ABSTRACT

In times past, searching for and finding people were challenging and difficult especially with the absence of modern communication gadgets. With the emergence of cellular technologies, locating people has been much easier and mobile phone users can easily be reached by calling their mobile phones. With the emergence of various network-based positioning techniques and Global Positioning System (GPS) locating people via their mobile devices with or without their knowledge has been a lot easier through Location Based Service (LBS) systems. LBS provide location dependent services to mobile users and therefore becoming a need in the present ubiquitous world. Intelligent Tracker (IntelTrack) is a mobile application that helps to track the current location of the mobile device and other devices with built-in GPS via their International Mobile Equipment Identity (IMEI) number with the sole purpose of locating the user and providing location dependent services. The application was deployed on Java enabled phone that has GPS chipset installed. “IntelTrack” a location based service (LBS) is based on Java 2 Platform, Micro Edition satisfying the Java Specification Requirement for Location (JSR 179) and Java Specification Requirement for Wireless Messaging (JSR 209). The LBS assists users recognize their location and in effect retrace their steps when they are in a new or unknown environment especially with the prevalent security issues in the world. The development toolkit was Java ME Platform SDK 3.0; it enhances execution of preverified java class. The result show that “IntelTrack” was able to locate the mobile device with less than 0.4 meter accuracy.

Keywords: Cellular network, GPS, LBS, mobile phones

INTRODUCTION

Location Based Services (LBS) are wireless-IP service that utilizes geographical information of mobile devices to serve a mobile user; it exploits the position of a mobile terminal to provide the requested service (Dao, Rizos, and Wang, 2002; Kupper, 2005; 3GPP, 2007). Typical LBS has a number of uses in a variety of contexts, such as health, entertainment, work, personal life, security, business etc. Examples include, recommending social events in a city, requesting the nearest business or service, such as an ATM or restaurant, turn by turn navigation to any address, and locating
people on a map displayed on the mobile phone. These services are accessible with mobile devices through the mobile network and utilize information on the geographical position of the mobile device (Raper, Gartner and Rizos, 2007; Dahunsi & Dwolatzky, 2009; Steiniger, et al., 2006).

**LBS Components and Technologies**
LBS represent a convergence of several technologies, these includes:
- Obtaining location information of a mobile device from base stations or satellites.
- Storing location data and
- Translating coordinates into human readable address.

Location Based Service systems contain a number of components as shown in Figure 1 and defined by (Steiniger, et al., 2006).

**Mobile Devices**: A tool the user requests for needed location information with; possible devices include Personal Digital Assistant (PDA), mobile phones, laptops etc. Location information requested for can be given in form of pictures, text and so on.

**Communication Network**: this is the connection between a MS and mobile network operator. The link transfers the user’s data and service request from the mobile device to the service provider and then the requested information back to the user.

**Positioning Component**: for the processing of a service request, usually the user position has to be determined. The positioning component estimates the user’s position using known measurements from fixed receivers/transmitters to estimate the location of a mobile station (MS). The user position can be obtained either by using the mobile communication network or by using the Global Positioning System (GPS).

**Service and Content Provider**: service and application providers process service requests of users and offer location information based on user’s request. Service providers will usually not store and maintain all the information which can be requested by users. This information is stored and maintained by the appropriate authorities for example, governmental or private mapping agencies or businesses and industry partners. Examples of such information include geographic data and information data of a particular area, state or country. These agencies or organizations maintain the maps by making sure that up-to-date information is stored and made available to service providers when needed.

Many researchers have worked on location based service applications and some of the related works which motivated this research are presented here.

Nadesh, *et al* (2011) presented a mobile phone tracking application which makes use of an hybrid of GPS and base stations (BS) information to obtain the mobile's location. To locate the phone it must emit at least the roaming signal to contact the next antenna tower nearby. The client-side system
of the designed application is a MIDlet application which serves as an interface to feed in the contents and control instructions which is interpreted on the server and appropriate action taken. The application developed works in open space areas only since it relies on GPS, it tracks the location of a mobile phone according to the radius maintained by the administrator.

