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CADBLOS: ANDROID –BASED UML-CENTRIC DESIGN APPROACH TO CAMPUS-DRIVE BUS LOCATOR SYSTEM

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Abstract: The delay; lack of flexibility, convenience and uncertainty associated in bus services in university of Calabar, Nigeria necessitated the development an Android-Based Bus Tracking System, otherwise called CADBLOS, using the UML-Centric design approach, to enhance bus service system within the campus communities, using University of Calabar, Nigeria, as a case study. Software systems are continually expanding in volume and complexity, and without efficient modeling proficiency in architectural modeling and design, developers cannot be successful. These proficiencies are the imperatives to produce quality projects and products, which are far most graded superior to programming, Quality Assurance, and other requirements management. Since modeling is the core of development and UML is the de facto standard as the modeling notation, UML (Unified Modeling Language), was adopted to provide the behavioural and structural representation of the CADBLOS software artifacts. We adopted a hybrid of the Structured System Analysis and Design Methodology (SSADM) and Object Oriented Methodology to design the CADBLOS, a mobile Based Bus Locator System using android application. The prototype system was developed using the underlining technology of the Global Positioning System (GPS) and the communication services provided by the Global System of Mobile Communication (GSM). The Global Positioning System (GPS) was the main technology that is implemented behind the system. A prototype of the system developed has been tested and implemented. After all modules integration, the system is able to provide its basic function of locating buses on real time and reduce workload associated with accessing web-based bus location facilities.

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1. INTRODUCTION

In developed and developing countries like Nigeria, one of the major needs of citizenry apart from food, clothe, shelter and basic amenities is the need for transportation. Today, the need is associated with flexibility, certainty and a high degree of convenience. People desire to get to their destinations - schools, churches, places of work etc. without waiting endlessly for bus services, which sometimes might not be heading their destinations.

The consequences of traffic congestion extend well beyond the personal inconveniences felt by individual voyagers. Environmental quality, roadway safety, and community access are among the various quality-of-life concerns that arise in areas beleaguered with congestion. Investigated and analyzed GPS travel time data can be used for congestion management in order to detect incidents and to determine the location and extent of bottlenecks and queues [1]. GPS was originally intended for military applications, being a satellite based navigation system made up of a network of 24 satellites placed into orbit by U.S. Department of Defense, but in the 1980s, they made the system available for civilian use [2].

In addition to the high demand for ease in transportation, there is an advent of highly innovative technology in the mobile industry. Telephone companies release new brands of sophisticated handheld gadgets such as iPhone, iPad, blackberry, android devices, only to mention but a few. These devices have evolved from their conventional use of making and answering calls only, as they come with exciting features such as video conferencing, skype, internet access, GPS facilities etc.

The primary standard of intelligent transportation systems is to match the complexity of travel demands with advanced supply-side analysis, evaluation, management, and control strategies (McNally, Marca, Rindt, and Koos, 2002). McNally, et al, however, noted that the basic setback is the lack of basic knowledge of travel demands at the network level. GPS or Global Positioning Systems are one of numerous existing technologies that permit individual vehicle routes and trajectories to be recorded and evaluated.

Also, Android is becoming very popular and trendy in embedded market for two main reasons. Firstly, it is open source software; in addition there are no royalty fees for Java VM (Virtual Machine). Secondly, deriving from the first, Android is highly suitable for expansion as the developer deems fit. The motivation for the development of this project is for the benefit of the student masses, by the idea of providing an easier means of accessing various web resources related to the university bus, as a result, providing them with an enhanced, better-off experience of travelling to the university. More so, the current advent and popularity of Android technology motivates the creation of an Android application for the same. Bus Locator system is an application for Smartphones that supports Android Operating system at client side.

This application uses the GPS function, available in most of Smartphones today, to pin point current location comparatively accurate. With this application installed on smart phone, all a student or a staff needs to do is to start up with application when he/she needed. This application will send co-ordinates to server, and then server sends SMS Alerts to student who all is registered from their specific pickup point and also server provides additional services through SMS alerts like, Blood donation, E-notice, and University related news.

Basically, this application at client side fetches the co-ordinates by using Google Maps, sends the co-ordinates to server, then server send SMS Alerts to students who are registered for this service, also server provides Graphical Map of current Bus Location by having markers on to the Map. It also runs in the background so students are free to use their phones for other activities.

The aim of the study to develop an Android-Based Bus Locator and Tracking System, called CADBLOS, using the UML-Centric design approach, to enhance bus service system within the campus communities, using University of Calabar, Nigeria, as a case study. The research focuses on the utilization of these technological innovations and makes a bridge with mobile communication. Communication which has always been a part of human existence just got better with mobile telephone technology. Public transportation, especially bus transport, has been well developed in many parts of the world. The bus transportation service helps to reduce private care usage, much fuel consumption and ultimately alleviate traffic congestion in major roads and suburbs. Considerably, this research work has gone a step further to consolidate the effort of mobile technology with the obvious need of our society, which is easy, flexible and convenient means of transportation.

