

Indoor Location Based Services Market Drivers and Challenges

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Abstract. Indoor Location Based Service (LBS) applications, such as indoor navigation, have not yet found a prominent position in the market as it deals with many challenges, both technical and non-technical. They include indoor positioning, availability and usability of indoor maps and privacy concerns. If these solved or handled there would be a 10 billion euro market waiting for indoor LBS. There are some upcoming and/or potential solutions and opportunities that may help to handle these challenges. They include new positioning technologies and multi-sensor positioning systems that can be applied for indoors, crowd-source mapping, change in viewpoint regarding the users privacy, standards, regulations and policies that can preserve privacy of LBS users. This paper analyses indoor LBS current markets, the challenges and trends and estimate future growth if these challenges are handled.

Keywords. Indoor Location-Based Services (LBS), Market Analysis, Indoor Positioning and Mapping

1. Introduction

Location Based Services (LBS), such as navigation and tracking, location-based social networking and location-based marketing and advertising, are being widely used by many people around the world. About three quarters (74%) of smartphone device owners are active users of LBS (Pew Research 2013).

Indoor Location Based Services (LBS) market is growing rapidly, however in comparison with other applications and segments of LBS, it still in its infancy. Although people spend most of their time in their homes, offices and in general indoors, the indoor LBS generates less than 25% of LBS revenue (ABI research 2015). This is because there are many challenges and

issues still remaining; indoor positioning, availability of indoor maps and associated privacy concerns are some of the most important challenges of indoor LBS.

It is difficult (if not impossible) to find a positioning technology which can provide real-time position of users for almost free, seamlessly in indoors and outdoors, with a high level of accuracy, with very low power consumption and preserving users' privacy (Torres 2014).

In addition to the challenges of indoor positioning in a pedestrian navigation system, the other main problem is the lack of good coverage of indoor maps. Even if the position of the users can be found, due to the poor coverage of indoor maps, it is difficult to provide indoor navigational instructions to users. The poor availability of indoor maps may be due to privacy concerns and/or lack of standards and policies for indoor mapping.

While indoor positioning and indoor geospatial datasets are the biggest challenge for indoor LBS, there are some potential solutions promised by upcoming technologies and policies. Mobile devices are now equipped with many sensors, which can be used as multi-sensor positioning. Bluetooth Low Energy (BLE) gives a big hope for indoor positioning based on proximity, Crowd-sourced geospatial data capture has shown success so it can be fully or partially applied by more "authoritative" mapping agencies.

If these challenges are handled, there could be a large market waiting for variety of indoor LBS applications. This paper focuses on indoor LBS market analysis and related challenges, market drivers and trends and potential opportunities presented by successful LBS, as one of the most promising but challenging segments of LBS. In this regard, the first section explains principles of market analysis and research methodology. Section three describes current market size and trends of indoor LBS, current challenges and future requirements and finally it estimates potential solutions impacts on indoor LBS market.

2. Indoor LBS Market Analysis

Market research is a systematic, objective collection and analysis of data about the target market, competition, and/or environment and goals should be to increase the understanding of them. A market analysis is essential to determine if there is a need for new idea, technology, service, policy, standard or product and to determine the correct approach to fulfilling this need. This section explains principles of market analysis, Indoor LBS current and future market and finally challenges and potential solutions.

2.1. Market Analysis

In order to have a better understanding of what technologies and policies can help indoor LBS for its future growth, this paper analyses its current market and trends.

Market analysis can have following dimensions and aspects as its outputs; market size (current and future), trends, growth rate, market profitability, cost structure, distribution channels, key success factors. The output information of market analysis can guide to very important strategic business decisions. In some specific areas, including indoor LBS, if market analysis is done properly, the findings and conclusions can have a value that exceeds the cost of the research itself. This is probably the most important reason why there are many market analysts and researchers have done LBS market analysis. There are many useful reports describing different aspects and dimensions of indoor LBS market, including Berg Insight, ABI research, Pyramid Research, Gartner Group, Juniper Research, MarketsandMarkets, GSA, Frost and Sullivan Analysis, McKenzie Global Institute, European Mobile and Mobility Alliance, Open Europe and many more.

