

Improved Fleet Management System Using Global Positioning System

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Faculty of Natural and Applied Sciences, Lead City University, Ibadan, Oyo
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Certification

This is to certify that Dajah Vincent ALI with matriculation number LCU/PG/002213 carried out this research work titled “Improved Fleet Management System Using Global Positioning System” in the Department of Computer Science, Faculty of Natural and Applied Sciences, Lead City University, Ibadan, Oyo state, for the award of Master of Science (MSc) in Computer Science and that this has not been previously submitted.

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Dedication

This research work is dedicated to God almighty who makes all things possible.

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Acknowledgement

Numerous institutions, organization and people supported my effort on this thesis. First, Lead City University with its conducive learning environment and the supportive library services. Secondly, I wish to thank and acknowledge Nigerian Breweries plc whose vision is 'winning with Nigeria'. The company really demonstrated this commitment with immeasurable support and access to information needed to make this research work a success.

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Though above-mentioned institutions and persons have assisted in the process of this research work, I alone stand responsible for the errors, if any, found in the work.

Abstract

The overall use and purpose of the improved fleet management system is the computerized management of fleet and other vehicular equipment. This is done to eliminate the use of manual system that rely on the use of books and manual documentation. The aim of the study is to develop a database that will be used to capture and store users' data, trucks and vehicular equipment data. To develop a web application interface that will track trucks and drives in real time and to able to view users' profile, trucks and other information and will be able to run reports from the system, develop a real time tracking and monitoring algorithm, also to be able to use the system as comparative measure to analyze existing systems. Methodology used was a web application developed using HTML, CSS and JavaScript for the front-end, while PHP was used for the server side. Also, flutter was used to develop the mobile application which runs on an android device that will be resident with the person operating the vehicle or truck. After successful development, quality testing was conducted on all unit of the project and system was tested for throughput and response time. The system was simulated for system behavior when multiple users are using the system at a time, and the average response time is 134ms for 25 users at a time. In conclusion, this system will be of great benefit to organizations that manages large fleet of trucks or vehicles for their operation, general recommendations are for such organizations or government agencies to adopt the use of a fleet management system and government at all levels to enforce the use of this system.

Keywords: Fleet management system, web application, HTML, CSS, JavaScript,

GPS

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List of Acronyms

Abbreviation	Meaning
AGPS	Assisted-GPS
AVI	Automatic identification of vehicles
AVL	Automatic vehicle location
BDS	Bei Dou navigation satellite system
CAN	Controller area network
ECU	Electronic control units
EDI	Electronic data interchange
EDI	Interchange of electronic data
ETSI	European telecommunications standard institute
FEI	Front-end intelligence
FMS	Fleet management system
IDS	Intrusion detection system
GEO	Geosynchronous earth orbit satellite
GIS	Geography information systems
GPRS	General packet radio service
GPS	Global positioning system
GSM	Global system for mobile communications
GUI	Graphical user interface
ICT	Information and information technology

IGSO	Inclined geo synchronous orbit satellite
KLOC	Line of codes
LIT	Logistics information technology
MAS	Multi-agent system
MVC	Model view controller
NMEA	National marine electronics association
PAN	Personal area networks
POI	Points of interest
RFID	Radio frequency identification
SMS	Short message service
WAN	Wide area network
WSN	Wireless sensor network

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Chapter One

Introduction

1.1 Background to the Study

Both transportation and logistics are critical components of a thriving economy. Governments and business organizations throughout the world attempt to boost their competitiveness by developing or replacing infrastructure. The transport and logistics sector contributes significantly to the global economy and to the national and local economies of any country or establishment. This sector underlies all economies, whether public or private, by facilitating the efficient flow of products, services, and people. The growth in the accompanying management needs for vehicle fleet operations has been more significant than the rise in human mental capacity as vehicle dynamics and design technology progresses yearly³.

Transportation is crucial to logistics because it entails the conveyance of goods among sites in a supply chain. End users expectations are high, and there is minimal tolerance for substandard performance, creating a competitive climate for fleet operators, compelling them to attain high degree of dependability and cost-effectiveness. Currently, it is of great advantages for government and non-governmental organizations to maintain a sizable fleet of vehicles, as this increases the efficiency and equality of opportunity for support activities. Nonetheless, managing big fleets cannot be easy for field logisticians³.

Fleet transport is the transfer of commodities of all types from origin to destination using the best available mode(s) at the lowest possible cost, with the least amount of delay, and with the least amount of risk in order to meet transportation demands. A sustainable fleet management strategy seeks to minimize ecological

effects through the use of cleaner vehicles and fuels, fuel-efficient operation and driving, and reducing the amount of road traffic caused by the fleet⁴. The fleet saves money on gasoline and vehicles, enhances employee safety and welfare, and minimizes its carbon impact, especially in developing nations. During emergency and development activities, the fleet fulfills a variety of functions⁴. For some firms, managing their vehicle fleet is the primary activity in their value chain and serves as their primary asset for providing their service. This is true for passenger transportation businesses, ground shipping, automobile rentals, rental firms, taxicabs, mail services, and city council-provided cleaning and trash collection. Other firms view it as a complement to their primary activity or as a bonus, such as a car, given to its executives for personal use. This is true for businesses with sales personnel (pharmaceutical sector, information technology services, etc.), as well as airports, supermarkets, and nongovernmental organizations³.

In Nigerian breweries, fleet transport services face a number of challenges, including inefficient, unreliable, slow, and unskilled fleet transport operators, a lack of security, an increase in operation costs, and a cumbersome manual paperwork procedure. To modernize fleet transportation and maximize the capacity of fleet transport operators, to reduce fleet transportation costs, to ensure efficient, reliable, and competitive fleet transportation, and to eliminate time-consuming and cumbersome paper work, the multinational company's management has taken drastic measures to implement an automated fleet management system.

As globalized goods trade grows, the need to track goods transport and deployed vehicles during their operations is increasing. Compliance reporting, for example, requires fleet managers to provide safe and accurate records about their equipment and goods traffic. International vehicles can travel in large numbers and

for a variety of reasons all over the world. To correctly fulfill the technology requirements of a delivery process, much information is needed in real time between Fleet Management System (FMS) operators' clients, drivers, and others⁵.

The global positioning system (GPS) and global system for mobile communication (GSM) technologies are also common network networks available to Fleet Management (FM) systems. GSM technology has grown in popularity because of its low cost and ease of use in transmitting data with high reliability over existing networks⁵. The Global Positioning System (GPS) is a global navigation satellite system that provides place and time information to people all around the world. Both systems are extremely effective at tracking, routing, and providing real-time fleet management⁶. Human errors ranging from inefficient routing choices to unintentional traffic accidents present a chance to significantly increase a business's revenue⁷. Software adheres to the system's design with minimal time lost; consequently, as long as the design is feasible, fleet management's overall performance improves. Among the notable benefits that require software to operate efficiently are real-time fleet tracking and analytics, automated route planning, and a centralized base of operation⁷. The capacity of a human being to multitask is restricted to a few tasks and comes at the expense of focus. A person driving a car while on the phone considerably increases the risk of an accident by slowing reaction times in unexpected circumstances. However, an autonomous vehicle continuously reads data from all implanted sensors, communicates the vehicle's current statistics to the operation center, and receives real-time orders without the chance of human error. Human faults may nevertheless manifest themselves in other ways, such as software flaws⁸.

In practice, the transition to autonomous fleet management will result in improved reaction times, significant cost savings, and dramatically reduced idle time⁷.



Figure 1.1 Different aspects of fleet-management

(Source: Hermanni Qvintus, 2019)

Several monitoring and tracking technologies have recently been developed to assist companies with vast fleets of transportation. A Fleet Management System (FMS) is necessary to maximize the expense and commitment required by staff and infrastructure in order to complete the whole operation effectively and in the shortest amount of time possible⁵. Assignments may also be planned ahead of time depending on the position of tracing vehicles. As a result, central fleet management is critical for major businesses to satisfy the varying and rising needs of consumers while still increasing efficiency. However, existing implementations do not adequately protect all FMS individuals (driver, car, mobile, and goods), and the system's open communication routes make it vulnerable to a wide range of attacks⁵. Large areas of security gaps exist in such a geographically distributed system, such as the injection

of falsified data and, in particular, the faking of vehicle and goods position information. Misconduct in terms of incorrect status facts has the potential to disrupt the whole procedure⁵. An assailant moving an operation-relevant mobile device to the wrong car, for example, could disrupt the fleet management process and misuse the whole system. Furthermore, even though an authentication process is added to the fleet management mobile, the vehicle identification number can also be forged. Through the use of technology and a low-cost sensor that can monitor its own location as well as monitoring any movements, impacts, and operating status, the proposed system ushers in a new period of fleet management in the multinational company.

A fleet management system is used to keep track of all types of vehicles, including cars, buses, trucks, boats, helicopters, ships, and rail cars. It can be used for car servicing, vehicle monitoring and diagnostics, optimizing driver performance, speed control, and fuel management, among other things¹. Fleet management is a function that helps businesses that rely on transportation to eliminate or reduce the risks associated with vehicle expenditure, while also increasing reliability, competitiveness, and lowering total transportation and personnel costs, while also ensuring 100% compliance with government regulations and much more. An in-house fleet management department or an outsourced fleet management contractor can do these duties¹. Fleet management refers to the use of a group of vehicles to deliver a service to a third party or to conduct an operation within an organization in the most effective and sustainable way possible while maintaining a defined level of service and expense. Transportation and logistics are important in operations research because they are at the center of human endeavor and support the majority of social and economic life. Studies also facilitated the development of many models and algorithms that have been applied to a number of other research and technological

fields over the years. Transportation, or fleet management, is a complex set of operations spanning many stakeholders and decision-making stages, as well as risks and large capital investments. This industry must focus on vast volumes of data, advanced models and optimization methods, as well as strong computer and information technologies to sustain and stay competitive in today's business world. The richness of possibilities in research areas, models, processes, and software reflects the diversity and complexity of the field of fleet management and logistics.

Fleet management is described as the control and improvement of a transportation fleet's efficiency². This involves the management of vehicles such as cars, aircraft, buses, and trucks. When it comes to fleet operations, a variety of tasks are taken into account, including car finance, vehicle servicing, vehicle telematics, driver changing and rostering, asset monitoring, pace management, fuel management, and health and safety management. The primary goal of fleet management is to reduce the risks associated with vehicle service, reliability, and competitiveness while also lowering transportation and staffing costs.

Both transportation and logistics are critical elements of a thriving economy. Non-governmental and government organization all over the world are looking to improve their sustainability by building or replacing infrastructure³. In every region, the transportation and logistics sector plays a critical role in the global economy and contributes significantly at both the national and local levels. This industry supports the economy by facilitating the productive flow of goods, resources, and individuals. As advancements in the technologies of vehicular dynamics and construction grow year after year, the related management needs of vehicle fleet operations have become more relevant than human mental capability³. Transportation is the actual transfer of goods from points in a supply chain, and it is at the heart of logistics. Customer

demands are strong, and there is no tolerance for poor service, creating a demanding atmosphere for fleet managers to maintain high levels of productivity and cost-efficiency³. Nowadays, having a large fleet of cars is advantageous for both public and non-governmental organizations, since it increases the reliability and equality of service operations. Nonetheless, logistic managers in the sector would find it difficult to control huge fleets and their operations. For certain businesses, car fleet maintenance is the most important operation in their supply chain, as it is their most valuable tool in providing services. This will apply to passenger transit providers, land shipping, auto rentals, leasing companies, taxicabs, postal systems, and garbage disposal. Some companies use it as a supplement to their core operation, or as a gift, such as a car, granted to their executives for personal use

1.2 Statement of the Problem

In most organizations, the fleet management systems that are currently available are manual systems in which users keep ledgers, books, and other records to preserve information such as vehicle or truck descriptions, location, booking details, vehicle or truck demands, permits and reports. In many Nigerian companies, the issue of fleet management system is at infant stage, since many of these companies are profit - making company, they have to rely on third-party logistics companies to supply their goods, which comes at a cost. Using these trucks with a manual system has been time consuming, slow, unreliable and problematic because the location of the trucks, fuel consumption, mileage, maintenance and the drivers has been a point of contention between the logistics company and their host companies, as well as distributors of what the company's goods to some extent. Improving this system would provide mileage to many companies, statistics and measurements to indicate

lapses in the logistics business, real time information of the goods and truck location, allowing them to debit the third-party contractors for any act that breaches the contract arrangement with their drivers.

Many reports have emerged of hijacked trucks, driver manipulation and suppression of paperwork, bribery and fraud as a result of manual system, inadequacy of trucks coverage in remote areas where there is no mobile telecommunication coverage which has resulted in time wasting, lack of valuable documents and records, and revenue loss, among other things.

To avoid such occurrences, it is necessary to create an integrated fleet management system that will meet the needs of a typical management of vehicle descriptions, vehicle location, personnel, expenditures, real-time tracking, and fleet reporting in the organization, as well as a booking option, and provide an automated interface to users to handle everyday transactions. This research work has derived the need to address the gaps seen from previous work.

From past antecedents, it is confirmed from other automated systems that uses GPS for tracking and monitoring fleet that people have a way of deviating and manipulating the system for dubious purposes. These are the reasons and motivation for this research work.

1.3 Aim and Objectives of the Study

The aim of the research is to develop an improved fleet management system using dual GPS system and real time monitoring algorithm.

The specific objectives include:

- i. design a database for fleet management to reduce the manual effort needed to manage transactions in a company.

- ii. develop a user interface to see vehicle information, car bookings, profile management, repair and maintenance schedules, expenditure information, daily reports, and feedback
- iii. develop a real time tracking and monitoring algorithm.
- iv. comparative analysis of the proposed system with currently available systems

1.4 Significance of the Study

The study focused primarily on developing a fleet management system and evaluating the effects of fleet management technology on companies that make use of large fleets of vehicles in comparison to manual techniques that may be in use. This research will be significant for both public and private organizations, particularly multinational organizations, which operate a large number of third-party logistics services throughout the country. Additionally, this study will primarily fill a gap by assessing existing fleet management systems, analyzing their contributions, and identifying the major challenges associated with fleet management services.

Also, the study is expected to contribute to the organization's fleet management system improvement by identifying and resolving detected difficulties, and this study may serve as a catalyst for other researchers to do additional research on fleet management. Beneficiaries of this study include the Federal Ministry of Transport, public and private freight operators, fleet management service providers, transportation policy makers, and researchers.

In general, the study's findings and recommendations may aid Nigerian breweries in making informed decisions on how to improve or address existing fleet management gaps.

1.5 Scope the of Study

The scope of this project will cover the logistics department of the Nigeria Breweries PLC, Ibadan. Nigeria breweries is founded 16th November, 1946, headquartered in Lagos which is the pioneer and largest brewing company in Nigeria. It serves the Nigerian market and export its product to other African countries and beyond, the company has created significant presence in Europe and the United States of America. Although this study will utilize a variety of diverse literatures, data analysis tools, and design techniques, it will have its own limits that should be discussed in order to pave the way for future research.

The first drawback of this study is its inability to generalize its findings; the findings of the study may not be relevant to a larger population because it will be confined to a particular organization and a small sample size. Another significant barrier will be the scarcity of primary and secondary sources on fleet management and fleet efficiency.

1.6 Limitations of the Study

Although this study will utilize a variety of diverse literatures, data analysis tools, and design techniques, it will have its own limits that should be discussed in order to pave the way for future research.

The first drawback of this study is its inability to generalize its findings; because it will be limited to a single organization and a small sample size, the study's findings may not be applicable to a broader population. Another significant barrier will be the scarcity of primary and secondary sources on fleet management and fleet efficiency.

Also access to funds is another limitation of this study, for example the project work utilize the use of map API and it would have been much more easy and more visual if google map API was used for this project. But google map API cost about forty-five dollars per one thousand requests, and this project will be able to send and receive over ten thousand requests in a single trip. So, an open-source map API will be used for this project.

1.7 Operational Definition of Terms

Nigerian Breweries: A multinational company, an operating company under the Heineken group that operate in Nigeria, it produces both alcoholic and non-alcoholic beverages

Freight Transport: Freight transport covers the movement of goods of all kinds from origin to destination using the best available mode with least cost, timely delivery and minimum risk to satisfy transport demand.

GPS Tracking: This is a device that uses Global Positioning System to determine and track precise location.

Fleet Management System: This is a technologically advanced method of remotely tracking of vehicle and also for monitoring

Freight Operators: Is any one that has a competency assurance license to give a freight transportation service registered as a company

Fleet Management: is an administrative technique that helps businesses to organize and coordinate their work vehicles in order to increase productivity, lower expenses, and comply with government laws. Fleet management comprises following and recording mechanical diagnostics and driver behavior, and is most typically used for vehicle tracking.

Vehicle Tracking System: combines the use of automated vehicle location in individual cars with fleet data collection software to provide a complete picture of vehicle whereabouts.

Vehicle Repair and Maintenance: involves maintaining, repairing, and replacing of necessary devices, equipment, machinery, building infrastructure, and supporting utilities in industrial, business, governmental, and residential installations.

Fuel Management Systems: systems are used to maintain, regulate, and monitor fuel use and stock in any industry that employs transportation as a mode of transportation, such as rail, road, water, and air.

Intelligent Transport System: This are integrated information technologies for monitoring and influencing a transportation system through direct control.

Truck: A vehicle constructed for use and used primarily for conveyance of goods.

1.8 Outline of the Thesis

The research work is structured into five chapters. The first chapter gives an introduction to the thesis, this encompasses the background to the study, statement of the problem, aim and objectives, significance of the study, scope of the study, limitation of the study as well as the operational definition of terms. The second chapter, which is the literature review, gives an in-depth overview of the concepts that relate to this work, it also presents a review of previous work done by other researchers in this field. The third chapter, research methodology, gives an insight into how the work was implemented, the methods and software adopted. Implementation, the fourth chapter, presents the implemented work, giving explanations on how the applications and databases function. Lastly, chapter five

gives a brief summary of the entire thesis work, what the study has contributed to the field of knowledge and also recommendation.

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Chapter Two

Literature review

2.1 Conceptual Framework

Fleet management is a function that enables businesses that depend on conveyance to eliminate or eliminate risks relating to vehicle investment, increase efficiency and productivity, reduce overall transportation and staff costs, and ensure compliance with all applicable government regulations (duty of care), among other things. These activities can be handled internally or through an outsourced fleet management provider¹. The proactive management of an organization's vehicle assets, which may include light automobiles, heavy trucks, specialist vehicles, and motorcycles, is known as fleet management. It encompasses a variety of activities, including vehicle acquisition and finance, vehicle maintenance, telemetric (tracking and diagnostics) vehicles, driver and staff management, speed and fuel management, and health and safety management¹.

Commercial companies have developed automated control systems and various approaches to vehicle management in recent years to solve fleet management challenges and the ever-growing requirement to monitor vehicle utilization. Simple management systems can be developed in-house for internal usage in order to offer accurate analysis of vehicle and driver performance. Fleet management systems are organized in such a way that data on different elements of fleet utilization, maintenance, and operations may be collected. For example, distances traveled; destinations reached; miles traveled per vehicle (including official and private

mileage); fuel consumption; repair and maintenance per vehicle; rate of spare component consumption; and scheduled and completed service are just a few examples.

2.1.1 Fleet Management Software's Advantages

On a worldwide scale, management and planning, as well as control and monitoring of different transportation-related activities, are now seen as vital, since they can lead to further economic, social, and even political growth. The following are some of the benefits of this system¹.

- i. Fuel consumption management for vehicles based on daily, monthly, and annual reports for a specific vehicle or group of vehicles.
- ii. Effective and precise fleet management, enhanced surveillance capabilities, and a common web browser such as Mozilla Firefox or Google Chrome.
- iii. Improved system efficiency and significant cost savings in comparison to conventional operator-based supervisory systems.
- iv. Receiving precise information about the vehicles' performance and operation
- v. Improve the system's efficiency in managing fleets
- vi. Notable reduction in driving violations while in service.
- vii. Improve customer satisfaction and transparency in the workplace.
- viii. Evaluation of affiliated organizations' performance
- ix. Within executive organizations, standardization of implemented concepts and forms with the goal of correcting current techniques and preventing subjective trends in the administration of diverse processes.

