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Location Determination of Dynamically Moving Mobile Nodes in Real Time

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Abstract

In today's world as the internet users become more mobile, hence the need for location determination is a key need to provide services based on location, but many devices do not have GPS receivers or transmitters, hence the location determination of these devices is important to provide the location based services, like Advertisements, security, so forth. Location determination of mobile devices has been there for some time but most approaches are based on client intervention, so they are not suitable for integrating in security related components like intrusion detection systems or access control systems. In this paper we propose an approach based on that works on concept of trilateration to determine client location without his/her intervention.

Keywords: Location determination; Mobile devices; Security; Intrusion detection system; Access control system; Trilateration

Introduction

The Main Objective of this project is to develop an application with the aim of increasing the efficiency of business communications in an enterprise environment which can automatically update presence information, which is used within a unified communication environment, depending on where the user is within a building, moreover due to the nature of free air propagation, which all radio communication is based on, wireless computer networks may be easy accessible for potential attackers. Infrastructure bound wired solutions do have an advantage in terms of security over wireless ones, due the inevitable physical connection to the target network [1-5]. The possibility to determine the physical location of any connected client would result in a significant gain of the achievable security level.

Idea of algorithm

Idea behind my algorithm is to calculate intersection of three or more spherical surfaces given the position of their centres and radii lengths. Given the distance to three centres (signal sources) and their position it is possible to determine the receiver's position. Because signal properties do not very well correlate with distance, estimated position can have a significant error. Here spherical surface is the access point RSS value (Signal Strength), since many of access points available are Omni-directional that transmits signal equally in all directions with some centre and radius. Though the signal properties doesn't correlate with distances that are used to determine receiver's position, I am calculating the attenuation factor, removing attenuation from transmitted signals and now I use the values of radius and centres of RSS making my algorithm more accurate [6-10].

Related Work

Algorithm used in developing my application is Trilateration. But Trilateration is error prone for many reasons like signal properties don't correlate with distance. Here we propose a new algorithm by modifying Trilateration algorithm.

Trilateration

Trilateration is a process of calculating client's position based on measured distances between itself and a number of access points with known locations. Given the location of an access point and a client's distance to the access point (e.g., estimated through RSS measurements), it is known that the client is positioned somewhere along the circumference of a circle centered at the access point's position with a radius equal to the client–access point distance. In 2-D space, distance measurements from at least three non collinear access points are required to obtain a unique location (i.e., the intersection of three circles) [11-14]. In three dimensions, distance measurements to at least four non-coplanar access points are required. In this technique there are two cases:

The client node may be at the intersection of 3 circles drawn by three non collinear access points as shown in Figure 1.

The non-client node may in the overlapping region of 3 circles drawn by three non collinear access points i.e. three access points circles are not intersecting at a common point as shown in Figure 2.

Trilateration problem

Trilateration problem occur in 2-D WSN localization, when unknown node is not at the intersection of 3 non collinear access points. A node N is the non access points whose position is unknown [15-20]. Location of node N is estimated with the help of three access points 1, 2 and 3. The trilateration problem is to find the coordinates of node N= (x_{est}, y_{est}) from the given information. Draw a circle of radius equal to the distance between access point and client nodes estimated through RSSI taking access point as center of circle. Similarly circles are drawn around access point 2 and access point 3. Since the circles centers and radii are subject to measurement errors, the circles will overlap in a (hopefully small) region rather than intersecting at a single point the unknown node location N is somewhere in this region. Each pair of circles yields two intersection points as shown in Figure 2. With three circles, there are six intersection points. Three of these points are clustered closely together, while the rest are far apart. The node N is located in the middle of this cluster. Now resolve that error centroid technique.

