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Towards Developing an Intelligent HAJJ Guide system

PILGRIM TRACKING AND IDENTIFICATION USING MOBILE PHONES

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***Abstract*— This paper presents the development of a system designed to track and identify pilgrims in the Holy areas in Makah-Saudi Arabia during the Hajj season (Pilgrimage). The target area is covered by a complicated network through several service providers. Mobile phone sends UID, latitude, longitude and time stamp frequently or as requested. On Google map there is a server that maps the longitude information and latitude. In case the internet connection is lost then the mobile phone saves the location information in its memory until the connection is restored. Once connection is restored, it will then send the saved location information to the server and clears this information from memory. The developed system works collaborating with a GPS identification system.**

Keywords*— *Tracking System, Identification system, Hajj, GPS

I. INTRODUCTION

It is well known that Hajj (Pilgrimage) is the most annual crowded Muslim gathering event on earth. The annual event has distinctive characteristics such as the religious practices (rituals) performed, the people who attend (pilgrims) and the place they meet in. These characteristics cause difficult challenges to the authorities in order to control the crowd and identify the personalities. What increases the challenge is the unity of movements as they all move from one place to another at the same time practicing the same rituals. Although a Muslim should perform Hajj once in a lifetime many prefer to perform it more. It is performed on the 8th-13th days of the 12th Hijri month in fixed boundaries around Makah city in Saudi Arabia. Although the Hajj authorities try their best to limit the flood of the crowd to the area by assigning quotas for pilgrims to each country, the number of pilgrims is still exceeds 2.5million annually and the number keeps growing.

The Saudi Ministry of Hajj released a statistic report stating that the number of pilgrims in 2014 was 2,085,238, where 73% of pilgrims are non-Saudi pilgrims [1]. A number of around 4 million pilgrims who come to the Holy areas every year other than Hajj times may benefit from the developed system as well. It is expected that the number of visitors will reach 10 million every year in the near future. Despite being a great spiritual experience for all pilgrims, at the same time it poses great challenges of all sorts for the authorities responsible for facilitating the Hajj. Koshak et al. [2] mentioned that apart from the Hajj period, Makah areas become very crowded during the last ten days of Ramadan. During the month of Ramadan, it was reported that there are more than 2,500 cases of missing people in the area of Masjid al-Haram, the grand mosque in Makah [3]. Adopting such a worrying figure even before the Hajj period begins would be very dangerous and if no further improvements are made, the safety and security of the pilgrims would be jeopardized. In spite of all that is done to facilitate the Hajj, some common difficulties are facing the pilgrims and the authorities which are listed as following:

- ✓ Identification of pilgrims (lost, dead, or injured)
- ✓ Medical Emergencies
- ✓ Guiding lost pilgrims to their camps.
- ✓ Crowd control

The aim of this paper is to study the Hajj pilgrimage crowed tracking and identification problem as well as propose a better Hajj pilgrimage tracking and identifying system that is reliable and affordable. The paper is organized as follow: section 2 presents related work; section 3 presents Hajj locator architecture; section 4 presents the hardware specifications for the Hajj locator system; section5 covers the software specifications of the proposed system; section 6 presents the

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system design; and section 7 presents the proof of concept model for the proposed system.

