



Hyperlocal Alerts and Tracking of Peoples Using Geofencing - A Virtual Boundaries

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Abstract: In every organizations and companies of public or private, it is require to track and locate the employees based on their authentication and identification. As per the current trends and technology, we need a technological support to virtually fence the boundaries among them. The tracking and locating may be Departmental level or entire organizational level, if the tracking is exclusively for a single department, then the alerts should reach to the expected users, who are available in that department location only but not in other locations [identified by using global position System or Network] of the organization. If the communication is related to the organizational level it should reach to the entire organization irrespective of the department location, but not out of the boundaries of the organization location. To satisfy the above needs, we need hyper-local smart phone alerts. The advancement of the smart devices and geofencing had created the hyperlocal alerts.

Keywords: Geofencing, GPS, Winding Number Algorithm and Tracking.

I INTRODUCTION

Tracking and locating the employee is the unwritten law of the organization to be sure that the employee is in the department. The human management must be intimated the presence of the employee without the knowledge them. This can be achieved through the geofencing. Geofencing is the exciting technology that makes the virtual boundaries of the organization and the departments or even the boundaries of the countries or states. Geofencing technology can be used as spying tool for a particular person. But, also it can be used to give announcement for the peoples in a particular location which was defined under the geofencing area. Geofencing technology can reveal the real time status of the people who enters or leaves the virtual fence., that defines a virtual boundary around a real-world geographical area[1]. Geofencing uses the advantages of the GPS (Global Positioning System) and RFID (Radio Frequency Identification) [2]. Geofencing can be visualized as a smart tool to take decision, which is purely based on the virtual boundaries of a physical geographic location. This boundaries can be a building or a area or a state or even a entire country. Location-based applications in the education sector can improve the learning fashion in the form of mobile learning (m-learning), which can provide the Educational resources such as academic material, reference material from multiple resources anywhere and at any time. As per the emerging trends, the institution should improve their relevance communication among the academic people such as administration, faculty, students and employees with fast accessing and broadcasting using the smartphone alerts or announcements. Now a days all the people even who are in below to the poverty lane also using smartphones, so we can take an advantage of the smartphone to use as the media in institutions to communicate the academic events, such as exams, safety, closing timings, holidays, events, arrival of new books, changes in time table, etc. Every educational institution divided into multiple departments, based on their educational system. Each department has its own alerts or announcements to their students, such as the dates of practical, change of dates, practical resources availability, assignments, delivery plans, material, achievements, news and media. In this case every department has its own announcements and sometimes it is not useful for all the people under all the departments, so we have to target only the relevant people for a particular department. To identify the relevance people we can't have any specific person or object targeted applications.

II LITERATURE REVIEW

Any geo-fence implementation requires obviously some form of location monitoring [3], which generate, compile, select, or filter information or perform other actions by taking into consideration the current location of the user [4]. Technically, this monitoring could be performed either right on the mobile device or via some centralized scheme [5]. One of the biggest and well known problems with the location monitoring is energy

consumption. It is, probably, the biggest limitation factor. The state that always started GPS consumes power of approximately 120 times in comparison with a standby state [6]. Nowadays, GPS is a standard feature of all mid and upper-class devices and delivers a much higher accuracy than Cell-ID, the preferred technology of first generation LBSs. Unfortunately, the latest GPS receivers inside smartphones still do not work indoors or near huge buildings, and they suffer from a long acquisition time (Time-to-First-Fix, TTFF) until the first position fix is available as well as from a high battery consumption. As these drawbacks would present a serious barrier for the success of modern LBSs, standardization and device manufacturers have created different variants of hybrid positioning technologies, which use a combination of GPS, WiFi, and Cell-ID positioning. All of them have different characteristics regarding battery consumption, accuracy, availability, and TTFF [7]. GeoFencing now supports so-called triggered services. They encompass periodic triggers, which may be defined by an external application server to receive periodic location updates from a mobile device, as well as event triggers. An event in this context refers to the moment when a mobile device enters or leaves a pre-defined GeoFence or, if combined with periodic reporting, when a mobile is inside or outside of a GeoFence [8]. The main sources for user's raw coordinates on mobile phones are Global Positioning System (GPS) and Wireless Positioning System (WPS) using cell tower and Wi-Fi access points (AP) [9]. Location-based service can be easily provided for terminals by using Geo-fencing. The monitoring system sets the movement allowable range of the target person outside of facilities as a virtual border on the map. When the target person goes through the virtual border, the system notifies the manager of facilities. In this way, monitoring of the target person becomes easy [10]. The GeoFence can possibly be created in the following formats. A GeoFence is a virtual fence. They are enhanced in accuracy by making use of global positioning systems which allow accurate, precise determination of the location of both the boundary of a geofence and position of a mobile platform relative to the geofence. A geofence typically operates by triggering of a physical response through the mobile, location sensitive device when the device crosses a boundary, though the system on which the method is implemented may simply operate to note the fact of the crossing to an operator. The spatial location of geofences have commonly been established by selecting a point feature, which may be a point defined by latitude and longitude, and then defining either a radius, or major/minor axis for the point feature, to establish a boundary around the point. You can setup alerts to warn you when an item enters or exits a GeoFence. You can create three types of GeoFence, namely Circle Fence, Polygon Fence, Rectangle Fence and Route Fence.