Businesses must operate at peak efficiency, provide prompt customer service, and still earn a profit in today's competitive marketplace. Thus, in light of these realities, it is frequently critical for business owners to identify areas for cost savings¹.

Three distinct ways exist for ICT systems to impact competition in the logistics sector. To begin, ICT systems have the potential to alter the structure and even the rules of competition in the logistics industry. This is because ICT systems enable the delivery of new value-added services that were previously unavailable through paper-based administration. Additionally, ICT systems increase efficiency and effectiveness, which improves a company's competitiveness. Second, information and communication technology (ICT) may be leveraged to create a long-term competitive advantage and provide enterprises with new competitive instruments. Third, ICT solutions do not need to change existing processes; rather, they should make them easier to execute inside the current business model¹.

Typically, technology is the catalyst for such breakthroughs. Those who manage fleets or a mobile sales force, as well as those who provide field service, face numerous challenges. These obstacles include enhancing compliance and organizational communication, as well as cost reduction and increased customer satisfaction. As a result, fleet management systems are judged on their ability to benefit businesses through increased efficiency and profitability. In today's knowledge-based economy, transport firms face their greatest challenge in addressing the current situation and capturing a competitive advantage. Increased market competence is a significant factor driving the adoption of new technologies and innovation, as businesses look for new ways to reduce costs through process optimization or product development¹.

2.1.2 Vehicle Tracking and Management

Apart from anti-theft purposes, vehicle tracking is most frequently used in logistics and transportation. These systems utilize GPS technology to provide an

individual fleet manager with precise and consistent location telemetric. Typically, these systems include features that allow for the monitoring of statistics such as fuel consumption, average speed, current driver time, and location. Demand for this technology has increased in recent years as regulations restrict the number of hours a driver can work in a given day. It is limited to nine hours per day at the moment. Businesses are required by law to install tachographs in all vehicles expected to transport goods. Many have attempted to cauterize this potentially onerous obligation by recasting it as a benefit. GPS is incorporated into fleet management systems. Similar to other types of trackers, but with more extensive diagnostic features due to their nature.¹

2.1.3. Fleet Management's Crucial Operational Stages

The approach to fleet operation bears numerous parallels to the management process of any operation established to meet a specific service need. The critical stages of operation are awareness of the service level agreement's requirements, creating a strategic plan to accomplish that goal, understanding the external pressures that may affect the operation's ability to deliver the service, as well as selecting or reviewing the assets, equipment, buildings, and systems used to deliver the service, as well as the staff required to make the operation work, managing the operation actively to ensure maximum efficiency on a daily basis, monitoring performance and incorporating lessons learned from similar operations; revising and amending the strategic plan in light of measured performance, changes in service demand, available resources, and other factors, initiating a continuous improvement process¹.

Minimizing fuel usage and increasing vehicle utilization are two methods that may be utilized to improve fleet management operational efficiency while still fulfilling service standards¹.

2.1.4 Operations, Maintenance, and Repair

The process of maintaining, repairing, and replacing devices, equipment, machinery, building infrastructure, and supporting utilities in industrial, corporate, governmental, and residential installations is known as maintenance, repair, and operations². This process has evolved over time to frequently include both scheduled and preventive maintenance as cost-effective practices. More recently, 'predictive maintenance' has been implemented, which monitors a system using sensor data and then compares it to historical trends in order to predict failures before they occur. Aircraft maintenance, repair, and overhaul services can include inspection, rebuilding, alterations, and the provision of spare parts, accessories, raw materials, adhesives, sealants, coatings, and consumables for aircraft manufacture and maintenance, repair, and overhaul. Scheduled or preventive paint maintenance programmers are used by marine transportation, offshore structures, industrial plant/equipment, and commercial facilities to maintain and restore coatings applied to steel, concrete, and masonry assets in environments prone to erosion, corrosion, and pollution¹.

While vehicle maintenance policies are primarily driven by safety concerns, it is critical to keep in mind that standards also affect vehicle performance and fuel consumption. Turbochargers, fuel injection systems, tire pressures, axle alignment, and oil and lubricants are just a few of the factors that affect fuel consumption and

should always be maintained to strict standards. It is critical to remind drivers that they are responsible for performing daily vehicle walk-around checks. This not only helps maintain legal road worthiness for vehicles, but also assists in identifying common problems such as oil and water leaks and incorrect tire pressure. Additionally, there is opportunity to improve the operation of maintenance facilities¹.

2.1.5 Tracking System for Vehicles

To produce a complete picture of vehicle whereabouts, a vehicle tracking system integrates the use of autonomous vehicle location in individual cars with fleet management software. While GPS technology is used by most current automobile tracking systems to find the vehicle, other forms of autonomous vehicle location technologies may also be used. Vehicle data is available on the Internet or through specialized software on electronic maps. Vehicle monitoring technologies are becoming increasingly popular among urban public transportation agencies, particularly in major cities¹.

Fleet operators typically utilize fleet tracking systems to manage fleet operations including tracking, routing, dispatching, on-board information, and security. Certain vehicle tracking systems are connected with fleet management software or interact with it. Urban transit agencies, like commercial fleet operators, use the technology to monitor bus schedule adherence, automatically change the destination sign displays on buses as they approach the bus terminus (or another predetermined location along a bus route, such as a specific bus stop), and trigger pre-recorded (or emailed) messages, among other things¹.

GPS vehicle tracking has grown in popularity among fleet owners as the technology has become more affordable and accessible. GPS vehicle tracking, in

general, makes use of a space-based global navigation satellite system to keep track of the time and location of fleet cars. This data is subsequently transferred to a remote user, who may monitor the vehicle's location, speed, routing, idle time, and engine start-up and shutdown, among other parameters. This data can be utilized to optimize a variety of fleet management processes, including fuel cost reduction. On average, fleets with GPS tracking save 13% on fuel costs³. Vehicle maintenance is a critical but difficult activity, especially if you do not have a comprehensive maintenance solution. To regain control of your fleet's maintenance, the first step is to assess your choices. You might go for a software that is solely dedicated to maintenance or for GPS tracking software that includes a maintenance module. GPS tracking is a superior solution because it not only enables maintenance monitoring, but also provides total visibility into your fleet via location intelligence for all your cars and heavy equipment. You can enter any type of service based on distance, run time hours, or dates using custom maintenance platforms, such as the GPS Insight Maintenance Module. Reminders for maintenance can be delivered directly to your team or displayed on the tracking software's dashboard³. The range of goods trucks operated is quite wide, as are the activities for which they are used.

2.1.6. System of Fuel Management

Fuel management systems are used to control, monitor, and maintain fuel use and stock in any industry that relies on transportation, including rail, road, water, and air. Fuel management systems are used in the transportation and construction industries to accurately assess and manage fuel use. They are commonly used for fleets of vehicles, such as railway and aviation vehicles, as well as any vehicle that requires gasoline to operate. They monitor and measure gasoline inventories, fuel

purchases, and fuel dispensed using a variety of methods and technology. This data can then be saved in computerized systems and reports generated to aid in management decision-making. Online fuel management is accomplished by utilizing web portals to offer detailed fueling data, which is often the back end of an automated fuel management system, this permits the regulation of fuel consumption, cost analysis, and tax accounting¹.

Fuel management systems come in a variety of configurations, typically, card-based fuel management systems track gasoline transactions using a fueling credit card and the driver's PIN. Reports can then be prepared depending on driver-specific fuel use, and data can be downloaded directly. On-site fuel management systems may make use of fleet refueling or bulk fuel storage on-site. Fuel is monitored as it is injected into cars, and storage levels can be adjusted on-site. Certain fuel firms provide total fuel management systems, which include aspects of a card-based system in addition to on-site fuel delivery and refueling. Mobile fuel management is a term that refers to a fleet of fuel trucks or tankers that supply gasoline to commercial truck fleets or construction equipment.

The growing usage of biofuel has added another layer of complexity to fuel management. There is a risk of microbial development with increased water content - depending on the storage circumstances, the fuel quality will decline with time, resulting in clogged filters and decreased productivity¹.

While service delivery and road safety are critical for fleet operations, fuel is a resource that must be properly managed. While fuel consumption varies significantly between public and private sector fleets, it remains a significant cost in the majority of situations. Fuel can account for 30% or more of overall operating expenses in certain operations¹. Establishing a structured fuel management program is a highly successful

means of achieving long-term cost reductions in operations. Given the scale of many sectors' fleets, even a small reduction in fuel use can result in annual savings of thousands of pounds and CO2 emissions reductions of several tons¹.

The term "information and communication technology" refers to technologies that enable the recording, processing, retrieval, and transmission of information or data⁴. ICT is a collection of technologies that enable the communication and cooperation of human beings and their organizations" as well as the "creation and exchange of knowledge⁴. Additionally, ICT is a collection of technologies that enable the gathering, exchanging, and storing of data. ICT encompasses a variety of electronic digital and analogue devices such as radio, television, fixed and mobile telephones, computers, electronic-based media such as digital text and audio-video recording, and the internet, but excludes non-electronic technologies⁴.

Additionally, some researchers define ICT as an umbrella term that encompasses computer hardware and software; digital broadcasting and the internet⁴. In recent years, businesses have seen an increased requirement for tighter cost control as well as an increased desire for larger returns. The use of ICT to create a competitive edge has become a critical strategic issue for organizations in a rapidly globalizing world⁴, owing in part to the fact that ICT plays a strategic role in organizational management. This suggests that ICT has the potential to benefit an organization. There are numerous opportunities for ICT applications in transportation and logistics, and numerous studies have identified numerous types of applications, each of which contributes uniquely to the transportation and logistics system⁶. ICT, often referred to as logistics information technology (LIT), can account for a significant portion of an organization's investment and includes hardware and software costs related with logistical tasks such as ordering, warehousing, inventory,

and transportation management. Electronic data interchange was the first application of ICT in the mid- to late-1970s (EDI). This facilitated the development of a novel method of chain management as a prelude to the development of numerous e-commerce apps.

E-commerce is any sort of economic interaction between two parties that is conducted electronically and includes the exchange of information. However, the high cost and lack of standardization of e-commerce applications hampered implementation to the extent that only major organizations could afford such technologies⁴. During this time period, numerous hardware and software applications were developed. These apps sought to improve infrastructure, traffic and fleet management, as well as to facilitate the effective tracking of commodities across transportation networks and to connect enterprises and government agencies⁶.

Radio frequency identification (RFID) has established itself as an effective, autonomous data collection and identification technique. The primary information technology applications accessible to freight transportation organizations are classified as follows: a) transportation fleet and freight management, b) supply chain execution, and c) field force automation.

According to a poll of consumers' opinions of the impact of new technologies on the functioning of urban distribution systems, the use of ICT is projected to lower the share of empty and partially loaded vehicles. When combined with logistical advances, advancements in e-economy technologies may result in changes to load factors. On the other hand, the employment of technology instruments may result in an increase in the number of urban small car trips. ICT is critical in today's knowledge-based economy, and as a result, organizations rely heavily on ICT solutions to thrive and grow businesses⁷. The revolution in the usage of ICT has had a

major effect on economic and social development, pervading virtually every element of human life⁴.

ICT is widely used, and ICT is viewed as a necessary instrument for the efficient management of any organization and the supply of services to clients. ICTs are being incorporated into business processes, organizational structures, and products across industries, governments, and communities. The usage of ICT expands the supply of information, as ICT plays a critical role in the sharing and distribution of information. ICT eliminates geographical and temporal limits on accessing necessary information flows. Additionally, ICT lowers the cost of production by enabling knowledge to be produced, transmitted, accessed, and shared at the lowest possible cost, while also lowering the degree of inefficiency and uncertainty by enabling businesses to interact more efficiently⁴. The use of ICT in many organizations has aided in lowering transactional costs and overcoming distance constraints through curation. ICT enables buyers and sellers to exchange data and move commodities across national borders, hence increasing access to global supply chains⁷.

Additionally, ICT has increased organizational transparency by enabling networking and information exchange, which results in increased demands for openness and transparency in organizational communication and adaptability. At the moment, widespread usage of ICT is transforming the way people and businesses operate. According to researchers, ICT is a critical tool for innovation in the modern day. ICT benefits include input cost savings, overall cost reductions, increased flexibility, and improved product quality⁶. ICT enables organizations to improve their production processes by reducing the number of supervisors necessary in the process through the use of monitoring technology. Additionally, ICT use has direct

consequences for businesses, as ICT is used in areas such as information collecting and distribution, inventory management, and quality control.

More precisely, ICT applications for transportation fleet and freight management have been defined as decision support tools for transportation planning, optimization, and execution. Applications assist planners in determining the best mode of transport, managing freight consolidation processes, and coordinating company shipments. Additionally, they can be utilized as reporting tools for logistics managers that require information on vehicle travel times, service times, and visited delivery places. Supply chain management programs are used to control and automate the movement of items throughout the transportation process and its various stages. They specifically assist information-exchange functions. Field force automation technologies offered by mobile technology enable considerable cost savings and customer satisfaction increases as a result of the increased integration between distant work teams and corporate business processes⁸.

It is critical for organizations to function at peak efficiency, deliver prompt customer service, and still make a profit in today's competitive industry. Thus, in light of these facts, it is frequently critical for business managers to identify areas where cost effectiveness can be increased⁴. ICT systems have three unique effects on competition in the logistics business. To begin, ICT systems have the potential to alter the structure of the logistics business and even the rules of competition. This is because ICT systems enable the provision of new value-added services that traditional paper-based administration could not. Additionally, ICT systems result in increased efficiency and effectiveness, which improves a company's competitiveness. Second, ICT may be used to sustain a competitive edge and supply enterprises with new

competitive tools. Thirdly, ICT systems do not have to alter existing processes; rather, they can enhance them.

Typically, technology is the impetus for such breakthroughs. Organizations that manage fleets or a mobile sales team, as well as those that provide field service, face numerous obstacles. These obstacles include enhancing compliance and organizational communication, as well as cost reduction and increased customer satisfaction. As a result, fleet management systems are seen through the lens of their ability to benefit businesses through increased efficiency and profitability. In today's knowledge-based economy, transportation enterprises face their greatest difficulty in addressing the present circumstances and capturing a competitive advantage. Increased market competency is a significant element driving the adoption of new technologies and innovation, as businesses look for new ways to save money by improving process efficiency or producing new products⁵.

The following is a summary of some of the organizational challenges that have been highlighted in the past and present according to numerous researchers, and which technology may help to enhance or even solve:

Satisfied Customers. Without technology, customer satisfaction is frequently extremely low, as human planning systems frequently fail to meet consumer needs, such as delivery windows, on-time delivery, product delivery in acceptable condition, and efficient returns. Customer satisfaction is increased by the usage of ICT, which improves service quality and hence creates new prospects for businesses. ICT enables customers to obtain fast feedback, which enables businesses to respond quickly to client wants and identify new market niches.

Reduction in Profit Margins. With profit margins shrinking, producers are continuously seeking for innovative ways to cut costs in order to enhance overall

profit and secure the survival of their businesses. ICT enables organizations to cut costs while increasing capacities, and it aids in the development of inter-organizational coordination.

Logistics Costs are Prohibitively Expensive. Rather than serving as a support function, the logistics department had become prohibitively expensive. Technology was required to help lower this expense. There is a need to strengthen compliance and organizational communications by recommending that enterprises leverage ICT to boost their service capability in an e-commerce environment.

Existing (Obsolete) Technology is Incapable of Supporting Growth. While some organizations had previously utilized technology, it became clear that present technology was incapable of supporting the expansion that was both wanted and necessary. Not only does the use of current ICT improve general management, but it also enables businesses to overcome the disadvantages of location and space utility in transportation.

Better Reporting. The requirement for enhanced reporting arose to enable management to comprehend and respond to events occurring within their organizations. Organizations must be able to manage information properly. Additionally, they must combine many logistical activities, such as inbound and outgoing transportation, distribution, warehousing, and fleet management, in order to optimize their customers' physical product flows⁴.

Investment in Computer Software and Hardware on a Continuous Basis. It became evident that technological costs were increasing, but with less advantages emanating from the technologies installed. Investment in cutting-edge ICT may be the primary differentiator between cutting-edge and typical logistics firms⁴.

Reporting that is Inefficient and Erroneous. The manual methods were incredibly intricate, and only a select few employees were capable of completely comprehending and utilizing them, leaving the organizations open to manipulation by these personnel. ICTs are critical for logistics providers in terms of cost reduction, business control, and mistake reduction.

Globalization and the development and growth of significant organizations necessitated the creation of systems capable of handling increasingly complicated and huge orders. Thus, the use of ICT can assist organizations in both reducing coordination costs and increasing outsourcing. By leveraging technology, an organization can strengthen its competitiveness by lowering costs and improving service levels. Numerous academics have discovered that integrating ICT enables businesses to increase their supply chain flexibility, resulting in increased agility and, ultimately, greater competitive company performance⁵.

Thus, ICT complements human activities by increasing organizational (or personal) efficiency and effectiveness, facilitating the execution of activities, enabling autonomous decision-making processes, enabling distributive operations, increasing logistics efficiency, increasing transparency for stakeholders, and resulting in the adoption of better business practices to meet customer service standards. In this perspective, we might consider the advantages of a lower-level system in the hierarchy of ICT systems.

2.1.7 Technologies for Real-Time Fleet Management

Real-time fleet management systems can be classified based on their functionality they process in real time. Available work addresses situations in which a fresh client request must be completed within a specified time frame. The previous

decade's systems were capable of accommodating new client requests because they either assumed constant travel times throughout the day or employed simple techniques to change such travel times, including multiplier factors associated with different times of the day. These assumptions, however, were imprecise approximations of real-world conditions, in which travel times vary more subtly over time. These variations may occur as a result of predictable events such as congestion during peak hours or as a result of unpredictable events such as accidents, mechanical breakdowns, and so on. As a result, the ideal solution to the formulation of an urban freight delivery problem under the assumption of constant journey times may be suboptimal or even impossible to implement.

In recent years, the world of fleet management has been transformed by the introduction of new tracking technology. ICTs have established themselves as critical enablers of the integration and alignment of dispersed suppliers, manufacturers, and logistics providers in transportation⁵. Coupled with the embeddedness of ICTs, a proliferation of mobile technologies has recently occurred, adding sophistication to the technology solutions available to complex supply chains.

Mobile technologies such as global positioning systems (GPS), general packet radio service (GPRS), and geography information systems (GIS), when combined with advanced Internet solutions, provide supply chain collaborators with both transparency and more specific information regarding shipment location and traceability, as well as delivery status⁴. Real-time tracking of physical goods enhances logistical performance, cost efficiency, and customer happiness significantly. GPS are satellite-based radio positioning systems that provide 24-hour three-dimensional position, velocity, and time information to suitably equipped users anywhere on the earth's surface⁴. The impact of these mobile technologies is all the more pronounced

on contemporary, sophisticated logistics systems that incorporate multi-tiered suppliers and manufacturers that are globally dispersed. Thus, it is clear that, as global integration and complicated corporate networks continue to grow, it is critical to build network possibilities beyond the confines of internal logistics. This creates both new opportunities and hazards associated with implementing new logistics. Additionally, the following emerging techniques include the following:

2.1.7.1 Automatic Identification of Vehicles (AVI)

Automatic vehicle identification (AVI) is a relatively new technology that has been used in a variety of traffic control and toll collection applications in recent years. An AVI system consists of an in-vehicle transponder (tag), a roadside reader unit, and a central computer system⁴. When a vehicle equipped with a transponder passes a roadside reader unit, the reader unit receives the information on the transponder. Transferrable data may include everything from a vehicle's identification number to toll account balances or trip information. The central computer monitors numerous consecutive reader units and compares them to the transponder identification numbers produced in the central computer system for the purpose of estimating journey times⁵.