II. RELATED WORK

There has been quite a number of tracking and monitoring systems developed for crowd management. Each system uses its own means and facilities to increasing its effectiveness. One of the most widely recognized system is the tracking via RFID chips. Nowadays, a lot of embedded RFID chips are placed in our belongings and because of its relatively small size; it has been used quite extensively for many applications. In order to have a system that suits events such as Hajj, Yamin et al. [4] proposed to track people using the RFID chip and wireless technologies which uses a database to save data and the entities for each person. Installing sensor networks for sensing and reading the chips for irregular events does have some serious economic considerations. Another approach is having an object recognition system where a picture, which usually is a land object or structure, is taken using a built-in camera common in any mobile phone to identify their location with respect to the picture taken [5]. GPS is used to read the actual location if available. If the data cannot be acquired then it uses an approximate evaluation of the cell information of the phone-network provider. As good as the system might get, the system relies solely on Internet connectivity. People need to register to have their own Internet connection available in their mobile phones. For those who do not have Internet connection, it is burdensome to go through the requirements only to be used for a short period time during Hajj. Another approach is by implementing a low cost object tracking system using GPS and GPRS [6]. The system allows a user to view the present and the past positions recorded of a target object on Google Maps through the Internet. It reads the current position of the object using GPS, the data then is sent via GPRS service from the GSM network towards a web server. Some might argue that using SMS is an expensive means of communication. Although it is cheaper to use wireless network technologies when usage is heavy, it is expensive when consider the duration of time it is used. Another approach is a prototype using passive RFID technology passed through several implementations and discussions with Hajj officials [7]. The developed prototype was tested on 1000 pilgrims from the country of Ivory Coast in collaboration with officials from the Hajj Ministry. The results of the experiment have convinced the Hajj authorities to utilize this technology for all pilgrims in the near future. However, authorities indicated the need for tracking pilgrims in addition to the identification process. Therefore, an active RFID system is developed for tracking pilgrims to work on coordination with the passive RFID system for identification. However, the system faced several difficulties and proved to be impractical, particularly with the crowd. Thus the idea of using wireless sensor network for tracking pilgrims was introduced [8, 9].

The tracking and monitoring system consists of portable wireless sensor units carried by the pilgrims and a fixed Wireless Network (WSN) infrastructure capable of gathering, processing and routing location and time stamp data of sensor units carried by the pilgrims. All the nodes in the fixed WSN are made equivalent to keep the deployment, configuration and reconfiguration process simple. Table 1 presents a comparison of the work that has been cited in literature regarding Hajj mobile applications.

Table 1: Presents a comparison of the work that has been cited in literature

Author	Solution	Economic Considerations	Internet Connectivity	Register
Yamin et al [4]	to track people using the RFID chip and wireless technologies	Have some serious economic considerations.		People need to register.
Luley, P et al [5]	having an object recognition system where identify their location according to the picture taken		The system relies solely on Internet connectivity.	People need to register to have their own Internet connection.
Hasan, K.S [6]	The system allows a user to view the present and the past positions recorded of a target object on Google Maps through the Internet.	Low cost object tracking system using GPS and GPRS.	Although it is cheaper to use wireless network technologies when usage is heavy, it is expensive to use if we consider the duration of time it will be used in, with the money we pay for it	
M. Mohandes [7]	Using passive RFID technology passed through several implementations.	The system faced several difficulties and proved to be impractical, particularly with the crowd.	Consists of portable wireless sensor units carried by the pilgrims and a fixed Wireless Network Infrastructure capable of gathering, processing, and routing data on locations and time stamps of sensor units carried by the pilgrims.	

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regarding Hajj mobile applications.

During Hajj the pilgrims will only be there for around a month and getting Internet services from ISPs might be troublesome and therefore might results in inability to use the local service. Also it was noticed that an expensive infrastructure would need to be built and the cost of each portable sensor unit is not significantly cheaper than a mobile phone equipped with a GPS unit. Particularly that the majority of pilgrims have their own mobile phones and a large percentage of their phones are already equipped with GPS. This leads us to develop a pilgrim tracking system using mobile phones. The System which is proposed promotes accessibility by choosing a common platform that is widely used by people, which is the mobile phone. The proposed system also provides connections availability towards the user, where we use two types of connections in updating the data to the server. We believe that the proposed system once implemented will provide a better way of tracking pilgrims.

III. HAJJLOCATOR ARCHITECTURE OVERVIEW

The framework of the proposed tracking system is designed in two parts; the mobile device of the connection server and the tracking system using the database server as shown in Figure 1. The GPS-enabled mobile phone is connected with the user and the coordinates are updated in the server and stored in the database server. The coordinates then are send with the Subscriber Identity Module (SIM) card number as its identification together with other useful data.

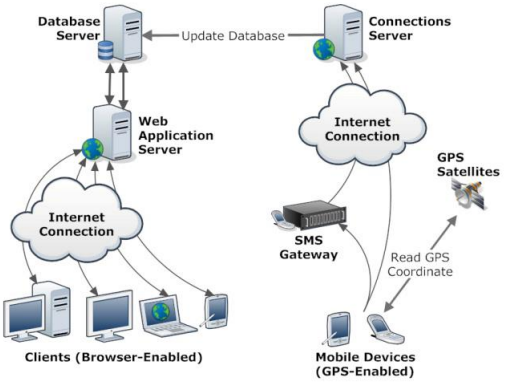

Figure 1: The mobile device of the connection server and the tracking system using the database server

The server which only provides reliable indoor and outdoor user location is divided into three parts; server side, processing side and connection side. Dissolution of servers is needed to handle the huge clients' updates. The database should be divided into different servers to ease the process of updates and avoids bottleneck.