a. Circle Fence:

A circle or polygon GeoFence is used to define an area. A route is used to keep an item on a designated path. Encloses a circular area. Which can be designed with single point with a pair of latitude and longitude coordinates along with specific radius. This could be used to determine whether a student or target is within a certain (radial) distance of a department.

b. Polygon Fence:

Encloses a many-sided area, which includes multiple Geo-Corners [GeoPoints, which can draw with coordinates]. This could be used to determine whether a student is within the specific boundaries. It is the most commonly used form of GeoFence.

c. Rectangle Fence:

Encloses a rectangular area. It is useful, when the area to fence is similar to the rectangle.

d. Route / StreetLink Fence:

A GeoFence that extends to the boundary of a StreetLink. This is often used to exclude one or more streets from a route. This can be used to test if a student is traveling on a link.

According to the invention there is provided a method of determining whether a reported position is within or without a geofence. The method provides the steps of first defining a geofence as a closed circuit of a plurality of straight line boundary segments in a polygon coordinate system

III. WINDING NUMBER ALGORITHM

Winding number algorithm is one of the best algorithms by the best of the authors' knowledge, because this algorithm automatically takes the intermediate points (latitude and longitude) if the end points are defined. The common method to find the winding number is the sum up all the angles between the lines of the polygon [11]. Mathematically we can do this by the inverse trigonometric function, which is expensive in terms of computational power. Hence this winding number algorithm is slower than all other algorithms. But this time compromise can be compensated in other computations, thus as a whole or as a gross, this algorithm is better than the other algorithms. Also it is not a mandatory to do inverse trigonometric, instead it is enough to analyze which quadrants the polygon winds [12]. As it turns around the test point, which makes the winding number algorithm comparable in speed to counting the boundary crossings. All the algorithms give the same results for a given point for the simple polygons. But, if the chosen polygon is complex then each algorithm will yield different points. Because of the one of the properties of the complex polygon i.e. overlapping area of its own. To solve this problem the complex polygon must be converted to simple polygon, which internally raises another burden

in the computations[13]. However, the Winding Number Algorithm produces the exact results inspite of complex and overlapping polygon[14].

Algorithms to find the point in Polygon:

Analyzing and determining a point in a planar polygon is an hectic job in geometric mathematics that gives a pathway to excited algorithms called Winding Number Algorithm. This method counts the number of times the polygon winds around the point P. if the point is outside then the Winding Number (WN) is zero. If the point is inside a simple polygon then the WN is one. WN is two if the polygon overlap once by its own and so on. as shown in the figure 1below.

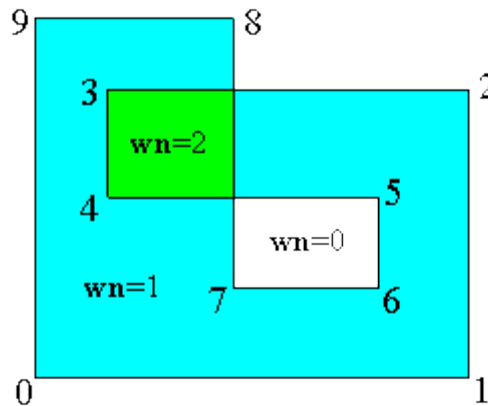


Figure 1: Winding Number Method

In the above figure, the polygon has $wn=0$, $wn=1$, $wn=2$, which states that the point is outside the polygon when $wn=0$. The point is in simple polygon when $wn=1$. $Wn=2$ if the point is in the onetime overlapping area. Winding Number can be WN is the function of C and P. C is the closed continuous curve i.e $wn(P, C)$. Curve C can be formed by the continuous points of x and y coordinates.