2.1.7.2 Automatic Vehicle Location (AVL)

Automatic vehicle location (AVL) is another transportation management technology that is used in a variety of applications. Automatic vehicle location (AVL) enables the location of a vehicle to be determined automatically. This is accomplished by the use of transmitters mounted on a vehicle (on-board telematic devices)⁴. The transmitters enable the location of a vehicle to be determined at regular, if not continuous, intervals. Each vehicle's location is projected onto a vector map. Travel

times can be determined in real-time mode by utilizing data such as the mean velocity and variation of a vehicle. AVL systems are becoming more prevalent in freight fleets as well as emergency and rescue vehicles. AVL encompasses a variety of technologies (both ground-based and satellite-based). GPS is the most widely used satellite technology, relying on orbiting satellites to determine a user's location in real time.

2.1.7.3 Instruments for Electronic Distance Measuring

Integrating an electronic distance measuring instrument (DMI) with the floating automobile approach enables the collection of comprehensive journey time data in a more convenient and secure manner. The electronic DMI's sensor is connected to the transmission of the test vehicle, and the DMI can offer instantaneous speeds up to every 0.5 seconds⁵. This detailed trip time information may be transferred instantly to a portable computer in an easy-to-use data format. A driver-only trip time run is possible with an electronic DMI and a portable computer. This technique gives precise trip time and delay statistics, which is particularly useful for identifying bottlenecks and evaluating intersections⁴.

2.1.7.4 Matching License Plates (Via Portable Computer or Video)

Although license plate matching was used for travel time studies as early as the 1950s, it is now more frequently used to track or identify vehicles in origin destination surveys⁶. Earlier methods relied on observers noting both the license plates of passing vehicles and the corresponding times on paper or into a tape recorder. Later in the office, license plates were manually matched and trip times calculated. However, recent advancements have significantly improved the ease and accuracy of

this technique, and portable computers can now be used to record and match license plates, significantly reducing the time required for data reduction⁸. Video cameras are also used to record license plates, with image processing and computer algorithms used to read the plates automatically and this happens in real time.

2.1.7.5 Tracking Cellular Phones

The growing popularity of cellular phones has permitted extensive use of them for traffic monitoring and travel time prediction⁵. In some regions, cellular phone users can call a dedicated number to report emergencies or accidents. Cellular phones can also be used by motorists to report their locations at designated checkpoints, allowing a traffic operations center to estimate travel times based on multiple cellular phone reports⁴. In the United States of America, mobile systems for vehicle tracking, also known as telematics, comprise an industry worth US\$41 billion by the end of the first decade of the twenty-first century. Road transport logistics is the dominant means of transport in Europe, accounting for 45% of total freight transit. Additionally, road transport logistics outperforms other modes of transport such as sea (41%), rail (8%), inland waterways (4%), and pipeline (4%).

Delivery controls, such as the estimated time of arrival (ETA) and the issue of late running; statistical reporting, such as vehicle and job histories; digital imaging for damaged goods; vehicle defect reporting; driver time reporting; and highways agency data/warnings are all part of the GPS fleet management system implementation process. Mobile tracking solutions can instill greater confidence in both shippers and carriers regarding delivery timelines, thereby overcoming one of the conventional barriers to back loading. Advances in information technology enable real-time re-routing and re-scheduling of vehicles while they are on the road. Operators can then

take advantage of both back loading and load consolidation possibilities that come on short notice⁵. One example of vehicle tracking technologies is the GPS devices used in logistics to track product shipments and storage. Currently, the most common commercial application of the GPS system is to combine it with geographic information systems (GIS) to locate an object on a graphical map or to give it a more meaningful geographical name (e.g., an address). Vehicle monitoring is presently employed in more than a quarter of the United Kingdom's vehicle fleets. Vehicle tracking use is highest in commercial vehicle fleets (30%) and big fleet operators (over 100 vehicles) (31 percent). A fascinating phenomenon is that adoption is particularly high in utilities (86 percent), logistics and road transport (40 percent), and service management (38 percent)⁸.

According to a recent survey of monitoring system users, benefits include higher productivity, cost savings, and improved fleet efficiency. Overtime claims, insurance premiums, gasoline usage, communications expenditures, and administrative costs have all been reduced⁵. The legislative and global economic conditions, firm infrastructure, and rivalry with other supply chains all impact transportation patterns. The hauler firm and shipping lines have been able to quickly identify job status and execute appropriate control measures to mitigate the unpredictability of the last mile by exchanging information such as container position via real-time vehicle tracking. By increasing delivery visibility and minimizing delays and errors, organizations in a given supply chain can work toward a common goal. Meanwhile, in addition to the immediate operational benefits of quicker response integration between carriers and hauler companies, the Internet-based container tracking system has the potential to create significant macroeconomic benefits through improved physical flows and trade security⁴.

2.1.8 GPS Fleet Management Systems

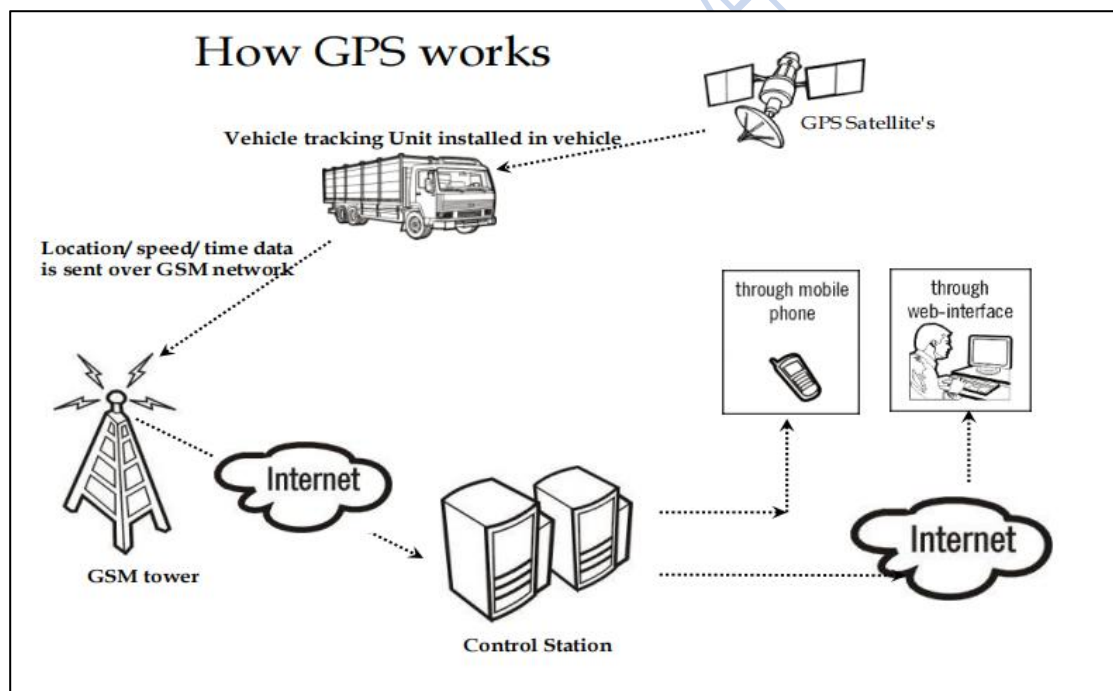
Effective management can be a demanding task, even more so for firms that deal with personnel or in-transit goods. Fleet management makes optimal use of GPS technology to track cars, employees, and assets. Additionally, the usage of GPS tracking has a number of advantages for traffic planning. For instance, vehicles equipped with GPS devices may transmit speed data to the Traffic Management Centre, which in turn distributes congestion information and forecasts to wireless information service providers⁵. GPSs were originally developed for military use, arising from the requirement for submarines to accurately locate their position prior to launching missiles.

All GPS receivers establish their location using orbiting satellites. The advancement of technology has resulted in an increase in the use of GPS. Handheld GPS units can be utilized for a variety of outdoor activities, including hiking, boating, fishing, and marine navigation. For example, a GPS receiver can be used to bring the user back to his/her current location if he/she becomes disoriented and then to assist the user in navigating out of the woods or at sea. The GPRS-based GPS-GSM vehicle tracking system interacts between the hardware and software via the GSM modem and the Internet to a server that may be accessed via a locally installed PC. While there are numerous GPS uses, the most prevalent is automobile navigation, in which most vehicles are equipped with a GPS receiver and monitor that displays the shortest road route to the user's destination. At the moment, most cell phones include an integrated GPS receiver. Additionally, a GPS can be used to track the whereabouts of a car in an emergency and as a security tool. The GPS is based on a constellation of satellites that orbit the planet continuously. These satellites, which are equipped with

atomic clocks, broadcast radio signals that contain information about their precise location, time, and other parameters. The GPS receiver receives radio signals from the satellites that are monitored and adjusted by control stations.

The GPS is one example of how satellites have permeated daily life. A GPS is divided into three distinct segments: space, control, and user.

Space Segment: 24 GPS satellites orbit the planet. In a 24-hour operation, the nominal orbit height is roughly 20,200 kilometers. Each GPS satellite provides a signal to the ground-based GPS receiver. After that, the GPS receiver estimates the distance between the satellites. Eventually, information about the receiver's present position,



time, and speed can be retrieved⁴.

Figure 2.1 Architecture of a typical GPS fleet management system

(Source: Tarudin and Adlan, 2020)

Control Segment: The control segment consists of a master control station and five ground stations positioned throughout the world that monitor the satellites' operation.

In the United States, the main control station (MCS) is located. GPS satellites communicate with ground stations to ascertain their location and the state of atomic clocks, among other things⁴.

User Segment: The user segment consists of GPS receivers that are designed to interpret satellite signals in order to calculate the receiver's position, velocity, and time. GPS users can choose between two types of service: civilian (SPS) and military (SMS) (PPS). GPS is available for free to all users worldwide⁴.

Fleet management systems provide real-time monitoring of a variety of factors, including vehicle position and velocity, as well as field data (for example, load temperature), in order to identify bottlenecks in delivery execution and save operational expenses. These systems are comprised of specialized software packages designed for fleet operations⁴.

Telematics Equipment Installed On-Board: This is a collection of microelectronic devices that are in charge of processing all the data collected by positioning satellites or on-board sensors and then transmitted to the control center via a mobile network.

Control Room: The control center is comprised of an application that is responsible for the management of all data transmitted by the on-board equipment. The route planner is able to determine the exact location of each vehicle in real time and collect all required data for the execution of each delivery schedule⁴.

2.1.8.1 Systems of Mobile and Satellite Communication

Communications are divided into two components. The mobile access terrestrial network (e.g., GSM) is in charge of wireless communication between the control center and the on-board gadgets, and the positioning system (e.g., GPS) is in charge of vehicle tracking. GPS-based navigation systems are now found in a range of

land-based vehicles, including automobiles, agricultural and mining equipment, and a number of other land-based vehicles (golf carts and mobile robots)⁴. Given that GPS is cheap and available worldwide, it appears that GPS is the greatest vehicle navigation system, and as a result, GPS is routinely integrated into existing automotive infrastructure. The United States Department of Defense created GPS, a satellite-based navigation and time transfer system. It is used by military and civilian users on the sea, air, and land. GPS is comprised of two components: the standard positioning service (SPS), which gives 100-metre accuracy to civilian users, and the precision positioning service (PPS), which provides 20-metre accuracy to military users. Both of these services are offered on a global scale and do not require the establishment of a local reference station. By comparison, GPS's differential functioning provides users within 1000 kilometers of a fixed GPS reference receiver with two-to-ten-meter accuracy. GPS is essentially a passive method in that it does not require the GPS receiver to disclose any information to any other device. It can, however, be paired with transmitters and transponders to create devices that communicate their whereabouts to a third party⁴.

GPS was originally designed as a navigation system for land, sea, and air, but it has since expanded to encompass surveying, space navigation, autonomous vehicle monitoring, emergency services dispatching, mapping, and geographic information systems. Given that the GPS's fundamental function is to disseminate accurate time, time intervals, and frequency standards, a large community of users has come to rely on the GPS as a primary source of control. Mobile geographic information systems that merge GPS with handheld computers and specialized software provide pertinent information to the individuals who work with them. For instance, firefighters can use these systems to locate the closest fire hydrant, while game park rangers can access

the proper map and report changes in the natural habitat while on the job⁴. Additionally, GPS equipment is capable of capturing data that would be impossible to collect through conventional techniques, such as travel speed and the precise routes or pathways taken by a motorist. This data is required in order for transportation planners to analyze GPS-tracked travel.

2.1.8.2 GPS Navigation System Types

Different types of GPS systems are classified according to their intended function. Modern technology has enhanced our navigation from the old compass and maps to the current global positioning satellite, or GPS, systems. When utilizing GPS, travelers no longer need to rely on stars, landmarks, or even constellations. Satellites that can emit and receive signals are used by GPS systems. The satellite's atomic clock transmits data about your current location and time to your GPS system. This data helps the GPS determine your location on the map. The entry-level GPS device provides the necessary operations of a GPS without a slew of additional capabilities. The system may report the location using latitude and longitude coordinates, which are displayed on a high-quality map that includes highways, landmarks, and streets. This type of GPS is suitable for individuals on a tight budget who require basic GPS functionality. Three distinct types of automobile navigation systems exist. These systems include stand-alone navigation approaches, handheld techniques that are useful for a variety of reasons, and systems that are compatible with laptops, PCs, pocket PCs, and PDA systems. Each sort of auto navigation system and device has distinct advantages and disadvantages. The stand-alone solutions are frequently the most popular choice because they provide a constant power source and turn-by-turn directions.

Users can access GPS navigation systems in a variety of ways. For instance, in a variety of settings, handwriting devices, speech recognition devices, and GPS systems enable people (particularly the disabled and elderly) to input their location data conveniently. Additionally, by utilizing eye-tracking devices, such systems may benefit those with impairments by automatically selecting a target device from a device set.

2.1.8.3 Vehicles Equipped with GPS

The advantages of equipping vehicles with the GPS system can never be overemphasized, a plug in GPS tracker is better utilized because it is easily purchased from most electronics outlets and its plug in the car OBD II port. These types of devices offer the best combination of price and features for everyday people who want to monitor the whereabouts of their vehicles. The main advantages of these devices are

- i. Reads vehicle engine trouble shooting codes and sends an alert if something needs the user's attention.
- ii. Detects impact to the vehicle in the course of transit or even stationary and send notification to the user. This can serve as a safety measure to users of the vehicle.

2.1.8.4 Components and functionality of a GPS Receiver

The GPS receiver is a device mounted on a vehicle, not a Global Navigation Satellite System²⁹. The receiver's primary components include a GPS internal antenna calibrated to the satellites' transmitted frequencies, a clock, and a processor. The GPS gadget is also equipped with an interface via which the user may enter a desired location and the receiver will deliver directions via text or speech. The GPS's display

shows the vehicle's location and speed, as well as the altimeter that is currently installed. Additional information that a GPS device can display includes traffic conditions, Points of Interest (POI) such as restaurants, museums, and gas stations. Several GPS devices also include a connection for an external antenna. Additionally, GPS receivers can be connected through Bluetooth or USB to a PC for the purpose of downloading fresh maps or to other devices²⁹.

A typical example of GPS application is the Bei Dou Navigation Satellite System (BDS) is a global satellite navigation system created by China. Three orbital satellites have been designed for the BDS constellations to enable continuous worldwide coverage and regional enhancement: the Geosynchronous Earth Orbit satellite (GEO satellite), the Inclined Geo Synchronous Orbit satellite (IGSO satellite), and the Medium Earth Orbit satellite (MEO satellite)²⁹. Five geostationary orbit (GEO) satellites and thirty non-geostationary orbits (non-GEO) satellites comprise the system space constellation. The GEO satellites were stationed in 58.75° (GEO01), 80° (GEO02), 110.5° (GEO03), 140° (GEO04), and 160° (GEO05), respectively. The non-GEO satellite constellation consists of 27 MEO satellites and three IGSO satellites, each of which has an orbit height of 21,500 meters, an orbit angle of 55 degrees, and is evenly spread throughout the three orbital surfaces. The IGSO satellite orbit is 36,000 kilometers high, with the three inclined track surfaces uniformly distributed. The orbit angle is 55°, and the sub-satellite point trajectory of the three IGSO satellites coincides. The intersection locations are located 118° east of the equator, with a phase difference of 120°²⁹. The fundamental premise of BDS is to use the satellite's instantaneous position as known beginning data and to determine the locations of points observed using the space distance resection method.

2.1.8.5 Radio-Frequency Identification (RFID)

Radio-frequency identification (RFID) is a data collection and wireless identification technology that can be employed in the supply chain management and tracking industries¹⁰. Radio frequency identification (RFID) is a communication technique that enables the transmission of data between a reader device and an electronic tag attached to an object via radio waves. RFID tags are classified into three categories: passive, active, and battery-assisted passive. Passive RFID tags are non-powered, which means they require an external electromagnetic field to initiate signal transmission. Active RFID tags are powered by a battery and begin transmitting signals when they detect an external source (reader). Finally, battery aided passive (BAP) RFID tags, like passive RFID tags, require an external source for initial transmission but have a longer transmission range. The majority of RFID tags are composed of at least two components. The first section is used to store and process data, while the second section serves as an antenna for receiving and transmitting signals. Additionally, RFID systems feature a host data system that stores and communicates information about the recognized items¹⁰.

A RFID system is comprised of transceivers (readers), tags, and a computer equipped with the necessary software. A reader is made up of three components: a radio interface, an antenna, and a control unit that interprets the data transmitted by the tags. A tag is a device comprised of a microchip attached to an antenna and encoded with an ID that is capable of transmitting and receiving data to and from the receiver via the antenna. Tags can be classified as passive or active based on their power source. The passive tags do not have a battery and are powered by the reader's field, whereas the active tags have their own battery. Certain tags can be read from

many meters away and beyond the reader's line of sight. The reader and the tag communicate via radio frequency signals¹⁰.

2.1.8.6 RFID Applications

In conducted research, an RFID system for monitoring truck freight content is proposed¹⁰. The EPCTM Radio-Frequency Identity Protocols/Class-1 Generation-2 UHF RFID/Protocol for Communications at 860 MHz – 960 MHz Generation 2 standard is followed by the system, which includes RFID tags and RFID readers. There are three ways to label the cargo: on the pallets, on the boxes, or on both. The third option was chosen since boxes can be transported separately. RFID scanners are deployed in strategic locations throughout the truck's interior. All data is communicated to the mobile data terminal during the loading or unloading of any cargo that is tagged on the vehicle. The placement of the readers and their antennas is a critical issue that varies every vehicle and is dependent on the available storage space in the particular truck. Typically, antennae are put in the compartment's entrance¹⁰.

2.1.8.7 Satellite Remote Sensing

The gathering of information about an item via wireless or non-contact sensing equipment is known as remote sensing (e.g., aircraft, spacecraft, satellite, or ship)¹². In practice, remote sensing is the collection of information about a given object or area through the use of a variety of devices. Tracking and monitoring of a mobile object can be accomplished using a variety of technologies, including electromagnetic radiation, force fields, and acoustic energy, as well as cameras,

scanners, lasers, radar systems, sonar, thermal imaging devices, and other sensing instruments¹⁰.

The control center collects this data in order to improve vehicle management. A study makes an intriguing concept for disaster management systems, combining remote sensing and existing fleet management technology to create an effective system. This approach offers to integrate GPS-based navigation systems and geographic information systems (GIS) with remote sensing in order to provide a well-managed disaster management system¹².

There are technologies that improve data visualization and area control, these technologies aid in the visualization of geographical data by giving maps and coordinates for the target location and monitored vehicles. Additionally, they aid in the management of certain geographical areas by presenting virtual limits on a map as long as any traceable object fits within them. Geographical information systems (GIS) and geofencing are two examples of such technologies¹⁰.