As for of connectivity, different services offered by any GSM mobile phone can be utilized. Any wireless network infrastructures available can be used, together with SMS as the means of data communication among clients and servers. The main precedence will be given to updates using any available Internet connection such as Wi-Fi, GPRS and 3G were it will then make use of the connection to update the server with pilgrim's GPS coordinates. In addition to that, SMS is also used as the other alternative connection to update the server. If Internet connections are not available, the device will then automatically use SMS as another option. This works as a solution for the availability issue especially in a situation such as alerting for a missing pilgrim .Security is also considered for this proposed tracking system. In case the administrative or authorized personnel wants to trace pilgrims, they need to log into the web server and get the position of the pilgrim using one of two choices; in a Google Maps view, and in a tabular view. Regarding security concerns, it is considered as control privacy, thus we will authenticate any user who wants to access the data.

A. Hardware Specifications

A HTC Touch Diamond2 smart phone has been selected in implementing the prototype for the Hajj Locator system. The Hajj locator is modeled as a stack hardware system as shown in Figure 2. The phone uses Windows Mobile 6.1 Professional and has an internal GPS antenna. In terms of network, it supports HSDPA/WCDMA network of up to 2 Mbps up-link and 7.2 Mbps down-link speeds, a Quad-band GSM/GPRS/EDGE and a Wi-Fi IEEE 802.11. More information about the mobile phone can be accessed through the web site at [10]. The server is running under normal PC with AMD Phenom 9600B Quad-Core Processor 2.31 GHZ, 1.75 GB of RAM.

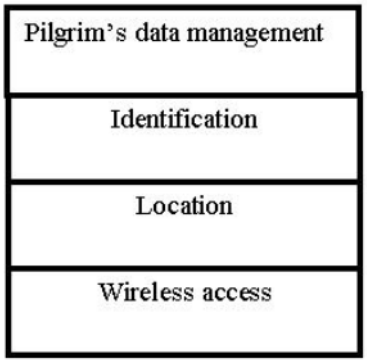

Figure 2: The hardware system stack

B. Software Specifications

For server update, a client application has been designed in parallel with the server process. We used java to implement the application. It reads the latitude and longitude of the location and process it based on the specifications defined by the user. The main specifications are through the distance-based and time-based parameters. The choice of distance-based and time-based parameter is designed to offer flexibility to the user in updating to the server. Figure 3 shows the flow diagram of the

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distance-based and time-based latitude and longitude calculation updates in the server. For the distance calculation of coordinates, the Cosine-Haversine formula technique has been used [11]. It results in a great-circle distance between two points on a sphere given the latitudes and longitudes. However, other parameters can also be used manually according to the user request such as the "Mark My Location" and the "panic alert". Mark My Location is a special button designed for users who intended to update the server about their current location. It uses only the chosen connectivity method to communicate with the server. This data of latitude and longitude will help the system to store reference points. The panic button is designed to alert the system in emergency situations. It uses all of the available resources, i.e. Wi-Fi, GPRS and SMS, to update current location of the user.

