INDOOR LOCALIZATION APPLICATION

Bălan Matei-Călin [1], Bălan George [2]
[1] Universitatea Politehnică București, mateibalan16@gmail.com
[2] Universitatea Romano-Germană din Sibiu, gbmuscel@yahoo.com

ABSTRACT: In this paper the authors have proposed to present the result of research on an indoor localization application. This experiment started with the idea of losing as little time as possible when you arrive in a large building and must get to a certain point and cannot find the way. We considered the most common methods in the field: 3D mapping, location of the Beacons, Wi-Fi location and location by geomagnetic field. After testing all solutions in different areas of Bucharest we concluded that a hybrid between Wi- Fi and the Beacons would be easier, combining ease of the method of mapping the building Wi-Fi to the accuracy of implementation by Beacons
KEYWORDS: indoor localization, mapping, beacons, electromagnetic localization, Wi-Fi localization

1. INTRODUCTION

Providing ,,personalized service to meet the needs of users has been a topic of interest to academia and the commercial. Using the current location of the user in this respect is not a new proposal, but location-based services (SBL) know now a new stage of development fueled by easy access of users to smart devices - devices which provide advanced ways of interaction man- device equipped with tracking technology but have increasingly faster Internet connections.

Because of the way of development of smart mobile devices and location-based applications for their literature does not always differentiate between location-based services and those based on context - considering them a single category of services that are used more elements of context, location is the most important of them`` [1].

Among the most used methods in the field, currently meet:

- 3D Video Mapping (M3d): Among the first methods tested for recording an interior space was 3D mapping with the smartphone camera. The person who wants to use your location in a mobile applications software uses a scanning camera and the app records all the objects that a person is filming. When this mapping is used in a mobile application and a user uses it, it will start to turn the camera, recording things around so that the application will automatically know which area of indoor location is the user in.The advantages of this solution are that It can be used by someone without technical knowledge as long as they are explained the technical parts and does not depend on the location itself.As disadvantages: if the building has been modified then the user will not be recognized in that location and another mapping is required; the solution uses a lot of the phone's resources, the battery is quickly draining.
- Indoor localization through beacons. Beacons are small sensors that communicate with the phone through Bluetooth signal and their role is just to receive and send signal to the phone to determine the position in space 3d. To calculate the user's position inside first there is an outline of the structure made and then loaded into the application. In any place inside the structure the phone needs to send and receive data from at least 3 Beacons in order to make a more efficient triangulation. This information is processed by our algorithms on a server. The processed information is sent then to the phone/tablet. Advantages of this method are: ease of implementation of these sensors on walls, low costs and more efficient calculation of position. Disadvantages are: this solution assumes a continuous communication between phone/Tablet and one or more Beacons meaning high energy consumption of the phone; beacons emits signal into an spherical perimeter adjustable to a maximum of 50 m and if used in buildings

with storeys then implementation cost will increase because they will have installed more to compensate for this limitation. The accuracy of this method is up to 1 m.

- Localization via Wi-Fi. Location via Wi-Fi uses the physical address of the network card of the mobile phone, physical address and SSID of the router. Depending on the number of routers that are in the user zone, the localization is done by "fingerprinting" methods and comparing the intensity of the signal with that of the database. ‘Fingerprinting ' method is a method of RSSI (received signal strength indication) and is based on the measuring signal intensity Wi-Fi at any point inside the building and store it into a database. A major disadvantage of this method is that the time in which the structure or furniture is moved then the signal intensity changes and errors will occur. Advantages: ease of implementation and low energy consumption because 90% of the buildings have a built-in Wi-Fi system. A disadvantage of this solution is the lack of accuracy. Because the high performance routers are expensive and the signal is variable, then positioning errors appear. The accuracy of this method is between 5 and 7 meters.
- Localization by geomagnetic field. By using the Earth's geomagnetic field and magnetic sensor embedded in your phone, the company IndoorAtlas has managed to develop a method for indoor location that is based on the detection of anomalies in the Earth's electromagnetic field, such as a person inside a building. This solution requires no external hardware and can be used in any building. Existing solution comes with a web interface and a cloud system to process all the data required for the application's operation. A big drawback of this solution is that if the building has large metal structures then the app gives positioning errors up to 8 meters.

