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An Indoor and Outdoor Positioning System using a Hybrid Approach

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Abstract: Continuous proliferation of modern handheld devices in recent years has increased importance of location information. It is due to the increasing number of location-based services; however, determining location of a device or object has some issues as well. For instance, location-aware applications require location or positioning information of the devices on continuous basis, however it becomes sometimes very difficult to achieve this goal due to the underlying positioning technology (e.g. global positioning system (GPS) provides location information very well only for outdoor applications). We advocate that by integrating GPS with other indoor positioning technologies will enhance the effectiveness and scope of location-based services/applications. In this paper, we are presenting such a system that integrates GPS and GSM/GPRS technologies to determine the location of objects in both indoor and outdoor environments.

Keywords: Object Tracking, Indoor/Outdoor Positioning System, GPS, GSM/GPRS Technologies.

1. INTRODUCTION

It is always human aspiration to locate, monitor and regulate or control the real world entities remotely. Modern technologies, such as GPS (global positioning system) (Tsui 2000) and/or GSM/GPRS (global system for mobile communications/General packet radio service), (Gprsuser and Grinde 2007) have enabled modern handheld devices (e.g. mobile phones) to locate their own positons or any other objects anytime, anywhere. Since last many years, several smartphone applications are emerging and used by the community to locate objects like vehicles, pets and kids. Most of these applications access location information from handheld GPS receivers attached to that object and store or retrieve that information to and from the web. A good positioning system uses existing infrastructure and provide location information to the users timely and accurately. Rather than requiring different proprietary location technologies or equipment, it should accommodate itself in existing infrastructure. We have followed this approach and using GPS, GSM/GPRS technologies, which are already present in almost all modern mobile phones, to provide location information in both indoor and outdoor environments. These days GSM/GPRS network in the cell phone has enabled us to communicate in any part of the world at affordable rates. The GSM/GPRS is very basic method for positioning and the cost of implementing this method is affordable. The overall objective of this research is to develop a system, which should be cost effective and track objects indoors and outdoors using GPS or GSM/GPRS enabled mobile phones instead of using proprietary positioning technologies.

The remaining part of the paper is organized as below: Section 2 presents the background of positioning technologies, section 3 describes the design details of the proposed system, section 4 provides implementation and system testing details and section 5 is the conclusion.

2. BACKGROUND

A lot of work has been done in the domain of positioning systems GPS, GSM, RFID, Bluetooth, and Wi-Fi are some Radio Frequencies based information and communication technologies that have been well developed and become commercially available in handheld devices, vehicles, and even mobile phones.

2.1 Positioning Technologies used in Application

Global Positioning System (GPS) (Tsui, 2000) is a satellite-based service, which is freely available all the time, everywhere in the whole world and is the only service, which gives very accurate positioning information. GPS comprises linkage of twenty-four satellites positioned into the orbit of Earth by the U.S department of defence, initially designed for US military use, however later on made available for non-military public use as well.

Global System for Mobile Phones (GSM) (Easy GPRS User Guide, 2007) is the technology, which provides a wide coverage in almost all parts of the world. In GSM networks, the mobile phones location can be determined through Cell ID positioning. The position of the mobile phone is calculated by determining the network cell to which it is connected. International Telecommunication Union (ITU, 2005)

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assigns every country a MCC (mobile country code), and within each country, a MNC (mobile network code) is assigned to every mobile company (i.e. cellular network operator). All GSM network operators create the LAC (location area codes) for their network and assign Cell IDs to each cell. Every time a mobile terminal joins the network, it is linked to one of these cells. Thus, the fairly accurate position of a terminal can then be expressed by the Cell ID and LAC. Cell ID, LAC are an approximate location of user which is supposed to be converted to latitude and longitude coordinates so that more specific location of mobile user can be traced out.

2.2 Related Work

A huge amount of work (Elahi, 2009; Malkani, 2009; papadoglou, 2001; Ward, 1997; Priyantha, 2000; Lionel, 2003; Vehicle Tracking Systems – Overview, 2008) has been done in the domain of location aware computing and there are number of applications (Google Play, 2014) developed for tracking objects. Some of the applications that are freely available on Google play store include: Plan B by Lookout Mobile Security, Cerberus by LSDroid, Prey Anti-Theft by Fork Ltd. and Foursquare by NYC & SF. Plan B locates mobile phone using cell towers and GPS; then sends the location to the users email account. Cerberus tracks via GPS, can remotely wipe SD card and internal storage, remotely locks the phone, and also sends SIM change alerts. Prey is activated via SMS with the words "GO PREY" and by logging into the Control Panel via the Web to mark the device as 'Missing'. Tracks down peoples and need to actively check-in to locations in order to share their whereabouts with others.