Conducting market analysis provides with enormous advantages including:

- **Identifying opportunities in the marketplace:** Research might make it obvious that a new product, technology or policy, which have planned, may not be what the market wants or needs. Market players may then decide to make modifications on what was going to offer to suit the audiences.
- **Minimizing risks:** Through market research, all the information one needs to decide whether to take action on a particular subject should be found, there are sometimes useful best practices and recommendations regarding when and how to take such actions. A market research report/study identifies the market drivers, trends, challenges, main competitors, market size, segments and other information. Therefore decisions are being made more robust.
- **Uncovering and identifying potential problems:** Potential reactions (from customers, competitors, value chain's key players, etc.) to a new product, technology, standard, policy or service can be estimated when it is still being developed. This should enlighten any further development so it suits its intended market.
- **Planning ahead:** Research can estimate the likely revenue of a new product/service/application and also policy and standards needed to achieve maximum profits (financially and societally).
- **Helping to establish trends:** It is very important to know that market research is not an activity conducted only once. It is an on going cy-

cle, or at least it should be if the real benefit is targeted. Therefore there are a lot of data sets to be able to analysed customers and establish any particular trends.

- Helping to establish the market positioning: It's important to know the position of an up-coming business at particular moments in time. Information from market research helps to benchmark and monitor its progress, which can be useful to make decisions and take action.
- Determining the most persuasive "promises": Any new service, technology, policy or standard is to handle a challenge or open up new opportunities in the market. However there are some "promises" which are not met. A market research report can identify real-world challenges and threats, requirements and needs, trends, and opportunities. Therefore it can help in two directions; first to define more persuasive and achievable promises and also to estimate their impact on the market to understand a new product/service/policy's profitability.
- Finding that compromise: The team involved in the launch of a new product, service, application, policy, standard or technology all have their individual perceptions and gut feelings. These certainly should not be ignored, but by going straight to the target audience, thoughts and opinions from people who may be less biased or less emotionally attached to a new development or service can also be gained. It helps gain a new angle, hopefully a compromise in just how to release or lunch new product, service, application, policy, standard or technology.

2.2. Indoor LBS Market Research Methodology

This section explains methods and approaches of market analysis, specifically for indoor LBS market and its outputs, explains both methods of market analysis, reasons of choosing top down approach for this research project and explaining each step of the analysis.

As it mentioned previously, the goal of market analysis is to determine the attractiveness of a market, both now and in the future. There are mainly two approaches to analyse markets; top down and bottom up.

The top down approach analyses the market (in this paper; indoor LBS market) by starting from the whole market overview; it looks at the "big picture" first, and then analyses the details of smaller components, see figure 1. The top down approach, firstly, start analysing the overall picture of the market, such as a macroeconomic trend, an investor and then narrowing potential companies.

On the other hand, the bottom up approach starts from the sub-segments, clusters and components and then gathers all of the components' contribution in final estimation, see figure 2. In order to analyse the market of LBS, within this project, the top down approach has been chosen. The most important reason for this is having access to large enough market reports specifically or partially analysing LBS market. In addition due to the project's timeframe and available resources (including number of experienced enough analysts working on this projects), having access to sub segments and most of market players was not the best approach, while there are large enough number of market reports, analysing the LBS market, which has been made available or their essential and relevant parts, data or assumptions have been made available for free through sample documents or by contacting analysts or contact points who have been mainly or partially involved in the market analysis and forecasting process. Availability of these LBS market reports and/or information, including total LBS market size and segments, assumptions, LBS market analysis/research methodology make it easier for this project to apply a top down approach. However in order to update available data, validation of available market report findings and also evaluate the results of our analysis, key players of the LBS market have been continuously contacted and/or research resources have been updated.