Zulfarhan and Ooi (2011) also presented a Location Tracker and Location Mapper, a mobile phone content that make use of the mobile phone’s device features in an event of a kidnapping. The system relies on the Short Messaging Service (SMS) capability of the two mobiles phones as the communication medium without the need to add any extra hardware. The application is easily executed and remains discrete in a kidnapping situation to avoid detection by the kidnappers. SMS text messages containing the location information of the victim are consistently sent out during a kidnapping situation to allow convenient and continuous tracking of the victim while on the move. On the receiver side, the Location Mapper J2ME application is able to successfully receive the SMS text messages containing location information from the victim’s device. The information received is extracted and the mobile phone’s network connection is employed to download a map of the location which is presented to the user [8].

A system was also presented by Pandey et al (2013) which was developed to find the location of a mobile device within a specified area. Because GPS system falls short in indoor and in closed environments, it is difficult to acquire the necessary satellites for accurate position computation. Some of the alternate techniques that are proposed for indoor location tracking include the integration of Bluetooth technology with 3G networks. The proposed solution suggested that Bluetooth terminals can exchange information with each other and then a Bluetooth access point provide the interface to a mobile network.

The system uses the information built in a typical mobile phone such as its IMEI (International Mobile Equipment Identity), IMSI (International Mobile Subscriber Identity), and various Wi-Fi (Wireless Fidelity) Access Points on campus to pinpoint the users’ position. A communication program installed on the web server communicates with the GSM modem to provide users real time data related to a person’s movement and location. Purnomo (2011) also conducted a research on a LBS framework application deployed in Melaka urban area. The Melaka Tourism application is to support tourist activity in finding any venue around their current location. The program is specifically designed for mobile phone which supports MIDP 2.0 profile and CLDC 1.1 configuration to run JSR 179 Java Micro Edition Location API due to its capability handling networking activity in handled device. Melaka Tourism Location Based Service is deployed using a client server environment in projection of the whole system. The clients act as a system component who requests for service and data from the server.

A low cost, easily deployable and scalable infrastructure was designed by Barahim et al (2013) for indoor location of mobile devices based on Bluetooth technology. The system consists of two main components; the Bluetooth (BT) Sensor System and the Central Navigation System which was developed using JDK 6.0. The Bluetooth Sensor System allows mobile devices whose Bluetooth mode is set to discoverable, to be scanned and detected, and they receive customizable text message of their positioning information, e.g. room identity. The positioning information is also sent to the Central Navigation System which in turn displays and updates the navigation map. The system also tracks the movement of different BT mobile devices within the implemented environment.

One of the major limitations of the presented reviews is their dependence on sensors and infrastructure which are not feasible in a developing country such as Nigeria. The proposed application in this paper has no need for a mobile operator intervention and it uses the built-in GPS chipset in smart phones. The application is designed around the GPS technology because the country in the last three years has experienced a high penetration of smart phones. More than 19% of the people in Nigeria, which is about 24 million people, use smart phones due to reduction in price and availability (Pew Research Center, 2014). Using GPS positioning eliminates the accuracy
challenges posed by network-based positioning methods. IntelTrack can be installed on mobile devices amongst friends, relatives and loved ones to track each other in the event of emergencies. There is no need to pay for and register for the LBS with mobile operators; it is a standalone system which utilizes the mobile operator’s network to send location information. This research developed an LBS application, which will enable mobile phone users to track the location of a mobile phone on Google map via Cell-ID (Cell Identification Module e.g. IMEI number).

Intelligent Tracker (IntelTrack) application can serve the following purposes:

- determining the address of a current location, especially when in a strange place,
- tracking a friend or loved ones to know about their location,
- tracking a lost phone or misplaced mobile device and
- helping security agents, paramedics, fire fighter service and other emergency personnel to attend to the right place on time in cases of emergency.

**MATERIALS AND METHODS**

The tracking System (IntelTrack) is an application which facilitates mobile users in finding friends, family or other people of relevance. It attains the phone’s GPS-location directly from the satellites, and sends location information via the network to the client. IntelTrack tracks the current position of a mobile phone that has the application installed, even when on the move displays it. Users also have the options of sending the location information as SMS to any friend or family members added into the application.