2. RESEARCH METHODOLOGY AND THE RESULTS OBTAINED

This experiment started with the idea of losing as little time at the moment when you get in a large building and need to get to a certain point and can't find your way, we've faced at the time that I visited one of the malls in Bucharest and was running late. He became a case study for about 100 people aged between 20 and 45 years of age and the result was a positive one, which gave us hope to continue. After this first experiment we started researching more about case studies from other countries and continents and what is the expected market value of this domain. A case study made by an American company resulted that the average person is willing to pay with 15% more on a product if he can save more time. “In a research made by Markets and Markets they forecasted that the indoor localization market will reach 4.4 Billion USD by 2019” [2].

We experienced localization through beacons but, following testing in an event in the Polyvalent Hall in Bucharest, we found that this technology is not feasible because it consumes a lot of battery. We have installed 18 beacons in the whole building on the main floor. One issue that we encountered was that if a person would pass the same beacon in a very short period it would not recognize the mobile phone and it would show you with a bit of delay. Behind this experiment we decided to continue on the localization of electromagnetic because it is not dependent on any external hardware. As a result of the implementation of the solution in the Rector of Bucharest University we found that this solution has trouble locating nearby metallic structures so it would not be used in new buildings erected. To map out the entire building it took us almost a day because you have to walk around every wall and structure that exists so it can make a virtual map. Another issue that we found was that you have make the whole map in one recording because if you would stop in the middle of the making of the map you would sometimes get errors if you would want to resume from the spot where you have stopped. We have experienced several concepts and ideas until we came to the idea of mobile application because the community is increasingly higher technologized. In this endeavour we encountered difficulties in making the solutions tested work on all of the different versions of the Android operating systems. When we tried implementing the solution on the IPhone operating system, the IOS, we found out that we can’t use the same algorithms and data. The only beacons that we could use that worked with the IOS system were the IBeacons, which emitted a specific signal recognizable by the phone.

Being a new technology it meant that it has problems being implemented for older versions of the operating systems and this meant that not everyone could use the application. We have managed to implement it to versions that were released 1 and a half years ago. This was an issue because a considerable amount of people were using an older version of the Android operating system and also older phones could not run the application because they were not performant enough.

After testing all of the solutions in the different areas of Bucharest we arrived at the conclusion that a joint solution between Wi-Fi and Beacons would be easier and we combine ease of method building mapping Wi-Fi implementation with accuracy through Beacons in order to reduce energy consumption through the use of Low Energy Beacons offer Bluetooth with a refresh rate that is set up between 10 and 20 seconds compared to the milliseconds in the original method Thus the phone and the app will no longer need to recalculate the position and surrounding information constantly. Operation of the application is shown in Figure 1.For the user to have access to the indoor localization of the venue, he should have the mobile application made for this location. As soon as the user has entered the building, the application connects the phone and sensors of the Beacon/Wi-Fi. To calculate the exact location, it takes a minimum of 3 sensors with signal areas interspersed. The distance between the sensors and the phone is compared to the database and the user is placed on the map. These calculations are done on a server.

In order for the user to be actively placed on the map, first of all he needs to be connected to the internet. For these calculations we have created special algorithms that improve the accuracy of the existing ones. Everything is run through our servers that we owned and transmitted towards the user and the client through a crypted transmission so that a 3rd party could not access this information. One of our main concerns was the security of the information that we collected and stored. Because of the highly sensitive nature of the personal information of people we decided not to record telephone numbers, identity of the user, email address. Each user would get a unique and randomized 16 digits ID which was linked to the physical address of the phone which is unique. This way we could identify each user and create accurate reports.