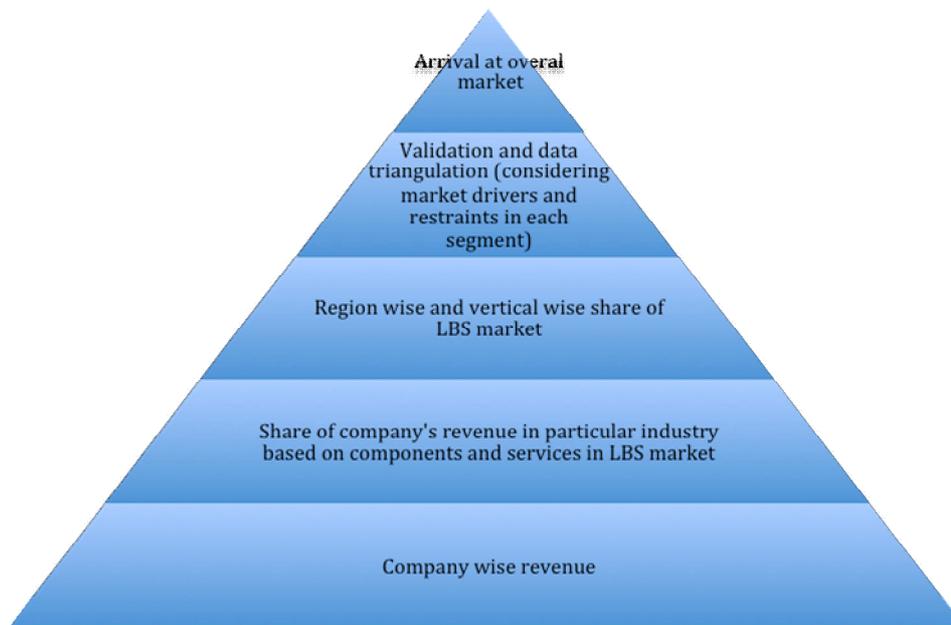


Figure 1. LBS market analysis: the top down approach

In order to have a better understanding of the LBS market and its application, at first, the boarder of the study was set. This includes defining what services and applications are considered as “LBS”. These assumptions are very important to understand where to look at and how far the economic impact of an upcoming technology or a new standard and policy should be considered.

