UNIVERSITY OF NAIROBI

SCHOOL OF COMPUTING AND INFORMATICS.

Project Proposal.

AN ARDUINO BASED VEHICLE TRACKING SYSTEM USING GPS AND GSM MODULES.

BRIAN KIBET RONOH.

P15/81773/2017.

Supervisor: Dr. Kahonge.

November, 2020

Abstract.

Automobiles are necessary for the movement of goods from one location to another. Consumers may face several problems as a result of delays in the delivery of goods. This delay may be due to drivers choosing incorrect or longer routes when delivering. To avoid these challenges, the Global Positioning System (GPS) is increasingly being used for management of vehicle fleets, recovery of stolen vehicles, mapping and surveillance. This project outlines the design and implementation of a real time GPS tracker system using Arduino. This proposal has significant application for vehicle security, salesman tracking, car hire businesses and private drivers.

An efficient vehicle tracking system is designed and implemented for tracking the movement of any equipped vehicle from any location at any time. The proposed system makes good use of popular technology that combines a smartphone with an Arduino UNO. This is easy to make and inexpensive as compared to others. This system works using the Global Positioning System (GPS) and Global System for Mobile Communication (GSM) technology which is one of the most common ways for vehicle tracking. The device is embedded inside a vehicle that its positions is to be determined and tracked in real time. An Arduino UNO is used to control the GPS receiver and GSM module. The vehicle tracking system uses the GPS module to get geographic coordinates at regular time interval. The GSM module is used to transmit and update the vehicle location to a database. The system gives a minute by minute update about vehicle location by sending an SMS through the GSM modem. This SMS contains the latitude and longitude of the location of vehicle. Arduino UNO gets the coordinates from GPS modem and then it sends this information to user in text SMS. GSM modem is used to send this information via SMS sent to the owner of the vehicle. Location is displayed on LCD. And then Google map displays location and name of the place on cell phone. Thus, the user is able to continuously monitor a moving vehicle on demand using a smartphone and determine the estimated distance and time for the vehicle to arrive at a given destination.

Table of Contents

List of Figures.

List of Tables.

Abbreviations.

GPS - Global Positioning System
GSM - Global System for Mobile Communication
SMS - Short Message Service
AVL - Automatic Vehicle Location
GIS - Geographic Information System
RF - Radio Frequency
AGPS - Assisted Global Positioning System
RFID - Radio Frequency identification
API - Application Programming Interface
DC - Direct Current
SRAM- Static Random Access Memory
EEPROM - Electrically Erasable Programmable Read only Memory
IDE - Integrated Development Environment

CHAPTER 1: INTRODUCTION

Project overview.

With advancements in technology, there has been an increase in the usage of vehicle tracking systems. Security, especially theft, of vehicles in common parking places has become a matter of concern. Commercial fleet operators are by far the largest users of vehicle tracking systems. These systems are used for operational functions such as routing, security, dispatch and collecting on board information. Tracking systems have found applications in areas such as military, navigation, automobiles, aircrafts, fleet management, remote monitoring, remote control, security systems, tele services, etc.

Previous approaches to vehicle tracking use expensive microcontrollers. Deploying a GPS based vehicle tracking system for a small company is still a nightmare when it compares with the setup and the running costs involved in such deployment. Most of the currently available GPS base vehicles tracking systems are satellite based and are very costly, and thus it is not affordable to many.

The proposed system is an embedded system, which is used to know the location of the vehicle using the popular and readily available technologies like the Global Positioning System (GPS) and Global System for mobile communication (GSM). The main feature of our design is that it is proposed to use a development board, which will have GPS and GSM module not as a separated module but closely linked with a microcontroller as in Arduino Uno R3. The advantage of using this development board is that it will reduce the size of whole system and it will reduce the power loss in terms of heat through external wirings used for the connection of GPS and GSM module with the microcontroller. Along with that, it will also increase the durability of the entire system. The Arduino Uno microcontroller will provide the interfacing to various hardware peripherals. To know the location of vehicle, the mobile user has to click on the Track location button in the android app. The message will be automatically sent to the SIM present in the GSM module present in the device. The system will respond by sending the coordinates (sensed by the GPS module) of the vehicle on the registered mobile user and these coordinates will be plotted on the map.

1. Problem Statement.

Deploying GPS based vehicle tracking systems for small companies is still a nightmare when it compares with the setup and the running costs involved in such deployment. Most of the currently available GPS based vehicle tracking systems are satellite based and are very costly, and thus it is not affordable to many. GPS based vehicle tracking systems are commonly used in Europe and mainly the developed countries like the United States (US) and United Kingdom (UK), but it is not well used here in Kenya.

Satellite based tracking systems are not very much affordable and cannot be commonly deployed by most clusters in the developing region. Therefore, it is really important to address this subject matter through a novel concept which would open up the same tracking exposure to organizations and individuals who have a lean budget.

Project Objectives.

i. Research objectives.

1. Research on application areas of tracking software.
2. Research on the applications of microcontrollers in making tracking systems.
3. Research on the applications of GSM and GPS in tracking systems.

ii. System Development Objectives.

4. Gather requirements of the system and come up with a requirement specification document for analysis.
5. Design the vehicle tracking system, including graphical user interface (GUI) design and the hardware components to be connected.
6. Design the Android app to be used alongside the system.
7. Develop the design on the Arduino IDE and connect the hardware components.
8. Develop the Android app based on the design developed above.
9. Test the implemented system.
10. Evaluate the system.
11. Document the project.

