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Tracking of Customers using Geofencing Technology

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***Abstract*— The next generation of Location-Based Services (LBSs) will be notably decided by geofencing applications and online background tracking. The majority of people have become active mobile technology users wherever they are and anytime. They request information anytime, anywhere, so it has to be personalized and contextual to better satisfy their needs. At the same time the service providers would want to find out whether their clients are within their neighbourhood so that they can alert them of events or services in their proximity. Geofence which is a small geographic area that is outlined to produce a location event as soon as a user enters or leaves this geofence. To process this event in the context of a location based service is considered as one of the best technologies to virtually connect mobile customers and service providers. Online tracking continuously monitors the whereabouts of a customer enabling service providers to avail location-based events to the customer. This paper endeavours to highlight geofencing technologies, their uses and then look at the challenges and issues within this area. The building blocks of geofencing and the technology of marking the region of interest are explained. In conclusion it was foundout that geofencing can be used to offer personal and contextual services to mobile users anywhere and anytime.**

Keywords—geofencing technologies, contextual services, mobile technology

I. INTRODUCTION

The majority of people have become active mobile technology users wherever they are and anytime. Information is requested anytime, anywhere, therefore it has to be personalized and contextual to satisfy the needs of the users. New applications in the area of information relevance has created a huge market [5]. These applications include one of the most ground-breaking applications which is the Location-based Services (LBSs). They consider the current location of the user to generate, compile, select, or filter information or perform other actions [7]. Recently, social community platforms have also adopted the idea of LBSs to enable location sharing, that is, the collaborative exchange of current whereabouts amidst their members [2].

It must be noted that location is just one example that defines the existing condition of the mobile user, there are many other parameters such as the time, weather conditions on the spot, the current means of transportation while travelling, or what the mobile user is doing [1]. Aggregate of all these parameters is taken into consideration for delivering the user with relevant information and there parameters are known as context. They are derived and processed by Context-aware Services (CASs). Thus, LBSs can be identifies as a unique appearance of the generic CASs. A technical barrier for a successful commercial introduction of CASs is still the automatic detection of context parameters. This is because of the unavailability of suitable sensors in mobile devices or in the environment as well as from the potential diversity of such parameters. The location of the user can be easily derived from various positioning technologies like GPS, Cell-ID or Wi-Fi. The key for LBSs is formed by these technologies. One of the preconditions for the latest corporate achhievement of these services is their wide availability. They are now standard features of smartphones and mobile networks.

LBSs determine the location of a user when the user is live in a service session. Geofencing allows to detect users entering and leaving geofences [8], which are pre-defined geographic areas. Depending on the type of geofencing available, the user needs to be perpetually tracked in the background even when the mobile device is idle. Also, this should apply when the user is executing other applications all the time or from the time the user enters the region of interest [6]. In the area of information relevance especially, a wide range of new applications have been introduced due to geofencing and background tracking. However, their introduction is also associated with new barriers, such as intesifying the battery consumption on mobile devices. The availability of these new applications has caused users now to be concerned about their privacy. This paper will look at geofencing, its challenges and open issues. The paper is arranged as follows: geofencing and background tracking in section two, challenges and open issue in section three and finally conclusion.

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II. GEOFENCING AND BACKGROUND TRACKING

Geofencing is determining the position of an object relative to a base position. It is a virtual perimeter for a geographic area in real world [4]. Thus, given a set of geographic areas G, each $g \in G$ is a polygon (P), which is described by a sequence of latitude (La) and longitude (Lo) pairs as shown:

$$P = ((x_1, y_1),(x_2, y_2),(x_3, y_3),.....,(x_n, y_n)) \quad (1)$$

where $x_i \in La, y_i \in Lo$,and $i = 1,2,3,.....n$

These pairs follow some order, for example anti-clockwise, with its existing time period $[t_1, t_2]$. This virtual boundary/perimeter located a predetermined distance away from the base position is a geofence. We get spatial-temporal tuples O, each $o \in O$ is expressed into a form as:

$$(o_{id}, x, y, t) \quad (2)$$

where o_{id} is an object identified by id located at $(x, y)\, at\, time\, t$.

The important thing is to determine if the object being tracked is either inside, directly on, or outside the geofence boundary. Thus for each o_{id} and g , it is to find whether at any given time t and during the existence period $[t_1, t_2]$ the following conditions are fulfilled or not:

$$o_{id} \in g \; or \; o_{id} \notin g \quad (3)$$

In order to mark the virtual location of interest one has to use Global Positioning System (GPS) or a non-GPS which can also be termed satellite system or terrestrial system. In using the GPS one has to build an application that a user has to download to his/her device. When using non-GPS for geofencing one needs no application. The following section describes the two types of geofencing.

III. TYPES OF GEOFENCING

The types of types of geofencing to be described are Application based (App based), network based and hybrid geofencing shown in Fig. 1.