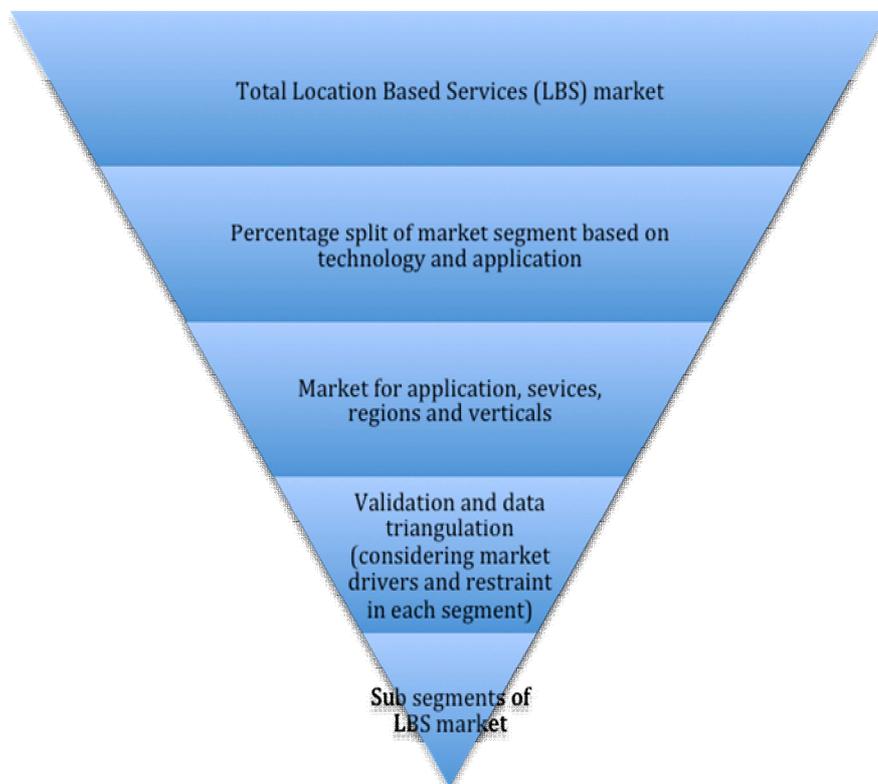


Figure 2. LBS market analysis: bottom up approach

3. Indoor LBS Market Analysis Findings and Assessments

Reviewing published market reports are a first step in the process of market analysis in top down approach. There are many market reports about LBS and related concepts, including positioning and location technologies, mo-

mobile applications, and context-aware services. Followings are some of findings of review of them.

The indoor location market, is forecast by ABI Research to reach \$4 billion in 2018, fueled by wireless technology as well as vendors offering venues such as shopping malls, warehouse retailers, airports and stadium products to provide content and services to mobile device users based on their location (ABI Research 2014). ABI believes advertisements and indoor marketing is one of the biggest revenue generators of indoor LBS. Using indoor LBS, retailers can offer coupons on discounts to shoppers based on their location in shopping malls. In addition, indoor location services can be used by enterprises to track and manage assets. ABI expects the overall number of indoor location technology to top 25,000 next year, while mobile devices capable of supporting indoor location services will reach hundreds of millions within two years.

TechNavio studies indoor LBS market in Western Europe. It describes indoor LBS requirements and then forecasts its market, specifically in Western Europe. It limits indoor LBS to a limited geographical area; therefore TechNavio believes that technologies such as WLAN, Wi-Fi, Bluetooth, AGPS, MEMS, UWB, and other hybrid technologies that cover smaller areas can be good solutions for indoor positioning challenge. This reports enumerates some of positioning requirements of indoor LBS, including high accuracy to locate the position of the object. According to this report, increased use of beacons is one of the most important market drives while technology-related complexities is a challenge for many retail enterprises.

All in all TechNavio believes that use of LBS is increasing within many verticals including financial institutions, retailers and marketing networks. TechNavio's analysts forecast the Indoor LBS market in Western Europe to grow at a CAGR of 56.24% over the period 2014-2019.

The Global Indoor LBS market expects indoor LBS to grow at a CAGR of 49.42% over the period 2013-2018. To calculate the market size, the report considers the revenue generated from the following:

1. Licensing of indoor LBS software, applications, middleware, and platforms
2. Annual sales of devices used for indoor LBS
3. Indoor LBS maps and navigation, tracking, monitoring, emergency services, and analytics
4. LBS search and advertising revenue
5. Indoor LBS used in commercial buildings, government offices, and important buildings as well as the Public Safety and Security, Edu-

cation, Healthcare, Travel and Hospitality, Manufacturing, Logistics and Distribution, Oil and Gas, and Mining industries.

Considering the reviewed market reports on indoor LBS, there are still some challenges and issues. Next section describes some of the most important ones and explains potential solutions.

4. Indoor LBS Market Challenges and Drivers

As it has described in detailed in (Basiri et al. 2015), the outcome of market analysis highly depends on assumptions. Therefore indoor LBS need to be defined precisely to have a distinctive boundary around. Different reports may have different assumptions and definitions and therefore different outputs for market size, growth rate and market segments. This paper defines indoor LBS as services and applications that are often being used inside buildings and roofed areas while location and positional data are essentially required to exclude or include relevant responses (Schiller 2004).