3. MATERIALS AND METHODS

3.1 Proposed System

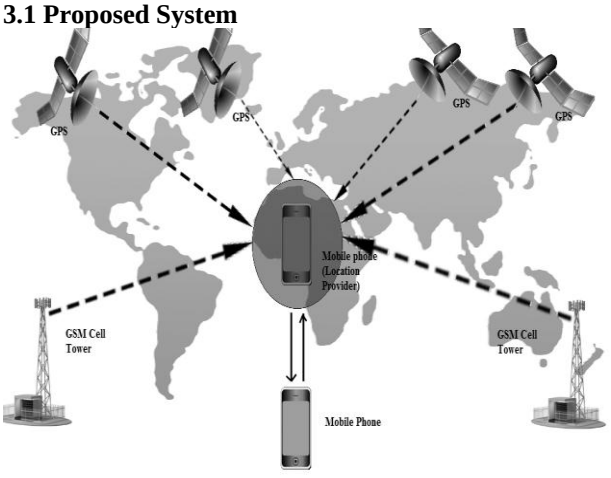


Fig.-1: High-level architecture of the proposed system

The proposed system for tracking remote objects/mobile phones is developed using android operating system, which utilizes the Global Positioning System (GPS) receiver in the mobile phones to obtain positioning information from the satellite. Alternatively, if the GPS service is not enable in the mobile then utilizes GSM cell identification to obtain cell id and Location Area Code and convert them to the latitude and longitude and are communicated between mobile phones via Short Messaging Service (SMS).

3.2 System Components

3.2.1 Global Positioning System

The Global Positioning System (GPS) (Wikipedia, 2014) is a network of about thirty satellites moving around the Earth at an altitude of twenty thousand kilometres. It is developed by the US government's defence depart for military purposes; however, later on it is made public and currently anyone having a GPS enabled device, such as smart mobile phone or handheld GPS unit, can receive the radio signals that these satellites broadcast. In fact, wherever we are on the planet, we are able to receive signals from at least four GPS satellites. Each satellite transmits current time-stamp information along with positioning information at fixed time intervals. The satellite signals are travelling at the speed of light. These signals are received by the GPS receiver, available in our mobile phones or GPS enabled handheld devices, which are capable of calculating how far away each satellite is using standard distance formula.

3.2.2 GSM cell Towers

The GPS is very popular positioning technology, but has some constraints, it does not work indoor and not all devices having built-in GPS receiver. A GSM Cell ID (CID) is a generally unique number used to identify each Base transceiver station (BTS) or sector of a BTS within a Location area code (LAC) if not within a GSM network. The Cell ID and Location area code (LAC) can be submitted to the Google database to retrieve location information.

3.2.3 Mobile Device and Application

The mobile device contains the proposed developed application, which has both the parts: (1) Client: to query location information, and (2) Background Service: to respond to the location query with the positioning information either from the GPS receiver or from the GSM cell tower.

4. RESULTS AND DISCUSSION

In this section, we describe the implementation and testing details of the proposed system. The system is implemented as Android application using GPS, GSM/GPRS capabilities of the Android phone along with the Google Maps Services and Google database for GSM cell Identification. The application comprises two parts: User Interface and Background Service.

4.1 User Interface

Fig. 2 shows the user interface of the developed application, while in figure 3 flowchart of the client part of the application is shown. The User Interface part provides visual interface to the user to track the mobile phone by providing the target mobile number, and upon the response from the target mobile, the user can view the target mobile's location on the map. The user can also find his own location on the map and switch between different views of the map and find any city or landmark by providing place name or zip code in the text field.