2.1.8.8 Geographical Information System (GIS)

The Geographic Information System (GIS) is a graphical user interface (GUI) that works in conjunction with a mapping system to allow users to see the exact position of cars in real time¹⁰. GIS integrates hardware, software, and data for the purpose of capturing, managing, analyzing, and displaying all types of geographically referenced information¹³. GIS applications are software that enables users to create interactive queries (user-created searches), analyze geographical data, change data and maps, and present the results of these operations¹⁰.

GIS must be connected with GPS to provide varied users with an electronic map. Both static and dynamic data may be stored in a contemporary GIS system.

Dynamic data includes any data that changes in response to a change in location (e.g., vehicle position) or status. Static data includes required road maps and networks (e.g., weather and traffic conditions). A GIS is an electronic road map that is exhibited on a graphic screen and is driven by the required workstations to provide the aforementioned information to the user on a single screen¹³.

To offer a general technique for tracking and navigation of mobile objects using a GIS module based on Google Maps in a paper. Google Maps is freely accessible and available on the Internet, and it includes both traditional street maps and satellite maps. They employ a GPS device and a mobile object database (MOD)¹⁰. MySQL was chosen as the database storage for the MOD application because it is both open source (freely available on the Internet) and dependable. This system can collect GPS data from a mobile object, such as its position, speed, and time, which can then be retrieved and presented on the Google Maps GIS module. For future reference, all data is kept in the database management system. Between the server and the web application is the database management system. Apart from storing acquired positional data, it also maintains 1) paths assigned in the GIS module for route planning and 2) information about boundaries used to restrict access to mobile items. Additionally, the module supports route planning, editing, and storage. Additionally, it is coupled with an SMS module that sends SMS warnings regarding the object's data. The proposed system in conjunction with Google Maps can be used for a variety of mobile tracking applications as well as object navigation systems, providing significantly more flexibility than the majority of existing tracking and navigation systems, which are primarily focused on specific targets¹⁰.

Another work on the GIS software environment focuses on a real-time GIS-based Automatic Vehicle Location (AVL) system that integrates GPS, GPRS, and

SMS technology to provide an accurate, flexible, and cost-effective method of vehicle location. Their solution is based on geographic information system (GIS) objects or controller software. Due to the low cost of these controllers, they are ideal for customizing local tracking system software to meet the specific demands of a client. For more precise positioning, conventional systems add GPS data corrections to the vehicle's gadget. They provide an alternative option in this research by using GPS correction to the centralized software. The car's position data is broadcast to the center's station, which computes the correct position and then sends it via SMS to the car's device. This eliminates the need for the vehicle unit to undertake extensive computations.

The proposed system benefits from GIS functionality without requiring complex GIS programming¹⁴. This solution is intended for local implementation and offers the benefits of flexibility and cost savings. The two technologies mentioned above both use the National Marine Electronics Association-0183 (NMEA-0183) data format for data transfer¹⁰. The NMEA format data has the advantage of being less than 160 characters in length, making it suitable for SMS transmission. Additionally, an initial validation of the data can be performed directly on the received NMEA data by checking a single letter (A for valid position, V for invalid position) within the message's string¹⁰.

2.1.8.9 Geo Fencing

Geo-fencing is a technology that is used to monitor moving objects that are located via GPS¹⁵. The object automatically transmits its geographic coordinates to the control center, while another set of geographic coordinates creates a virtual boundary (Geo-fence) around a specified geographical area¹⁵. The control center is

constantly determining whether the moving object is within the geo-fence. When a tracked object violates the Geo-fence, an alert is generated. Among the other uses for geofencing, fleet management is one¹⁶. Many professional vehicle fleets (for example, couriers or public transit vehicles like police cars) operate in a specified geographic region, such as a neighborhood or a larger area, such as a city. Geo-fencing is used to track these vehicles automatically and ensure that they remain within predefined boundaries¹⁷.

To begin, there is the geo-fenced zone and this technique enables the automatic monitoring of mobile objects in and around a Geo-fenced area¹⁸. The area can be as small as a few meters in size or as large as several kilometers. Coordinates of the area's characteristic points must be introduced into the calculation algorithm. Proximity to a point of interest is the second technique. This technique is used to track a moving object's location in reference to a point of interest (POI). The geofenced area in this case is essentially a circle centered on the POI. This is the simplest strategy, as the calculating algorithm simply requires the POI's coordinates and the circle's radius. Another strategy is route adherence¹⁷. In this case, the mobile object is tracked from its departure point to its end destination.

Geo-fencing is used to ensure that the vehicle stays on the designated path. Finally, another critical technique is route and schedule adherence, which utilizes geofencing to track a mobile object and ensure that it adheres to its established route in respect to a certain time schedule. It can be used to monitor and govern regions that are limited. This might be extremely beneficial for trucks hauling combustible or poisonous chemicals, as well as vehicles that are abnormally high or heavy, by preventing them from entering geofenced regions such as tunnels or highways with extremely steep slopes. Additionally, this technique could be utilized to monitor

highway routes. This manner, tracked vehicles can be monitored to ensure they remain on the designated road and do not escape until the limited corridor is complete. Another possible application of geofencing is in the service area parking management sector, where it might be used to monitor specified locations and available parking spaces, as well as the quality of dangerous items entering these areas via hazardous goods vehicles¹⁶.

2.1.9 Control Center for Fleet Management System

The control center of a fleet management system is its heart. If not all of the system's intelligence is located here, the majority of it is¹⁰. The Fleet Management system control center is in charge of gathering, analyzing, and distributing data that allows the system, its infrastructure, and services to be used more efficiently. In other words, it is in charge of interacting with the fleet's vehicles, monitoring and tracking vehicle and, of course, cargo status, dispatching vehicles, evaluating, managing, and storing all data received from cars and other data sources, and evaluating, managing, and storing all data received from cars and other data sources. The information handled by the control center can be static, such as waiting times, information about specific regulations, holiday information, existing speed limits and anticipated traffic volumes on specific road segments during specific time periods, or dynamic, such as congestion, accidents and incidents, road work, and weather conditions. The control center houses all of the equipment and tools required for vehicle guidance and fleet management¹⁰.

In recent years, tremendous progress has been made in the realm of computers and microprocessors, enabling us to handle and process progressively larger volumes of data. Hardware is required in the control center to enable this and to store the data

in data servers for further processing and analysis. The conventional systems are connected to local servers for the purpose of storing massive volumes of data in the system for immediate retrieval if necessary and communicating with other servers over the Internet for the purpose of collaborating on information exchange. Significant technological advancements in the realms of computer software and hardware have enabled control centers to visualize more accurate, detailed, real-time data and to perform better control and decision making. These technologies can be classified according to the control center field to which they are applicable. As a result, we can classify them as technologies that¹⁰:

- i. Have an effect on the exchange and processing of data,
- ii. Improve the visualization of data and area control, and
- iii. Aide in the development of computational approaches and decision-making.

Technologies that have an impact on the exchange and processing of data. As such, we regard any new technology that enables the systems control center to exchange data between the various components of the system and to store and process it in the data servers as such technologies. Electronic Data Interchange (EDI), Push Technology, Floating Car Data (FCD), Application Service Providers (ASPs), and remote sensing are all examples of such technologies¹⁰.

2.1.9.1 Interchange of Electronic Data (EDI)

EDI can be defined as the automated movement of structured data from one computer system to another using agreed-upon standards. Its adoption has accelerated due to increased client demand and a number of other benefits, including reduced manual data entry, faster and more accurate transactions, cheaper communication

costs, and streamlined procedures¹⁰. It has been implemented in nearly every component of the logistical chain (including manufacturing and retailing) and has significantly enhanced the quality, availability, and usefulness of data on virtually every aspect of fleet or cargo movement. EDI has aided significantly in the transmission of information between shippers, carriers, and administration officers, in improving communication between dispatchers in control centers and vehicle operators, and in delivering data to the firm's planning and monitoring center faster and more accurately.

A demonstration of the desire for improved data transfer and quality is the 2002 development of the Fleet Management Systems Interface (FMS) by the six main European manufacturers Daimler AG, MAN AG, Scania, Volvo (including Renault), DAF Trucks, and IVECO. FMS is an endeavor by those companies to create a standardized interface for commercial vehicle data¹⁰. With the FMS-Standard, manufacturer-independent applications and analyses of data are now feasible. The amount of data collected varies according to the manufacturer and type of the car.

2.1.9.2 Push Technology

Push Technology is a method of requesting information from a central server and receiving it quickly and accurately. Increased data availability on the fleet and fleet management organization has aided in the implementation of software solutions that "push" information at any time and in the quickest manner feasible. Push technology enables the automatic distribution of essential management information via e-mail, fax machines, pagers, personal digital assistants, and other communication devices. Numerous Fleet Management businesses maintain their own websites for the purpose of disseminating invoices and reservation confirmations¹⁰.

2.1.9.3 Floating Car Data

Floating Car Data is a technique that utilizes fleet vehicles as probes that collect and exchange data, which is then gathered by the control center in order to provide a more accurate, real-time opinion about road conditions in order to make better decisions. A technique for creating Floating Car Data is to employ vehicles as probes to build highly accurate maps using the vehicle's position traces. The cars will continuously scan the road networks, while the fleet management system's control center will collect and process their traces into constantly updated digital maps. The vehicles will then have access to the maps. This concept possesses a number of intriguing characteristics. To begin, it is truly dynamic, as the control center will continuously collect trace data and will be able to identify any significant occurrences such as traffic jams, car accidents, and road hazards. Second, this is an entirely automated scenario. As a result, hiring digital cartographers or supervisors for the control center becomes less necessary¹⁰. Additionally, the risk of human error is reduced. Thirdly, the created maps are highly accurate, particularly if the control center obtains data for the same road via many vehicles pass.

Finally, the lines plotted on the maps to depict lane center lines will be based on actual driver behavior, not the concrete center. While the technology will not be able to completely replace conventional cartography, it will provide a cost-effective and accurate alternative to manual map production¹⁰.

In a similar study, traffic data was gathered using Floating Car Data. The article presents an alternate method for assessing vehicle travel times and routes on urban roadways by utilizing FCD and GPS. The proposal was founded on a Taxi firm at this location. Several hundred taxis serve as FCD data providers. Each taxi

transmits data to the system's control center once per minute, where it is analyzed by the on-line taxi disposition system. The advantages of this system are that it eliminates the need for extra hardware and software costs and reduces the cost of communication between the cars and the control center by utilizing the company's current communication infrastructure¹⁰. A database management system is used to handle and store all positional data, as well as many types of static data about the traffic network, vehicle identifying data, and so on. The server is connected to a local information provider through the Internet in order to obtain meteorological information, current happenings, and accidents. Naturally, it is combined with a geographic map that visualizes many layers of real-time data, including current position and velocity, journey time, and congestion warnings. The system under consideration is a low-cost traffic information system that can be utilized to collect real-time data for inner-city applications.

Another application of Floating Car Data for real-time traffic information management is demonstrated through the use of appropriate hardware for data streaming computing¹⁰. The system processes real-time GPS data collected from taxis and trucks traveling through Stockholm, generates various types of real-time traffic statistics, and performs customized analysis based on a user-defined query. These tailored assessments may include updated speed and traffic condition measures for all of the city's streets, traffic volume measurements by territory, travel time estimation between two destinations, and shortest path routes depending on current traffic conditions, among others. The primary feature of this study is the use of stream processing to the management of real-time traffic information. This is made possible by the deployment of the system research platform, which enables high-performance stream processing. While the application was built to work with GPS data, it is also

capable of working with data from other sources such as meteorological data, road incident information, and video cameras in order to improve traffic estimation and prediction.

2.1.9.4 Application Service Providers

Application Service Providers make apps and other information systems available to users on a rental basis. This technology enables Fleet Management control centers to manage their fleets more effectively from a control standpoint¹¹. By utilizing ASPs, fleet managers and other information systems and application software can be rented rather than installed on their terminals as was previously the case. This method, a third-party provider is responsible for providing the organization with the server platform that includes the fleet management system. The servers are housed in data centers that ensure continuous uptime, data security, daily backups, and ample bandwidth for consumers. All system users who require access to this fleet information can do so remotely over the Internet¹⁰.

There has been some concern about the use of an ASP platform in terms of data security. Nonetheless, there are well-developed Internet security systems and services that are provided by large industries globally. ASP platforms are just as secure as any other network with an Internet connection. The primary benefit of employing an ASP platform is that it enables fleet management businesses to manage cars and equipment and to service fleet users while also allowing for cost savings associated with purchasing, implementing, and operating a state-of-the-art technology platform. It is a technology that enables the viability of a control center and also provides the essential technology infrastructure, particularly for smaller and small businesses, to manage the fleet without investing in costly, heavy equipment¹⁰.

2.1.10 Technologies that Aid in the Computing and Decision-Making Processes

This category includes technologies that aid in the optimization of the Fleet management system control center's computation methods and aid in decision-making by simplifying the essential parameters that affect this process. Agent-based computing and Front-End Intelligent Technology are two examples of such technologies

2.1.10.1 Agent-Based Computing

Agent-based computing is a rapidly emerging technology with enormous potential in the field of transportation management¹⁹. An agent-based model (ABM) is a type of computational model for modeling the activities and interactions of autonomous agents. Game theory, complex systems theory, emergence, computational sociology, multi-agent systems theory, and evolutionary programming are all incorporated. Individual-based models are another term for ABMs. After object-oriented design, agents are the most significant new paradigm for software development. The concept of intelligent agents has found numerous applications in manufacturing, network management, real-time control systems, and transportation systems²⁰. For transportation systems, the characteristics of intelligent agents that make them so appealing are autonomy, collaboration, and reactivity. Because agents are self-contained, they are well-suited for creating automated traffic control and management systems.

Agents in a multi-agent system (MAS) communicate with one another to achieve a shared goal. External circumstances and events can also be detected and responded to by agents. Agent systems may monitor traffic conditions, respond to

changes in traffic flow, and connect real-time traffic flow changes with operational responses by combining data from many detection stations and systems¹⁹. Operations can be made more efficient by integrating data from multiple sources, while the distributed computing capability of agents enables various stations to cooperate. Agents can be utilized in a variety of applications, including traffic management, urban traffic control, and decision assistance²⁰.

A typical urban transportation roadway system is comprised of supply-side management, users, an information service provider, and a variety of data sources. The supply-side is created by parallel virtual managers. They are in charge of collecting and storing network data, coordinating incident management, and communicating various passenger information to users. These managers are computers in a fully automated transportation management system. The users of the network are the travelers and vehicles that wish to travel via it. They are classified according to their mode of travel and communication connectivity. By collecting data from transportation system operators and transferring it to other system operators in the network or to other ISPs, the information service provider (ISP) provides generic buffer storage for information²⁰. The information offered includes real-time traffic conditions, yellow pages listings, parking availability, and public transportation schedules. Additionally, ISPs can assist passengers by providing particular directions and generating trip plans. The numerous other information sources are entities connected to the network that provide auxiliary data such as weather and special events. The research proposes a multi-agent system that can be used to replace all of the above-mentioned components of a typical described network. In numerous aspects, the proposed approach to traffic management is appealing. To begin, it is capable of managing a variety of driver, system operator, and information service provider

combinations (ISPs). Second, it enables drivers to retain control during the routing process. Improved customer support is available, and ISPs can expand their subscriber base. Finally, the technique enables the ISP to acquire real-time information on trip planning²⁰.

Another application of agents is demonstrated in a study that employs a multi-agent technique to automate a taxi dispatch system¹⁹. Currently, the system queues incoming requests at the system's control center in a first-in, first-out fashion. For each customer request, the system selects from a pool of available taxis in the vicinity of the demand and dispatches one when the taxi driver accepts the task. The most efficient method of dispatch is to allocate the taxi with the shortest route to the pickup location. This is not viable due to the enormous amount of computation time required. The solution is determined by allocating one of the taxis closest to the pickup point with the shortest straight-line distance. To improve the service provided by the taxi fleet, the suggested system assigns vehicles concurrently and ideally to service all available customer bookings made within a specific time range²⁰. Thus, the approach prioritizes group average customer happiness over individual customer pleasure. This multi-agent system employs taxi agents who, on behalf of taxi drivers, can collaborate and decide on servicing assignments for the many taxi requests generated within a time window. Through cooperative bargaining, numerous cab brokers can work together to find a mutually agreeable assignment solution. The suggested taxi dispatch system has the potential to be extremely efficient in terms of reducing customer wait times¹⁹.

2.1.10.2 Front-End Intelligence (FEI)

Front-End Intelligence (FEI) is a technology that has the necessary artificial intelligence to make decisions in the same way that human's do²¹. Artificial intelligence technologies that resemble human intelligence can be employed in the control room to replace manual decision-making methods.

Research on the use of FEI to fleet management systems was conducted. The authors propose a system with high position precision that can track the target vehicle in areas where GPS signals are poor or non-existent. Front-End Intelligent Technology-enabled terminals are installed in the targeted automobiles (FEI). With FEI, you may get faster response times, more accuracy, and less reliance on data from a central server. The terminal is linked to the onboard computer of the vehicle¹⁰.

2.1.11 Sensors and Sensor Networks

A sensor is a fundamental element for a Fleet Management System that is mounted on a vehicle¹⁰. A sensor is a hardware device that is used to measure or record the response that occurs when a physical condition, such as temperature or pressure, changes. Sensors collect physical data about the monitored parameter and the data is processed by a microprocessor, which accepts a digital signal as an input. The starting signal is a continuous analog signal that has been transformed into a digital signal using an analog to digital converter. The sensors should be wired or wirelessly connected to sensor networks that govern and collect all data collected by the sensors^{24, 25}.

2.1.11.1 Wireless Sensor Network

The Wireless Sensor Network (WSN) is a relatively new sensor-based technological system. It is a network of wireless sensors deployed throughout the

vehicle to monitor ambient parameters such as temperature, pressure, sound, and vibration²⁸. A wireless sensor device is composed of a microprocessor, a radio module, and one or more sensors. The device is often powered by a long-life battery, but is increasingly being replaced with solar energy. Periodically (in milliseconds), each sensor node transmits data to the Wireless Sensor Network gateway, which relays it to the On-Board Computer. The number and type of sensors in a WSN may vary according to the vehicle's size and cargo. When compared to a wired network, the advantages of a WSN include reduced weight, which results in fuel savings, ease of installation and maintenance, and increased flexibility¹⁰.

2.1.11.2 Controller Area Network (CAN)

Controller Area Network (CAN) is an on-board wiring network that was developed in the 1980's for the purpose of communicating between Electronic Control Units (ECUs) such as microcontrollers and devices (CAN)²⁶. CAN is a message-based network. Each node in the network is capable of sending and receiving messages, but not concurrently. Each communication is assigned a priority, and the message with the highest priority is transmitted first. Another issue is that on the CAN network, devices cannot be directly linked to the bus; instead, they must be connected via a CAN controller and a host processor²⁷.

2.1.11.3 Hybrid Systems

A notable example of a hybrid system utilizing CAN and WSN is the monitoring of products and vehicles through the use of sensor technology. They propose a hybrid system that combines an already-installed Controller Area Network (CAN) with Wireless Sensor Networks (WSNs), resulting in an On-Board Computer

(OBC)¹⁰. Electronic Control Units (ECUs) are connected to the CAN bus in order to communicate. Due to manufacturer restrictions, the bus cannot be directly connected to the internal vehicle bus system, but only to an FMS gateway that complies with the FMS standard. Truck elements that are not controlled by the CAN can be added to the WSNs. The WSN is made up of many wireless sensor devices and a gateway that connects to the OBC via the WSN. The advantage of WSNs is that they are lighter, take up less space in the cockpit, and ultimately cost less than wired buses.

Temperature, humidity, light, detection of opening doors, and trailer coupling processes were all monitored using Zigbee technology and distributed sensor devices in the proposed system. For the driver's convenience, an OBC and a user-friendly interface with text-to-speech capabilities, voice recognition and navigation tools, as well as hands-free commands, were incorporated. Through the HMI device, the driver will have access to capabilities such as real-time schedule adjustments, incoming order display, vehicle condition, and monitoring¹⁰.