In order to fulfil the stated objectives several steps must be taken. These steps involve both software programming and hardware implementation.

These steps are as follows:

1) Establishing a wireless network communication between the GSM module and the smartphone, using a microcontroller (Arduino-Uno).
2) Create a simple yet reliable vehicle tracking system using Arduino-Uno as a microcontroller that will be the medium between the GPS and the GSM module so that the embedded system works efficiently.

3) To find a suitable place locator app (in this project I will be using Google Maps) that will work efficiently with the internet connection (online as well as offline) in order to track the vehicles.
4) Program the Arduino-Uno board in a way that will let it interact with the GPS and GSM module directly and easily.

The main outputs from the expected vehicle tracking system to the end-user are summarized as follows:

1. Plot tracking vehicle's current location on Google Maps.
2. Send location data with a link as an SMS to the user.

Constraints.

1. Cost/Budget.

The project uses hardware and thus budgetary limitations exist. An Arduino Uno R3 microcontroller is used as it is inexpensive and readily available. The GPS and GSM modules interfaced with the Arduino Uno microcontroller are also costly. The budget for this project is estimated to be Kes 10,000.

2. The target hardware.

The Arduino Uno microcontroller has little functionality unlike the Raspberry Pi microcontroller. It does not have an inbuilt GPS module unlike the Raspberry Pi processor. The workaround to this will be to acquire separate modules to interface with the Arduino Uno microcontroller.

3. Limitations on access to specific resources.

Access to GPS and GSM modules are limited as only a few sellers in Kenya deal with the products.

4. The research topic.

Resources on real-time vehicle tracking using cheap micro-controllers e.g. Arduino UNO are limited hence the need for further research on the topic.

Research topics.

1. The application areas of tracking systems.
2. Research topic two will be the use of vehicle tracking software in Kenya and examples of tracking systems already being used in the automotive sector.
3. Research topic three will be the use of microcontrollers in tracking software.
4. Research topic four will be the role and use of GPS and GSM in tracking systems.

System Context Diagram.

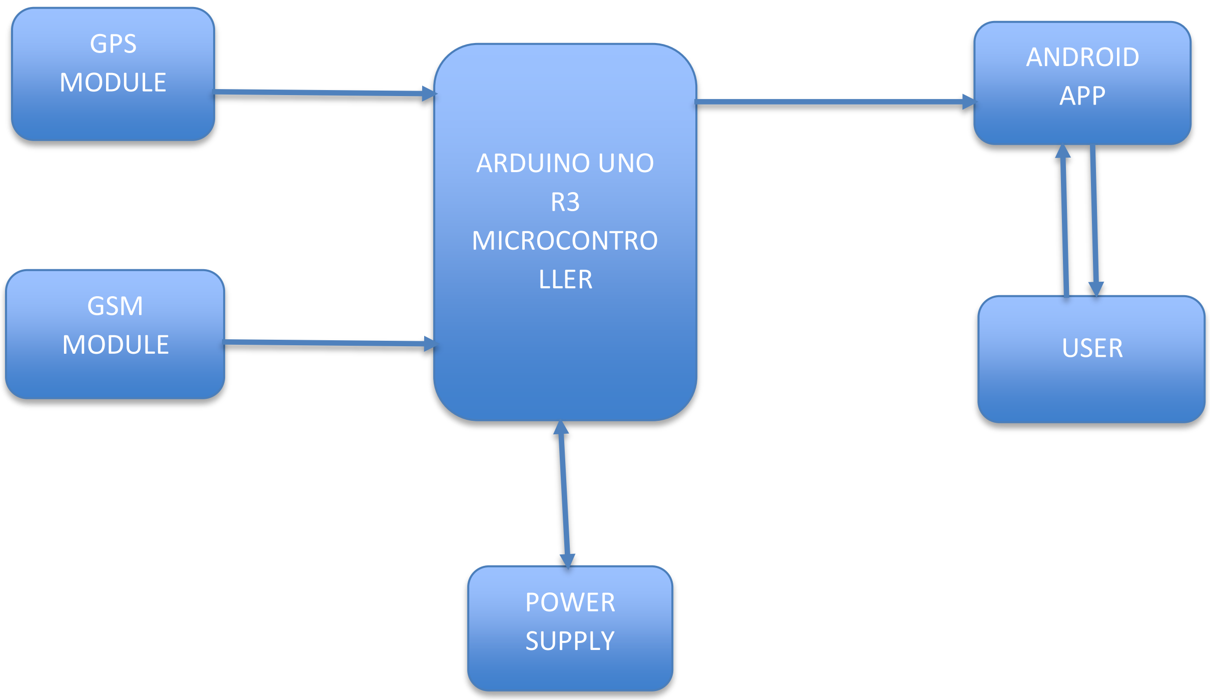

Figure 1: System context diagram.

CHAPTER 2: LITERATURE REVIEW.

Vehicle tracking systems.

A vehicle tracking system combines the installation of an electronic device in a vehicle, or fleet of vehicles, with purpose-designed computer software at least at one operational base to enable the owner or a third party to track the vehicle's location, collecting data in the process from the field and deliver it to the base of operation. Modern vehicle tracking systems commonly use GPS or GLONASS technology for locating the vehicle, but other types of automatic vehicle location technology can also be used. Vehicle information can be viewed on electronic maps via the Internet or specialized software. Urban public transit authorities are an increasingly common user of vehicle tracking systems, particularly in large cities.