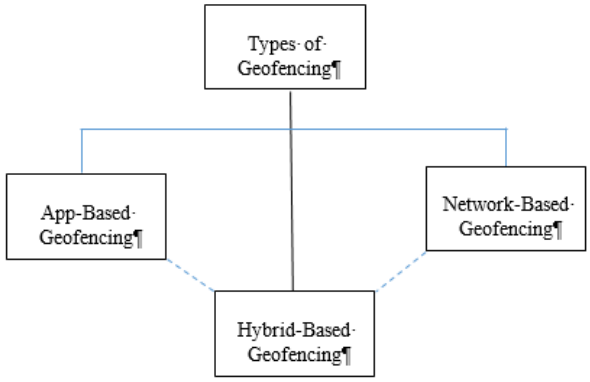

Fig 1: Types of Geofencing

A. APP-BASED GEOFENCING

App-based macro-geofenceing requires an application to access GPS data. In order to mark the region of interest one has to give the latitude and the longitude of the region in question then the radius. The radius is used to mark the virtual perimeter of the region of interest. This is shown in Fig 2.

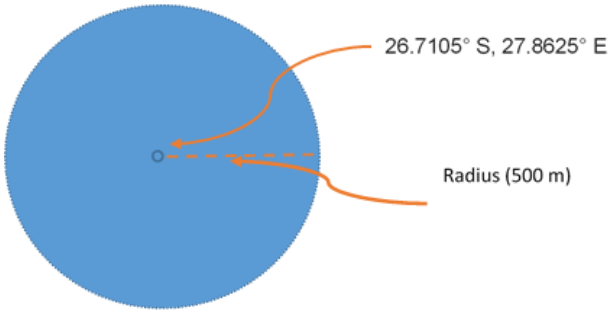

Fig 2: Geofencing of Vaal University of Technology

This is set at the server and then users can opt in to receive the messages related to what is being offered at the area of interest. Users must have a GPS receiver devices to be tracked and GPS data from the receiver is used to determine where the user is relative to the geofence. The goal of a geofence application is to report whether a GPS receiver is inside or outside the user specified geofence volume [9].

Geo-fencing technology enables remote monitoring of geographic areas surrounded by a virtual fence (geo-fence), and automatic detections when tracked mobile objects enter or exit these areas [4]. A Geo-fence becomes a layer of intelligence that allows users to make decisions or take some action based

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on a geographical area. It can circle anything/ any area you like – a retail store, a stadium, a neighbourhood. It must be noted that the user have to download the app on their mobile devices.

App-based micro-geofencing requires an application to derive the proximity to beacons. The beacons are the ones that form the geofence. The beacons can be placed around a building then the geofence is established as shown in Fig. 3.

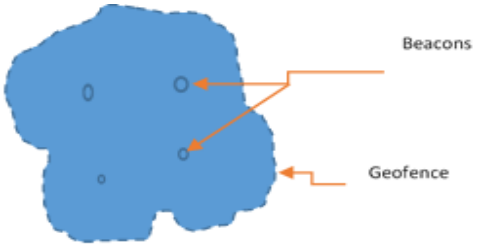

Fig 3: Beacon based geofencing

These devices whose range of transmission is approximately seventy metres (70m) repeatedly convey a detection signal that is received by BLE enabled smartphones inside the range of transmission. Its compulsory for a beacons to allow a one-to-many experience.

Fig 4: One-to-Many mapping

As shown in Fig.1 signals that are picked up by all the phones within the beacon's range are transmitted by one beacon. Once a user's BLE enabled smartphone is inside the range of the beacon, it receives and measures the signal strength in order to calculate the relative distance from the beacon. The operating system of the phone then extracts the beacon ID and makes the ID available to the app on the phone. Based on the user's position, the app determines the next course of action, after these steps are completed.

B. NETWORK BASED GEOFENCING

A network based geofencing can be called a non-GPS based geofencing. A network based geofencing can be categorized into micro and macro – geofencing. The macro-geofencing would use the cell towers while micro-geofencing use wifi hotspots. At any given moment, depending on the ID of the Base Transceiver Station (BTS) that the consumer is connected to, the mobile operator can pinpoint the location of a mobile device and distinguish it with a with cell tower ID. Depending on the known range of the particular BTS serving the user at

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the time of the query, the precision of the Cell ID method therefore can be determined. It can range from a few hundred meters in urban areas to several kilometres (approximately one to two kilometres) in rural areas. So the macro-geofencing is marked by the BTS's strength as shown in Fig. 4.

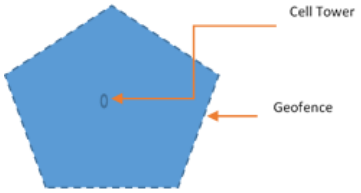

Fig 5: Cell Tower based geofencing

The Wi-Fi hotspots are used to mark the region of interest as shown in Fig. 5.

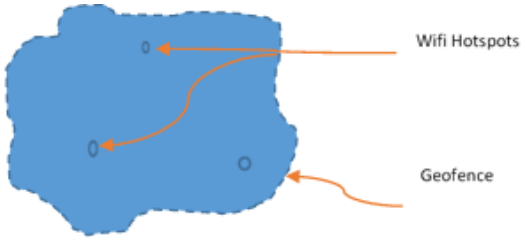

Fig 6: Wi-Fi hotspots based geofencing

, the general range of accuracy for Wi-Fi positioning is at roughly 100 meters. Wi-Fi technology does not require the consent of the user because the user of Wi-Fi enabled device is the one who turns on the Wi-Fi on the device in search of free Wi-Fi networks. This is then used to detect the presence of the user who crosses the geofence into the region of interest. Wi-Fi is technically designed to precisely point to a device's exact position with wireless access points, by measuring parameters such as MAC address and SSID.