2.1.12 Infrastructure for Mobile and Satellite Communications in Fleet Management

The mobile and satellite communication infrastructure is used to connect the vehicles' mobile data terminals to: a) the fleet management system control center, b) the numerous sensors and microcontrollers aboard the cars, and c) the satellites used to position the vehicles. This communication involves the exchange of data between the aforementioned components indicating either vehicle condition, speed, position, or control of the vehicle, such as the arrival of a new order, rerouting, etc. This communication is wireless in nature. The term wireless communication is frequently used to refer to telecommunications systems that transmit and receive information

without the use of wires¹⁰. These telecommunications systems (e.g., computer networks, network terminals, radio transmitters and receivers, and remote controls) transmit and receive information via some form of energy (e.g., radio frequency (RF), infrared light, laser light, visible light, or acoustic energy, etc.).

The communications business has undergone remarkable growth in recent years, and The improvements taken have enabled us to connect devices placed across extremely great distances via wireless networks. Even the amount of data communicated and the pace at which it is transmitted have significantly risen, leading in the capability of transferring any amount of data in a matter of minutes. Additionally, the mobile and satellite communication infrastructure has seen the emergence of new technologies that have improved the way it delivers data to other departments pertaining to the fleet management system¹⁰.

The infrastructure for mobile and satellite communications can be divided into two categories. The first part is responsible for mobile communications between the system's hardware components (e.g., computer terminals at the control center, microcontrollers on the vehicle), and the second part is responsible for communicating with satellites for vehicle positioning¹⁰.

The mobile communications infrastructure is the component that enables the mobile data terminal to communicate with the fleet management system's control center and with all of the vehicle's local devices, such as sensors, microcontrollers, and encoders¹⁰. The first component enables the fleet management control center to gather all of the necessary data from the vehicles (speed, position, mileage, etc.). The second section enables the vehicle to gather data from all onboard devices via the local network, which may include fuel consumption, mileage, temperature, cargo condition, driving hours, and stops made)¹⁰. As a result, we can classify mobile

communications as a subset of Wide Area Networks. (WAN) and in Local Area Networks (LANs) (PAN). A WAN is a network that connects devices over long distances, whereas a PAN is a network that connects devices locally (such an area could be considered the vehicle itself)¹⁰.

2.1.12.1 Wide Area Network (WAN)

In other words, a wide area network is a computer network that covers a large geographic area. WANs can span cities, countries, continents, and the entire globe³⁴. WANs are frequently used to join together numerous smaller networks, such as local area networks (LANs). For instance, a city's primary LANs can connect to form a WAN. When multiple networks link to form a larger network (a larger WAN), the resulting network is referred to as an internetwork, or simply an internet^{10, 35}. In vehicle fleets, a WAN is formed between the vehicles and the control center, as well as between the vehicles themselves, due to their wide geographic coverage³⁴. Data transmission in these formed WANs is accomplished via wireless technology, which is data transmission without the use of wires. GSM, GPRS, EDGE, and 3G are the wireless technologies that have arisen in recent years that are utilized to establish this link within the fleets' WAN. In the future, the development of 4G systems will satisfy the yearning for even greater wireless communication¹⁰.

2.1.12.2 General Packet Radio Service (GPRS)

The General Packet Radio Service (GPRS) is a packet-oriented mobile data service that is implemented on the global system for mobile communications (GSM)³⁶. GPRS over GSM is sometimes referred to as 2.5G, indicating that it is a technology that falls between the second (2G) and third (3G) generations of mobile telephony³⁶.

GPRS enhanced the capabilities of existing GSM implementations by allowing information to be transmitted via packets through the mobile network more rapidly, instantly, and efficiently. It can establish rapid connections via radio coverage, eliminating the requirement for a dial-up modem.

The increased data transfer speed enables users to participate in video conferences and engage with multimedia Web sites and other applications using both mobile handheld devices and notebook computers. SMS over GPRS can transmit approximately thirty SMS messages per minute, which is significantly faster than standard SMS over GSM.

A method for utilizing GPRS over GSM networks is demonstrated, in which a system utilizing these technologies is developed in collaboration with a GPS module for acquiring vehicle location and transmitting messages¹⁰. This is essentially a real-time tracking system for vehicles that can be used for fleet planning. GPRS operates over current GSM networks without overburdening them, ensuring effective data transmission. Due to the enormous coverage area of GSM networks and the fact that GPRS is the largest network for data transfer that is constantly on and available, this approach is suited for use as a real-time tracking management system. The GPS module determines the vehicle's location and transmits this information to the control center over the GPRS network³⁶. Following this, the fleet operator collects this data and can thus efficiently schedule a plan. Additionally, the system can be used to collect real-time traffic data, such as in congested locations, or in emergency scenarios to swiftly and automatically notify a vehicle's location to a rescue fleet operator.

2.1.12.3 3G

3G, or Third Generation International Mobile Telecommunications, is a mobile telecommunications technology that enables wide-area communication in a mobile context. Wireless voice telephone, mobile Internet access, video calls, and mobile television³⁸. In comparison to prior standards, 3G enables simultaneous usage of speech and data services at higher transmission speeds and with increased data security. 3g wireless technology is being employed in communication technologies to develop a system that enables fleet management systems to provide cost-effective, accurate, efficient, and responsible services¹⁰. Route planning and execution are two critical areas that can benefit from such a system. The system can collect data from the vehicle and compute optimized routes for the vehicles, assisting fleet planners in dispatching the most appropriate vehicle based on demand¹⁰.

The system's ability to do so in real-time enables fleet management to dynamically reschedule routes, minimizing transportation time and cost. The vehicle transmits position and status information to the control center via wireless 3g communication, where appropriate software develops the best routes^{37, 38}. As a result of these optimized judgments, the fleet planner may determine which jobs should be assigned to the vehicle and transmits route update information back to the control center for execution. The system offers automatic updates based on the connection's availability and status changes.

2.1.12.4 4G

A technology that is projected to improve the speed and accuracy of data transfer inside a fleet management system is 4G, the wireless communication standard that will succeed the 3G and 2G generations. It is a developing standard that is supposed to deliver a more secure and quicker mobile telecommunications solution.

4G will enable seamless mobility³⁷. By this, we mean that the network will be able to continue transferring a file or data without interfering with the transfer when a terminal moves from one cell (one base station coverage area) to another, but changeover is possible. Additionally, it will let users' devices to retain their IP addresses while traveling, which means that a mobile server can be contacted as long as it is within the coverage area of another server³⁸. While retaining seamless mobility, 4G will deliver extremely high data rates, with 100 Mbits/s wireless services expected. Due to the improved bandwidth and data transfer speeds, 4G users will be able to access and share high-definition video and video conferencing services on their 4G-enabled devices. The 4G wireless system would enable the delivery of multimedia apps and services to users "Anytime, anywhere" at a suitable high data rate, premium quality, and high level of security¹⁰.

2.1.12.5 Personal Area Networks (PANs)

A Personal Area Network (PAN) is a type of computer network that is used to connect devices such as computers, telephones, and personal digital assistants within an individual's workspace^{10, 39}. A PAN typically covers an area of a few meters. PANs may be used to communicate between devices or to connect to a higher-level network (such as WAN and the Internet). In fleet management systems, a PAN is established onboard the vehicle between the mobile data terminal and the different sensors and microcontrollers, with the network covering the entire vehicle. To achieve a wireless personal area network a wireless local area network (WLAN), the usage of specialized wireless network technologies is required. Bluetooth, Zigbee, and RFID are examples of such technologies¹⁰.

2.1.12.6 Bluetooth

Bluetooth is an open wireless connectivity standard that utilizes short wavelength radio waves to facilitate data exchange between fixed and mobile devices over short distances⁴⁰. It establishes secure personal area networks (PANs). It is capable of connecting several devices without encountering common synchronization issues. The communication established is of the master-slave kind, in which one device assumes the position of the master and is capable of sending data to any other slave device⁴¹. Roles can be switched at any time, and any device can assume the role of the master while the others become slaves.

A Bluetooth application is seen where the formation of wireless sensor networks via Bluetooth is used to improve road travel safety⁴⁰. The information from the on-board sensors of the vehicles is used in a collaborative network (the network's vehicles collaborate by exchanging information) to improve road travel safety. These sensors gather critical data on the car, the driver, the passengers, and the vehicle's environment, among other things. The research proposes that automobiles be used to build mobile ad hoc networks. An ad hoc network is a network of mobile devices connected via wireless networks that self-configures. Each device in such a network is free to move in any direction, and so regularly changes its connections to other devices. The vehicles on the road will act as ad hoc networks devices, capable of moving in any direction and so establishing connections with other vehicles at any time⁴⁰.

This allows the vehicles to exchange information obtained by their sensors and expands each vehicle's field of view. Bluetooth was chosen as the communication medium for the ad hoc networks because sensors can readily communicate with Bluetooth hardware and the overall cost is low. The range is up to 200 meters, and

communication is sufficiently efficient. Bluetooth's communication topology is capable of supporting real-time circumstances such as highway driving. Finally, each vehicle just needs a single sensor for such a system, making it even more cost effective¹⁰.

2.1.12.7 Zigbee

Zigbee is a wireless protocol that was developed to provide a safe and dependable data transmission solution¹⁰. Its goal is to be simpler and less expensive than existing WPANs, such as Bluetooth. It is suited for radio-frequency (RF) applications that demand a modest data rate, a long battery life, and secure networking. Due to its inexpensive cost, it has the potential to become widely used in wireless communication applications. Additionally, the low power consumption enables a longer life with batteries that are more compact. Finally, one of Zigbee's advantages is its excellent reliability due to its structure and also, its broad range⁴³.

One possible application of Zigbee technology is demonstrated in a work that introduces collaborative transportation applications through the design of two applications for resolving traffic congestion and parking problems using Zigbee as the medium for short-range wireless communication¹⁰. Historically, the solution to such transportation challenges has been communal transportation (for example, public transit), which aimed to reduce the number of automobiles on the road. SmartPark and SmartRide are the two applications¹⁰. The first collects information about available parking spots in order to direct vehicles to them, while the second connects available unoccupied seats provided by drivers with pedestrians looking to get somewhere. The suggested scenario uses a mix of current short range wireless technologies to establish

an ad hoc network and organize a fully distributable network that allows communication between automobiles, pedestrians, and other vehicles sensors for parking. Zigbee is a short-range wireless technology that has been used in the creation of the apps in question⁴³.

2.1.13 The GSM System, Smart Mobile Phones, PDAs and Android System

GSM, the European Telecommunications Standard Institute's (ETSI) digital mobile communication standard, has been adopted by over 100 nations. GSM-compatible equipment currently accounts for more than 80% of the global market for cellular mobile communication equipment. It is the most extensively used standard for mobile phones at the moment²⁹. The short messaging service (SMS) provided by the GSM system is a value-added service. It sends data through the signaling channel, and its transmission mode is recorded and forwarded first; that is, when a short message is sent, it is kept in the short message center (SMC), and the SMC then sends it to the receiver. SMS messages are sent through a wireless control channel and can be saved and routed through a short message center²⁹. The short message center also serves as a storage location for short messages, ensuring that they are not lost when the terminal equipment is turned off. The bidirectional communication features of short messages, known to as remote control and telemetry, may be used to control and acquire information from various sorts of electrical equipment. The GSM short messaging service allows for the transfer of vehicle position data across long distances. It provides the benefits of vast coverage, inexpensive investment, and low operational expenses, as well as other unique features that other means of communication lack³¹. GSM (Global System for Mobile Communications) is a mobile communications

global standard. The distinction between GSM and comparable older technologies is that GSM's signaling and speech channels are digital. As a result, GSM is classified as a second generation (2G) mobile phone network. This is also why it is frequently employed in a wide variety of data transfer applications. Additionally, GSM was the first. The short message service (SMS), usually known as text messaging, is a mobile standard. Another significant aspect of GSM is that it enables international use via roaming agreements between mobile network carriers. A study conducted on the use of GSM with the SMS capability presents an example with a two-way multiple tracking system¹⁰. The system enables the vehicle to communicate with the control center in real time. The communication is carried out via GSM, which gets data about the vehicle's location from a GPS device and transmits it to the control center, while also receiving information from the control center and transmitting it to the vehicle. The manner of transfer is provided using short messaging by GSM, which makes it more appealing and cost effective. This system enables referred to as "full duplex communication" or "two-way communication." This is the vehicle's communication with the control center and with other cars. There are numerous applications for this system. It can be used as a multi-vehicle tracking device, a fleet management system, or even as a vehicle anti-theft security service. Because the communication engine is GSM-based, tracking may be accomplished internationally using the roaming capabilities of the cellular service provider employed, and the car can be traced in any GSM-connected country.

A smart mobile phone is a phone that has more advanced processing capabilities and connectivity to district or local networks than a standard mobile phone. Smart phones include huge screens that can satisfy a user of a Fleet Management application, sufficient memory that can hold real-time data, the ability to

function as GPS tracking modules, and connectivity technologies such as Bluetooth. Furthermore, smart phones operate on mobile operating systems such as Windows Mobile or Android, which allow for the installation and operation of complex applications. The personal digital assistant (PDA), which functions as a portable personal computer, is a forerunner to the smart phone. It is equipped with a powerful processor and a variety of capabilities comparable to those found on smartphones. They include a large touch screen and can connect to the internet via Wi-Fi or a Wireless Wide Area Network. Additionally, there is a RAM expansion slot and Bluetooth or IrDA connectivity for PAN applications. Andy Rubin designed the Android system, which was eventually acquired by Google²⁹. The open-source mobile operating system was developed by Google and the open mobile alliance and is mostly used on mobile devices. It is the most widely used operating system for mobile terminals worldwide. Android's foundation is constructed on top of the Linux operating system²⁹. The system is divided into four layers: application software, user interface, middleware, and operating system. Its architecture is based on a software layer that serves as a barrier between layers and determines the division of labor inside each. Additionally, this segmentation provides reduced layer-to-layer coupling. When the lower or internal layer of the program changes, the upper application remains unchanged³³. Using the Android operating system, this study will implement real-time vehicle position display and voice notifications following vehicle movement on mobile phones.

2.1.13.1 Single-Chip Computer Control Technology

A single chip is a total microcomputer system that uses ultra-large scale integrated circuit technology to consolidate the operations of a central processor,

random memory, a variety of I/O ports and interrupts, and timers onto a single piece of silicon²⁹. As a result, it's known as a single-chip microcomputer and is classified as a programmable operation. The single chip microcomputer has the following benefits due to its unique manufacturing technique and hardware structure design: high operating speed, powerful control capabilities, low power consumption, low voltage, ease of fabrication, and portability. It's adaptable and may be used in a variety of situations³². A microcontroller unit (MCU) can be used to filter the vehicle's longitude and latitude information via program operation and to initially monitor the vehicle's movement state²⁹. The serial port communication module processes the geographic information and converts it to text form.

2.2 Theoretical Review

In "dynamic capacities theory of IT-enabled performance"⁴⁴, Dynamic capacities (DC) theory developed as an extension of and response to the resource-based view's (RBV) incapacity to interpret the formation and redevelopment of resources and capabilities in response to quickly changing surroundings⁴⁴. DC may be viewed as a means of achieving a competitive edge. DC theory extends beyond the notion that a firm's sustainable competitive advantage is contingent upon the acquisition of valuable, rare, inimitable, and non-replaceable (VRIN) resources. Organizations' dynamic capabilities enable them to integrate, marshal, and rearrange their resources and capabilities in response to quickly changing circumstances. Thus, DCs are processes that enable an organization to realign its strategy and resources in order to attain long-term competitive advantage and superior performance in rapidly changing contexts. Despite the abundance of study on the concept of DC, furthering the theory requires a collaborative effort on the part of researchers to illustrate theory

concepts and to demonstrate how to connect them to empirical practices within organizations.

Dynamic capabilities (DC) theory emerged as a counter-argument to RBV theory's shortcomings⁴³. DC theory proposes path-dependent processes that enable firms to adapt to rapidly changing environments by building, integrating, and reconfiguring their resource and capability portfolios⁴³. However, until the 1980s, little interest in the subject of strategic management existed. Porter's industry-based theory garnered the most attention, particularly in the 1980s⁴³. During that time period, the RBV theory was the dominant topic of discussion. It considered a firm as a collection of tangible and intangible resources, as well as human resources and capabilities: the capacity to combine resources in novel and efficient ways was referred to as the firm's capacities. Competitive advantage, in this view, is defined as "when a firm implements a value-creating strategy that is not being implemented concurrently by any current or potential competitors," while sustainable competitive advantage is defined as "when a firm implements a value-creating strategy that is not being implemented concurrently by any current or potential competitors and when these other firms are unable to duplicate the benefits of this strategy"⁴³.

DC theory evolved from RBV theory and made up for RBV's deficiencies in explaining lasting competitive advantage and superior performance in a dynamic context. DCs are thus the organizational and strategic routines by which businesses attain novel resource configurations as markets develop, collide, split, evolve, and die⁴³. Nonetheless, the theory has come under fire for a variety of reasons, including the term's nature and the difficulty of determining the merits of the theory's outcomes, the difficulty of understanding the nature of DCs, and the lack of clear models to quantify these capabilities and their impact on organizational performance.

Additionally, the idea has been critiqued for being repetitive and inefficient at offering a comprehensive explanation of how DCs work. DC theory has also suffered from a lack of clarity regarding the definition of its core concepts⁴³. Despite the rapid growth of studies examining the concept of DCs, the theory's advancement still requires additional collaborative efforts from researchers to illustrate theory concepts and how to connect them to empirical practices within organizations.

This idea serves as the conceptual foundation for the research inquiry. In the context of this study, which is focused on IT-enforced and IT-enabled business processes via automation, IT-enforced and IT-enabled business processes can be defined as the extent to which IT enforces and enables "the specific ordering of work activities across time and space (or location), with a beginning, an end, and clearly defined inputs and outputs"⁴³.

IT resources (including business applications) are responsible for the development of automated or IT-enabled business processes⁴⁴. Automated processes refer to the extent to which IT enables the specific sequencing of business operations across location and time. These activities have a beginning and an end with identifiable inputs and outputs⁴⁴. According to him, automated business processes do not generate gains in organizational performance; rather, it is the gains in operational efficiency achieved through automated business processes that generate organizational performance⁴⁴. This is referred to as business process operational efficiency. However, the conceptual model is appropriate for guiding and informing this research study, particularly when illustrating how automated IT-enforced and IT-enabled business processes improve business performance and corporate governance.

2.3 Review of Empirical Studies

In a paper titled Global Positioning System: Monitoring the Fuel Consumption in Transportation Distribution⁵, the researchers examined the fuel consumption of companies that use this technology in their transportation distribution operations. They collected data through two methods: site monitoring and structured interviews. In another related work titled GPS-based location monitoring system with geo-fencing capabilities¹⁵. The paper presents a study on GPS-based location monitoring system with geo-fencing capabilities. This system provided a high-security system that prevents vehicles from being stolen and also alerted the user based on the location's boundary via the Internet of Things (IoT).

In another study, Design and implementation of a wireless OBD II fleet management system²⁴, the authors describe their work on the design and development of a wireless on-board diagnostics (OBD II) fleet management system. The system is intended to measure the speed, distance, and fuel consumption of vehicles for tracking and analysis purposes. Along with the state estimates acquired by estimating the smartphone dynamics using a typical global navigation satellite system-assisted inertial navigation system, this will also supply us with estimates of the vehicle's attitude. These estimates are utilized to enhance the navigation solution and also allow for the estimation of additional vehicle, road, and driver attributes, which require information of the vehicle's attitude. The proposed method's performance is tested using both simulations and experimental data.

Another study on the subject, titled "IMU alignment for smartphone-based car navigation²⁵. The authors of this work provide a system for concurrent car navigation and smartphone-to-vehicle alignment. Along with the state estimates acquired by estimating the smartphone dynamics using a typical global navigation satellite system-assisted inertial navigation system, this will also supply us with estimates of

the vehicle's attitude. These estimates are utilized to enhance the navigation solution and also allow for the estimation of additional vehicle, road, and driver attributes, which require information of the vehicle's attitude. The proposed method's performance is tested using both simulations and experimental data.