2. REVIEW OF RELATED LITERATURE

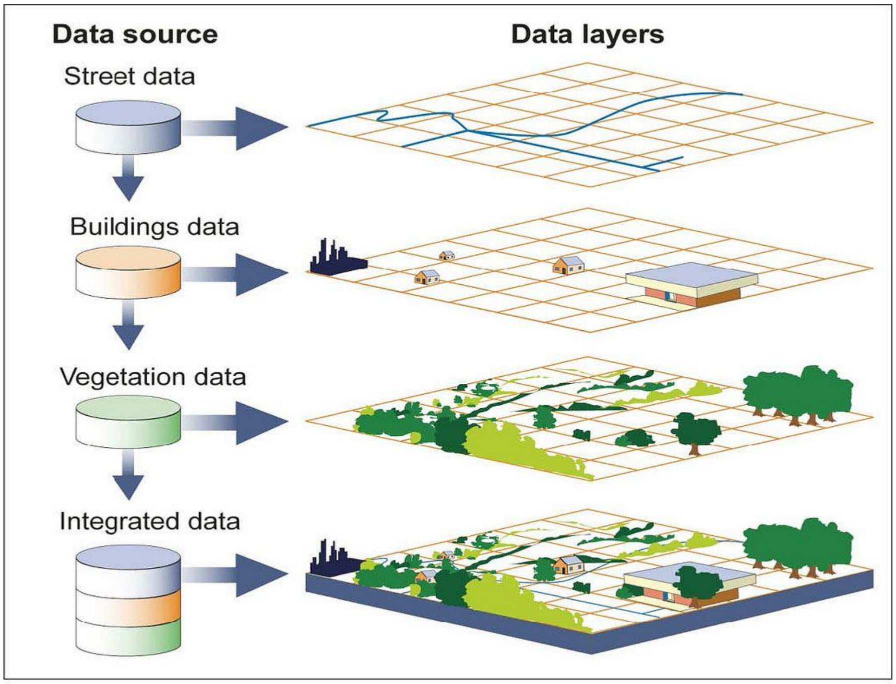
According to [4], the security of transportation has becomes extremely significant with the demanding for road transport of dangerous goods in recent years. Eken and Sayar [5], added that when it comes to taking the public transportation, time and patience are of fundamental. In other words, many people using public transport buses have experienced time loss because of waiting at the bus stops. While they maintained that public transport has become a part of live, they stressed further that most people get from homes to places of work or school by means of public transportation. Here, they upheld, that people can lose time in transportation because of unwanted waiting.

Again, People have the right to know where buses are now and how long time it takes those buses to reach their bus stops. The services provided to passengers by transport systems are very significant. There are two kinds of services that all transport systems must provide: route and schedule information. The scheduling information includes maps, schedules, and information on connections; the second type of service are basic information, including fare policy, stop locations, and other relevant information [5].

Ahmed, et al [6], who studied and developed and application on University Buses Routing And Tracking System, stated that Android is becoming very popular because the source code is completely free; in addition, Android is highly suitable for expansion as the developer see fit, so building a mobile application for Android devices is very common these days due to the mentioned reasons.

The authors who made use of the GIS technology went further to say that a geographic information system (GIS) is a machine framework intended to catch, store, control, investigate, oversee, and show different kinds of spatial or land information. The acronym GIS is in some cases utilized for geographical information science, as noted by Tyler [7]. GIS, according to Tyler, can relate disconnected data by utilizing area as the key record variable. Areas may be recorded as x, y, and z directions. All Earth-based spatial–temporal area and degree references ought to, preferably, be relatable to each other and at last to a "true" physical area or degree. This feature of GIS has started to open new streets of exploratory. The National Geographic Society [8] defined a geographic information system (GIS) as a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface. By relating seemingly unrelated data, GIS can help individuals and organizations better understand spatial patterns and relationships. The society went further to say that GIS technology is a crucial part of spatial data infrastructure, which the White House defines as "the technology, policies, standards, human resources, and related activities necessary to acquire, process, distribute, use, maintain, and preserve spatial data."

GIS applications are made up of both hardware and software systems. These applications may consist of cartographic data, photographic data, digital data, or data in spreadsheets. Cartographic data are already in map form, and may contain information such as the location of rivers, roads, hills, and valleys. Cartographic data may well contain survey data, mapping information which can be directly entered into a GIS.



Source: GAO.

Figure 1: Geographic Information System data sources

Source: National Geographic Society, USA (2018)

According to Thilagavathi and Rao [9] GPS is one of the primarily enabling technologies for ITS. For many years GPS has addressed an ever-growing list of applications in navigation. During the last five years GPS has grabbed the imagination of public. However, there are still scope for future improvement and increased use of GPS in transportation engineering. Per Per [2], the Global Positioning System (GPS) is a satellite based navigation system made up of a network of 24 satellites placed into orbit by U.S. Department of Defense. GPS was originally intended for military applications, but in the 1980s, they made the system available for civilian use. The authors continued by stating that the GPS works in any weather conditions, anywhere in the world, 24 hours a day. Consequently, it makes easy everyday activities like banking, mobile phone operations and even the control power grids by allowing well synchronized hand-off switching. The GPS applications, according them, are realized in following: in Air navigation by general aviation and commercial aircraft; At Sea navigation by recreational boaters, commercial fishermen, and professional mariners; and for Surveyors cost saving by drastically reducing setup time at the survey and providing incredible accuracy

It was added that [10], GPS has 3 parts: the space segment, the user segment, and the control segment. The space segment, according to him, consists of 24 satellites, each in its own orbit 11,000 nautical miles above the Earth. The user segment consists of receivers, which you can hold in your hand or mount in your car. The control segment consists of ground stations (five of them, located around the world) that make sure the satellites are working properly. The GPS satellites each take 12 hours to orbit the Earth. Satellites are equipped with very precise clocks that keep accurate time to within three nanoseconds – that's 0.000000003, or three billionths, of a second. This precision timing is important because the receiver must determine exactly how long it takes for signals to travel from each GPS satellite.