This paper, categorises indoor LBS applications into following segments: Indoor Navigation and Tracking (such as pedestrian navigation, indoor tracking), indoor marketing and advertisements (such as in mall ad services, proximity-based voucher sharing), Entertainment (such as location based social networking and fun sharing, location-based gaming), indoor-based information retrieval (such as in-gallery tours, underground real-time information retrieval), emergency and security (such as ambient assisted living, E112), see table 1. Obviously indoor positioning is one of the biggest challenges in front of indoor LBS market development (PROGRESS Report 2013).

Indoor LBS category	Application Domain	Positioning Component's Requirement
Navigation and Tracking	<ul style="list-style-type: none"> • Pedestrian Navigation • Indoor Positioning • Path Finding and routing • Tracking • Asset Finding 	<ul style="list-style-type: none"> - Very high availability (seamless indoors, outdoors) - Response in real-time or few seconds (in general applications) - accuracy of few meters or less - Very high reliability and continuity - Medium to low power consumption - Reasonable or cheap price - High privacy preserving

Indoor Marketing	<ul style="list-style-type: none"> • LB (social) Marketing • In mall Advertisement • Proximity-based voucher/ Offers/ Rewards • LB Social Reward Sharing • Indoor location based Dealing 	<ul style="list-style-type: none"> - Medium availability - Response in few minutes - Accuracy in the order of hundreds of meters - Medium reliability and continuity - Very low power consumption - Almost free or very cheap - Medium privacy preserving
Entertainment	<ul style="list-style-type: none"> • LB Social Networking • LB Gaming • LB Fun Sharing • Find Your Friend • LB Chatting • LB Dating 	<ul style="list-style-type: none"> - Medium to high availability (seamless indoors and outdoors) - Response in real-time or few seconds - Accuracy in the order of tens of meter - High reliability and continuity - Low power consumption - Reasonable or cheap price - Medium privacy preserving
Indoor Location-Based Information Retrieval	<ul style="list-style-type: none"> • Indoor Location-Based Q&A (Query) • Proximity Searching • Tourist Guide • Transportation Info. 	<ul style="list-style-type: none"> - Medium availability - Response in real-time or few seconds - Accuracy from a few meters (for Tourist Guide and proximity search) to hundreds of meters - High reliability and continuity - Low power consumption - Reasonable or cheap price - Medium Privacy preserving (depending on the application)

Safety and Security	<ul style="list-style-type: none"> • Emergency Services • Emergency Alert Services • Ambient Assisted Living • Security Surveillance 	<ul style="list-style-type: none"> -Very high availability (seamless indoors and outdoors) - Response in real-time or few seconds - Accuracy of tens of meters or lower -Very high reliability and continuity - Low power consumption - Reasonable or cheap price - Medium or low privacy preserving
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TABLE 1. INDOOR LBS SEGMENTS

4.1. Indoor Positioning Requirements and solutions

The indoor positioning is the needed capability for indoor LBS applications. Some industry analysts believe that indoor localisation may need some major technology improvements. They also think that for many LBS applications, which need indoor positioning service as an input, the technology hasn't developed fast enough. A continuous and cheap (ideally free of charge) positioning service which can provide a meter level (or ideally less) accuracy inside houses, shopping centres, offices and airports is needed for many applications. Acceptable indoor positioning can improve indoor LBS market from two sides; more frequent use (indoor and outdoor) of current LBS applications, and also having new indoor-specific applications addressing indoor-specific challenges and needs.

- **Indoor Positioning Challenges**

Although Global Navigation Satellite Systems (GNSS), such as Global Positioning System (GPS), is the most widely-used positioning technology, working acceptably in open outdoor environment (GSA 2013), it cannot provide the position of its users with an acceptable level of accuracy indoors. This paper categorise localisation techniques into four main categories; Radio-Frequency (RF) based positioning systems, Dead-Reckoning (DR) positioning systems, Multisensory positioning and finally Surveillance positioning systems. Table 2 (Basiri et al., 2014) is a review of available technologies of each four categories in more detailed from different point of views including availability, cost, privacy and accuracy (Mautz 2012).