C. SELECTION OF GEOFENCING TECHNOLOGY

In selecting the geofencing technology to use one needs to take so many things in consideration such as tracking the mobile user every time whether outside the region of interest or not, is it in doors or not, etc. Comparison of these technologies will help in deciding whether to use one technology or mix.

TABLE I: COMPARISON OF APP-BASED AND NETWORK-BASED GEOFENCING

	App-based Geofencing	**Network-based Geofencing**
Location Source	GPS	Bluetooth	Cell Towers	Wifi
Location range	As required	10 metres	Cell Tower range	100 metres
Accuracy of the object being tracked	30 – 100 metres	3 -10 metres	50 - 5000 metres	3 – 30 metres
Indoor Coverage	No	Yes	Yes	Yes
Battery Drain	High	Moderate	Low	Low
Internet	Yes	Yes	No	No
Download	Yes	Yes	No	No
Static Location	Yes	No	Yes	No
Service Location suitability	Out-door	In-door	Out-door and In-door	Out-door and In-door

IV.

D. HYBRID GEOFENCING

Hybrid geofencing is where the technologies for geofencing are combined to work together taking into consideration technologies that complement each other in the environment in question. The possible combinations is given in Fig. 7 below.

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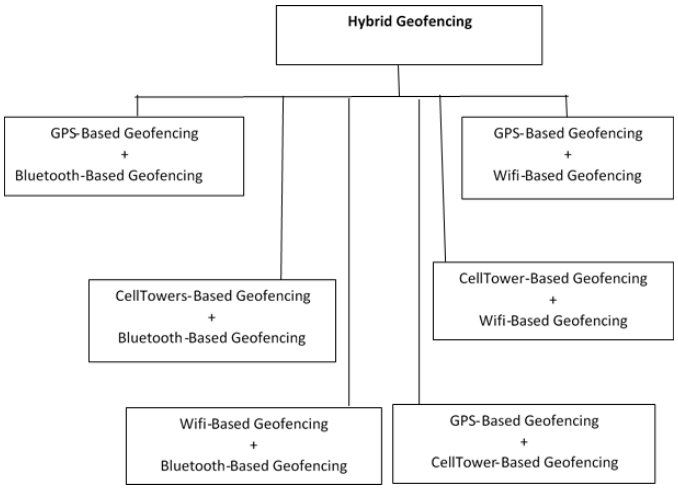

Fig 7: Forms of Hybrid Geofencing

In general the most appropriate combination is the macro-micro combination because it makes it possible to track a user the moment one enters the region of interest up to the point when the user is now on the proximity of the service provider. The micro-micro combination can be used to cover a small area of interest and can serve as a backup in the event of failure of one of the technology. The macro-macro combination can be used in difficulty places to go and where the region of interest is just temporal and there are buildings or caves that GPS cannot operate properly. The choice of the mix depends mostly on what is the objectives of the service provider.

V. CHALLENGES AND OPEN ISSUES

To be aware that a geo-fence has been crossed, geofencing apps actually have to be running. This background tracking depletes mobile users' battery power. App-based Geo-fence only run on smartphones thus excluding a large number of mobile users who are using feature mobile phones. The macro app-based geofencing requires connection all the time thus consumes the mobile users' data and that translates into cost to the mobile user. App-based geofencing has added cost in building and maintaining the app.

The macro network based geofencing cannot pinpoint were the mobile user is within the region of interest. It is possible to track a mobile user without consent thus violating personal privacy of the mobile user.

Geofencing services deals with large heterogeneous data that need proper storage and analysis for it to be useful. Some of these applications fall under to the group of Location-based Services (LBSs), which generate, compile, choose, or screen information or perform other actions by considering the current position of the user [3].

VI. CONCLUSION

Vendors refine their trading area and offer well-timed and relevant promotional schemes to customers in their immediate neighbourhood through geofencing. This is made possible by the ability to track customer's moves through use of mobile devices. As customers cross virtual fences, retailer utilises a "push" strategy to send personalized messages to them. That is how geofencing is especially useful. Users does not need to indicate their location in push-based LBSs. The location is automatically transmitted through the customer's mobile device to the geofencing platform. When the user enters the virtual fence area messages are spontaneously sent to customer's mobile device in the form of invitations, coupons or other types of promotions. Customers can locate interesting services with ease in such an innovative technology. This is equivalent to an online marketplace for proactive contextual services. However, customers are concerned about their privacy in using the technology and getting irrelevant and useless messages that fill their mobile devices. Continuous background tracking of users' positions depletes current mobile device battery life in a relatively short time, therefore it is also a concern to customers. Major technology companies are actively researching solutions to these technological problems because the way forward appears to be the adoption of location-based services.

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