James [11], in his contribution to Ubergizmo blog, said that The GPS system makes use of the geographical lines of latitude and longitude to provide coordinates for a person's location or a place of interest. Reading and understanding GPS coordinates requires a basic understanding of navigation using the lines of latitude and longitude. Using both sets of lines provides a coordinate for the different places around the world.

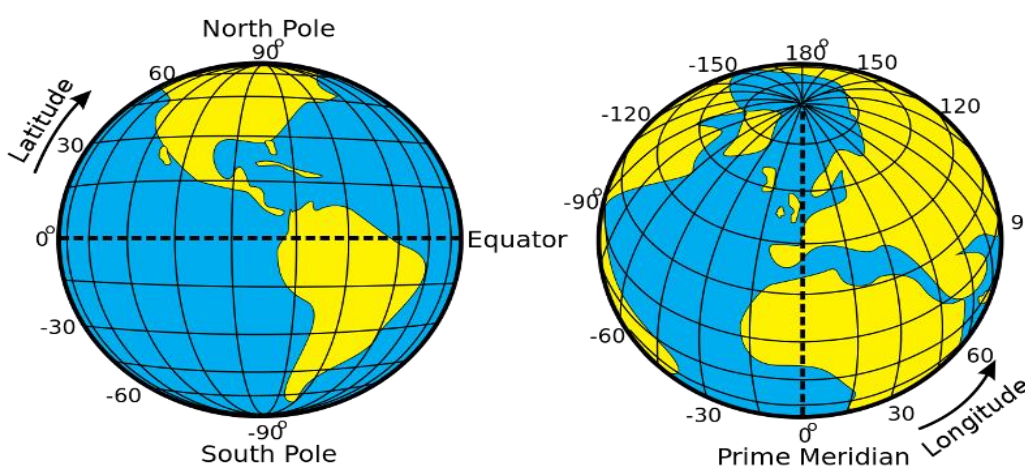


Figure 2: Line of Latitude and Longitude (James, 2018)

Lines of latitude, he said, are horizontal lines that stretch from east to west across the globe. The longest and main line of latitude is called the Equator. The Equator is represented as 0° latitude. Figure 3 below displays the 15°, 30°, 45°, 60°, 75° and 90° lines of latitude above the Equator.

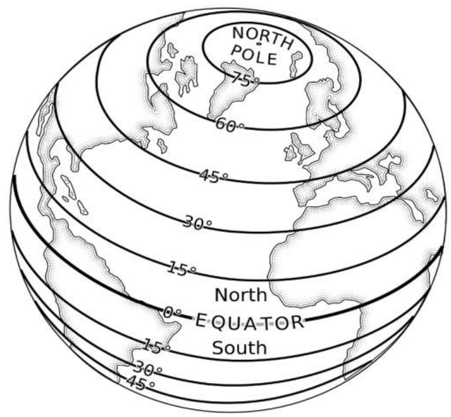


Figure 3: Lines of Latitude above Equator (James, 2018)

[10], went further to explain that the Lines of longitude are vertical lines that stretch from the North Pole to the South Pole. The main line of longitude is called the Prime Meridian. The Prime Meridian is represented as 0° longitude. Figure 4 below displays the 20°, 40°, 60°, 80° and 90° lines of longitude east of the Prime Meridian.

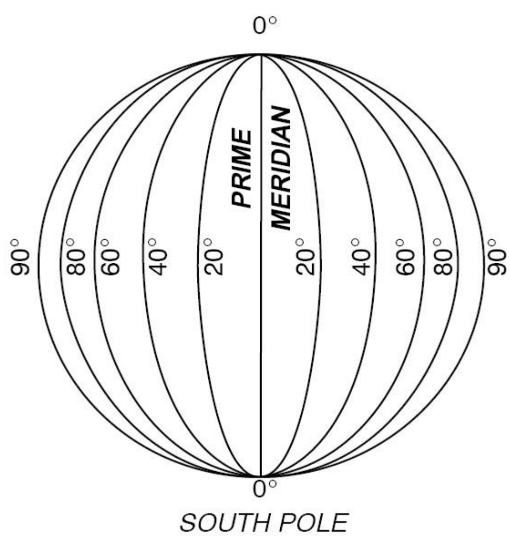


Figure 4: Lines of Longitude east of the Prime Meridian [10]

Global navigation uses lines of latitude and longitude to identify a given location on the Earth's surface. It is represented as geographical coordinates. The location is lies along the line of latitude 10°N and along the line of longitude 70°W [10].

How the GPS Work

The GPS is a constellation of 24 or more satellites flying 20,350 km above the surface of the earth. Each one circles the planet twice a day in one of six orbits to provide continuous, worldwide coverage.

i. GPS satellites broadcast radio signals providing their locations, status, and precise time {t} from on-board atomic clocks.
ii. The GPS radio signals travel through space at the speed of light {c}, more than 299,792 km/second.
iii. A GPS device receives the radio signals, noting their exact time of arrival {t} and uses these to calculate its distance from each satellite in view.
iv. Once a GPS device knows its distance from at least four satellites, it can use geometry to determine its location on Earth in three dimensions

The GPS Master Control Station tracks the satellites via a global monitoring network and manages their health on a daily basis. Ground antennas around the world send data updates and operational commands to the satellites.

Computation of the GPS Position

The position of a GPS is calculated from distance measurements to not less than three satellites. Theoretically, we need 4 satellite signals (as indicated in figure 5) to create 4 equations of the distance.