Several types of vehicle tracking devices exist. Typically, they are classified as either "passive" or “active".

Active versus Passive Tracking.

"Passive" devices store GPS location and maybe other information such as speed, heading and sometimes a trigger event such as key on or off, door open or closed. Once the vehicle returns to a predetermined point, the device is removed and the data downloaded to a computer for evaluation. Passive systems include auto download type that transfer data via wireless download.

"Active" devices also collect the same information but usually transmit the data in real-time via cellular or satellite networks to a computer or data centre for evaluation.

Passive trackers do not monitor movement in real-time. When using a passive GPS tracker, you will not be able to follow every last move that a tracked person or object makes. Instead, information that is stored inside of a passive tracker must be downloaded to a computer. Once tracking details have been downloaded, it is then possible to view tracking details. After we have gathered all of the information we need from a passive tracker, we can place the tracker back on the same (or different) vehicle. Aside from the fact that a passive tracking device is entirely reliable, the main reason people choose passive trackers is that these devices are less expensive than active trackers. Most passive GPS tracking devices are not attached to a monthly fee, which makes these trackers affordable.

On the other hand, active GPS trackers will allow one to view tracking data in real-time. As soon as an active tracker is placed on a vehicle, one is able to view location and other information such as stop duration and speed from the comfort of their homes or offices. Active GPS trackers are ideal when it comes to monitoring vehicles that need to be tracked at a regular time interval.

There are many advantages associated with a real time tracker. The most important advantage is the convenience of the tracker. Rather than waiting to download data to a computer (as is the case with most passive trackers), a tracker that works in real-time does not require any waiting. Since real-time trackers come with software that allows a user to track an object in real-time, watching any object's progress is simply a matter of sitting at a computer.

Many modern vehicle tracking devices combine both active and passive tracking abilities: when a cellular network is available and a tracking device is connected it transmits data to a server; when a network is not available the device stores data in internal memory and will transmit stored data to the server later when the network becomes available again. Historically vehicle tracking has been accomplished by installing a box into the vehicle, either self-powered with a battery or wired into the vehicle's power system. For detailed vehicle locating and tracking this is still the predominant method; however, many companies are increasingly interested in the emerging cell phone technologies that provide tracking of multiple entities.

Types of Tracking Systems.

There are three main types of GPS vehicle tracking that are widely used. They all use active devices. They are:

1. Automatic Vehicle Location (AVL) system 2.
2. Assisted Global Positioning System (AGPS) 3.
3. Radio Frequency Identification (RFID)

Automatic Vehicle Location (AVL) system

AVL system is an advanced method to track and monitor any remote vehicle with the device that receives and sends signals through GPS satellites. AVL comprises of Global Positioning System (GPS) and Geographic Information System (GIS) in order to provide the real geographic location of the vehicle. AVL system consists of PC-based tracking software to dispatch, a radio system, GPS receiver on the vehicle and GPS satellites. Among the two types of AVL, GPS-based and Signpost-based, GPS-based system is widely used. The tracking method uses GPS satellite to locate the vehicle equipped with GPS modem by sending satellite signals. The accuracy of the tracking method depends on the AVL system which provides the vehicle location with the accuracy of about 5m to 10m. The information transmitted by the tracking system to the base station is location, speed, direction, mileage, start and stop information and status of vehicle. The information of the vehicle is often transmitted to the central control system (base station) from the vehicle after every 60 seconds. If the base station receives the data, it displays it on a computerized map. GPS receiver on the vehicle receives the signals of its geographic location. If AVL system is used to track a vehicle the average cost of per vehicle is $1 to $2 per day.

The system can provide additional services like: vehicle route replay facility, external sensor data, speed alerts. The system also has some limitations; using the AVL system we cannot get accurate, complete and sufficient satellite data in dense urban areas or indoors and when transmission is blocked by natural obstructions (heavy tree cover) or many buildings. It can also occur in RF-shadowed environments and under unfriendly Radio Frequency (RF) conditions. Sometimes, a position fix can be impossible.

Assisted GPS (AGPS) system

In AGPS system, a terrestrial RF network is used to improve the performance of GPS receivers as it provides information about the satellite constellation directly to the GPS receivers. AGPS uses both mobiles and cellular networks to locate the accurate positioning information. AGPS is used to overcome some limitations of GPS. With unassisted GPS, locating the satellites, receiving the data and confirming the exact position may take several minutes. AGPS uses GPS satellites to track the vehicles. A GPS receiver in the vehicle is always in contact with 4 satellites (3 satellites determine latitude, longitude and elevation and the fourth provides an element of time) hence it never fails to detect the location of a vehicle. Location of the vehicle is provided with accuracy of between 3m and 8m, and speed of 1km using this method. Information like Vehicle location, average speed, direction, path traversed in a selected period and alerts (Engaged/Unengaged, speed limit, vehicle breakdown and traffic jam) are delivered by the tracking system to the base station. The system provides continuous updates after every 10 seconds while the vehicle is in motion. It also provides data storage for up to 1 year. The location is retrieved from the GPS device and relayed as a SMS using the cell phone by the Client Node to the Base station. This system is more expensive than the AVL system as it gives a continuous update of the vehicle location. If the user needs an update after every 10 seconds then the subscription for this system is $1.33 per day per vehicle and if the user needs an update after every 5 seconds it is $1.67 per day per vehicle. The system can provide further services like atomic time (Accurate Time Assistance). There is a "panic" button. When pressed, you can contact an operator and he or she will help you out or keep you safe from accidents or hijacks. The system has also some limitations as GSM network is used to transmit data from the vehicle to the base station, and the cost of sending SMS is a major concern to be considered.