In SOVCAN: Safety-oriented vehicular controller area network²⁷, this article proposes an SDN-based approach for developing a safety-oriented vehicular controller area network capable of ensuring traffic safety through driver fatigue detection and emotional recognition, both of which are monitored via the driver's physiological and psychological state.

In another paper titled: A cost-effective decentralized vehicle remote positioning and tracking system using BeiDou Navigation Satellite System and Mobile Network²⁹. The authors propose a cost-effective decentralized vehicle remote positioning and tracking system using the BeiDou Navigation Satellite System and a Mobile Network in another paper titled: A cost-effective decentralized vehicle remote positioning and tracking system using the BeiDou Navigation Satellite System and a Mobile Network²⁹. In this paper, we propose a cost-effective decentralized vehicle remote positioning and tracking system architecture. This architecture consists of only two components: (1) a vehicle terminal that collects real-time vehicle location data from a navigation satellite system and transmits it to a user terminal via an existing mobile network; and (2) a user terminal on a mobile phone that analyzes the location data from (1) and notifies the owner. They developed a prototype locating and tracking system by combining the BeiDou Navigation Satellite System (BDS) and the Global System for Mobile Communications (GSM) (GSM). Experiments demonstrate that the system is capable of detecting the location of a car and alerting the owner if it unexpectedly moves more than 100 meters at a cheap cost. With a design philosophy

centered on vendor neutrality and high availability, the system is capable of utilizing numerous available navigation satellite systems and mobile networks.

In research titled Accurate vehicle location system using RFID, an internet of things approach³⁶ the primary objective of this project is to design and implement an accurate vehicle location system that utilizes radio-frequency identification (RFID) technology in conjunction with global positioning system (GPS) and global system for mobile communication (GSM) technology in order to overcome the limitation. In essence, tracking autonomous vehicles will be facilitated through the use of RFID technology in areas where GPS signals are unavailable. We designed and implemented the proposed system. A successful RFID transponder design was achieved, with a read range of roughly 31 cm in the low frequency communication range (125 kHz to 134 kHz). The proposed system was created, implemented, and field tested, and it was discovered that a vehicle could be accurately detected and tracked. Additionally, it is discovered that the antenna size of both the RFID reader unit and the RFID transponder is crucial for achieving the highest communication range possible.

In another study, the design of an obstacle and location-based detector using a microcontroller system was examined⁴⁵. The purpose of this study is to develop an obstacle detection system that utilizes an ultrasonic sensor and an Arduino board to track the location of visually impaired patients, notify them, and transmit location signals to their guardians as a feedback mechanism using a GPRS and GSM module. The C programming language was used to create the instruction code that interfaced with the Arduino device in order to perform specified tasks. Prior to hardware construction, the circuit was evaluated on Proteus software for simulation reasons. The test results indicate the variation in distance as the patient approaches the obstacle,

as well as the messages received when a fix is reached. This design proposal would assist persons with vision impairments in avoiding danger and navigating to familiar locations without assistance.

Additionally, in an article titled "Real-time Google map and Arduino-based vehicle monitoring system"⁴⁶. The authors employed a real-time Google map and an Arduino-based car tracking system that utilizes GPS and GSM technology. At regular time periods, the GPS module delivers geographic coordinates. The GSM module then broadcasts the vehicle's location in terms of latitude and longitude to the owner's/cell user's phone. Simultaneously, the location is presented on the LCD. Finally, on a cell phone, Google Maps displays the position and name of the site. Thus, the owner/user will be able to watch a moving car continually via the cell phone. Their research includes experimental results from the vehicle tracking system in order to demonstrate the system's viability and effectiveness. The authors assert that the proposed system is user-friendly and provides security and surveillance at a cheap cost.

The design and implementation of a web-based GPS-GPRS car tracking system⁴⁷ resulted in the creation and deployment of an integrated, cost-effective web-based GPS-GPRS vehicle tracking system. The solution enables enterprise owners to view the target vehicle's current and previous positions on Google Maps via a custom-designed web site. The current position of the car was determined using a GPS device integrated within the target vehicle, and the location coordinates were transmitted via the GSM network's GPRS service. The GPS data is transmitted via the HTTP protocol's Get method; the data is kept on the server in database tables and can be requested via a request for position browsing on the map. PHP, JavaScript, Ajax,

XML, and MySQL are used to construct a web application that retrieves and displays information about tracks.

Additionally, in a study on an Internet of Things-based smart anti-theft vehicle tracking system for Bangladesh⁴⁸. The paper describes a Smart Anti-Theft Vehicle System based on the Internet of Things (IoT) that enables real-time monitoring of any equipped vehicle from any location. Global Positioning System (GPS), Global System for Mobile Communication (GSM)/General Packet Radio Service (GPRS), and microcontrollers were utilized to enable customers to conveniently monitor their automobiles. This system enables remote monitoring and control (emergency stop by shutting the fuel line) of vehicles using a mobile application. Their study includes a hardware prototype of the proposed system and a user application for monitoring and controlling automobiles.

Another study on the implementation of a vehicle tracking system utilizing a smartphone and SMS service⁴⁹. The authors proposed the technique to assist in tracking the whereabouts of buses in real time. The suggested approach leverages two key elements of today's mobile platforms: location services, mostly GPS-based, and basic telephone services, primarily SMS-based. The system is divided into two components: the server and the client. The server device's primary job is to provide the server with the exact location of the bus, or to the user in the case of an SMS-based query from the client's mobile. On the other hand, the client's smartphone can determine the bus's location via SMS or the internet. If the client's device is an Android-based smartphone, he or she can install the program and use the internet to track the bus's whereabouts. The server's device will be put on the car of interest, along with an Android application. According to the authors, trials with this system

revealed that it outperforms other similar vehicle tracking systems in a variety of ways.

In a work titled Internet of Things for a smart transportation system⁵⁰. Their research examined two distinct methods for tracking the car using GPS: standard GPS and Assisted-GPS (AGPS). A-GPS enhances the starting performance (time-to-first-fix (TTFF)) of a GPS satellite-based positioning system in the central business districts of major cities that rely on 4G/LTE cellular networks. The suggested system is based on a Raspberry Pi (3) equipped with a 4G model shield and key telematics technologies such as representational state transfer (RESTful API), which is critical in the Internet of Things (IoT) industry.

In another similar study titled Development of a Real-Time Bus Tracking System Using Android, the authors proposed in their study a real-time bus tracking system for students utilizing Android devices that may be used to track and locate buses via the Global Positioning System (GPS). This real-time android application enables students to determine the actual location of buses in order to avoid being late or arriving at the bus stop too early. It displays the exact position of each student's bus on a Google map. Additionally, this application provides information on the bus, the driver, contact information, and routes. The developed application saves students time waiting for buses by displaying the current location of the buses on Google maps in the form of latitude and longitude.

In a project involving the development of an arduino-based automobile accident prevention and identification system⁵². In their paper, they propose an accident prevention system with vehicle identification that will increase the likelihood of reducing the number of accidents that occur on roads each day. Additionally, if an accident occurs, the system will locate its location and automatically notify those

people who can take immediate action. The purpose of this study is to construct an Arduino-based system that utilizes Global Positioning System (GPS) and Global System for Mobile Communication (GSM) technology. Additionally, an accelerometer will be utilized to determine the velocity and amount of tilting of the vehicle when it collides with something. When the vehicle's velocity exceeds the road's designated maximum velocity or when the vehicle tilts, an automatic warning is issued. Additionally, anytime an accident occurs, the GPS will determine the geographical coordinates for that location and will send an SMS via the GSM. The method is inexpensive and simple to use.

Additionally, in a study on smart garbage collection utilizing GPS and the shortest path algorithm⁵³, the authors proposed a technique for collecting kitchen wastes from urban or town council regions. It is new to combine GPS with the shortest path to moving waste collection vehicles. The advantage of this system is that the end user does not need to wait at the roadside to drop off his garbage bag to the truck, as the end user may install the application on his smart device and monitor or follow the garbage collection truck's drive path. However, if a person misses the truck, this application will direct them to the shortest route to drop off the waste to any other truck in the group of trucks that circulate to collect rubbish in a certain geographical area. Indeed, the public as an end user of this app can benefit from lower costs and better time management.

2.4 Conceptual Framework

Conceptual framework as a concise description of the phenomenon under study accompanied by a graphical or visual depiction of the major variables of the study, a conceptual framework is a pictorial depiction of the relationship between

dependent and independent variables. The conceptual framework for the research will examine the impact of fleet management strategies on service quality.

Independent Variable

Dependent Variable

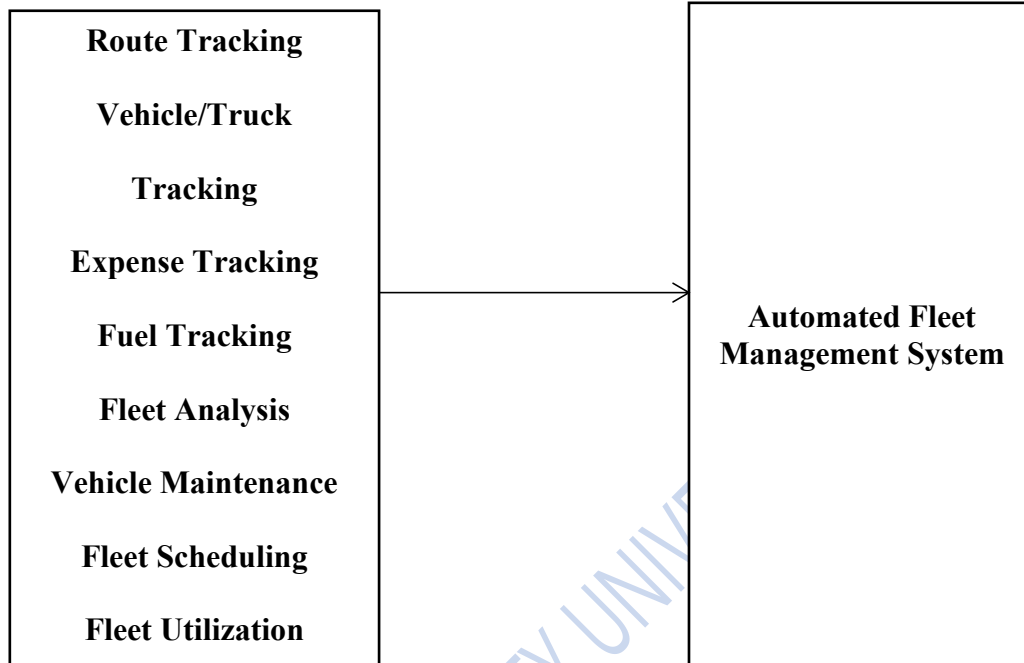


Figure 2.2 Conceptual model on automated fleet management system

(Source: Ali, D. V., 2022)

The figure above shows that an effective fleet management system depends on independent variables as shown in the figure above, an effective fleet management system will have a route tracking and vehicle/Truck tracking to know the route and location of the fleet for effective monitoring, expense tracking and fuel tracking to excesses fuel and maintenance on. Also, fleet scheduling, utilization and analysis to scrap to time wasted on manual and paper work for fast and prompt fleet management. The manual work required to manage fleets and transactions in a corporation will be reduced with an automated fleet management system.

2.5 Summary of Literature Reviewed

In the study, a cost-effective decentralized vehicle remote positioning and tracking system Using BeiDou Navigation Satellite System and Mobile Network. The results of the experiments demonstrate that the system is capable of at a reasonable cost, tracking the location of a car and alerting the owner if the vehicle unexpectedly moves more than 100 meters is possible.

The system is able to exploit maximum vendor neutrality and high availability due to the design concept of maximum vendor neutrality and high availability. Numerous navigation satellite systems and mobile networks are available. Following testing, it was determined that when the car departed from its original parking place 100m, the system could dynamically display the vehicle's location at the specified time, and then transmitted the voice alarm information at the specified time. Key gaps from the study are that the study is based on GSM network capacity. Ant failure in the network signal of the GSM jeopardize the result.

In the research study Internet of Things for a smart transportation system, the research examined two distinct methods for tracking the car using GPS: standard GPS and Assisted-GPS (AGPS). A-GPS enhances the starting performance (time-to-first-fix (TTFF)) of a GPS satellite-based positioning system in the central business districts of major cities that rely on 4G/LTE cellular networks. The suggested system is based on a Raspberry Pi (3) equipped with a 4G model shield and key telematics technologies such as representational state transfer (RESTful API), which is critical in the Internet of Things (IoT) industry.

Key research gaps identified from the study is that it is expensive and difficult to implement. However, a cheaper and simple system can be developed for smart transportation.

In the research, Implementation of a vehicle tracking system using smartphone and SMS service. The researchers design and capitalizes on two key elements of the mobile platform: location services, which are mostly GPS-based, and basic telephone services, which are primarily SMS-based. The system is divided into two components: the server and the client. The server device's primary job is to provide the server with the exact location of the bus, or to the user in the case of an SMS-based query from the client's mobile. On the other hand, the client's smartphone can determine the bus's location via SMS or the internet. If the client's device is an Android-based smartphone, he or she can install our program and use the internet to track the bus's whereabouts. The server's device will be put on the car of interest, along with an Android application. Experiments with this system revealed that it outperforms other similar vehicle tracking systems in a variety of ways.

After examining the research, key gaps from the design and implementation are that the system can easily be compromised, since there are no security features in the system. A better security example is an intrusion detection can be incorporated into this study. Intrusion detection is the process of monitoring network/computer system activity for indications of prospective events, such as threats or infringements of use guidelines or accepted security procedures. IDS primarily concentrate on anticipating occurrences, documenting these events, and relaying recorded information to security administrators. IDSs are also used for additional purposes, such as identifying problems with security policy, reporting current risks, and deterring people from security assaults. In general principle, components must be secured for an efficient and successful IDS. Users, devices, database servers, management servers, networks, and other components make up an IDS. Because they

are targeted by attackers who try to stop IDSs from obtaining key data, exploiting known security flaws, or detecting attacks, IDS component security is essential.

In the study, *Comparative Analysis of Fleet Management Usage in Ethiopia: The Case of Cross Border Freight Operators*⁵⁴. The purpose of the research is to conduct a comparative analysis of fleet management technology in Ethiopia against cross border freight operators. It is descriptive research using various research instruments. Major gaps identified from the research in the limitation of samples, scope and data collection instruments. Data collection instrument used in this study was based on internet based⁵⁴. There were several advantages for researchers with the introduction of internet-based surveys. These advantages include having access to more diverse populations with a wider range of characteristics, being able to collect higher quality data volumes than in the past, which increases the confidence in the findings of research studies, saving time and money, and allowing participants to participate anonymously, which may encourage more people to participate.

The difficulty to get a completely random sample of the population is a significant drawback of internet-based research. There are at least three ways that internet-based research makes random sampling impractical. In order to reduce bias in participant selection, a random sample must provide each potential participant an equal chance to participate. To begin with, the only persons who will be eligible to take part in these online surveys are those who register for the websites that advertise them. Due to the fact that they are not browsing the websites that allow access to these surveys, the other individuals of the target demographic might not get an opportunity to participate. As a result, due to the absence of certain crucial values from the final data set, essential perspectives or crucial facts may be omitted. Second, the study is only open to participants who are online at the precise moment it is being

conducted. This may be more challenging when trying to gather data from other time zones since a researcher must take into account the schedules of participants who live in different time zones. This issue has been resolved by some researchers by putting their studies online and leaving it overnight, giving people in other time zones plenty of time to complete the survey.

Thirdly is the issue of bias that survey participants have by nature. Only those respondents who answer quickly enough after a study is uploaded will finish it. For instance, if research requires 200 respondents at any given time, more than one million people may be interested in responding to the survey but for the fact that only the first 200 will get access to the study, and the system will be closed when its limit has been reached.

In the like manner, the study the effect of fleet management on fleet efficiency from the perspective of employee (the case of world health organization Ethiopia). This study mostly analyzed data quantitatively. The data were described using descriptive statistics such as mean, percentage, and frequency tables. A sample of 154 employees was drawn from the total population of 250 employees utilizing availability sampling techniques. To address the fundamental question and test the hypothesis, inferential statistics such as the ordered logit model were used. The study's findings indicate that the WHO's operational efficiency is lacking. Additionally, the study discovered a positive association between three supply chain characteristics (repair and maintenance, fuel management, vehicle tracking, and driver management). In terms of correlation, one may conclude that there is a significant and positive association between the four variables on which this study is based. It was observed that technology is vital for the development of one organization; therefore,

modern technology of GPS for vehicle tracking system is essential to the improvement fleet efficiency in the organization.

Also observed in the study, Smart anti-theft vehicle tracking system for Bangladesh based on Internet of Things⁴⁸. They device the use of Global Positioning System (GPS), Global System for Mobile Communication (GSM)/General Packet Radio Service (GPRS), and Microcontrollers are utilized to enable consumers to conveniently monitor their automobiles. The system enables remote monitoring and control (emergency stop by shutting the fuel line) of vehicles via a mobile application. Like other studies, it was observed that the study is a prototype, the system can be designed in real life situation. Drawbacks from the use of prototypes is developers may become preoccupied with a small prototype instead of thoroughly evaluating the entire project. The likely outcome: Ignoring better options, creating inadequate specifications, or turning limited prototypes into final projects that are poorly conceived and engineered and are challenging to manage.

In Advanced Technologies for Fleet Management Systems, they presented technologies for efficient fleet management systems. They presented cybercars whose technologies are emerging, with some of them to have already been applied in industrial scale and others to be in a prototype state. Major issues in this study are that it is expensive and difficult to implement. However, a cheaper and simple system can be developed for Fleet management.

Then the Amaro—an on-board ship detection and real-time information system, key findings here is that the researchers developed AMARO, a comprehensive prototype system for real-time ship detection on-board satellites and other Earth observation vehicles in the future. Within minutes after seeing, the device detects vessels and transmits the information to the interested user. The system is not

a monolithic block, but is extendable and deployable in a flexible manner. It is comparable to modern internet search engines in that it consists of a large database and a number of services that access and modify the database. As a result, the software system is simple to grow, adapt, and maintain. Gaps identified in this study is that the AMARO-box was created as a proof-of-concept device that could be constructed and implemented for research purposes. Additionally, the system can be used for various time-sensitive earth observation situations that would benefit from a quick information system, such as real-time traffic, sea ice, or disaster monitoring.

In the study Design and implementation of a wireless OBD II fleet management system. The system is designed to track and analyze vehicle speed, distance, and fuel consumption. An OBD II scanner is used to determine the speed and mass air flow of a vehicle, as well as the distance and fuel consumption. This data is subsequently transferred to a remote server through WIFI. Additionally, the technology utilizes global positioning system tracking to establish the vehicle's location. At the distant server, a database management system is established for the storing and management of sent data, and a graphical user interface is developed for data analysis. Numerous qualification tests are undertaken to ensure the system's operation. The results reveal that the system is capable of reading a variety of parameters and processing, transmitting, and displaying the readings successfully. Gaps from the study were that the system is not flexibly, expandable but deployable. The software system is therefore difficult to expand, to adapt, and to maintain.

Lastly, in the study accurate vehicle location system using RFID, an internet of things approach³⁶. A successful RFID transponder design was achieved, with a read range of roughly 31 cm in the low frequency communication range (125 kHz to 134 kHz). After developing, implementing, and field testing the suggested system, it was

determined that a vehicle could be correctly detected and tracked. Additionally, it is discovered that the antenna size of both the RFID reader unit and the RFID transponder is crucial for achieving the highest communication range possible.

Gaps arising from the study is that One possibility is that the project should be developed for the high frequency spectrum (or possibly the UHF spectrum), given the success of the low frequency concept. This would result in increased read ranges and a significantly higher rate of data transfer. The project's focus might be changed to the development of predictive models, which would enable the accurate forecast of vehicle routes and positions. This can be accomplished through the design and implementation of Hidden Markov Models (HMM), which provide static route and destination predictions.

