in the world wide web. Second, the review is focused on LBS in selected literature only. However, the studies reviewed covering various perspective of LBS applications and services to be integrated with future research of LBS.

Table 2. LBS Applications and Services Classifications by various sources

Related Work	LBS Applications and Services Classifications							
	Emergency Services	Tracking Services	Navigation Services	Social Media Services	Information Services	Gaming/ Entertainment Services	Advertising/ Promotion Services	Others Classification
[21]	Emergency	Tracking/ Management	Map/ Navigation	Social	Information	Gaming/ Entertainment	Advertising/ Promotion	-
[23]	Emergency	Tracking	Navigation	-	Information	-	Billing (Pull) and Advertising (Push)	-
[24]	-	Tracking	Navigation	Location Enhanced and social networking and Geotagging	Location based content delivery (Push/Directory Search)	-	Location based Charging	Proximity Applications
[15]	Emergency	Tracking and Management	Navigation	Leisure	Information	Games	Advertising and Billing	-
[25]	Safety	Enterprise	Telematics	-	Information	-	Triggered Location	Consumer Portal
[26]	Emergency	Tracking	Navigation	-	Information	-	Billing and Marketing	-
[27]	Security	Tracking	Navigation	-	Information	Entertainment	Commerce	-
[28]	Public Safety	Tracking	Navigation	-	Information	-	Charging	Enhance Call Writing Network Enhance Services
[29]	Public Safety	Tracking and Device Management	Navigation and Travel	Geosocial Networking	News and Weather	Gaming and Entertainment	Retail Advertising	Real Estate
[30]	Emergency	-	-	-	Information	-	Promotion	-
[31]	Emergency	Tracking	Navigation	Location-Based Social Media	Point of Interest	Mobile Location-based Gaming	Billing	Sports Geotagging

5. Conclusion

A literature review of diversity issues in definition, standards, architecture and classification of LBS applications and services were presented in this paper. We highlighted the various definitions of LBS in literature as well as its integration supporting standards and underlying architecture. These diversities and heterogeneity of carrying components had gone rise to the development of multi classification of applications and services serving various requirements and specifications. Due to this complex issues of developing a framework for the developers of LBS applications and services to identify the most suitable component, standard or architecture accompanying the application or services, classification is vital. This study has identified based on an extensive literature review, the seven (7) of the most common LBS application and services classifications, namely (1) Emergency, (2) Tracking/Management, (3) Map/Navigation, (4) Social, (5) Information, (6) Gaming/Entertainment, and (7) Advertising/Promotion.

Acknowledgement

This work has been supported by the Fundamental Research Grant Scheme (FRGS) Grant from UTM and Ministry of Higher Education (MOHE) with the project number R.K130000.7838.4F787.

References

- [1] N. J. P. Chin, "Critical Success Factors of Location-Based Services," University of Nebraska - Lincoln, 2012.
- [2] S. Ryschka, M. Murawski, and M. Bick, "Location-Based Services," *Bus. Inf. Syst. Eng.*, vol. 58, no. 3, pp. 233–237, 2016.
- [3] GSA, "GNSS Market Report Issue 4," 2015. [Online]. Available: https://www.gsa.europa.eu/system/files/reports/GNSS-Market-Report-2015-issue4_0.pdf. [Accessed: 31-Mar-2016].
- [4] Juniper, "Location-Based Services Market to Reach \$43.3bn by 2019, Driven by Context Aware Mobile Services," *Juniper Research*, 2017. [Online]. Available: <https://www.juniperresearch.com/press-release/context-and-location-based-services-pr2>. [Accessed: 08-Apr-2017].
- [5] H. Feldman and T. McElvaney, "NIST Technical Note 1914 2015 Location-Based Services R & D Summit," 2016.
- [6] MIMOS, *National Internet of Things (IoT) Strategic Roadmap*. 2014.
- [7] R. Anas, "Gis in Emergency Communication – the Mers 999 Experience," *Simp. Mklm. Geospacial Kebangs.*, no. May, 2012.
- [8] Maxis, "Maxis launches Location-based Advertising service," *Maxis Bhd site*, 2013. [Online]. Available: <http://www.maxis.com.my/en/about-maxis/media-centre/press-releases/2013/06/20130613-en-1.html>. [Accessed: 08-Apr-2017].
- [9] MaCGDI, "Mygeoportal websites," *Mygeoportal Initiatives*, 2017. [Online]. Available: <http://www.mygeoportal.gov.my/geospacial-initiatives>. [Accessed: 08-Apr-2017].
- [10] A. Kupper, *Location Based Services Fundamentals and Operation*. 2005.
- [11] A. Aloudat and K. Michael, "The application of location based services in national emergency warning systems: SMS, cell broadcast services and beyond," *Natl. Secur. Sci. Innov.*, pp. 21–49, 2010.