$C(U)=C(x(U), y(U))$

Where,

U lies between 0 to 1. With $C(0)=C(1)$

If P is outside the curve C then, Vector $C(P,U) = C(U)-P$ and the Unit vector $w(P,U)=C(P,U) / |C(p,U)|$, produces a continuous function $W(P):C \rightarrow S^1$, where S^1 can be equated as $S^1=\{(x,y)|x^2+y^2=1\}$ and $w(P,U)=(\cos \theta(U), \sin \theta(U))$

Then, the Winding Number $WN(P,C)$ is the number of times the $w(P)$ wraps the curve around S^1 . This corresponds to a homotopy class of S^1 , and can be computed by the integral:

$$WN(P,C) = \frac{1}{2\pi} \oint_{w(P)} d\theta = \frac{1}{2\pi} \oint_{U=0}^1 \theta(U) dU$$

When the curve C is a polygon with vertices $V_0, V_1, \dots, V_n = V_0$, this integral reduces to the sum of the (signed) angles that each edge $V_i V_{i+1}$ subtends with the point P. So, if $\theta_i = \angle(PV_i, PV_{i+1})$, we have

$WN(P,C) = \frac{1}{2\pi} \sum_{i=0}^{n-1} \theta_i$ $WN(P,C) = \frac{1}{2\pi} \sum_{i=0}^{n-1} \arccos \left(\frac{(V_i - P) \cdot (V_{i+1} - P)}{ V_i - P V_{i+1} - P } \right)$	
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The above equation is computationally expensive because of the arccos function. This cost of computation may be reduced by choosing any point Q on S^1 which was wrapped by the curve C. The curve passed through the point P. If the curve pass through the point Q in anticlockwise then count positive one else negative one if

passes in clockwise direction. Then the accumulated sum is exactly the total number of times that $W(P)$ wraps around S^1 , and is equal to the winding number $WN(P,C)$. For example, consider the figure 2.

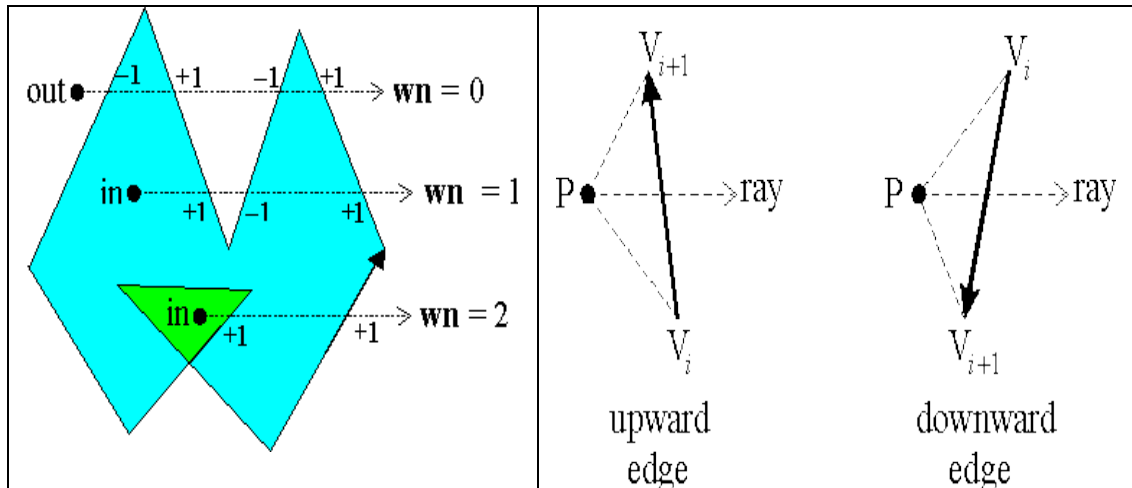


Figure 2: Alternate method to find the WN

Pseudo-Code: Winding Number Inclusion

```

wn PnPoly( Point P, Point V[], int n )
{
    int wn = 0; // the winding number counter
    // loop through all edges of the polygon
    for (each edge E[i]:V[i]V[i+1] of the polygon) {
        if (E[i] crosses upward ala Rule #1) {
            if (P is strictly left of E[i]) // Rule #4
                ++wn; // a valid up intersect right of P.x
        }
        else
            if (E[i] crosses downward ala Rule #2) {
                if (P is strictly right of E[i]) // Rule #4
                    --wn; // a valid down intersect right of P.x
            }
    }
    return wn; // =0 ==> P is outside the polygon
}
    
```

Although the above pseudo code may not be accurate. But, there is notably sufficient algorithms are there to enhance the point in the polygon which gives good results.

IV IMPLEMENTATION

GeoFencing:

Before creating a GeoFence for a particular department, it is necessary to identify the boundaries either based on the building structure or based on the availability of the location. After confirming the location boundaries, and then we have to choose the possible GeoFence from the specified above. It is not possible to choose the same type of GeoFence for each department; we can use the different GeoFence for different departments. After confirming the location and GeoFences, we need to setup a server with the required software to communicate to the clients, for the specific announcements or alerts to the related target.