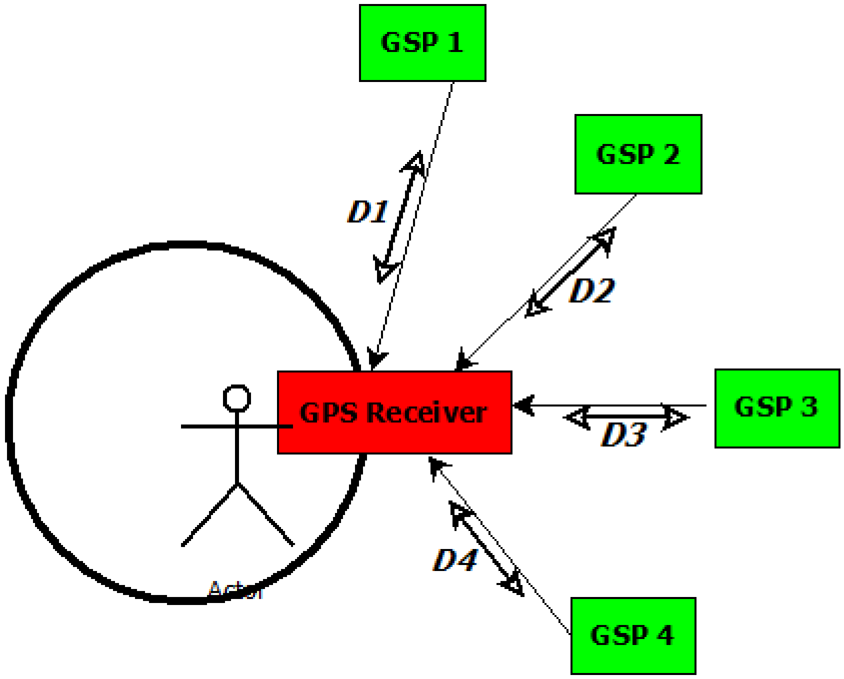


Figure 5: Detail of GPS Calculation from Distance

Form figure 5 above, the GPS calculation in the receiver uses four equations in the four unknowns X, Y, Z, T_c,, where X, Y, and Z are the receiver's coordinates, and T_c is the time correction for the GPS receiver's clock. The four equations derived from those parameters would be:

$$D1 = C(T_{t,1} - T_{r,1} + T_c) = \sqrt{X_1 - X)^2 + (Y_1 + Y) + \sqrt{(Z_1} - Z)^2} \quad (1)$$

$$D2 = C(T_{t,2} - T_{r,2} + T_c) = \sqrt{(X_2 - X)^2 + (Y_2 + Y) + \sqrt{(Z_2} - Z)^2} \quad (2)$$

$$D3 = C(T_{t,3} - T_{r,3} + T_c) = \sqrt{(X_3 - X)^2 + (Y_3 + Y) + \sqrt{(Z_3} - Z)^2} \quad (3)$$

$$D4 = C(T_{t,4} - T_{r,4} + T_c) = \sqrt{(X_4 - X)^2 + (Y_4 + Y) + \sqrt{(Z_4} - Z)^2} \quad (4)$$

Where**:**

C = Speed of light (3 X 10^8)

$T_{t,1}$, $T_{t,2}$, $T_{t,3}$, $T_{t,4}$ = time that the respective GPS satellites (1, 2, 3, and 4) transmit their signals, it is provided to the receiver as part of the information that is transmitted.

$T_{r,1}$, $T_{r,2}$, $T_{r,3}$, $T_{r,4}$ = time that the signal from respective GPS satellites (1, 2, 3, and 4) are received.

X, Y, Z = the coordinates for the GPS satellites, which provided to the receiver as part of the information transmitted.

The receiver solves these equations simultaneously to determine X, Y, Z, and T_c.

Based Stations provides correction factor for accurate GPS locations. Different types of individual based station Networks include; Virtual Reference System (VRS), Continuously Operating Reference Station (CORS), National Differential GPS (NDGPS), and On-line Positioning User Server (OPUS).

3. SYSTEM METHODOLOGY AND SYSTEM DESIGN

The model adopted in this work for our design is based on object-oriented analysis and design (OOAD) using Unified Modeling Language (UML) as the main modeling tool. The UML is now the most widely used graphical representation scheme for modeling object systems. It specifies diagram for documenting the system behavior [12]. An attractive feature of the UML is its flexibility [13]. UML modelers are free to use various processes in designing systems. The UML is a complex, feature-rich graphical language [14]. To model the blueprint for the CADBLOS software artifacts, the Unified Modeling Language (UML) was used. The UML is related to object-oriented problem solving. Our motivation for a UML-Centric approach is to ensure quality, completeness, and scalability of the system, and condense production time in the software development.

In our modeling process, the high-level functional requirements of the system were represented using Use Case Diagrams. Classes were utilized to wrap attributes or data and behaviors or functions of the CADBLOS into a single distinct entity. Activity diagrams were used to represent the work flow of stepwise activities and actions with supports for choice, interaction and concurrency for the CADBLOS system.

3.1 **Use Case Diagrams**

The Use Case is a method for capturing the functional requirement of a system. It describes the system's action from the point of view of the system user. In our Use Case design, we identified the **Admin** who handles the update of routes and registration of other users, **Driver** and the User (**Passengers**), as our Actors. The use case for the CADBLOS is presented in figure 6 below.