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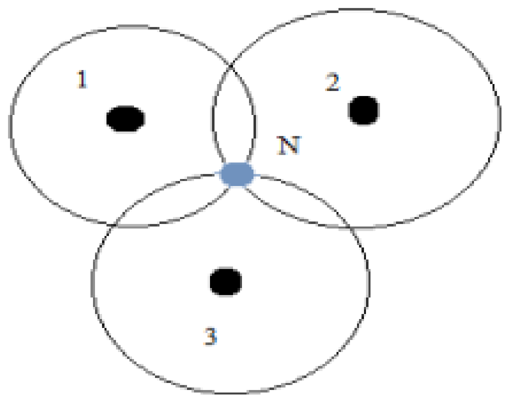

Figure 1: Trilateration.

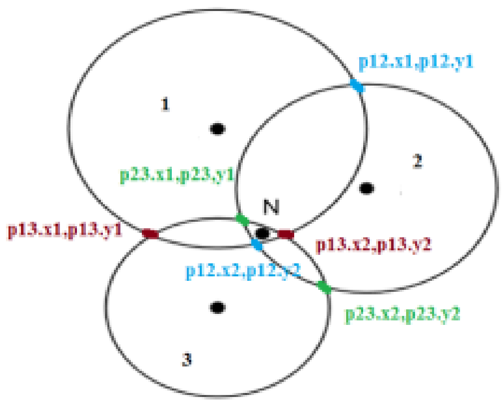

Figure 2: Trilateration Problem.

Fundamental centroid

After finding the innermost intersection points fundamental centroid technique is applied to calculate the position of client node. The task of the centroid method is to take several nodes around the unknown nodes as polygon vertices and the unknown node as the centroid of polygon which is indicated in Figure 3.

After receiving the message, there is a relation for estimating the coordinates of unknown node as given in equation 1:

$$(X_{est}, Y_{est}) = \left(\frac{x_1 .....x_n}{n}, \frac{y_1 + ...y_n}{n} \right) \quad (1)$$

Where (x_{est}, y_{est}) indicates the estimated position of the client nodes. Equation 1 is general equation for n nodes; in case of trilateration n is 3 i.e. innermost three intersection points. The result looks simpler but is not sufficient for correct estimating position so, to improve the result we have modified trilateration and so is used.

Proposed Algorithm

We proposed an algorithm where we don't determine any error because the finding distance between access point and sensor (client) is always error prone because always there will be attenuation in signal because of walls or furniture around Access Point. Hence rather than finding these values manually by us, it's better to ask an organization to give attenuation values of each access point, because our design will always be error prone if we calculate attenuation manually as we can't estimate attenuation values since we don't know how many walls, furniture available in some other organization.

Signal Strength (RSSI)

Transmitted Power (tx power)

Attenuation

When I have all the above values I am able to find the common chords i.e. three common chords for three circles where the point of intersection of the chords lie in the common region of three circles intersection and that point of intersection is the clients or sensor or person position. Figure 4 shows the common chords and their point of intersection where the client is located [21].

Experimental Results

While assigning devices on to floor map the location details of access points are stored in database and database values are as shown in Figure 5.

The location of client is calculated with help of our trilateration algorithm by using location of access points stored in database as shown in Figure 6.

The location coordinates stored in database are used and client location is updated on UI screen and will as shown in Figure 7 (Floor Map shown here is a dummy image).

Conclusion

A monitoring application, which will gather location information of a client and provide location services like security, who is connected to our network is been implemented. We used technologies like Meteor for the purpose of reactivity, NoSQL databases like MongoDB to handle

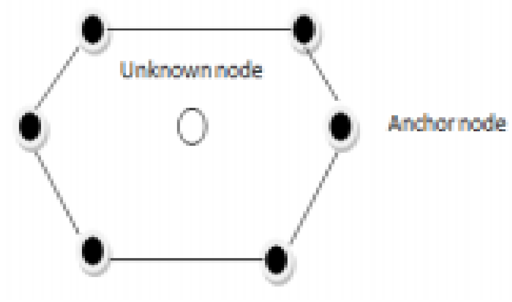

Figure 3: Centroid technique.