Radio Frequency Identification (RFID) System

RFID is an automatic identification method using devices called tags to store and remotely retrieve data. RFID uses radio waves to capture data from tags. The tracking method of RFID comprises of three components: tag (passive, semi passive and active), reader (antenna or integrator) and software (middleware). RFID tag which contains microelectronic circuits sends the vehicle information to a remote RFID reader which is then read via the software. This system provides the location of the vehicle with the accuracy of 4m to 6m. Information such as location of the vehicle, mileage and speed are delivered by the tracking system to the centre. The information is updated every one minute. The information is sent to and received from RFID tags by a reader using radio waves. RFID reader, basically a radio frequency (RF) transmitter and receiver, is controlled by a microprocessor or digital signal processor (DSP). RFID reader with an attached antenna reads data from RFID tags.

Benefits of vehicle tracking systems to businesses.

Companies are starting to realise the benefits of vehicle tracking systems. The benefits cut across all industries, both in the commercial and public sector. Tracking makes it easier to eliminate fleet inefficiencies such as journey duplication/overlap and unscheduled journeys. It also encourages a safer, more economic driving style among mobile employees and a more efficient call placing. Other benefits include reduced vehicle wear and tear and reduced administration time associated with meeting health and safety policies (Marchet, Perego & Perotti, 2009).

The potential benefits of a vehicle tracking system can be immediate, with enhanced fleet reactivity and productivity making it possible to generate a fast return on investment and increase business capacity. It can also assist with meeting the needs of government legislation and security for mobile employees (Ting, Wang &Ip, 2012).

Vehicle tracking is a way to improve company efficiency and in effect, increase profitability, especially in the business of large vehicle fleets (Hsieh, Yu, Chen & Hu, 2006). Vehicle tracking systems are the enabling technology, and is the key to release the value trapped in asset management. By its non-contact, scan-based data reading characteristics, it automates the asset tracking and data acquisition that enables an enterprise to locate vehicles (cars, trucks, etc.) and even uses location information to optimize services. With the help of tracking information, the manager is able to access one or more driver locations and gets their status information on a real-time basis (for instance, checking if the drivers execute the order; if they follow the driving routes; if there is any traffic congestion (Roh, Kunnathur &Tarafdar, 2009).

Existing Vehicle tracking systems in Kenya.

STrack Kenya LTD.

STrack Kenya Limited is a company founded in the year 2006 to meet national and personal security needs of Kenya and the East Africa Region. The Company specializes in provision of unmatched vehicle tracking and fleet management service delivery for motor vehicles and assets using Global Positioning System (GPS) Technology, supported by proven advanced technology devices from

Sweden, an online tracking software based on Google Maps and a Linux server environment for enhanced reliability and user security.

Regent Tracking Services.

Regent Tracking Services Limited is a security solutions provider and a member of Regent Automobile Group. The company provides services ranging from fleet management solutions, security and surveillance to vehicle and asset tracking. Their fleet management solutions use advanced GPS tracking and real-time vehicle monitoring and control.

Myriad Services Ltd (MSL)

Myriad Services Ltd is a company that provides fuel management, fleet monitoring, on board vehicle cameras, vehicle accessories services and many other services. It is a Kenyan company with offices in Nairobi, Mombasa and representatives in Kenya major towns, and specializes in the procurement and supply of Fuel Management solutions and many other services to the private and public sector corporations within East Africa.

Nairobi Car Trackers.

Nairobi Car Trackers is a company providing tailor made automobile tracking and fleet management solutions to various companies in Kenya. Their services include: Vehicle GPS tracking system, motorbike GPS tracking system and an auto watch system that prevents unauthorized access into a vehicle. Key features of their tracking systems are: Stop engine remotely, set speed limit, Geo-fence real time tracking, Satellite view, Traffic monitoring, History playback (3 months), Alerts on Over-speeding, low battery, Engine on/off, external power disconnected, Reports on Mileage, Parking details, Trip report, Alert reports.

Pinnacle Systems (K) Ltd

Key features of their tracking system include: Live, web-based Vehicle Tracking, Vehicle Tracking uses high quality Mapping including Satellite and Street view, Journey Trails and Replays, Find Nearest vehicle and Job Dispatch Tools, Monitoring of Driver behaviour, Points of Interest, Barred Locations and Geo Zones, Comprehensive reporting suited to Ad hoc and Automated Reports.

Smart Track Vehicle Tracking System

Smart Track Vehicle Tracking System is a Real-time vehicle tracking system that relies on both the Global Positioning System (GPS) satellites and a cellular system. It was developed by Endeavor Africa Group. Key software features include: fuel management, tyre management, fleet maintenance, Real Time vehicle location monitoring, Multiple and secure login, SMS/ Email alerts and scheduler, Route planning and analysis, History / Speed analysis, Route deviation notification and Report analysis.

Other tracking systems/companies include: Rivercross Tracking, Trailmycar, Solutions Unlimited tracking system, Carro Tracking Solutions and Nimba Technologies LTD.

CHAPTER 3: SYSTEM DEVELOPMENT METHODOLOGY.

System Development Life Cycle (SDLC).