Positioning Technology	Availability	Cost	Accuracy	Power	Privacy
INS only (low cost MEMS)	Very high	Cheap	Hundreds of meters in seconds	Low	Very high
INS only (tactical grade)	Very high	Expensive	Few meters in seconds	High	Very high
Map aided SHS (Step heading system/ low cost MEMS)	Very high	Moderate	Few meters per hour	Medium	Very high
User Camera aided SHS	High	Moderate	Few meters in a minute	High	Medium
User Camera	Medium to Low	Moderate	10 -100s meters	High	Low
Passive environment	Medium	Expensive	Depending on technology	On network	Low
Bluetooth LE (Beacons)	Medium to low	Cheap	Few centimetres to meters	Very low	Medium/low
Bluetooth	Medium to low	Cheap	Meters	Low	Medium
IEEE 802.11	High	Cheap	10s of meters	High	Medium
DVB-T	High	Cheap	Couple of meters	Medium	High
WLAN	Medium to high	Cheap	Couple of meters	Medium	Medium to low

TABLE 2. POSITIONING TECHNOLOGIES'S FEATURES

- **Indoor Positioning Potential Solutions**

As the practical experiments and application requirement analysis have shown that a single positioning technology cannot be an answer to the requirements of many applications of indoor LBS. Multi-sensor positioning can solve some aspects of indoor positioning for some applications. BLE

and upcoming sensors also promise more opportunities as the power consumption, accuracy and cost have been distinctively moderated.

Using multi-sensors for positioning, equipment of mobile devices with more and more sensors, high sensitivity and accuracy of current sensors, upcoming technologies, including BLE, Galileo with higher signal penetration, change in policy and legislation regarding use of some technologies such as pseudolites can help to improve quality of positioning services for indoors.

When it comes to multi-sensor positioning technologies, the indoor LBS role of applications' requirement becomes more and more important to decide what combination of sensors is the best fit for each application and scenario. However based on levels of positional accuracy, cost, coverage and availability provided by different sensors, it seems that BLE and Wi-Fi are two default players in most of such multi-sensors solutions. They can be combined with other sensors including barometers, cameras, accelerometer, gyro, microphone, etc. to provide better positioning service for indoor LBS application. ABI Research (2014) forecasted the shipment of BLE to reach 500 million USD (60 million unites) by 2019. Shipment of 60 million unites BLE is promising many new LBS applications, which will work based on proximity beacons. In addition to BLE, growth of LTE (4th generation) and Wi-Fi 5G popularity can confirm that in near future Wi-Fi and BLE are default choices for positioning, however they cannot provide acceptable positioning service unless they are being used in a multi-sensor framework, i.e. in combination with other sensors. .

4.2. Indoor Map Coverage and Privacy Issues

One of technical challenges of indoor LBS is poor coverage of indoor maps. In general indoor plans and indoor geospatial data coverage is not comparable with map coverage for outdoors. Users want to navigate inside airports, universities, schools, museums, shopping malls and other public buildings but maps are not available for navigation systems in most cases. Multimodal navigation is another facility useful for of pedestrians. They want to navigate to their destination through different transportation systems, but again underground maps; train stations maps are not as available as street maps. So in addition to seamless positioning services, another challenge of indoor LBS is poor indoor geospatial data sets (Wirola et al 2010).

Google seems to be one of the major players in indoor LBS. The Google product tells customers what floor they are on in a building. Google's indoor mapping partners include only 18 U.S. airports, detailed floor plans automatically appear when the user is viewing the map and the map is zoomed

to buildings where indoor map data is available. But even for this newest release of Google Maps, a lot of (indoor) areas have not been added to Google maps also the indoor mapping does not provide proper navigational instructions (e.g. between floors navigational instructions don't suggest to take stairs). Overall, indoor map coverage is not comparable with outdoors mapping coverage and resolution.