Targetting the related or specific students in an educational institution.

- Draw or select the boundaries on the Google Map to create a GeoFence for a specific area (Server).
- Load GeoFence Android application in target student's smart phone first-time (Client).
- Send the position of a student to the Server (which contain GeoFence on the Google Maps).

- Track the position of a student, using Geo Location, we can identify the student, whether inside the specific GeoFence or not.
- Raise an event when the student leaves or enters the specified GeoFence,
- Sending Alerts to the staff and students based on the required for a specific GeoFence

V ARCHITECHTURE

The architecture of the proposed work starts with defining the boundaries using the google maps refer figure 3. The marking of the boundaries is noted as the latitude and the longitude in the XML file. This coordinates servers as a server and the corresponding client application is developed in any smart device, this server as a client. The application in the smart phone uses the GPS location service offered by google corporation. The application extracts the GPS coordinates and send them to the server. The server in the other hand constantly monitors the incoming coordinates and a decision is made according to coordinates. Server with all the information about the GeoFences of the institution, which contain specific Geographic location. We can draw the GeoFence on a google map using specific co-ordinates. Each co-ordinate can be represented with the help of specific latitude and longitude, where each coordinate forms a corner of the GeoFence.

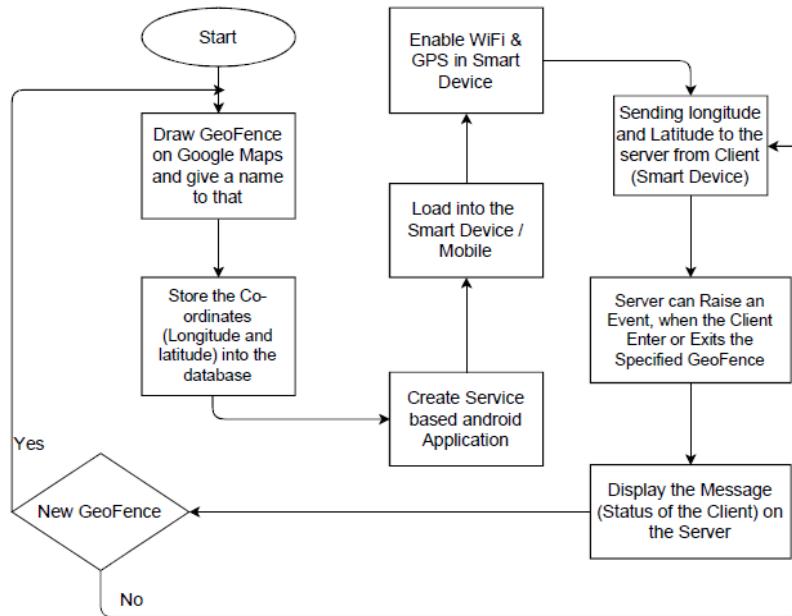


Figure 3: Architecture for the proposed system

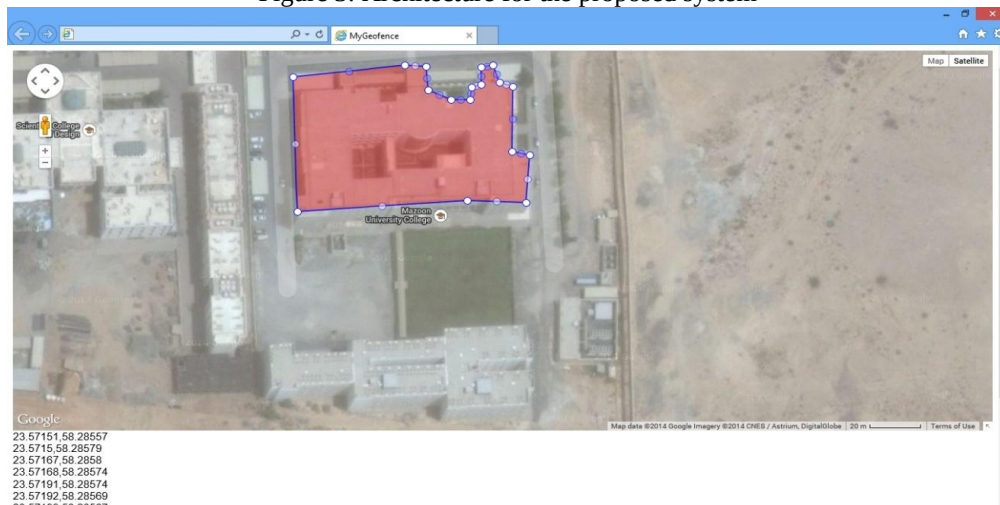


Figure 4: GeoFence using PolygonFence

Here the smart devices are acts as clients. Each client should enable the GPS and load our Institutional Alerts Mobile Application as shown in Figure 4.