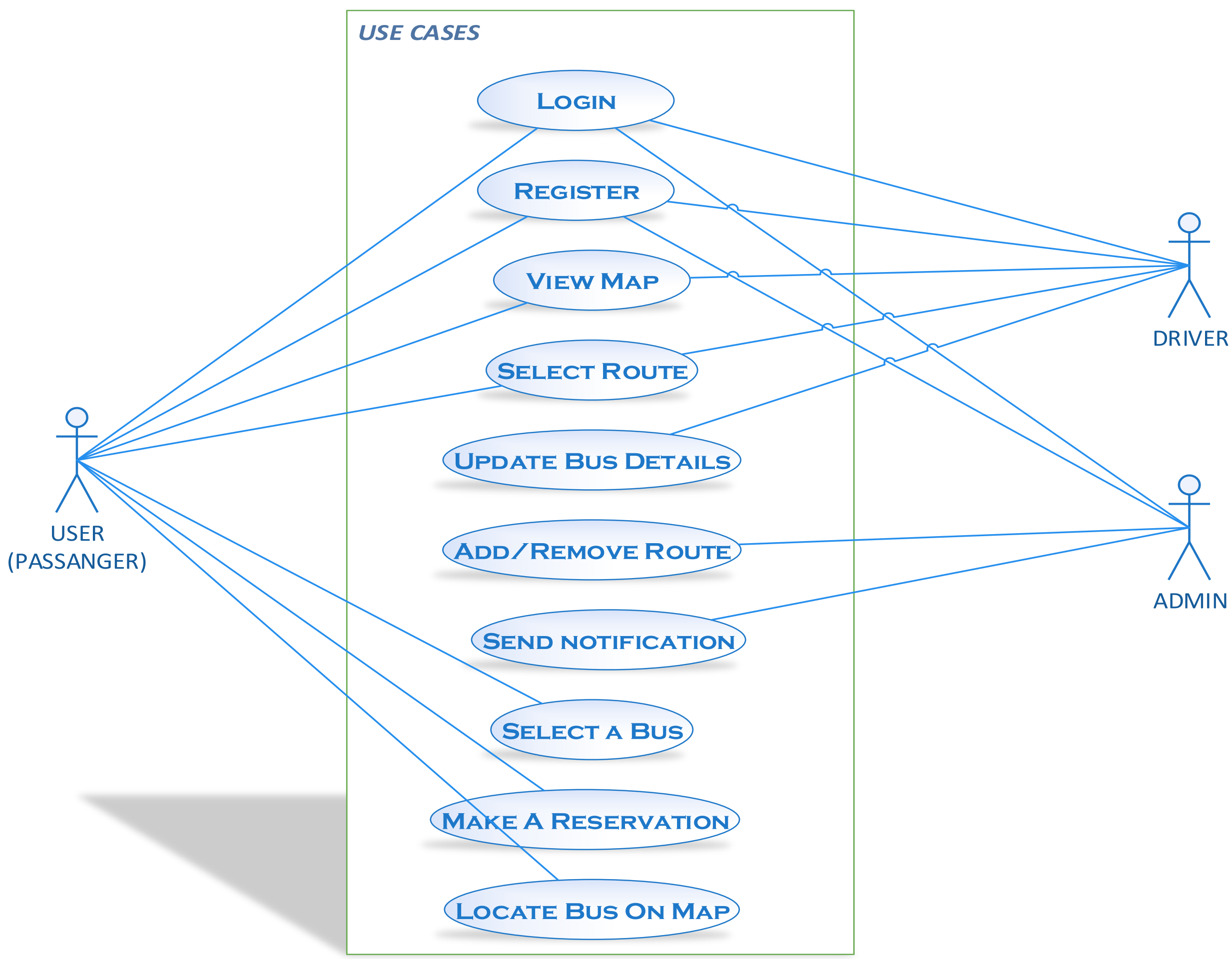


Figure 6: Use Case Diagram of the CADBLOS

3.2 **Class Diagram**

The class diagram also defines the architectural level abstraction of a system design. It provides improvement to wrap attributes or data and behaviors or functions of the CADBLOS into a single distinct entity. We present the class diagram for the model system in figure 7 below.