- [12] K. Virrantaus and H. Tirri, "Developing GIS-Supported Location-Based Services," 2002.
- [13] A. Rainio, "Location-Based Services and Personal Navigation in Mobile Information Society," 2001.
- [14] A. Brimicombe and C. Li, *Location-Based Services and Geo-Information Engineering*. 2009.
- [15] S. Steiniger, M. Neun, A. Edwardes, and B. Lenz, "Foundations of LBS," 2012.
- [16] K. Roebuck, *Location-Based Services (LBS): High-impact Strategies - What You Need to Know: Definitions, Adoptions, Impact, Benefits, Maturity, Vendors*. Lightning Source, 2011.
- [17] Gartner, "LBS (location-based services)," *gartner.com*, 2017. [Online]. Available: <http://www.gartner.com/it-glossary/lbs-location-based-services>. [Accessed: 09-Apr-2017].
- [18] OGC, "Location Service (OpenLS)," *ogc.org*, 2017. [Online]. Available: <http://www.opengeospatial.org/standards/ols>. [Accessed: 09-Apr-2017].
- [19] L. J. Sanglyne, "Android Application to Locate and Track Mobile Phones (AALTM) - An Implementation of Location-Based Services," pp. 387–393, 2015.
- [20] A. Buczkowski, "Location-Based Services," *geoawesomeness.com*. [Online]. Available: <http://geoawesomeness.com/knowledge-base/location-based-services/>. [Accessed: 09-Apr-2017].
- [21] R. Chen and R. E. Guinness, *Geospatial Computing in Mobile Devices*. Artech House Mobile Communications Series, 2014.
- [22] K. Madadipouya, "An Examination and Report on Potential Methods of Strategic Location-Based Service Applications on Mobile Networks and Devices," *Int. J. Manag. Public Sect. Inf. Commun. Technol.*, vol. 5, no. 3, pp. 25–31, 2014.
- [23] G. M. Giaglis, P. E. Kourouthanassis, and A. Tsamakos, "Towards a classification framework for mobile location services," *Mob. Commer. Technol. Theory Appl.*, pp. 67–85, 2003.
- [24] A. M. Bernardos, J. R. Casar, and P. Tarrío, "Building a framework to characterize location-based services," no. Ngmast, 2007.
- [25] H. A. Karimi and A. Hammad, *Telegeoinformatics Location - Based Computing and Services*. 2005.
- [26] A. Kealy, M. Duckham, G. Retsher, G. Roberts, and S. Winter, "Location Information Taxonomy for Location Based Services," no. 2002, 2009.
- [27] P. Chen and Y. Lin, "An Analysis on Mobile Location-based Services," *Ipcsit.Com*, vol. 16, pp. 88–92, 2011.
- [28] 3gpp, "3gpp Technical Specification Group Services and System Aspects Location Services (LCS) Stage 1 (Release 14)," 2015.
- [29] FCC, "Location-Based Services An Overview of opportunities and other consideration," 2012.
- [30] M. Yassin and E. Rachid, "A survey of positioning techniques and location based services in wireless networks," *2015 IEEE Int. Conf. Signal Process. Informatics, Commun. Energy Syst.*, no. Ii, pp. 1–5, 2015.
- [31] H. S. Maghdid, I. A. Lami, K. Z. Ghafoor, and J. Lloret, "Seamless Outdoors-Indoors Localization Solutions on Smartphones : Implementation and Challengers," vol. 48, no. 4, 2016.