The System Development Life Cycle (SDLC) is a conceptual model for software development that consists of multiple phases: Software Conceptualization; Analysis; Design; Coding and Debugging; System Integration and Testing; Implementation; Maintenance and Support. Each phase can be thought of as a building block for the next phase.

There are different SDLC models that may be followed, such as the classic “Waterfall Model,” “Spiral,” and “Evolutionary Prototyping,” as well as many modified Waterfall models.

The waterfall approach is one of the oldest SDLC models, but it has fallen out of favor in recent years. This model involves a rigid structure that demands all system requirements be defined at the very start of a project. Only then can the design and development stages begin.

Once development is complete, the product is tested against the initial requirements and rework is assigned. Companies in the software industry typically need more flexibility than what the waterfall methodology offers, but it still remains a strong solution for certain types of projects, especially government contractors.

The sequential phases in the Waterfall model are:

- **Requirement Gathering and analysis** − All possible requirements of the system to be developed are captured in this phase and documented in a requirement specification document.
- **System Design** − The requirement specifications from the first phase are studied in this phase and the system design is prepared. This system design helps in specifying hardware and system requirements and helps in defining the overall system architecture.
- **Implementation** − With inputs from the system design, the system is first developed in small programs called units, which are integrated in the next phase. Each unit is developed and tested for its functionality, which is referred to as Unit Testing.
- **Integration and Testing** − All the units developed in the implementation phase are integrated into a system after testing of each unit. Post integration the entire system is tested for any faults and failures.
- **Deployment of system** − Once the functional and non-functional testing is done; the product is deployed in the customer environment or released into the market.

- **Maintenance** − There are some issues which come up in the client environment. To fix those issues, patches are released. Also, to enhance the product some better versions are released. Maintenance is done to deliver these changes in the customer environment.

All these phases are cascaded to each other in which progress is seen as flowing steadily downwards (like a waterfall) through the phases. The next phase is started only after the defined set of goals are achieved for previous phase and it is signed off, so the name "Waterfall Model". In this model, phases do not overlap.

In a practical software development project, the classical waterfall model is hard to use. So, Iterative waterfall model can be thought of as incorporating the necessary changes to the classical waterfall model to make it usable in practical software development projects. It is almost same as the classical waterfall model except some changes are made to increase the efficiency of the software development.

The iterative waterfall model provides feedback paths from every phase to its preceding phases, which is the main difference from the classical waterfall model.

Feedback paths introduced by the iterative waterfall model are shown in the figure below. When errors are detected at some later phase, these feedback paths allow correcting errors committed by programmers during some phase. The feedback paths allow the phase to be reworked in which errors are committed and these changes are reflected in the later phases. But there is no feedback path to the stage – feasibility study, because once a project has been taken, does not give up the project easily.

It is good to detect errors in the same phase in which they are committed. It reduces the effort and time required to correct the errors.

The development of this system uses the iterative waterfall method. The stages of system development process using the iterative waterfall method are illustrated in the following diagram:

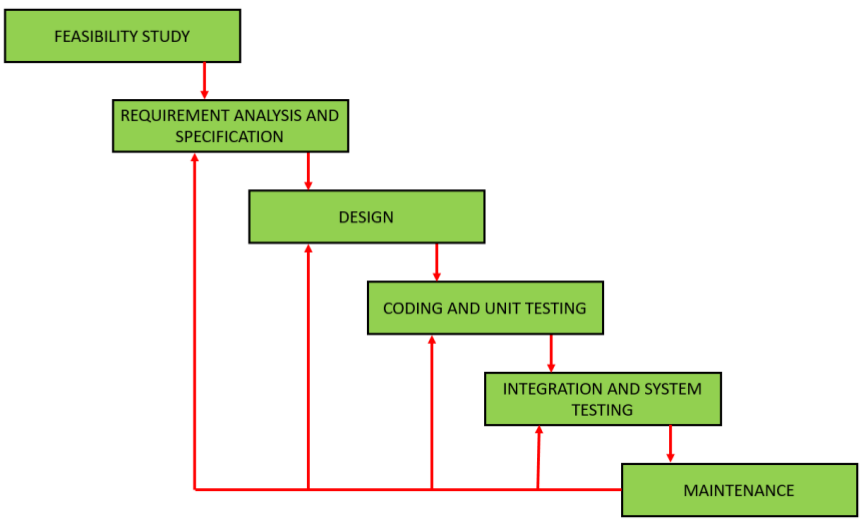

Figure 2: Steps of the iterative waterfall SDLC model.

This model will be used because of the following reasons: Requirements are very well documented, clear and fixed, the technology is understood and is not dynamic, there are no ambiguous requirements, ample resources with required expertise are available to support this project, clearly defined stages, easy to arrange tasks, Phases are processed and completed one at a time, and it's easy to manage due to the rigidity of the model. Each phase has specific deliverables and a review process during the development of the project, the following activities will be carried out at each stage:

Requirements Gathering and analysis.

Activities to be carried out in this phase are as follows:

I. Conduct a feasibility study.
II. Gather requirements using methods such as interviews, questionnaires, internet sources, existing systems analysis and observation of main user groups.
III. Identifying actors.
IV. Identifying scenarios.
V. Identifying use cases.
VI. Refining of use cases.
VII. Identifying relationships among use cases and actors.
VIII. Identifying initial analysis objectives.
IX. Identifying non-functional requirements.
X. Managing requirements elicitation -
XI. Maintaining traceability by documenting the requirements elicitation i.e. coming up with a Requirements Analysis Document (RAD)

The **key deliverable** for this stage is the Requirements Specification document.

