WIFI-Based Indoor Positioning System

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***Abstract*--- The easy access and availability of wireless technologies and mobile computing and internet have lead to new opportunities in developing mobile applications which purpose is to make people's life more easier. Nowadays, a person can possess more than one mobile device intend for different usage such as communication, entertainment, office works. This paper proposes a mobile application which will be able to estimate the position of a user within a building by using WIFI technology.**

Keywords: WIFI, Indoor Positioning System

I.INTRODUCTION

The easy access and availability of wireless technologies and mobile computing and internet have lead to new opportunities in developing mobile applications which purpose is to make people's life more easier. Nowadays, a person can possess more than one mobile device intend for different usage such as communication, entertainment, office works.

During the last decade, researchers have been working on various possibilities on how to make your mobile device not only a communication tool but also a navigation tool. Navigation system is becoming more and more important in our everyday life as they make life easier and more comfortable. For instance, imagine yourself going to explore a new country or even another state in the country where you live. Would you go without at least a paper map? During the last generation, when people wanted to buy a mobile phone, they were looking for those able to connect to the internet using WIFI. In our time, most people are buying mobile phone with in-built GPS.

Global Positioning system is the most prominent contribution in determining position of user and in routing him to his destination. This system uses satellites to triangulate the location of the GPS device. Though this system has made a good impression in terms of accuracy and is the preferred location-based system for outdoor positioning, when it comes to indoor environment, GPS has proved to be inefficient. The reason for its inefficiency is that in order for GPS to perform a triangulation, the device needs to be in line-of-sight from the satellites. Moreover, GPS system has a low precision which make it not suitable for indoor areas. [1] Therefore, when it comes to indoor positioning system, other alternatives such as Bluetooth, WIFI, RFID and Infrared Red are more preferable.

The rest of the paper is organized as follows. In section two, we will talk about the various positioning system that were developed in the past and what are their features, advantages and disadvantages. In section three, we will propose a new indoor positioning system which is derived from the previous systems with a little amelioration on the negative aspect of these systems. Conclusions and discussions of future work are given in section four.

II.RELATED WORK

The earliest location system was the Active Badge developed at Olivetti Research Laboratory where the user was wearing a badge that emitted infrared signals. [1] Every 10 seconds, a unique identifier is communicated to fixed receivers. The data is then sent to a central server that provides an API. [2] The accuracy of the location depends on the number of receivers. The two limitation of this method are that it requires line-of-sight between the receivers and the badge and infrared red has a short-range transmission signal.

RFID has also demonstrated its capability in location-based system. One famous location sensing system using RFID technology is known as mTag. The mTag architecture uses fixed RFID readers located within the environment and a passive RFID tag attached to a mobile phone or PDA. [3] The disadvantage of using RFID is that the cost of deploying and implementing this kind of system can be very high.

The pervasive adoption of Wifi in indoor environments has provided an opportunity to develop indoor positioning systems that will not requires investing in specialized hardware. Some of the well-known systems using WIFI are RADAR, Herecast and PlaceLab. Radar is one of the first indoor positioning systems

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based on IEEE 802.11 wireless network. The system, developed by Microsoft research uses the Radio Frequency Signal strength to measure the distance between the Access Point and the Mobile station. [4] The RADAR system includes two phases, the Training Phase and the Online Phase. In the training phase, an area is divided into a 1x1 meter grid where the signal strength measurements of the access points are taken at each intersection. The mean of the signal strengths which have been obtained, is recorded to create a radio map to be used in the online phase. In the Online phase, when the user looks for its location, the mobile station will detect and record the signal strength from as many access points as possible. Then, the signal strength received will be compared to the radio maps to determine the location of the user.

Herecast is another system using the WLAN technology. [5] It allows the WIFI-enabled client device to determine its location by listening from signals from known access points within the building environment. The system creates a database where the MAC address of the access point is stored together with the symbolic name of the location. In the localization process, the position of the user is the one associated with the access point with the strongest signal strength. The weakness of the system is if an access point is faulty or has been removed, the position of the user may be distorted.

The PlaceLab system is similar to Herecast in that it allows the client device to automatically obtain its location by listening to signal from access point. PlaceLab stores the MAC address broadcast by each access point as well as its longitude and latitude in the client device. Therefore, for when the client device receives a signal from each of the access point, the location is calculated as the average of retrieved longitude and latitude. [6]

When using WiFi technology to estimate the position of the user, different approach may be used. Antenna-centric algorithms focus on antenna and their propagation model. In these methods, high computation power is required for the training phase, but low memory is used in the positioning phase. Propagation-based positioning model use a signal propagation model which converts RSS to a distance measurement and then use some methods to compute and determine the location of the mobile device. The disadvantage is that signal attenuation of this system is affected by lot of environmental factors. Therefore, it is quite impossible to come out with a general signal propagation model. [7]

Another approach is by using Location-centric algorithms. It uses parameters based on sample location. In the preparation phase, calculation is usually not necessary to stored sample data. But in the estimation process, algorithm will search the database and perform calculations based on the search result. One good method adopting location-centric method is the fingerprint algorithm which has proved to be accurate enough in estimating the position of the mobile user in RADAR.