VI ANALYSYS

With the help of this application we can get the position of a client [smart device], based on the availability of the position, we can communicate with the specific client with related information or alert. We can raise an

event when the client enters into or exits from the specific boundaries. When a client enters into a department automatically we can identify the client and send the updates to the target. If we create a server with auto install the application, then immediately the student gets the updates, without specifying the department by the student. Refer series of figures given below.

Raising an event when the user enters into the GeoFence

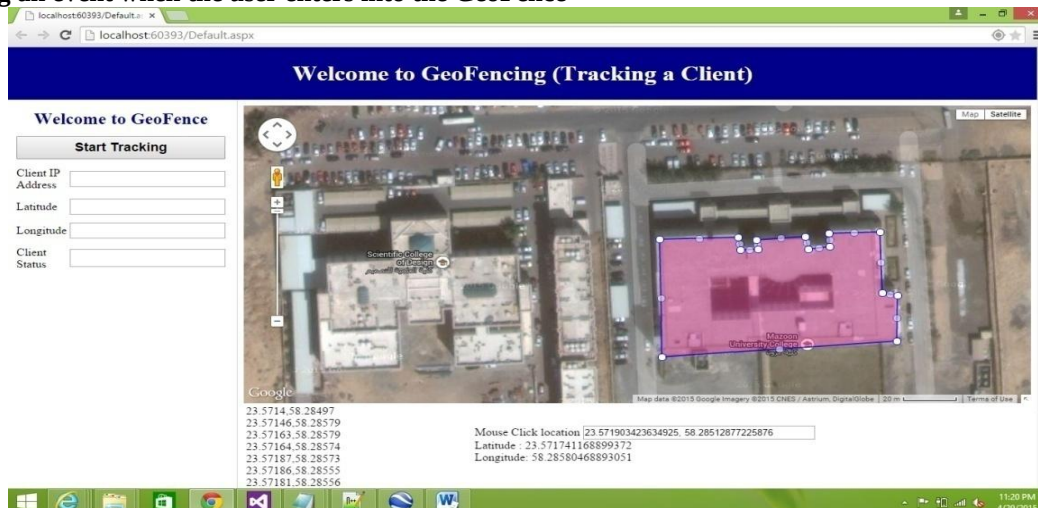


Figure 5: Identifying the boundaries in Google Maps

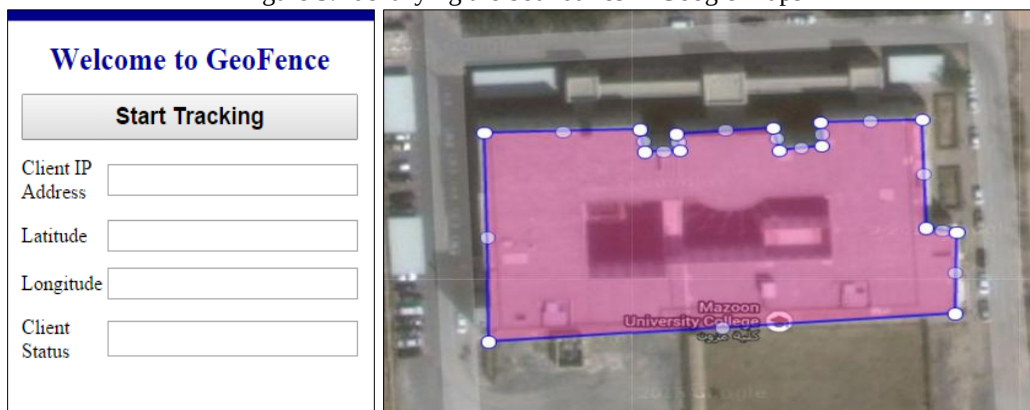


Figure 6: Defining the boundaries in Google Maps

<pre> LangLat.xml <PointsList> <Point> <Latitude> 23.5714 </Latitude> <Logitude> 58.28497 </Logitude> </Point> <Point> <Latitude> 23.57146 </Latitude> <Logitude> 58.28579 </Logitude> </Point> <Point> <Latitude> 23.57163 </Latitude> <Logitude> 58.28579 </Logitude> </Point> <Point> <Latitude> 23.57164 </Latitude> <Logitude> 58.28574 </Logitude> </Point> <Point> <Latitude> 23.57187 </Latitude> <Logitude> 58.28573 </Logitude> </Point> <Point> <Latitude> 23.57186 </Latitude> <Logitude> 58.28555 </Logitude> </Point> <Point> <Latitude> 23.57181 </Latitude> <Logitude> 58.28556 </Logitude> </Point> </pre>	<pre> <Point> <Latitude>23.57181</Latitude> <Logitude>58.28548</Logitude> </Point> <Point> <Latitude>23.57185</Latitude> <Logitude>58.28547</Logitude> </Point> <Point> <Latitude>23.57184</Latitude> <Logitude>58.2853</Logitude> </Point> <Point> <Latitude>23.57181</Latitude> <Logitude>58.2853</Logitude> </Point> <Point> <Latitude>23.5718</Latitude> <Logitude>58.2852</Logitude> </Point> <Point> <Latitude>23.57185</Latitude> <Logitude>58.28523</Logitude> </Point> <Point> <Latitude>23.57184</Latitude> <Logitude>58.28496</Logitude> </Point> </PointsList> </pre>