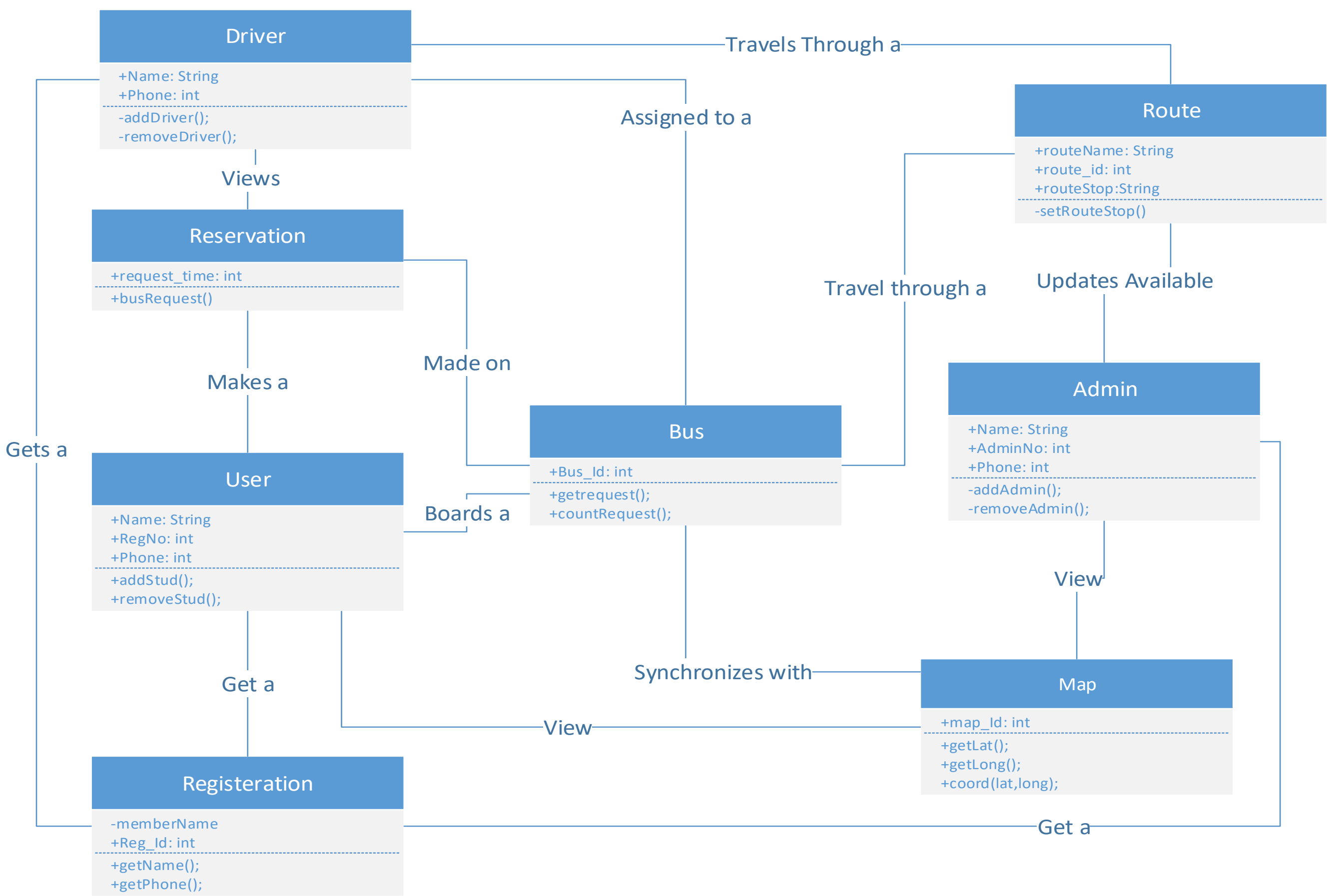


Figure 7: Class Diagram of the CADBLOS

3.3 **Activities Diagram**

Activity diagrams are object-oriented corresponds of flow charts and data-flow diagrams from structured development. It explains the workflow behaviour of a system and also illustrates the dynamic nature of a system by modeling the flow of control from one activity to another. The activity diagram is represented in figure 8 below.

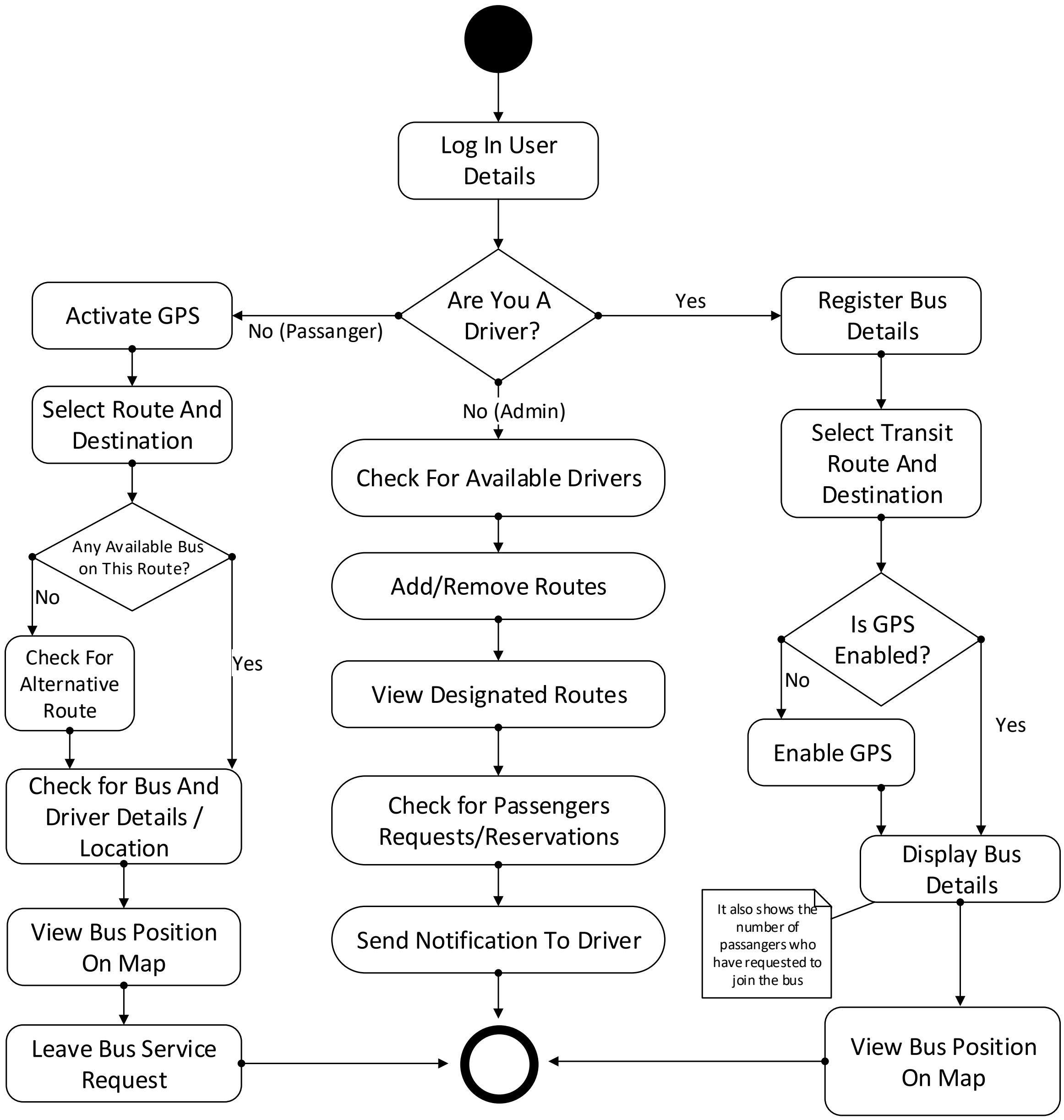


Figure 8: Activity Diagram of the CADBLOS

3.4 The System Architecture

The Architecture of the CADBLOS is presented in figure 9 below.