The application was developed with Java mobile location-based client server application using JSR 179, servlets and Google Maps. JSR is considered because; it’s able to obtain location from GPS signal. This works by:

- deploying a MIDlet that captures the mobile phone’s GPS coordinates,
- visualizing the location in Google Map after updating the web server which will be accomplished using the Google geocoding API.

- Once information has been passed to the Location API, it calculates the distance between the mobile device to nearby fixed stations by measuring angles to the device from known points at either end of a fixed baseline.
- the result will be in form of latitude and longitude (geographic coordinates) which will then be converted to normal human readable address (reverse geocoding).
- the geographic coordinates obtained can be passed to Google map URL to view the mobile station’s position on the map
- Once the address is obtained, information to friends and family via text message.

**SYSTEM ANALYSIS AND DESIGN**

The current location of the user is calculated using in-built GPS chipset receiver in the phone. The GPS chipset embedded in mobile phones communicates freely with the satellite by sending signals whenever the mobile phone is switched on. The communication of GPS chipset with the satellite enhances the possibility of GPS triangulation of the mobile phone which in effect makes positioning possible.

**System Architecture**

Data sharing center comprises of three Application Programming Interfaces, which are Location API (JSR 179), Wireless Messaging API (JSR 205), and Google Map API. The center controls and share data between these APIs and client running the application. To locate a device, the application invoke the location modules (Location Provider, Location Listener, Coordinates, Proximity Listener, and Landmark) in JSR 179, by which location information signal is sent to the satellite through the device and translate the receiving signal into coordinates of about 16 digits formatted in degree, minutes, and seconds of arc (E.g. 57°18′22″N 4°27′32″W).

Data sharing center also uses the location provider to transfer the coordinates address to java servlet map using a third party Google maps API by passing Google Map URL into the MIDlet Content Connection and thereby downloading map information to the device. Furthermore, the application is text message enabled, such that the address tracked can be sent as payload text.
messages to friends and family through the Message Connection of the MIDlet. The centralized data sharing provides a coordinate’s landmarks to users to enable them get the location of friends and relatives and also update their own location on the server. The purpose of choosing centralized data sharing is to reduce the storage overhead on each phone.

The internet is the medium used to transfer the user data and service request from the mobile to the server and then the requested information back to the user, including the messaging services. When the application starts up, it can be accessed as either admin or user. As an admin user, the user has a privilege to add to friend’s list. Users can check their current location or the location of their friends from the friends list. On getting the coordinates (longitude and latitude) of the tracked device, this is passed into Google map URL to enable viewing of the coordinates in Google map. The coordinate can also be sent via SMS to the mobile device and other mobile devices.

The client-side system is a MIDlet application. It serves as an interface to feed in location content information and control instructions which is interpreted on the server and appropriate action taken. The MIDlet has the task of getting the coordinates of users, allowing users to add friend’s information, and enabling user to send a payload text message to friends and family. Figure 2 shows the architecture of IntelTrack and Figure 3 the application’s flowchart.

![System Architecture](image)

**Figure 2: System Architecture**

**System Implementation**

The welcome page contains two list items; Users and Admin. On Admin Page, users are allowed to add friends by entering the friend’s username and phone number. However, the admin page is password enabled. The User page gives access to track the location of the mobile phone, view the co-ordinated position on map, and essentially make friends and family aware of their location by sending text messages about their coordinate.

The application was developed using Java Standard Development Toolkit (J2ME SDK 3.0 Platform), Java Specification Requirements (JSR 179) supports location Application Programming Interface (API), a required tool in Java to Mobile Edition (J2ME) for building Location Base Services. J2ME SDK 3.0 Platform also supports JSR 205 for Wireless Messaging API, a required tool for J2ME for sending text messages.

**SYSTEM RESULT**

After the deployment of IntelTrack, the following are features of the application.