System Design.

Objective:

The objective of this phase is to transform business requirements identified during the requirements phase, into a detailed system architecture which is feasible, robust and brings value to the organization.

Activities to be carried out in this phase are:

1) Review of the Requirements elicitation document.
2) Identify the Inputs, outputs, databases, forms, codification schemes and processing specifications of the system.
3) Decide on the programming language and the hardware and software platform in which the new system will run.

4) Develop the system architecture.
5) Develop the master plan for testing and evaluation.
6) Develop the user interface designs.
7) Come up with a database design.

Key deliverables: Flowcharts, Data flow diagram (DFD), Data dictionary.

Implementation.

Objective:

The objective of the Implementation Phase is: first to install the system in the production environment and to bring it into operation; and second, to ensure that the system, as developed:

- Satisfies the functional requirements
- Satisfies the business needs;
- Adheres to all mandates, physical constraints and service level agreements; and
- Operates as described in the requirements phase.

Activities:

1) Review of the design.
2) Selection of standards, methods, and tools for developing the system.
3) Coding - Includes implementation of the design specified in the design document into executable programming language code. The output of the coding phase is the source code for the software that acts as input to the testing and maintenance phase.
4) Document the system by coming up with system documentation.
5) Evaluate and review the final system to ensure it meets the requirements and it maps the design well.

Key deliverable: Source code that is an input to the testing phase and system documentation.

Integration and Testing.

All the units developed in the implementation phase will be integrated into a system after testing of each unit. Post integration the entire system will be tested for any faults and failures.

Evaluation

Once the system is operational, it will be assessed. The system will be given to outside users to test the system and give feedback based on their actions and experience in form of questionnaires. This will help in handling the residual errors that may exist in the software even after the testing phase. This phase will also monitor system performance, rectify bugs and requested changes are made.

Project Schedule.

Table 1: Project Schedule.

Task No.	Task Name	Planned Days	Actual days	Start day	Actual start day	End day	Actual end day	Deliverables
1	Develop Project proposal	22	23	**01/11/2020**	**01/11/2020**	22/11/2020	23/11/2020	Summary of what has been done in the field of research and what's to be developed.
2	Discuss Project details with Supervisor	3		22/11/2020		25/11/2020		Key changes to the project proposal.
3	Correct proposal as advised by the supervisor	2		25/11/2020		27/11/2020		A refined project proposal as required by the supervisor.
4	Eliciting requirements	3		27/11/2020		30/11/2020		Determine what requirements will consist of and document.
5	Analyse requirements	3		01/12/2020		03/12/2020		Determine whether the stated requirements are unclear, incomplete, ambiguous, or contradictory

6	Evaluate system for feasibility	2		04/12/2020		05/12/2020		Determine technical and operational feasibility and document
7	Requirements modelling	2		06/12/2020		07/12/2020		Requirement Specification document.
8	Document requirements in RDA	4		08/12/2020		11/12/2020		Requirement Specification document.
9	**System Design**	22		12/12/2020		02/01/2021		Flowcharts, Data flow diagram (DFD), Data dictionary, test plan.
10	**Implementation**	42		03/01/2021		13/02/2021		Source code
11	Integration and testing	14		14/02/2021		27/02/2021		
12.	Document the system	14		**28/02/2021**		**13/03/2021**		Project report

Gantt Chart

Task name	Start date	End date	Duration	Finish	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Preparation and planning	**01/11/2020**	**27/11/2020**	**27 days**																				
Develop Project proposal	**01/11/2020**	22/11/2020	22 days	23/11/2020																			
Discuss Project details with Supervisor	22/11/2020	25/11/2020	3 days																				
Correct proposal as advised by the supervisor	25/11/2020	27/11/2020	2 day																				
Requirement gathering and analysis	27/11/2020	11/12/2020	14 days																				
Eliciting requirements	27/11/2020	30/11/2020	3 days																				
Analyse requirements	01/12/2020	03/12/2020	3 days																				
Evaluate system for feasibility	04/12/2020	05/12/2020	2 days																				
Requirements modelling	06/12/2020	07/12/2020	2 days																				
Document requirements in RDA	08/12/2020	11/12/2020	4 days																				
System Design	12/12/2020	02/01/2021	22 days																				
Implementation	03/01/2021	13/02/2021	42 days																				
Integration and testing	14/02/2021	27/02/2021	14 days																				
System documentation	**28/02/2021**	**13/03/2021**	**14 days**																				

CHAPTER 4: SOFTWARE AND HARDWARE REQUIREMENTS.

Hardware requirements.

For designing this system, many types of devices are used to make it perfectly working. The following list of hardware are required for this system.

I. Arduino Uno R3
II. SIM808 Module
III. GPS and GSM antennae
IV. 16x2 LCD
V. Power Supply - to supply power to the microcontroller board and all other components connected to it.
VI. Connecting Wires that connect the various hardware components.
VII. LED
VIII. A laptop.