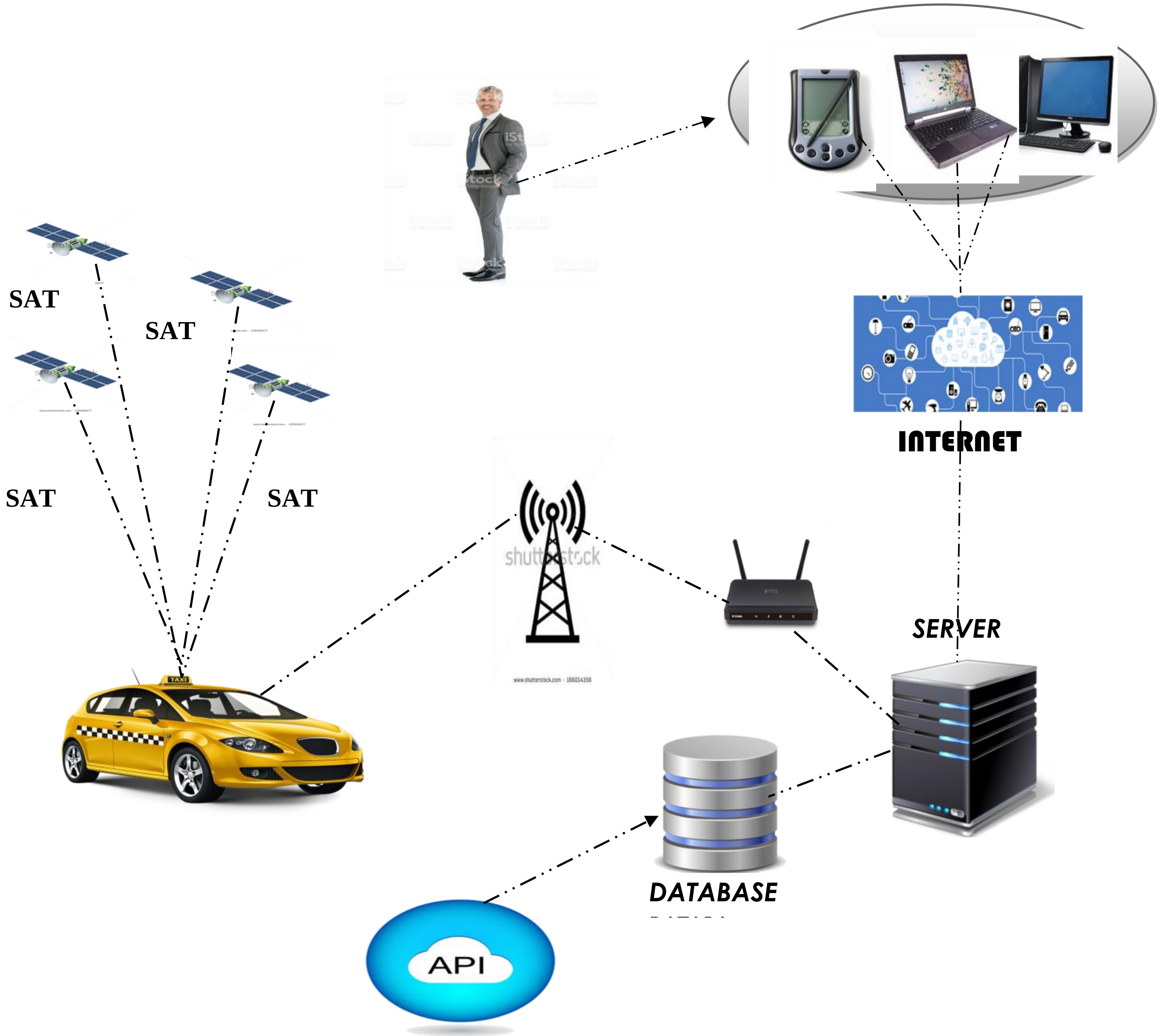


Figure 9: General Architecture of the CADBLOS System

3.5 Database Design

Database management is a central part of this system. The reason is because vital data input from external environment, provided by all classes of CADBLOS users are to be handled properly therefore, the need for good storage design process. Good database design would enhance the system data flow process and facilitate data storage and retrieval. The entities relationship diagram (ERD) was created for preparation of system development. A good design of an ERD would enable easy modification of the system where necessary, and provide accurate information for system users. The Entities identified for this system were *ADMIN*, *DRIVER*, *USER*, *BUS*, and *ROUT.E* The ERD and the tables showing the database schema can be seen in figure 10 below.