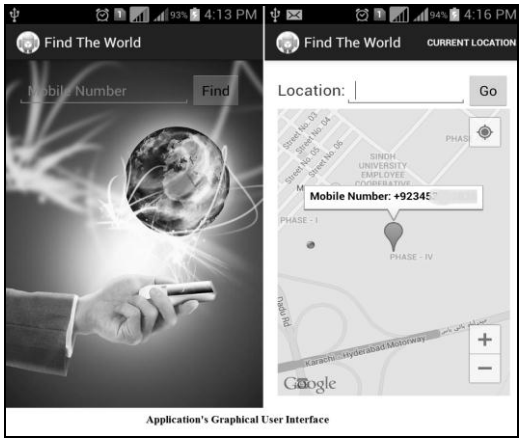


Fig.2: Application User Interface

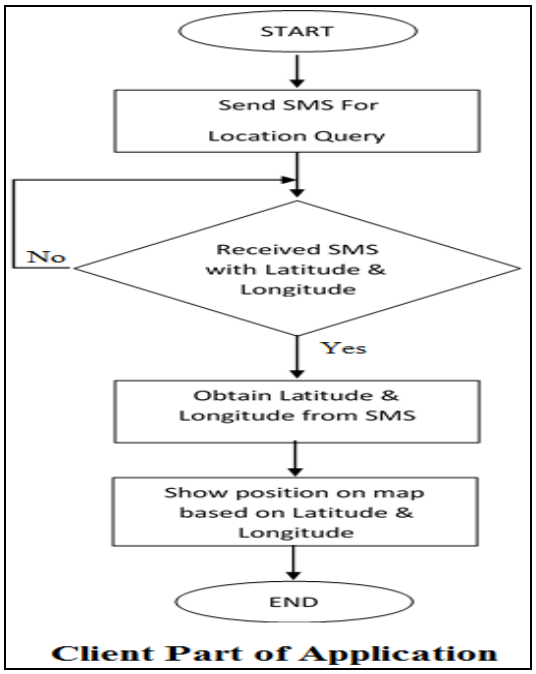


Fig.-3: Flow chart showing client part of the application

4.2 Background Service

Figure 4 shows the flow chart of the background service of the developed application The background service which is continuously running on the mobile phone and checks incoming SMSs if the SMS contains the word "LOC" then the service first checks if the GPS is enabled in the mobile phone then get the latitude and longitude from the GPS and send them to the requesting mobile through SMS as response. If the GPS is not enabled on the mobile phone then the service gets the current GSM network information i.e. Cell Id and Location Area Code and send them to the Google database for cell identification, the latitude and longitude information is retrieved which is sent to the requesting mobile phone through SMS.

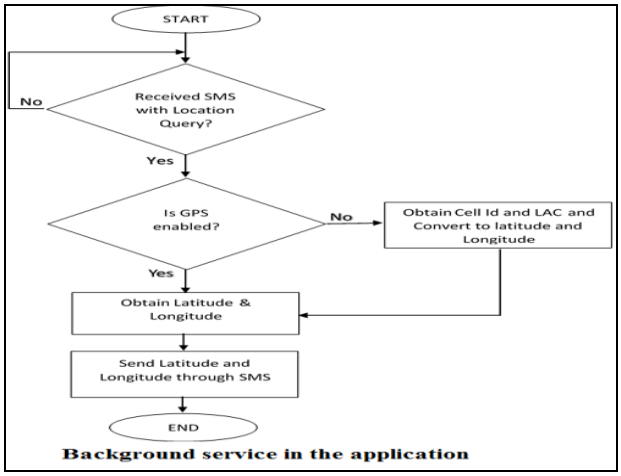


Fig.-4: Flow chart showing background service in the application

4.3 Discussion and Analysis

The application is designed and developed for the android phones with built-in GPS and GSM/GPRS modules using Android Development Toolkit (ADT) and tested on android based mobile phones.

GPS is ubiquitous and free of cost service available all the time and gives accurate positioning information but may not work inside the buildings due to weak signals so GSM cell identification technique is useful because it works inside the buildings and available in every mobile phone, but still limited with availability of network to geographical areas and gives less accurate positioning information. The Application uses hybrid positioning techniques the GPS and the GSM cell identification in sense that if GPS does not work at some places such as buildings then the position information can be queried from the GSM cell identification technique.

The application is cost effective because it is made for mobile phones which are widely and inexpensively available in market and the application costs only one SMS in order to track.

The application use some available services and techniques in the android mobile phone to provide the user with positioning information to track objects:

4.3.1 Short Messaging Service

The query and the responses to and from the application are completed through Short Messaging Service (SMS), which is widely available service to GSM networks by the service providers. For query of location the application sends "LOC" word in SMS to the mobile phone which also contains the application and background service which in response gets positioning information as latitude and longitude and send to the requesting mobile phone through SMS.

4.3.2 Global Positioning System

The application gets latitude and longitude from the GPS receiver within mobile phone and sends to the requesting application via SMS.

4.3.3 GSM cell Identification

If GPS is not enabled in the mobile phone then the application gets the Cell id and Location Area Code (LAC) and sends them to the Google database for cell identification to convert them into latitude and longitude, which are then sent to the requesting application via SMS.

4.3.4 Google maps

Google maps service is integrated in the application to present the positioning information more visually to the user because the positioning information received via the SMS contains only latitudes and longitudes which are numbers and not sufficient for the user to know the location of the object.

This application can be used to benefit the people in:

- Locating the lost mobile phone
- Locating the Childs, family and friends

5. CONCLUSION

The overall objective of the research was to design a cost effective application for the mobile phone, which have both the GPS and GSM/GPRS built-in modules to locate the objects simply through SMS and display the position of the object on map. The application uses hybrid positioning technologies GPS and GSM cell Identification to provide information available all the time because GPS some time does not work inside the buildings.

Furthermore we will extend the functionalities of this application such as guide the users with proximity alerts when reaching to the point of interest, provide user the directions and information about cities, landmarks and nearby places which can be used to help the users when in trouble.

6. ACKNOWLEDGEMENT

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