Endnotes

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Chapter Three

Methodology

3.1 Introduction

Research methodology generally incorporates a body of knowledge that enables researchers to explain and analyze the research methods they use, indicating

their limitations and resources, identifying their assumptions and consequences, and relating their potentialities to research advances. Research design may be viewed from many perspectives and is often seen as controversial. However, it underpins the types of questions that may be addressed and the nature of the evidence that is generated. As a result, research approach is critical to all study, and a good fit between the research paradigm, data type, and data collection methods has a big impact on the research outcomes. A research methodology is a method for conducting a study that is followed in a structured manner.

3.2 System Requirement Analysis

The purpose of System Requirements Analysis is to obtain a thorough and detailed understanding of the business need as defined in project origination and captured in the business case, and to break it down into discrete requirements, which are then clearly defined, reviewed and agreed upon with the customer decision makers. During system requirements analysis, the framework for the application is developed, providing the foundation for all future design and development efforts.

System Requirements Analysis can be a challenging stage, due to the fact that customer interest is brought into the process of determining requirements. The quality of the final product is highly dependent on the effectiveness of the requirements identification process. Since the requirements form the basis for all future work on the project, from design and development to testing and documentation, it is of the utmost importance that the development team create a complete and accurate representation of all requirements that the system must accommodate. Accurately identified requirements result from effective communication and collaboration among all members of the project team, and provide the best chance of creating a system that

fully satisfies the needs of the Customers. System requirements specifications are often published in simple papers and are not meant to be technical; readers and users with a basic or broad understanding of the system should be able to comprehend the system requirements in simple terms without ambiguity.

In the case of this improved fleet management system, the system requirements are: -

- i. **Introduction** – This is essentially the design framework's covering area. It may also include the application's statutory and regulatory considerations, as well as the scope of the system and important objectives to be reached at the conclusion of the project.
- ii. **Program Requirements** – This is a list of the functions and workflows that the system must be capable of in order to provide the desired outputs.
- iii. **Data Requirements** – This refers to the type of data the system must be able to process and generate meaningful information to the user or business organization.
- iv. **Life Cycle Requirements** – The system life cycle is mainly concern with how the system will be maintain user's requirement.

3.2.1 Functional Requirements

The major category of this Improved Fleet Management system will be assessed on two platforms, on the web application and also the mobile application platform

For the web application platform:

1. Security Function (Secure Login and Logout, Demarcation of responsibilities between admin users and other users).

2. Administrator User Functions.
3. Other Users Functions.
4. Fleet Management Functions.
5. Report Management Functions.
6. Realtime Tracking Function (Using dual GPS trackers)
7. Feedback Management Functions.

For the mobile application platform:

1. Security Function.
2. Administrator User Functions.
3. Other Users Functions.
4. Fleet Management Functions.
5. Realtime Tracking Function (Using dual GPS trackers)

1. Security Function

This is a critical interface; this functionality of the software provides an interface (form) for all users to be able to login to the system using their unique usernames and password. This will provide security and will restrict access to unauthorized people from having access to this system, only those who needs to have access will be given permission and authority to manipulate and operate it. The second unique idea about the function is that it will be able to demarcate users who legitimately have access, this demarcation will be on the basis of administrative users and other users. Administrative users will have more privileges and will be able to carry out more tasks than those who have basic or other users' privileges.

2. Administrator User Functions

Software Administrators usually have higher privileges compared to other users, this is done to ensure reliability and to limit the number of users with access to higher resources. The administrator will carry out their own responsibilities, and since they have higher access, whenever the need arises for other users to change their password, then the administrator can initiate this process on behalf of the other users. The software administrator can add new users and can equally delete and remove unrequired users from the software platform, admin can also view the details of all the users.

This Improved Fleet System is mainly concerned with logistics and transportation, so admin users can have access and view all details of drivers and other users who are charged with the responsibility of routing trucks using this system. They can also view reports regarding driver ID Number, Number of trips, distance covered etc. Administrator users can add and remove other categories such as vehicles in used, they can also view information regarding vehicles that are in use in the company. In this system every vehicle in used must have their unique identification number, registration number of the vehicle, the type of vehicle, the vehicle size and quantity are also important.

3. Other Users Functions

These categories of users will be registered into the system by the administrator user, their access is limited and resourcing allocated to them is on the need-to-know basis, they usually have minimal information. They can be able to see bookings, see the listed vehicles available on the application with full description.

Admin has full access to the fleet management, bill management, daily reports, expenses, terminations and reimbursements functionalities while other users could only access the transport and booking functionality. They could optionally access expenses and daily reports sections whereas drivers could access fleet management and expenses functionalities of the system.

4. Fleet Management Functions

This function is critical and it is the supporting pillar in which all other function and build upon, this is the main business objective of this system. The main objective of this function is: -

- Vehicle sizes, capacity and rating.
- Distance covered and routes.
- Repair and maintenance.
- Parts changed records.
- Tracking and monitoring.

In the vehicle size and capacity logs, in help in planning purpose to determine the amount of payload the vehicle can accommodate, admin and employee can view this log and assign consignment according to the truck capacity.

Admins and employees may examine and add the distance traveled by the vehicle as well as its fuel efficiency in distance records.

In lubricant logs, administrator and other users can view and add the lubricant consumption details along with bill details to the system.

In fuel logs administrator and other users can view and add all details of fuel consumption to the fleet management system.

Repair and maintenance files keep records of maintenance and repair on a vehicle all parts changed on the vehicle, this can give verifiable data on quality of maintenance, parts in used, road conditions etc.

5. Report Management Functions

The beauty of any software program is to generate some insights from data that has been inputted into the system, report's function keeps all the different transactions made by the company. Users can save and print the required information generated by the software after analysis, it can also be exported to a spread sheet for further analysis.

Admin users and other users has the access to view reports. It has Menu Options

- View Expenses
- View Fuel Logs
- View Repair and Maintenance Logs

Because reports are created on a daily basis, this module includes a View Reports by Date option.

6. Real-time Tracking Function (Using dual GPS trackers)

This function will utilize dual GPS coordinates from an in-built device that will be installed in the truck to track and give real-time location of the trucks and vehicles. To make the system more scalable, it will also use the GPS device on a smart that will be in custody of the drivers to also send locations to the web application. In case of loss connection, the last known coordinates will be sent to the control center.

7. Feedback Management Functions

This function has two main parts

- Give feedback
- Check feedback

In giving feedback, since majority of vehicle that rea in used in Nigerian breweries plc are outsourced, this is very important functionality that will minimize conflict between service providers and Nigerian breweries plc. It will also give service provider direction on where to focus their energy for enhanced service delivery.

In checking feedbacks, admin and users can both check feedbacks submitted by the users.

3.2.2 Hardware Resources

The minimum hardware requirements needed to perform operations are

Table 3.1 Minimum system requirement

Resources	Minimum Requirement
Processor	Intel Pentium CPU
RAM	2Gb or above
ROM	250Gb or above
Android phone	Kernel version 4.4.147, Android version 9 or above, minimum of 1Gb RAM.

(Source: Ali, D. V., 2022)

3.2.3 Software Resources

The software required to perform the implementation are

- HTML, CSS as front end

- JavaScript for the back end
- PHP for server-side scripting
- MySQL as database and
- Windows operating system.

3.3 Fleet Management Database Design

A web-based software application will be used for the Fleet Management System, this is necessary for many reasons. A Web application (Web app) is an application program that is hosted remotely via a server and deliver services via the internet through a browser interface³. A web application is usually a client-server program, what that means is that it has a client-side interface and a server-side which usually interface with the server at the backend. Client refers to the program that the individual uses to manipulate or operate the application. It is part of the client-server environment, where many computers share information. For example, in the case of a database, the client is the program through which the user enters data.

A web-based software application will be used for the Fleet Management System. The application will allow data administrators to manage car inventory, month-by-month history of costs for oil, petrol, and other items, as well as instructions and directions for vehicles, via dynamic web pages. The application also aids asset management by maintaining vehicle records and planning scrapping and replacement schedules, future fleet justification, and a month-by-month record of private hire vehicles and expenditure.

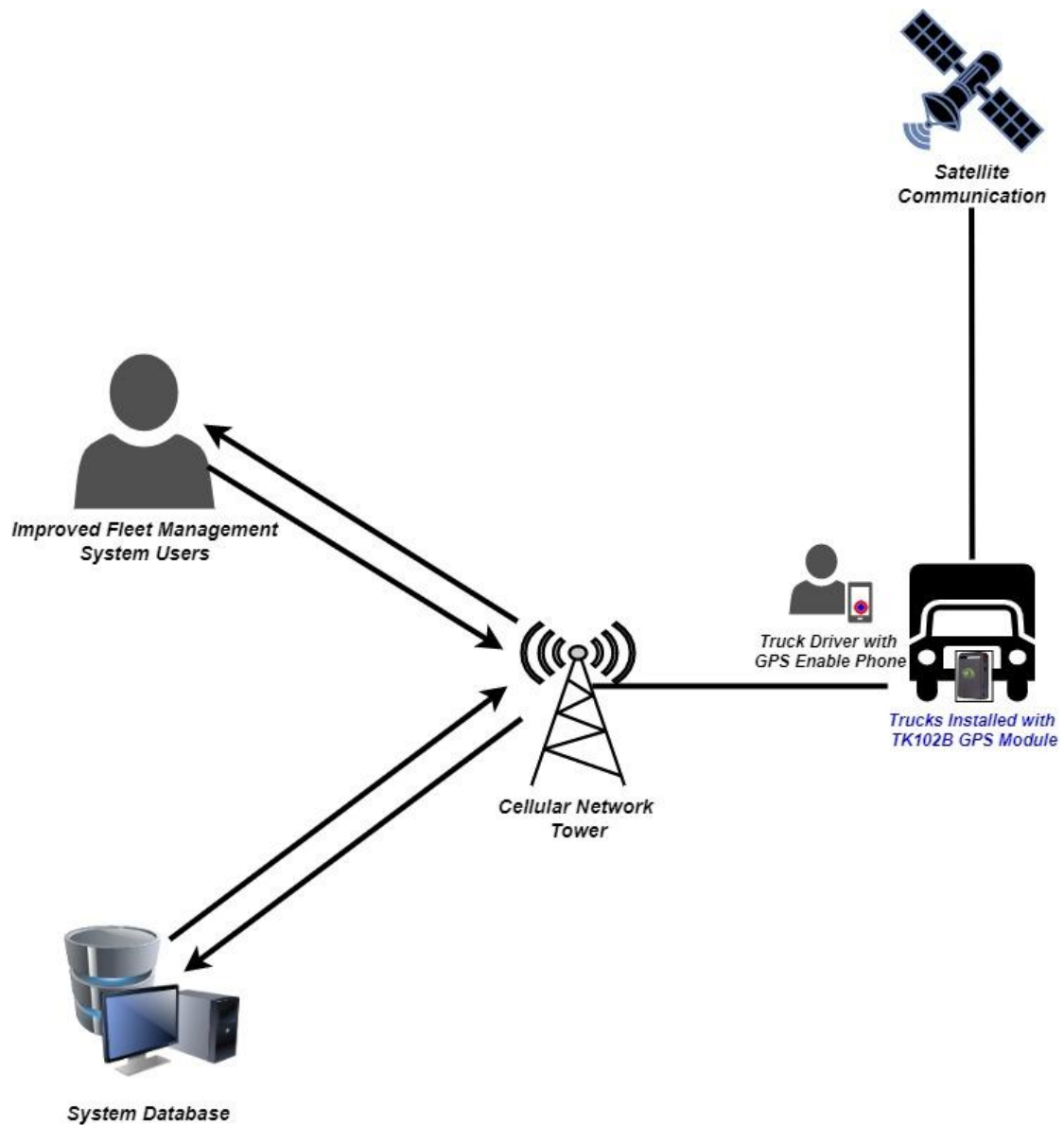


Figure 3.1 Conceptual framework of improved fleet management system

(Source: Ali, D. V., 2022)

The improved fleet management software will be made up of two parts, namely;

- i. Web App
- ii. Mobile App

3.3.1 Web App

This controls and monitors the driver's movement with geolocation and map. It will also enable registration of drivers of various car types. Drivers can also be enabled and disabled from the web app. The web app is developed with Laravel. All the code structure follows an MVC (model view controller) coding standard so every action has a model, a view and a controller, the view is the HTML and JavaScript codes. MVC is a software architecture that separates domain/application/business logic from the rest of the user interface. It does this by separating the application into three parts: the model, the view, and the controller¹. Also, Laravel is a PHP-based web framework that is largely based on the MVC architecture¹.

3.3.2 Mobile App

The mobile application is developed using flutter, flutter is a software development kit that can enables smooth and straightforward cross-platform mobile applications development and it is an open-source software. It is a software that grant developers access to build multiple applications without restrictions or without facing any challenges, and it's solved the cross-development problem by the developers. For this project, the mobile application will be developed and implemented such that users of the device will have to request for permission and subsequently transmission of the current coordinates of the device hence the driver.

3.4 Entity Relations Diagram

Figure 3.2 below shows the system entity relations diagram, the system contains six tables for the database. The ER diagram also show the cardinality of

relationship between each table to another in the database.

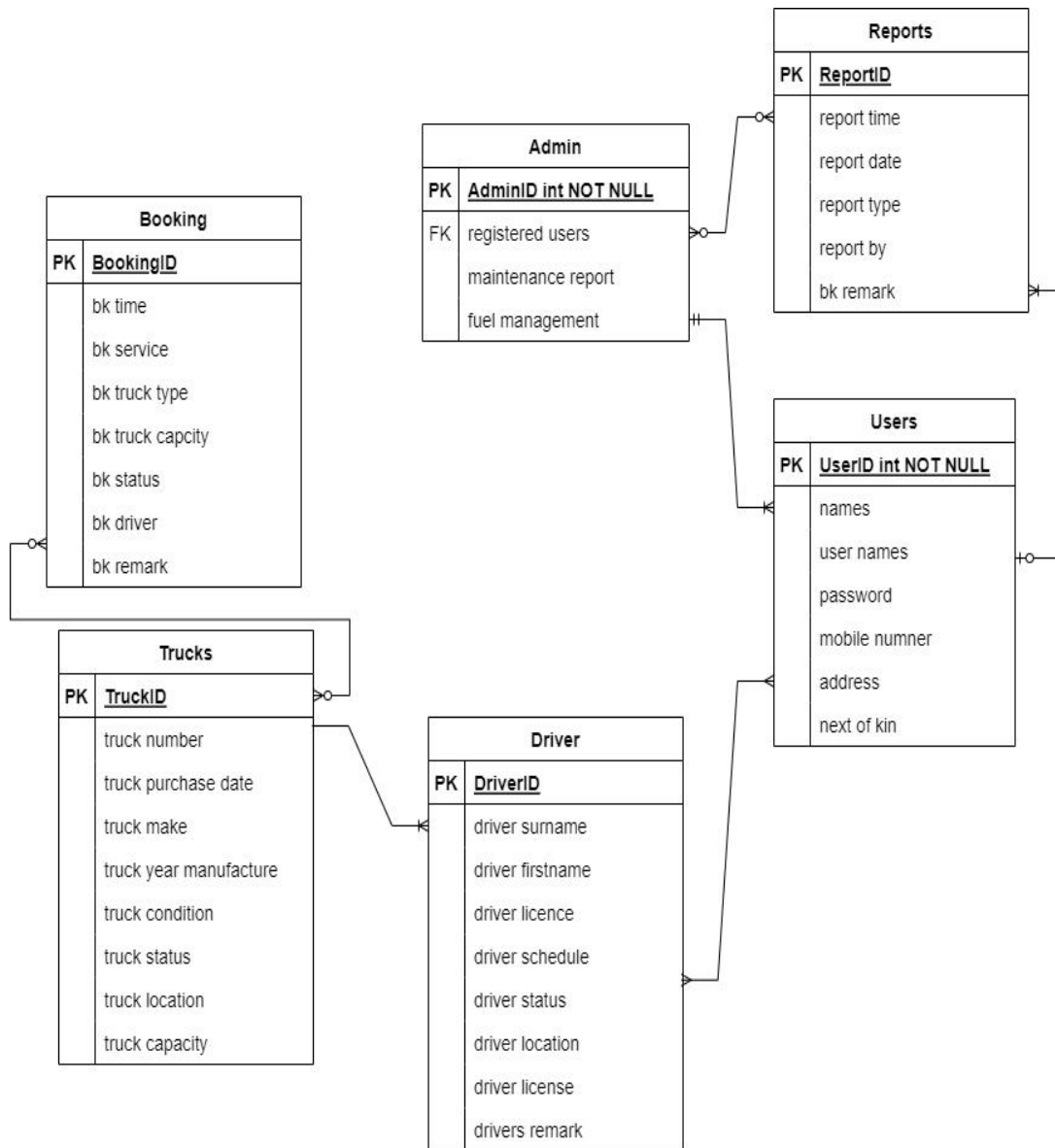


Figure 3.2 Entity relationship diagram

(Source: Ali, D. V., 2022)

3.5 Database Design and Tables

The database design and implementation in this project was done using a relational design model database design. That being said, PHP was used for the development of the backend of this project which is a tool for MySQL database management. The database tables were design to hold and save information of all

administrative and other users of the system. Also, the tables were designed to save information regarding truck details, user's details, trucks movement, coordinates from the mobile phone communication. PHP was the preferable tool in this system design because it proffers ease of data manipulation at the backend. Example, users can create, alter already existing data, can import and export data from MySQL. Additionally, the table were design with primary keys which are data that have unique attributes, all data entry to the primary key field cannot be duplicated and cannot be left blank.

Primary key: UserId.

Table 3.2 Users table

Field	Type	Collation	Attributes	Null	Default	Extra
UserId	int(6)			No	None	Auto_Increment
Name	text	Time New Roman		No	None	
UserName	varchar(18)			No	None	
Password	varchar(18)			No	None	
EmailId	varchar(18)			No	None	
Address	varchar(120)			No	None	
Mobile_No	int(11)			No	None	
UserType	text			No	None	

(Source: Ali, D. V., 2022)

This is the database table that shows the caption of all users of the system, it shows the users name, username or id, password, email address, mobile phone number etc. most of the attributes in this table can be manipulated upon by the administrative users of the improved fleet management system. In this data table, the unique id for all data that will be captured here will be the `userId`, what that means is that the `userId` will be continuous incremental as users are added to the database and each user at any point in time will have a unique user id.

Primary key: `TruckNumber`

Table 3.3 Trucks registration table

Field	Type
DriverId	int(11)
TruckName	varchar(40)
TruckNumber	varchar(40)
Location	varchar(40)
TruckType	varchar(40)
PurchaseDate	Date(DDMMYY)
Capacity	varchar(40)

(Source: Ali, D. V., 2022)

This table captures information about the trucks, it will capture basic information about the truck such as the driverId, truck name, truck name, location, truck type etc.

Repair and maintenance table

Primary key: VehicleNumber

Table 3.4 Repair and maintenance table

Field	Type
UserId	int(6)
Category	text
TruckNumber	varchar(40)
Description	varchar(100)
BillNumber	int(10)
BillAmount	float
VendorName	varchar(30)
Date	Date(DDMMYY)
Bill_Image	blob

(Source: Ali, D. V., 2022)

This table will capture the repair and maintenance of the each truck in the system, it will capture all trucks information and basic information about what items were purchase for repair and maintenance. It will capture the truck number, items used,

description of the items, the vendor (Mechanic) that carryout the repair, amount and so on.

3.6 Use Cases

A use case diagram is a pictorial representation of the way and manner people will interface with the system. Use cases have had wide acceptance and it's been acknowledged globally as a specification tool for specifying the functional requirements of a software system. Many variations of use cases exist which tries to address the issues such as their comprehensiveness, degree of formalism, automated information extraction, usability etc. Use cases provide a means to capture and depict the requirements. For this project, the use cases are shown below.