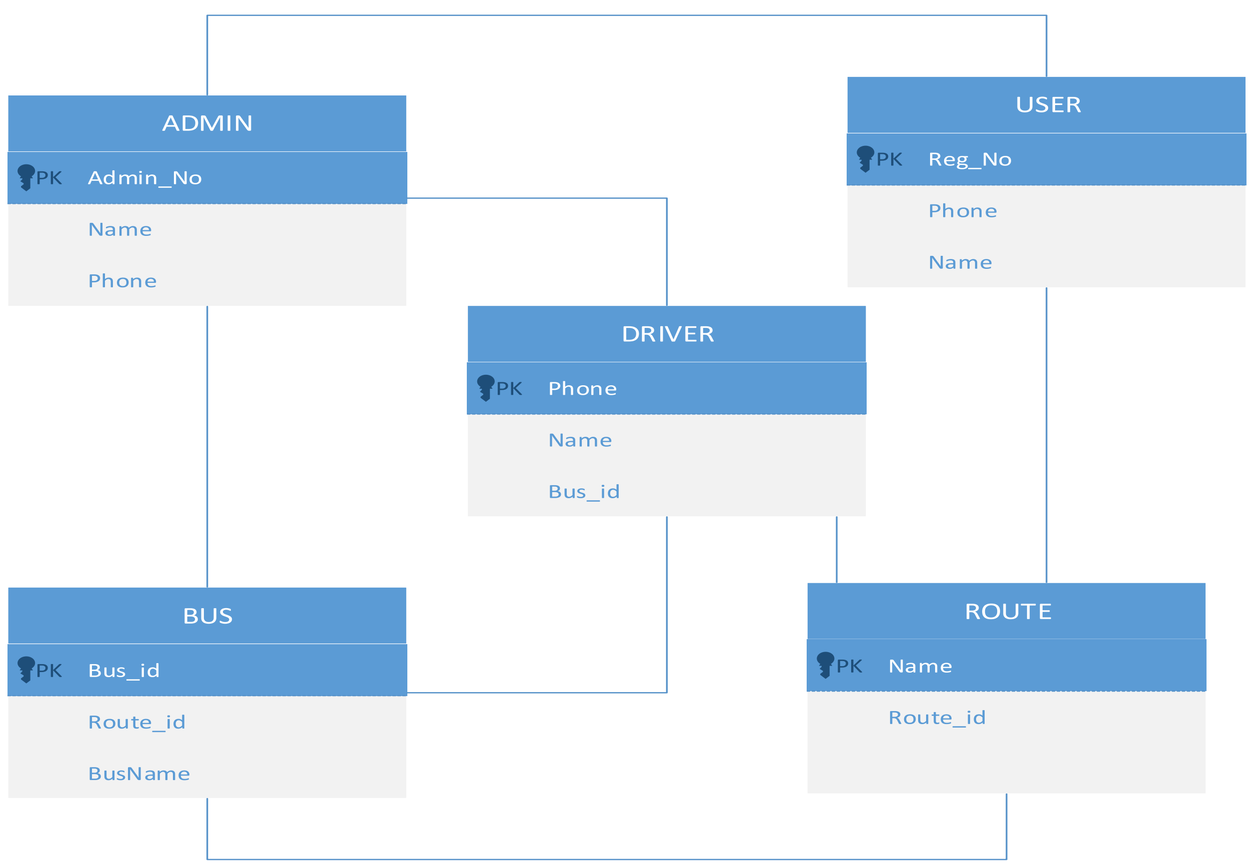


Figure 10: The CADBLOS Entity Relationship Diagram (ERD)

Driver_Table

Field	Description	Data Type	Null	Primary Key
Name	Name of the bus Driver	VARCHAR (20)	No	No
Driv_ID	Identifies the driver in the system	INT(10)	No	No
Phone	Driver's Phone number	INT (15)	No	Yes
Route_ID	Identifies route chosen by driver	VARCHAR (20)	No	No
Bus_ID	Uniquely assigns a bus to a driver	INT (10)	No	No

Admin_Table

Field	Description	Data Type	Null	Primary Key
Name	Name of Admin	VARCHAR (15)	No	No
Phone	Admin's Phone Number	INT (15)	No	No
Admin_No	Uniquely identifies each admin	INT (15)	No	Yes

User_Table

Field	Description	Data Type	Null	Primary Key
Name	Name of user	VARCHAR (20)	No	No
Phone	User's Phone number	INT (15)	No	No
Reg_No	Uniquely identifies each user	INT (15)	No	Yes

Route_Table

Field	Description	Data Type	Null	Primary Key
Name	Name of route	VARCHAR (20)	No	No
Route_ID	Uniquely identifies each route	INT (15)	No	Yes
Route_Stop	Specifies route destination	VARCHAR (20)	No	No

Bus_Table

Attribute	Description	Data Type	Null	Primary Key
Plate_Number	Uniquely identifies each Bus	INT (10)	No	Yes
Bus_Name	Name of the Bus	VARCHAR (10)	No	No
Route_ID	Identifies the Bus route	INT (15)	No	No

4. CONCLUSION

The research work aspired to reducing difficulties associated with bus transportation in major campuses of the Nigeria where there are teeming population densities and less likelihood of getting bus services at both odd and rush (lecture) hours for events that are very important to students. The application when fully developed would use the GPS function, available in most of Android phones, to identify current location quite accurate. With the proposed application installed on Android smartphones, what students have to do is to start up the application. This application would fire co-ordinates to server, the server in turn powers SMS Alerts to student who has registered from their specific pickup point. The application is entirely Android that will runs only on Android devices. In order to track the location of the Bus Google Maps would be used for mapping locations transmitted by the mobile phone. The mobile phone will fetch the GPS location and communicates with server through the use of General Packet Radio Service (GPRS). As a proposal to further studies, a real time bus locator system using android application, that can predict bus arrival and departure time by studying patterns, and notifying users using SMS, can also be advancement to this research work.

CONFLICT OF INTERESTS

The author(s) declare that there is no conflict of interests.

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