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174
User Access Level: the user access level has two parts; admin access and regular user access level. The system administrator is an individual or user with special privilege of adding or populating friends list by taking in friends mobile phone number, phone IMEI number and username. This is necessary for the application to track the position of users that are not yet added into the application. Before the admin can perform such, a correct authentication password dedicated for the admin page has to be provided. Figure 4 show the image snapshot for the admin page which comprises of logging in and adding friends to the tracking list.

The user can decide to check their current location or the location of their friends. To check friend’s location, users can choose from friend’s list and check their address via their IMEI phone number which has been acquired when adding a friend from admin page. User application operation includes the decide target mode and sending location to friends and families.

Figure 3: IntelTrack System flowchart
Figure 4: Inteltrack (Admin)

**Decide target mode:** User can decide their target i.e. whom they are trying to locate, whether friends or family or just checking for his own mobile device in case of theft or misplacement as shown in Figure 5a

![Figure 4: Inteltrack (Admin)](image)

**Figure 5a:** User target mode

**Figure 5b:** User friends list

**Decide location information sharing method:** after deciding the mode users want to check for the location, users can decide whether to view the location directly on the map or to just see the Geolocation coordinates as shown in Figure
Send location information to friends and family: users can decide to send the location coordinates to friends and family to make them aware of the mobile device’s presence. Users can select whom to send the information to, either by typing the phone number or selecting from contacts list as shown in Figure 7.

PERFORMANCE ANALYSIS
The developed application is largely dependent on the accuracy and availability of GPS signal. Mobile phones don’t often get appropriate number of base stations (BS) to receive signals from for accurate positioning indoors and in urban canyons (Dao et al., 2002; Kupper, 2005). Table 2.0 shows the performance evaluation of IntelTrack based on five different locations. Using a central location area with latitude of 7.304494294580698 and longitude of 5.133984088897705, it was observed that the measurement of five different locations using IntelTrack gave varied accuracy. Table 1 presents the result of the five areas where location information was measured, showing the difference between the actual location and the location obtained through measurement using IntelTrack (accuracy) and the time required to get the location information (throughput).

<table>
<thead>
<tr>
<th>S/N</th>
<th>Location Area</th>
<th>Accuracy (m)</th>
<th>Throughput (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Location 1</td>
<td>0.00045</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>Location 2</td>
<td>0.139</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>Location 3</td>
<td>0.0348</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>Location 4</td>
<td>0.2641</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>Location 5</td>
<td>0.2966</td>
<td>28</td>
</tr>
<tr>
<td>6</td>
<td>Location 6</td>
<td>0.000</td>
<td>10</td>
</tr>
</tbody>
</table>

Figure 6: Checking viewing users coordinates location (Address and Map Services)

Figure 7: IntelTrack (SMS service)
After harnessing the objectives of this research in comparison to related works done by others, the limitations include:

- It only runs on Java phones that are GPS enabled.
- The restriction of a mobile device’s screen size makes zoom levels of Google map challenging when running the application.
- The accurate location coordinates of new friends added is indeterminable as the application will have to get used to the roaming signal of IMEI number of the phone added.
- Accuracy challenges of integrated GPS chips on cheaper smart phones with error of up to about 15 meters in the worst case scenario (Nokia, 2014).
- Low accuracy indoors due to lack of access to the required number of satellites for better positioning

CONCLUSION

IntelTrack application for Java enabled mobile phones, using Global Positioning System (GPS) as the location provider was presented in this paper. The application provides the user with his current location coordinates and displays it on Google Maps on the mobile phone. The application is also implemented as a client server system that helps users to locate their friends and family or anyone whom he wants to share his location. The average location accuracy in open space using this system is less than 1 meter with a throughput between 10-30 seconds. IntelTrack J2ME application can be installed on any mobile smart phone that meets basic hardware and software requirements. Furthermore, utmost importance was placed on ensuring that the application is easily executed and remains distinct in an emergency situation to enable users retrace their steps and locate family and friends in case of emergency or otherwise. SMS containing location information of users can be consistently sent out when the mobile phone is lost. The application will be very helpful during a kidnapping situation and other prevalent security situations in the country.

REFERENCES

3GPP TS 22.071 V 8.0.0 (2007) 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Location Services (LCS); Service description; Stage 1, Release 8