I. Arduino Uno R3 microcontroller.

The microcontroller used for this project will be Arduino Uno R3. The R3 is the third, and latest, revision of the Arduino Uno. The Arduino Uno is a microcontroller board based on the ATmega328. The ATmega328 has 32 KB (with 0.5 KB occupied by the boot loader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library). It has 20 digital input/output pins (of which 6 can be used as PWM outputs and 6 can be used as analog inputs), a USB connection, a power jack, an in-circuit system programming (ICSP) header, and a reset button. It is simply connected to a computer with a USB cable. The V_{in} is the input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). The 5V pin outputs a regulated 5V from the regulator on the board. The microcontroller board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the V_{in} pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. So, it is advised not to do so. Maximum current draw is 50 mA [5]. An Arduino board is based on an AVR microcontroller chip and when the board with nothing wired or attached to it consumes around

80mA of 5 volts current. The Clock speed of the Arduino is 16 MHz so it can perform a particular task faster than the other processor or controller. The AVR chip is clocking at 16 MHz continuously no matter what the code is doing, it never 'halts' so its current consumption is basically independent of the code you have it execute. Only if you put the AVR chip into one of its 'sleep modes' can you halt code execution and drastically cut current consumption for the AVR chip, however the rest of the other components on the Uno will continue to draw their normal current consumption. Also, the Arduino does not provide any 'sleep mode' examples so one will have to look for other user supplied coding example. Arduino board supports I2C and SPI communication. The Arduino software includes wire library for I2C and SPI library for the SPI communication

Software Components required.

II. SIM 808 Module.

SIM808 module is a complete Quad-Band GSM / GPRS module which combines GPS technology for satellite navigation. It has a SIM application toolkit where SIM card can be inserted. The compact design which integrated GPRS and GPS in a SMT package significantly saves both time and cost for one to develop GPS enabled applications. A modem GSM & GPRS with SIM808 module allows to create data connections on the GSM network through a standard USB interface. The cellular modems, particularly USB-stick ones, are now at very affordable prices. However, they are limited: they are explicitly designed for Internet connections, so one cannot use it as a normal modem and so implement, for example, a point to point data communications with them.

To switch ON the cellular module, the microcontroller has to put high the line ON/OFF (pin 1 on connector). This saturates the T2 transistor that drives to low the line PWR of GSM. SIM808 is designed with power saving technique so that the current consumption is as low as 1.0mA in sleep mode (GPS engine is powered down). The range of DC005 voltage input is 5 - 26V, when use the 5V power as the power, it is needed to make sure that the power supply can provide 2A current.

The SIM808 module has two different serial ports on board, one for the cellular section of the module and one for the GPS section. The serial port on cellular allows the full management of SIM808 module, therefore it can be used to configure and communicate with the GPS receiver, in order to call for data about satellite status and geographical positioning and to transfer them to the microcontroller. This is the approach followed in the design of this project.

All the GPS function is controlled by AT command via serial port. This module uses AT command to execute user’s desired functions. While using the GPS function, two AT commands are sent to open the GPS function, and the commands are AT+CGPSPWR=1 and AT+CGPSRST=1 respectively; two instructions are used to power GPS and reset GPS. And then, the GPS TTL level interface will send data out and the baud rate is 115200 by default.

The SIM 808 module interfaces with our GSM and GPS antennas and holds the SIM card used to send messages to the user.

III. GPS and GSM antenna.

GPS antenna.

This GPS antenna draws about 10mA and will give you an additional 28 dB of gain. It's got a 5-meter-long cable so it will easily reach wherever it is needed to. The antenna is magnetic so it will stick to the top of a car or truck or any other steel structure. Its operating frequency range is 1575.42±1.023 MHz and voltage range is 2.5V- 5.5V and corresponding current range is 6.6 mA - 16.6 mA [9].

GPS signals are extremely weak and present unique demands on the antenna so the choice of antenna plays an important role in GPS performance. A GPS unit needs to have a clear, unobstructed sky view, to best receive the microwave signals that allow it to communicate with satellites. GPS Down/Up converter used for very long cable runs. This GPS antenna that receives the GPS signal, converts it to a lower frequency which is then sent down the cable. Next to the GPS receiver is an up converter that converts the signal back to the original frequency and delivers it to the GPS receiver.

GSM antenna.

GSM communications are dependent on antennas. The antenna is what allows communications signals to be sent and received. The antenna that we have used in our project provides operation at both GSM Quad Band Frequencies with +2dBi gain [10]. This antenna operates in Quad Band 890/960, 1710/1880 MHz Frequencies and it's omni-directional.

IV. LED.

A light-emitting diode (LED) is a two-lead semiconductor light source. It is a pn-junction diode, which emits light when activated. When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the colour of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor.

The LED will be used to indicate the status of the hardware. When online, it will light Green.

V. LCD.

A liquid-crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly.

LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images which can be displayed or hidden, such as pre-set words, digits, and 7-segment displays as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements.

LCDs are used in a wide range of applications including computer monitors, televisions, instrument panels, aircraft cockpit displays, and signage. They are common in consumer devices such as DVD players, gaming devices, clocks, watches, calculators, and telephones, and have replaced cathode ray tube (CRT) displays in most applications. The LCD screen is more energy efficient and can be disposed of more safely than a CRT. Its low electronics equipment.

The LCD will be used to display the system status and also the latitude and longitude location data obtained from the GPS.

Software Requirements.

Arduino IDE Compiler.

The Arduino IDE is a cross-platform application written in Java, and is derived from the IDE for the Processing programming language and the Wiring project. It is designed to introduce programming to artists and other newcomers unfamiliar with software development. It includes a code editor with features such as syntax highlighting, brace matching, and automatic indentation, and is also capable of compiling and uploading programs to the board with a single click. There is typically no need to edit make files or run programs on a command-line interface. Although building on command-line is possible if required with some third-party tools such a Ino.