The application gives relevant information to the owners of the venues such as hot zones, preferred areas, preferred shops and the most common paths that the people take. Because these reports are based on the number of people that are using the application we made an algorithm that calculates the number of unique devices that connect to the WI-FI network in the venue or that are in range of the network by sending a small signal that recognizes the devices that are able to connect. This way we could provide information about the number of people that enter the location compared to the number of people that use the application.

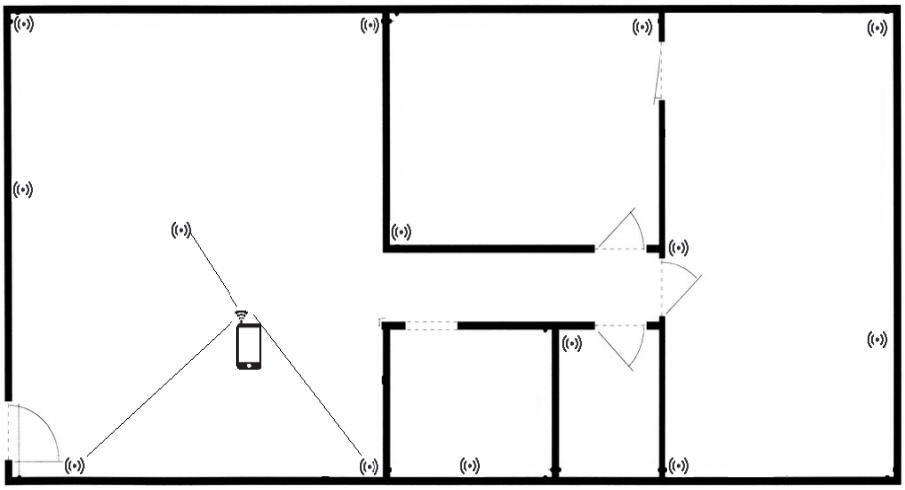

Figure 1. Operating scheme of application

Legend:

> The user's smartphone,

> Beacon/Wi-Fi sensor for sending and receiving data

3. CONCLUSIONS

The basic idea from which we started is to waste as little time when you go into a mall/super market, with many offices on several floors and you need a certain product/address and do want to waste time searching for them. In the preparation of the application we have relied on a local case study done on dozens of people aged between 20 and 40 years and on case studies made in America and Europe. All information is loaded on a mobile application which can be downloaded by any user. Besides indoor localization the user has access to information relating to the areas around you, such as: schedules, stores, promotions, discounts, and they will be forwarded to your phone using a server that makes all of these operations in the database. As a result of the tests, we propose a hybrid solution between those mentioned above in order to increase efficiency and mitigate the costs of implementation. To reduce energy consumption through the use of Low Energy Beacons offer Bluetooth with a set refresh rate between 10 and 20 seconds in front of milliseconds in the original method, so the phone and the application will no longer have to recalculate the position and surrounding information constantly. Comparing the advantages and disadvantages of each method, we developed an experimental application which we presented it at Innovation Labs 2015- pre accelerator for start-ups, I Like It at ProTV, Mobil Pro 2016.

4. REFERENCES

1. Akex Varshavsky, Mike Y. Chen, Eyal de Lara, Jon Froehlich, *Are GSM phones THE solution for localization?,* (2006)
2. Anthony Tomasic et. al., *Design Uncertainty in Crowd-Sourcing Systems*, (2011)
3. Rainer Mautz, *Overview of Current Indoor Positioning Systems*, (2008)
4. Stefan Steiniger, Moriz Neun, Alistair Edwardes, *Foundations of Location Based Services -Lesson 1*, (2006)
5. http://yeti.albascout.ro/blog/wp-content/uploads/downloads/2011/11/Referat-1.pdf
6. http://www.marketsandmarkets.com/PressReleases/indoor-location.asp