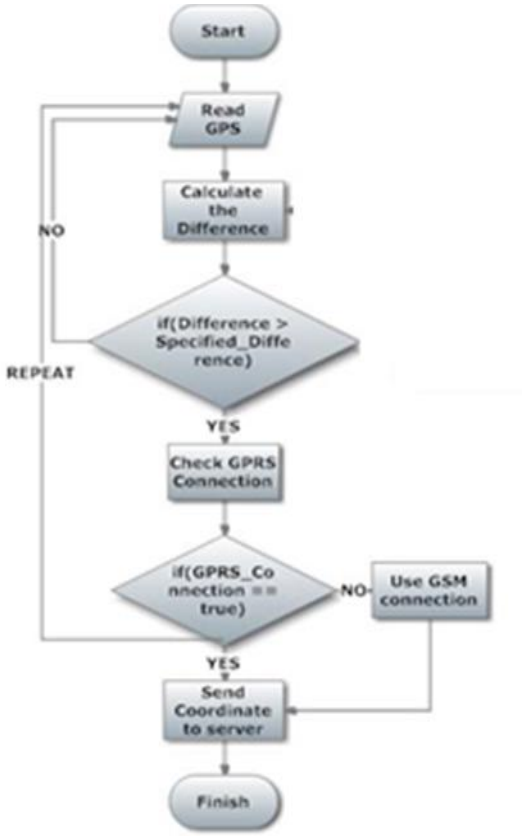

Figure 3: The flow diagram of the distance-based and time-based latitude and longitude calculation updates in the server.

In order to compensate the real-time update and at the same time being cost-effective, we have decided to use the dynamic update triggering to the server. In other words, the user will be in an area of circle with a defined radius and the system will only send an update to the server, should the user moves more than the defined distance. For this reason, to gain popularity and widespread usage, our proposed System is developed in a balanced approach and provides the ability to facilitate real time update in a cost-effective way. On the server side, the development was done using, Java, AJAX and DHTML. To provide reliable data management, MYSQL is used in database server. To read coordinates from database, we use a PHP file, and parse it into an XML format. These XMLs are then will be processed by the application processing server. To display the tracking and monitoring of the user, a web based application has been developed. Through the web application, administrative or authorized personnel will be able to view the live position of the tracked user, together with the past positions and the route they have chosen. A web application is responsible for accepting data that has been sent by the mobile device via GPRS or GSM, using GET method of the HTTP protocol. This data consists of SIM number of the device, latitude, longitude, time, date, update mode, and distance between two consecutive coordinates based on their updating mode. SIM number is used to authenticate the device. For the real-time aspect, we use the technique of checking the database in periodic basis. Once real-time mode is activated, the current time will be stamped and then the database will be checked, as shown in Figure 4. If new data was found, the marker will be added to the map. Checking the database in a specific interval will automatically animate the marker on the map. We use the publicly accessible Google Maps API for some part of the code.

```
function realTimeUpdate()
{
GDownloadUrl(sqlXmlUrl, function(dat
var xml = GXml.parse(data);
markers =
xml.documentElement.getElementsByTagl
"marker");
var databaselatestdate =
markers[0].getAttribute("date");

var latestdate =
changeToDate(databaselatestdate);
if( latestdate >= currentTime)
{
   currentTime= new Date();
   addMarkerToMap(0);
}
});
}
```

Figure. 4: The code for the function for real-time update calculations.

IV. SYSTEM DESIGN

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The developed system uses web service as the back end and mobile application is used to obtain the location information and sends it to the web service. The web service saves the received data in a database server using a secure channel and then the website connects to the web service to retrieve a specific user location and show his/her location on a Google map. The mobile application is developed using Java. The application has the following tasks:

- Obtain the current user's location, and
- Based on a predefined time parameter send the location data (longitude, latitude, and time stamp)to the web service

The mobile application continues sending the location data periodically until the administrator stops the process or closes the application. The application uses assisted GPS. The location data is sent using Internet provided by either wireless network that is available in the Holy sites during Hajj season or using GPRS over HTTP protocol and using SOAP for data exchange with the server. If location information is not sent for any reason, it will be saved in the memory of the mobile until connection is restored. At that stage all gathered location information with the time stamps are sent and the information is cleared form the mobile memory. If the location information data size exceeds a pre-specified limit, the old location data is cleared to free the memory for new location information. Web service is used as an interface for both the mobile application and the website. It provides a web method to save the current user location using the mobile application and also retrieve the data either for a specific pilgrim or a group of pilgrims. The web service is implemented using PHP and it connects to a back end database exchange data between the mobile application and website. It connects to the web service to retrieve specific pilgrim's locations and then it uses Google static APIs to show these locations on a Google map. The database is used to store and retrieve the user's data and it is accessed only from the web service secured by authenticated administrator. The database is implemented using MYSQL and it is hosted on a separate server. Figure 5 shows a snap shot of the GU for the system on a mobile phone.

Figure 5: A snap shot of the GU for the system on a mobile phone.