- **Indoor Mapping and Privacy Protection Policies**

In contrast with indoor positioning challenge, the poor coverage of indoor maps is not mainly a technical issue. It is more due to privacy issues associated with personal properties and also lack of privacy protecting policies and technical standards of indoor mappings.

One of the solutions, which has already shown its practicality and growing popularity, is crowd-source and volunteer-based mappings. Collaborative mapping and crowdsourcing are two methods of generating spatial content on the Internet, which involves contributions from a large, disparate group of individuals. These methods rely upon web applications that allow people to upload information easily and allow many others to view and react to this information. Such web applications are often considered part of Web 2.0.

There are several tools available, which allow users to create and edit web content, such as tagging tools, wiki software (Wikipedia), and web-based spatial data editors (e.g., Google Earth, Google Maps, Google Map Maker, OpenLayers). This method of map data collection and generation is based on involving citizens to participation in large-scale data collection, sometimes with the participation of companies. This crowdsourcing approach could be very suitable for indoor mapping. The popularity of VGI is growing. For example, by looking at the entire OpenStreetMap (OSM) dataset, it has been found that there was a growth of 75% in contributions to the project in 2013, and over 150% over the last two years. On average during 2013, each week over 96,000 kilometres of new roadway data are added to OSM. These approaches can be partially or completely applied by many mapping agencies and data gathering institutions.

Despite the popularity and involvement of citizens with the collection of geospatial data there is still poor mapping coverage for indoor spaces. VGI projects, such as OSM, and geospatial mapping companies are contributing to the increasing trend of interest in indoor map generation but both approaches have still has a long way to go. Data formats, scale, metadata, privacy issues, etc. have not been fully standardized yet. In truth, having a global coverage of indoor mapping may find obstacles in the form of privacy issues and political opposition. Many of those who openly contribute to VGI projects for outdoor environments might not want to publish their home's

indoor map because of security and privacy issues. In addition, if they do contribute this data to a VGI project, these maps cannot be edited by other contributors since they may have not been there in that house. This simple example highlights accuracy, reliability, and precision as some of the key criticisms regarding VGI data.

It seems that the best option to have a better coverage of indoor maps is changing policies and legislations to encourage more companies and people to contribute in crowd-sourced data. This is a big challenge as privacy concerns are still an issue. There is a high demand to have a standard and policy for preserving privacy of users, however there are many “public” places, such as shopping malls, airports and universities which have already provided their map online but locally on their own web pages. These kinds of areas can be a good target to start or expand the indoor map network of contributors, as there are less privacy concerns.

Considering these prevalent issues in indoor LBS; indoor positioning, indoor map coverage and privacy it appears that indoor LBS is quite a challenging segment of LBS. Additionally there are some other challenges such as a need to customize current services for indoors, more need to consider context awareness and adaptability of applications with variety of indoor scenarios.

5. Conclusion

Indoor LBS has not got its position in mobile applications market yet as there are many challenges still remain. In order to develop markets for indoor LBS and provide solutions to bridge the gap between requirements and demands, there is a need to understand challenges and potential solutions. This paper studies indoor LBS current market conditions, trends and directions. Then upcoming events, planned actions or actions which have been already taken, that might have impacts on the future market of indoor LBS are considered and reviewed, they include BLE, new policies on privacy and crowd-sourced indoor mapping. This helps to have a better understanding of future potentials, challenges and opportunities. Afterward using available or developed models, it is possible to estimate the economic impact of such events and actions in future market of LBS. Finally considering underlying trends, market conditions, upcoming events and challenges, future market of LBS can be estimated. In addition, current market challenges and technological requirements need to be addressed. In this regard, new business models should be developed, new policies and standards should be issued to address identified challenges.

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