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Figure 7: Mentioning the coordinates in XML file

Algorithm

The function will return true if the point x,y is inside the polygon, or false if it is not. If the point is exactly on the edge of the polygon, then the function may return true or false. If the point is exactly on the edge of the polygon, then the function may return true or false.

<pre> classPoint { publicdouble X; publicdouble Y; } classPolyGon { publicList<Point>myPts = newList<Point>(); publicPolyGon() { } publicPolyGon(List<Point> points) { foreach (Pointp in points) { this.myPts.Add(p); } } publicvoid Add(Point p) { this.myPts.Add(p); } publicint Count() { returnmyPts.Count; } List<Point> points = newList<Point>(); //int sides = how many corners the polygon has (no repeats) //myPts[i].x = horizontal coordinates of corners //myPts[i].Y = vertical coordinates of corners //double x, y = point to be tested </pre>	<pre> boolFindPoint(double X, double Y) { int sides = this.Count() - 1; int j = sides - 1; boolpointStatus = false; for (int i = 0; i < sides; i++) { if (myPts[i].Y < Y &&myPts[j].Y >= Y myPts[j].Y < Y &&myPts[i].Y >= Y) { if (myPts[i].X + (Y - myPts[i].Y) / (myPts[j].Y - myPts[i].Y) * (myPts[j].X - myPts[i].X) < X) { pointStatus = !pointStatus; } } j = i; } returnpointStatus; } //***** // load polygon points from the XML privatevoidloadData() { DataSet ds1 = newDataSet(); ds1.ReadXml(Server.MapPath("LongLat.xml")); foreach (DataRowdrin ds1.Tables[0].Rows) { Point p = newPoint(); p.X = Double.Parse(dr[0].ToString()); p.Y = Double.Parse(dr[1].ToString()); points.Add(p); } } </pre>
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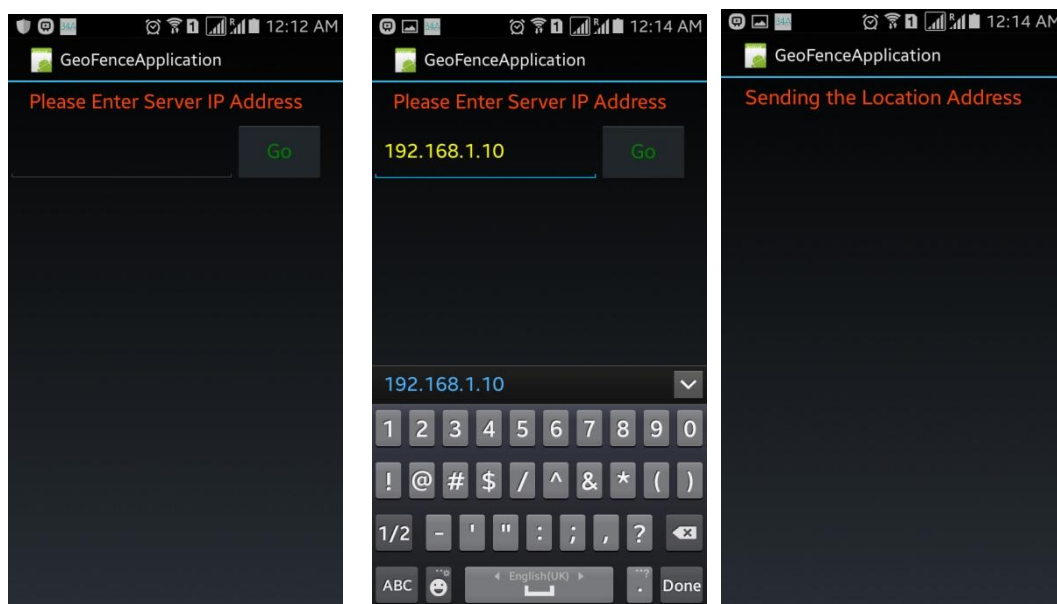