The following section describes the software tools and platforms that were used to the development the system:

- Programming languages used:
- Java for development for the mobile application
- PHP for web Service and website development
- MYSQL
  - ✓ Tools
- Symbian Series 60 3rd edition SDK"S60-SDK-200634-3.1-Cpp-f.1090b"
- Nokia PC Suite
- ✓ Website and Web service
- PHP XML
- Database
- MYSQL

A concern for pilgrim identification system using RFID is the tag type, format and quality. One can use a wristband tag or a plastic card tag that is hanged on the neck of the pilgrim as a business card. In the first case there was a concern that during the cleaning before prayers (Wudo) were the pilgrim has to clean his/her hands until the elbows and so he/she may take off the wristband and thus may lose it. In the latter case some pilgrims may not feel comfortable putting the card on their neck and thus may lose it. With the proposed system of using mobile phone for tracking, the RFID chip can be placed inside the mobile phone. Users already are extremely careful not to lose their mobile phones. Moreover, we have started working on using mobile phones with NFC (Near Field Communication) capability so that the same mobile phone can be used for tracking as well as identifying and thus all what a pilgrim needs during Hajj journey is his/her mobile phone. Figure 6 shows a high level design for the proposed system.

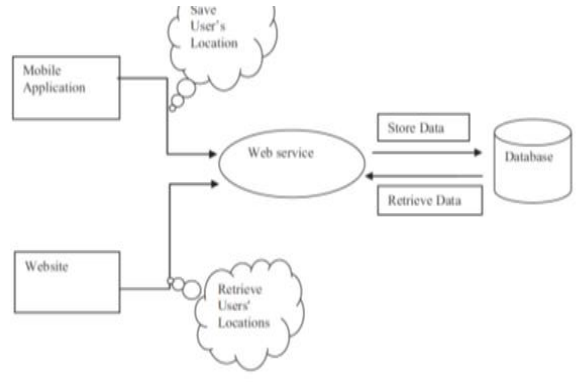

Figure 6: High level design for the proposed system.

V. PROOF OF CONCEPT

The developed system was tested in Makah, the Holy sites, during the 2014 Hajj season. A set of pilgrims having mobile

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phones equipped with GPS units volunteered to test the system. The developed system was downloaded into the mobile phones and preset to get the location information and send it every minute. It was very easy to change the time interval between sending the successive location information. Each volunteering pilgrim was given the option to start the operation time so that he/she can collect and send the information in the Holy area and during the pilgrimage days only. During the four pilgrimage days the location information was collected and sent from all participating phones automatically without the disturbance or distraction of the pilgrims. The system run on the back ground of the phones without affecting their normal operations of initiating or receiving calls or short messages. The 2.5 Million pilgrims are usually divided into groups and each group belongs to a Guide (Mutawif) that is responsible for the group from the time of arrival until the time of departure from the Kingdom of Saudi Arabia. The Guide takes care of the group residence, food and transportation. The developed system can be used to send location information to the group Guide in addition to sending it to the main pilgrimage authority server. The group Guide can also track any pilgrim and provide help when needed. The developed system could be used to track schoolchildren as well. The mobile phone of a child can be programmed to send location information to a server. The server can be accessed from the mobile of a parent or custodian of the child. Additionally, the system could be programmed to automatically give alarm if a child leaves a pre-specified region to his or her parents. Finally, if a user forgets or loses his mobile somewhere, then he can find its last detected location from the server, thus it would be easier to be found.

IV. CONCLUSION

The paper presents a system for pilgrim tracking and identification during Hajj in the Holy area using a mobile phone. The system consists of software that can be downloaded to the mobile phone of every pilgrim upon arrival to the Kingdome of Saudi Arabia. The mobile uses the Internet or SMS to send location information to a server managed by Hajj authority and to a server managed by the Guide of the group that the pilgrim is a member of. If the connection is lost, the mobile can store the location information in its memory until connection is restored. In that case the mobile sends the stored information to a server then clears its memory. The developed system provides an option for the pilgrims to request help in case of emergency. The location information is mapped onto a Google map or any geographical information system for ease of localization and efficiency in providing needed help. A proof of concept experiment was implemented in the Holy area during the past pilgrimage season. The experiment has shown the viability of the proposed system for tracking pilgrims. For future work we plan to use mobile phones with NFC capability so that it can be used for identification as well as for tracking. Such a system will make a mobile phone be all what a pilgrim needs for his Hajj journey.

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