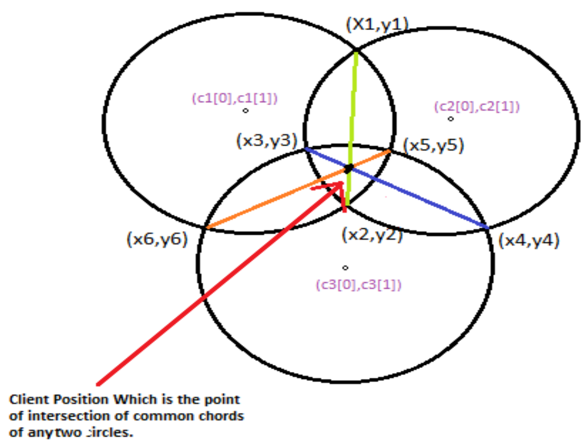

Figure 4: Client position.

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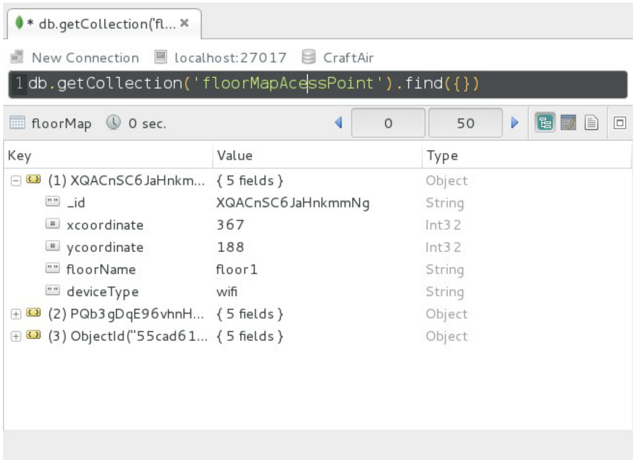

Figure 5: AccessPoints Location in database.

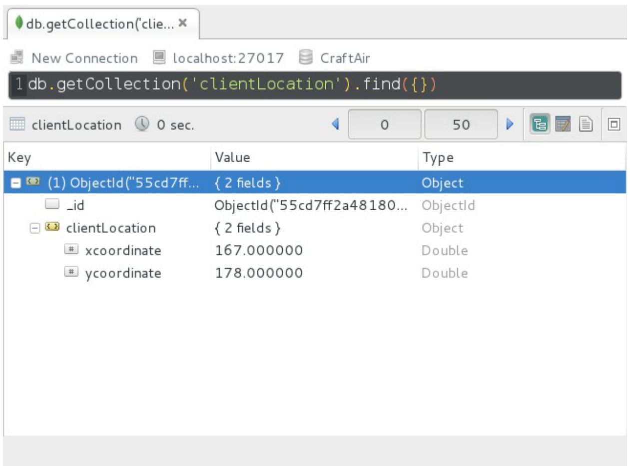

Figure 6: Client located coordinates stored in database.

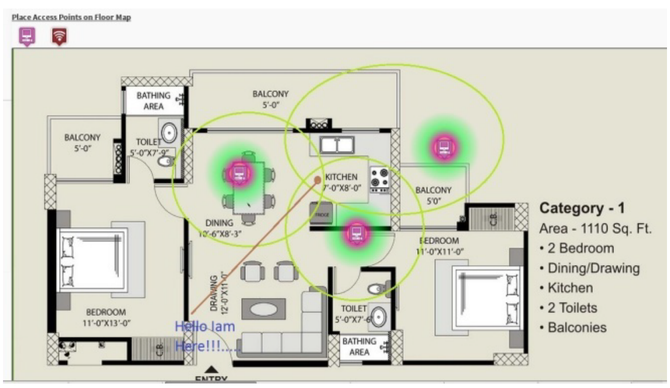

Figure 7: Location of client.

such large amounts of data since client is not static his coordinate always changes so there will be huge data to update very frequently, and these are used along with C++ and JSON-RPC to make my backend have a tight connection with JSON documents.

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