Figure 8: Client Screen Shots

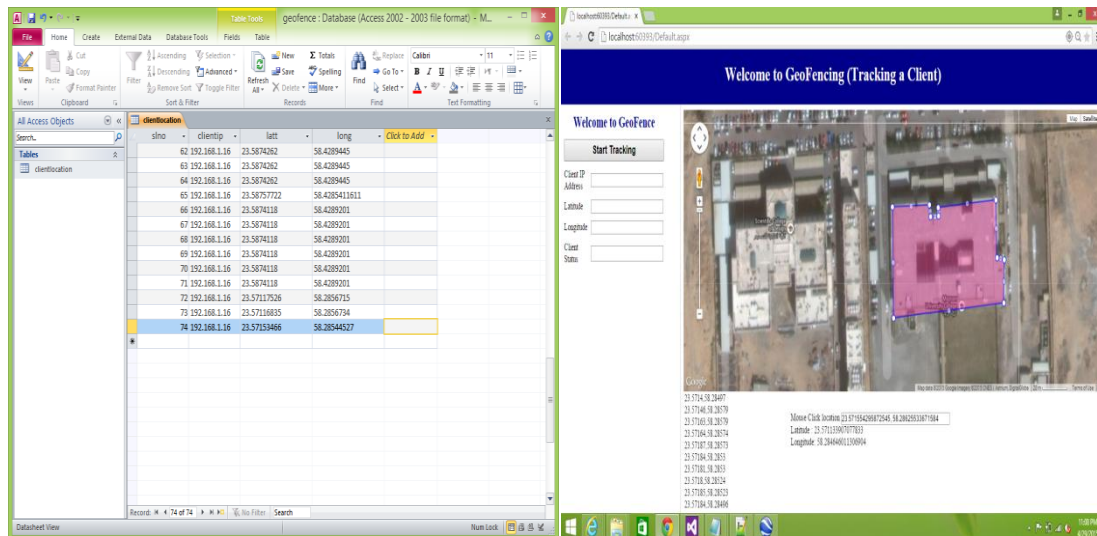


Figure 9: Tracking the Peoples

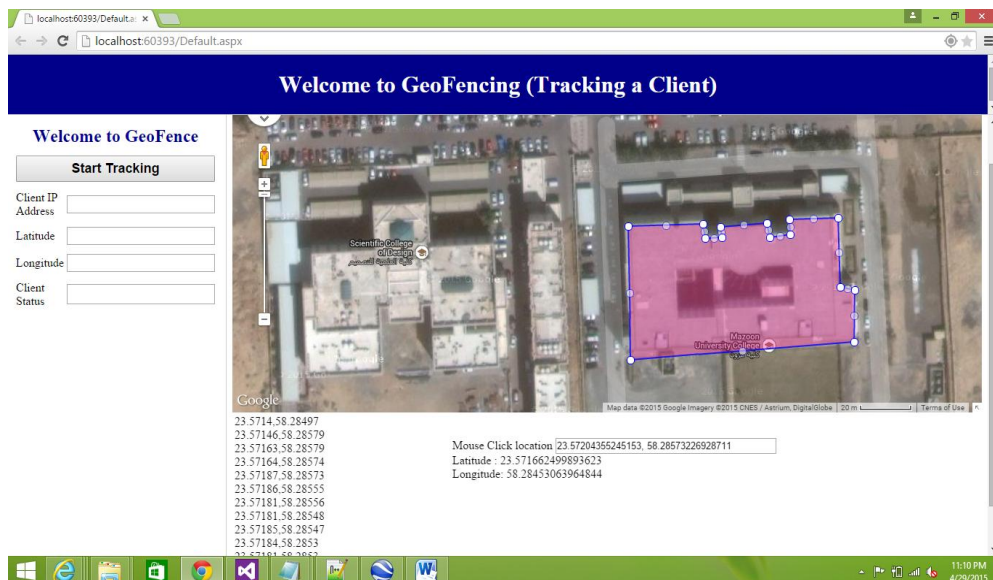


Figure 10: Locating the Peoples

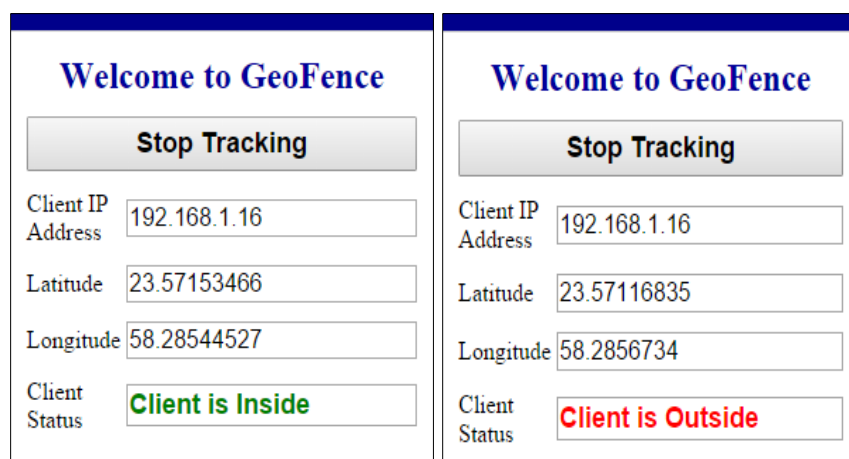


Figure 11: Tracking the Peoples

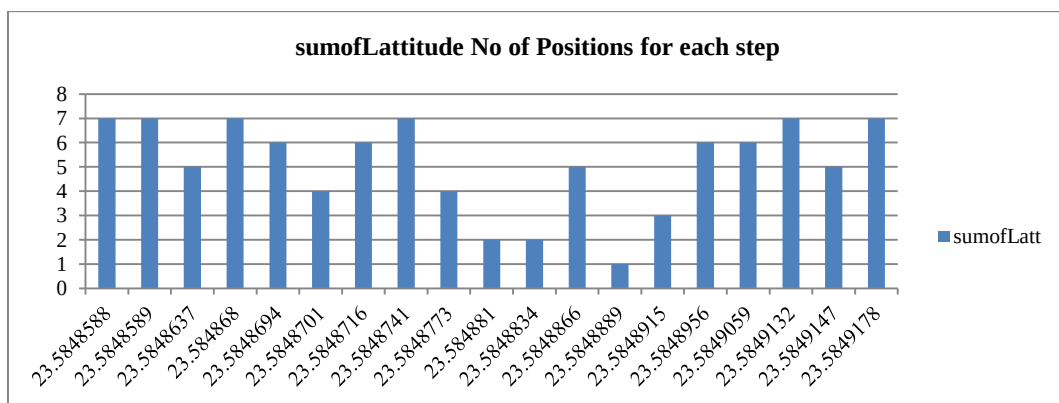
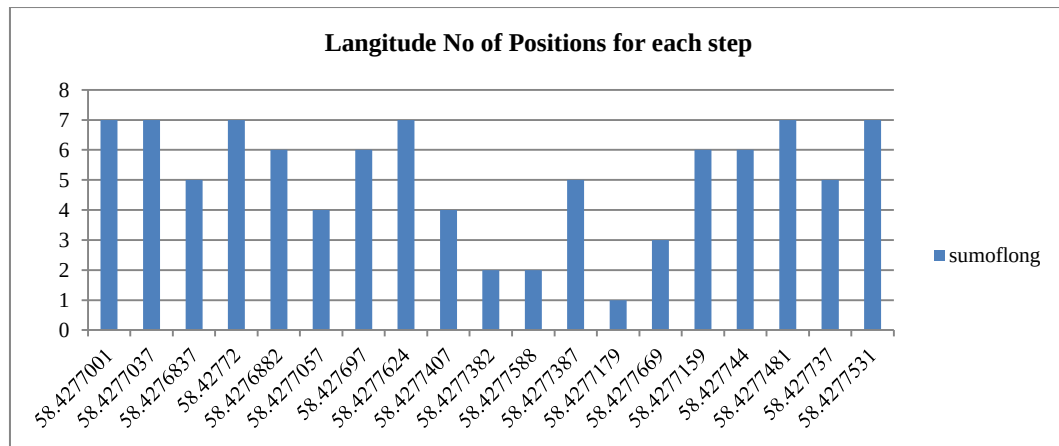


Figure 12: WN for a point

VII CONCLUSION

Geofencing is the inexpensive approach to make boundary to a geographical location in ease of action and cost. This technology can be extended to any location including the defense and restricted area to alert who enters and leaves the area. This proposed work was implemented in real time in Mazoon University College, Muscat, Oman, and observed better results to track the students and the staffs. By defining a particular ID's to the students, they can be intimated their time table, or other notification of event to them while entering into the campus (boundary). Also alters the staff about the number of students waiting for his lecture in a dynamic fixation avenue.

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