The Arduino IDE comes with a C/C++ library called "Wiring" (from the project of the same name), which makes many common input/output operations much easier. Arduino programs are written in C/C++.

This is where code to program our microcontroller is edited, compiled and loaded into the microcontroller.

Google Maps.

Desktop and mobile web mapping service application and technology provided by Google, offering satellite imagery, street maps, and Street View perspectives, as well as functions such as a route planner for travelling by foot, car, bicycle (beta test), or with public transportation. Also supported are maps embedded on third-party websites via the Google Maps API, and a locator for urban businesses and other organizations in numerous countries around the world. Google Maps satellite images are not updated in real time; however, Google adds data to their Primary Database on a regular basis. Google Earth support states that most of the images are no more than 3 years old.

Google Maps will help in decoding location data (latitude and longitude) to place names and help to plot them on the map.

Budget.

Resource	Cost (Kshs)
Journals/ Research papers	5000
Internet sources	500
Arduino Uno R3 microcontroller.	1500
SIM 808 with GPS and GSM modules.	2600
Power supply (Size AA Battery holder and three dry cell batteries)	300
LED	5
LCD (16X2)	500
Connecting Wires	300
Software (Google Maps, Arduino IDE and Android Studio)	Free
Total	10705

Table 3: Project Budget.

Conclusion.

This research notes the increased demand for vehicle tracking systems for tracking the theft of vehicles through GPS and GSM technology. This system can be used for both personal and business purposes to improve safety and security, communication, and performance monitoring. Vehicle tracking systems have become increasingly important in large cities and are more secured than many other systems. Nowadays, vehicle theft is rapidly increasing. With this technology however, vehicle theft can be better controlled. This technology can also help to advance transportation systems, and can be used in many organizations for security and tracking purposes.

The product designed is user-friendly, anyone with little knowledge of using a smartphone can use the system. It is easy to install the system in the vehicle and it requires low maintenance. The coordinates received show the correct location on the Google Map using the Android app. Also, the size of the device is compact since the GSM and GPS modules are not present as separate module.

References.

1. Bett, H. K. (2012). GPS tracking technology adoption in the motor vehicle insurance sector in Kenya (Doctoral dissertation, University of Nairobi, Kenya).
2. Bharath, C.H., Kumar, P.V.,Reddy, P.A. &Abishek, B. (2013). Vehicle tracking system using GSM and GPS (SAGAR Institute of Technology).
3. Baburaokodavati, V.K Raju , S.SrinivasaRao, A.V Prabhu, Dr. Y.V Narayan GSM AND GPS BASED VEHICLE LOCATION AND TRACKING SYSTEM, www.ijera.com(Magazine)
4. Abid Khan ,Ravi Mishra, GPS-GSM based tracking system, International journal of engineering trends and technology-Volume 3Issue 2-2012
5. Marchet, G., Perego, A., & Perotti, S. (2009). An exploratory study of ICT adoption in the Italian freight transportation industry. International Journal of Physical Distribution & Logistics Management, 39(9), 785-812.
6. Ambade Shruti Dinkar and S.A Shaikh, Design and Implementation Of Vehicle Tracking System Using GPS, Journal of Information Engineering and
7. Applications, ISSN 2224-5758, Vol 1,No.3, 2011.
8. Asaad M. J. Al-Hindawi, Ibraheem Talib, “Experimentally Evaluation of GPS/GSM Based System Design”, Journal of Electronic Systems Volume 2 Number 2 June 2012.
9. Sonawane, S. GSM and GPS based Real Time Vehicle Tracking System.

10. Dhup, A. Vehicle tracking using the Global Positioning System and the global system for mobile technology.
11. Vehicle tracking system. En.wikipedia.org. (2020). Retrieved 23 November 2020, from https://en.wikipedia.org/wiki/Vehicle_tracking_system.
12. Software Engineering | Iterative Waterfall Model - GeeksforGeeks. (2020). Retrieved 23 November 2020, from: https://www.geeksforgeeks.org/software-engineering-iterative-waterfall model/#:~:text=The%20iterative%20waterfall%20model%20provides,from%20the%20classical%20waterfall%20model.&text=When%20errors%20are%20detected%20at,by%20programmers%20during%20some%20phase.
13. Vehicle Tracking System Based on GPS and GSM. (2020). Retrieved 23 November 2020, from https://create.arduino.cc/projecthub/muchika/vehicle-tracking-system-based-on-gps-and-gsm-57b814
14. Arduino Uno. (2020). Retrieved 23 November 2020, from https://en.wikipedia.org/wiki/Arduino_Uno
15. SIM808 | SIMCom | smart machines, smart decision | simcom.ee. (2020). Retrieved 23 November 2020, from https://simcom.ee/modules/gsm-gprs-gnss/sim808/#:~:text=SIM808%20module%20is%20a%20complete,to%20develop%20GPS%20enabled%20applications.
16. Aqeel, A. (2020). Introduction to Arduino IDE - The Engineering Projects. Retrieved 23 November 2020, from https://www.theengineeringprojects.com/2018/10/introduction-to-arduino-ide.html
17. Information, U., & System, T. (2020). The Advantages of GPS Tracking System | GPSWOX. Retrieved 23 November 2020, from https://www.gpswox.com/en/blog/useful-information/the-advantages-of-gps-tracking-system