III.THE PROPOSED SYSTEM

The proposed system works in two phases; offline and online phase. The offline phase involves creating a radio map. The radio map, will stores distributions of RSS values from all detected APs at specific points which are known as marking positions. The marking positions together will the MAC address of each detected APs and their corresponding RSS values will be stored in the database to create the radio map.

In the online phase, when the user will initialize the mobile application, the sniffer component will collect sample of RSS values from all detected APs. To estimate the position of the user, the data collected will be compared in the radio map.

The radio map will consist of a set of samples taken at specifici location on a map called fingerprints. The fingerprint will consist of the location name and a measurement vector which consist of all the detected Access points and their corresponding signal strength.

The measurement vector for the signal strength will be illustrated as below;

$$a = \{a\_1, a\_2, \ldots a\_i, a\_P\}$$

Where a is the location name, a_P is the number of access points detected at this location and a_i is the signal strength of access point no. i. For instance, if a location is to be taken at the following point on this floor plan. For each sample, the measurement will be taken at four different directions (north, east, south, and west). This will reduce the error cause by signal attenuation due to human body, interference and furniture. Therefore, at each specific location, measurement will be taken at four different direction and the mean values of the data obtain at these direction will be used as the final measurement for the location.

A filtering technique is applied when collecting signal strength in order to reduce the number of measured signal strength that will be used to represent the fingerprint of a current location. Moreover, by using a reduced number of signal strength, the time for computation can be reduced as well as the size of storage required to store the data. At each specific location, the range of RSSI values which used will be: $-90 < ss < -20.n$

An interpolation technique will be used to reduce the time spent on training the system. I am going to use the same technique that was adopted by Tsai et al. To calculate data for un-calibrated grid points, they used either one of the following formulas based on the situation. For instance, point A and B was calibrated and we need to calculate for point C which is in

between, if only point A is used to infer the location of point C, the first equation is used and if both points are used to infer the location of point C, then the second equation is used. After the grid-points have been calculated, Segment process is used to divide the data of each point into *m* parts.

$$S_{Ci} = \frac{\log d_0}{\log (d_0 + d_1)} \times S_{Ai}$$

$$S_{Ci} = \frac{\log d_2}{\log (d_1 + d_2)} \times S_{Ai} + \frac{\log d_1}{\log (d_1 + d_2)} \times S_{Bi}$$

Figure1: Interpolation Model [8]

Euclidean distance will be used to compare the current fingerprint obtained at the mobile application and the existing fingerprint stored in the database of the server. The Euclidean distance will compute the minimal distance between two set of fingerprint. For instance, assume that the current fingerprint is *s = {s_1, s_2 ... s_N}* and a saved fingerprint is S = *{S_1, S_2... S_N},* then the squared Euclidean distance between the vectors *s* and *S* is:

L(s, S) = (s_1 – S_1) ^2 +.... + (s_N – S_N) ^2

This can be represented as:

$$L = \sqrt{\sum_{i=1}^{n} |s_i - S_i|^2}$$

Figure2: Euclidean distance algorithm [9]

FUTURE WORK AND CONCLUSION

As a future enhancement, the accuracy of the system can be increased by applying various techniques such as backtracking which will avoid the system from choosing between two close measurements. By applying backtracking, when ambiguity occurs, the system will go back to the user's previous location and then compare which might be the user's next location between the candidate locations.

Another future improvement will be to use other signal source such as Bluetooth and GSM wireless technologies. By having more signal sources, the accuracy of the system will increase and the system will be able to be used on bigger scale.

My main goal is to make the system feasible to be used in real-life. Until now, it is still in the prototype phase where various improvements need to be amended and research need to be perform on how to integrate the system in real-life. The main objective is on how to get a signal that is less sensitive to attenuation and to develop a system that can be implemented in different indoor environment.

Nowadays, positioning system is very useful in outdoor environment as well as indoor environment. Indoor environment is increasing in size and is becoming more complex. Therefore, developing an indoor positioning system is indispensable as it will avoid stress and reduce time for people to look for a specific location in an indoor environment.

Also, since we are moving to ubiquitous computing and that technologies are increasing, what researchers are visioning is to make mobile phone not only a communication tool but also a navigation tool. To conclude, the system that was proposed and developed in this major project is still in the stage of prototype. The intention of this system is to collaborate in the research on indoor positioning system and to do one more step in building an indoor positioning system that will be feasible and used in real-life.

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