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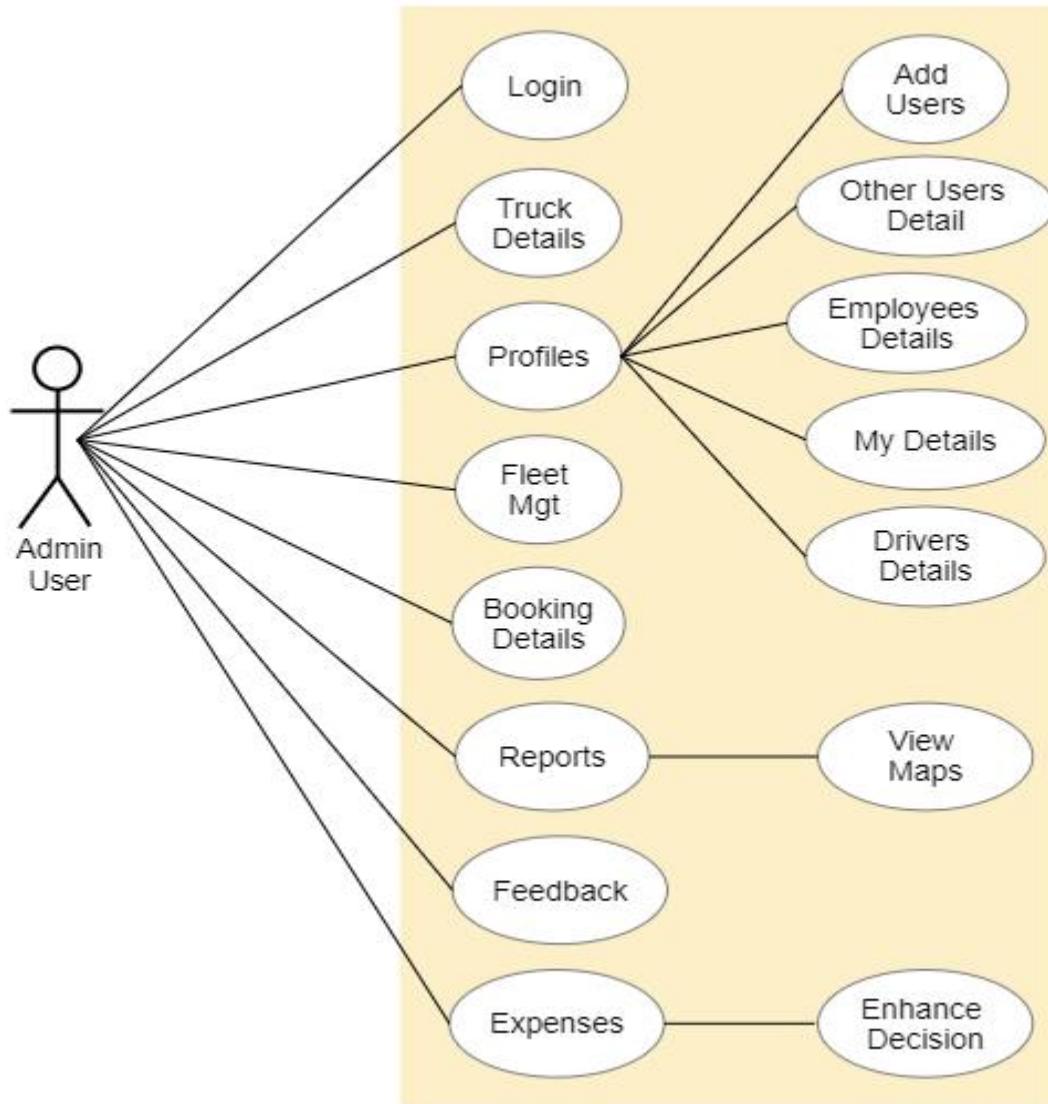


Figure 3.3 Admin user
 (Source: Ali, D. V., 2022)

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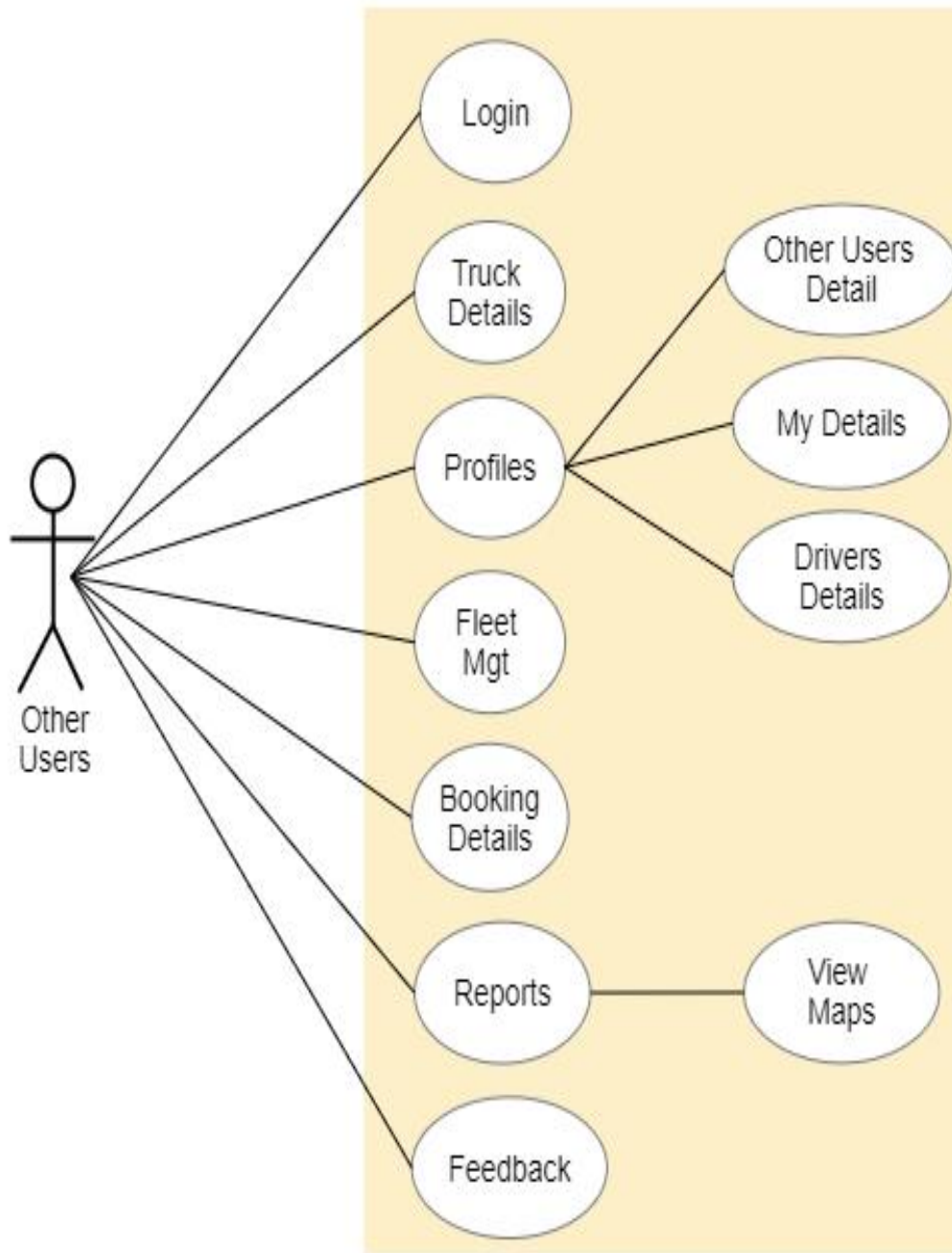


Figure 3.4 Other user

(Source: Ali, D. V., 2022)

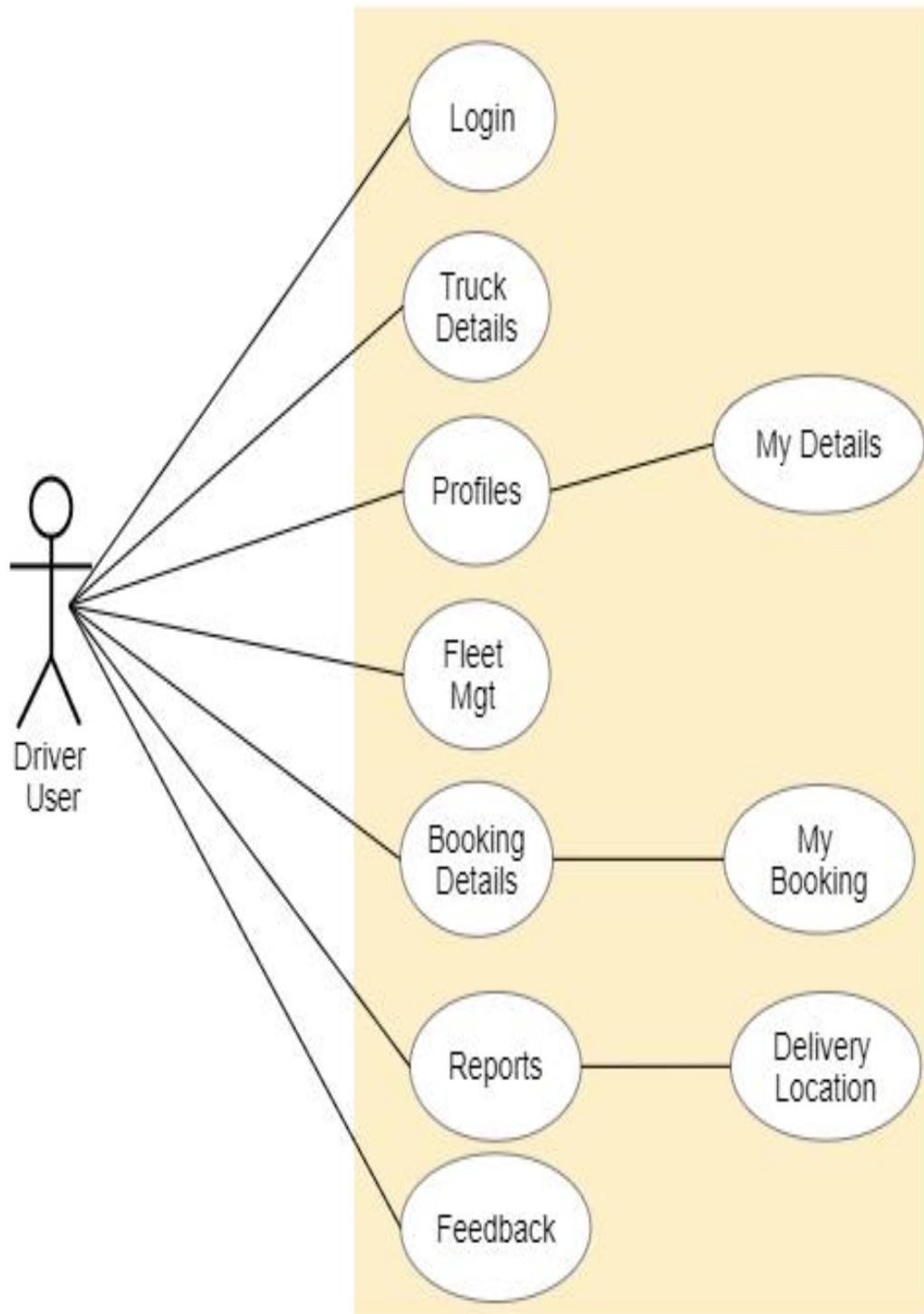


Figure 3.5 Driver users

(Source: Ali, D. V., 2022)

3.7 Real Time Tracking and Monitoring Algorithm

Dynamic fleet management makes use of data made available by satellite and mobile communications to enhance the real-time utilization of transportation resources. Furthermore, by rerouting vehicles in real-time to accommodate new requests, the deployment of intelligent transportation systems technologies, particularly precise positioning devices and in-vehicle computing and communication equipment. To turn these facts into precise judgments at the right moment, one merely needs the right approach and in this art of the world where mobile network connectivity is not guaranteed in some remote areas, there is consistent need for redundancy, in implementing this system algorithm, we make an improvement in the sense that dual GPS system was use to reduce the down effect of mobile network connectivity. Below is the system algorithm that was used in implementation.

Dijkstra's Algorithm

```
1: procedure MAIN (Graph, source)
2:   for  $\forall$  node  $v$  in Graph → Initialization
3:      $\text{dist}[v] = \infty$ 
4:      $\text{previous}[v] = \text{undefined}$ 
5:    $\text{dist}[\text{source}] = 0$  → Distance from source to source
6:    $Q = \text{the set of all nodes in Graph}$ 
7:   while  $Q$  is not empty
8:      $u = \text{node in } Q \text{ with smallest } \text{dist}[ ]$ 
9:     remove  $u$  from  $Q$ 
10:    for  $\forall$  neighbor  $v$  of  $u$ 
11:       $\text{alt} = \text{dist}[u] + \text{dist. between } (u, v)$ 
12:      if  $\text{alt} < \text{dist}[v]$  →relax ( $u, v$ )
13:         $\text{dist}[v] = \text{alt}$ 
```


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1. Message, Bird. *“How Laravel implements MVC and how to use it effectively”*. Accessed February 2022. <https://blog.pusher.com/laravel-mvc-use/>
2. Fowler S., and Stannick V., *Web Application Design Handbook Best Practices for Web-Based Software*, 2004.
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Chapter Four

Results and Discussions of Findings

4.1 Results and Discussion of Findings

This project was implemented to improve fleet management system and was built on the limitation of the project work Implementation of a vehicle tracking system using smartphone and short message service¹. In this chapter, the implementation of the project will be discussed in details and various steps of the development of the framework for the project work. The development of the web application, forms design and module. Also contain is the development of the mobile application that will be used to by truck driver to give access to the web application in acquiring the actual location of the truck and drivers location.

4.2 Results

Results arising from this project are divided into two, first we have the web application that is residence at a central office, system administrator can log into the system to view, add, delete, disable, check routes as well as do so many other things at the backend. Then the mobile application which will be logged into by the drive and will be used to track routes taken by the driver, it will be used to make contact by the administrative users of the system in the main office to give feedback to the driver via the use of instant messaging services.

4.2.1 Web Application Screens

The web application system is designed to be secured and can only be accessed by people that have the right credentials, username and password.

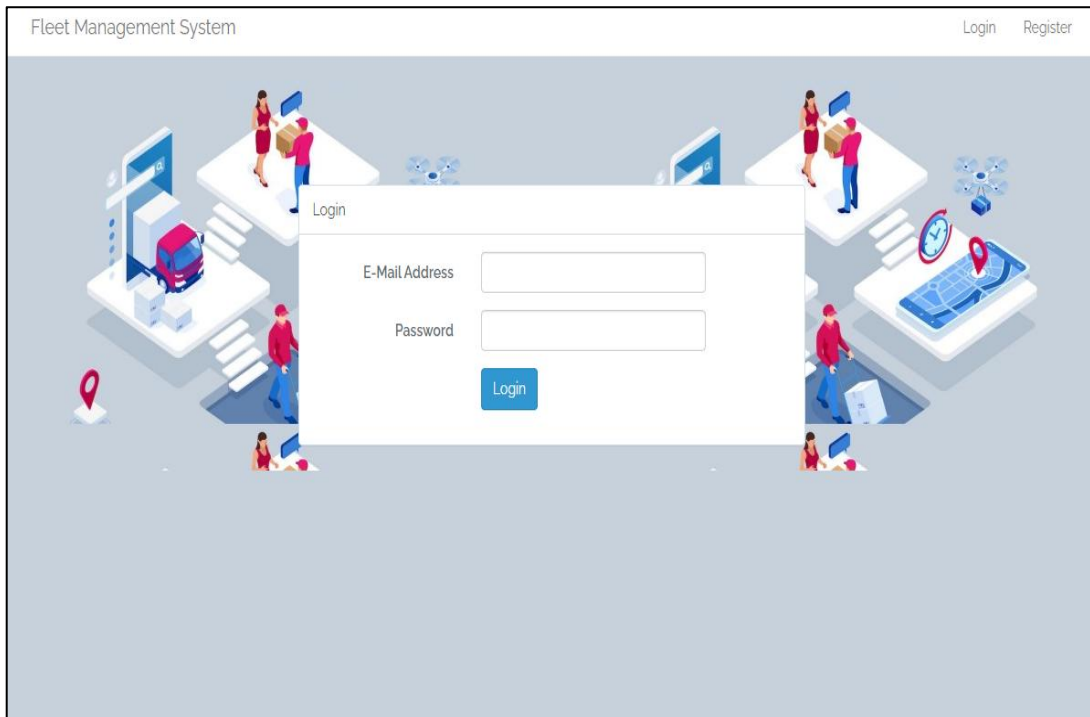
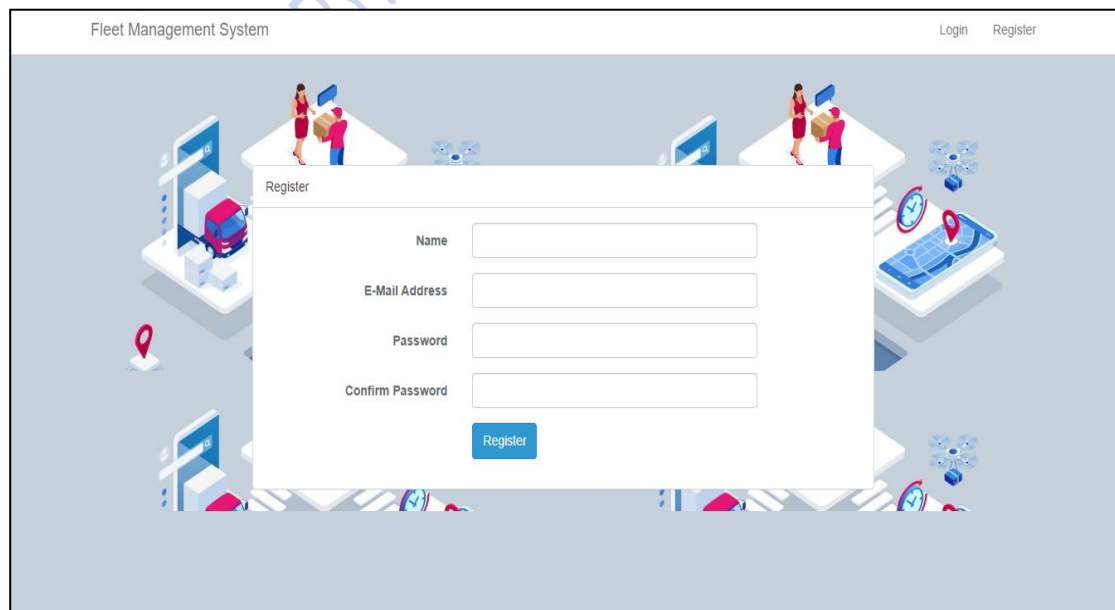


Figure 4.1 Login page of fleet management system

(Source: Ali, D. V., 2022)

New users can be registered into the system by an administrative user and must be able to provide details such as their full name, email address and their unique



password.

Figure 4.2 New user registration page

(Source: Ali, D. V., 2022)

Administrative user will be able to register a new driver to the system using their unique details like name, email address, password, next of kin and phone number. Also new trucks can be registered to the system by the admin user and all relevant information will be stored in the system like the truck make, color, capacity, engine

The screenshot shows a web interface for a 'FLEET MANAGEMENT SYSTEM'. On the left is a dark sidebar with a user profile for 'dajah Administrator' and a 'PAGES' menu containing 'ACCOUNT', 'DASHBOARD', and 'LOG OUT'. The main content area is titled 'Create Driver' and contains a form with the following fields: 'Name:', 'Email address:', 'Password:', 'Next of Kin:', and 'Phone Number:'. Each field has a corresponding text input box. At the bottom of the form is a dark 'SUBMIT' button. The breadcrumb at the top of the main area reads 'Homepage / Create Driver:'.

number

Figure 4.3 Driver registration page

(Source: Ali, D. V., 2022)

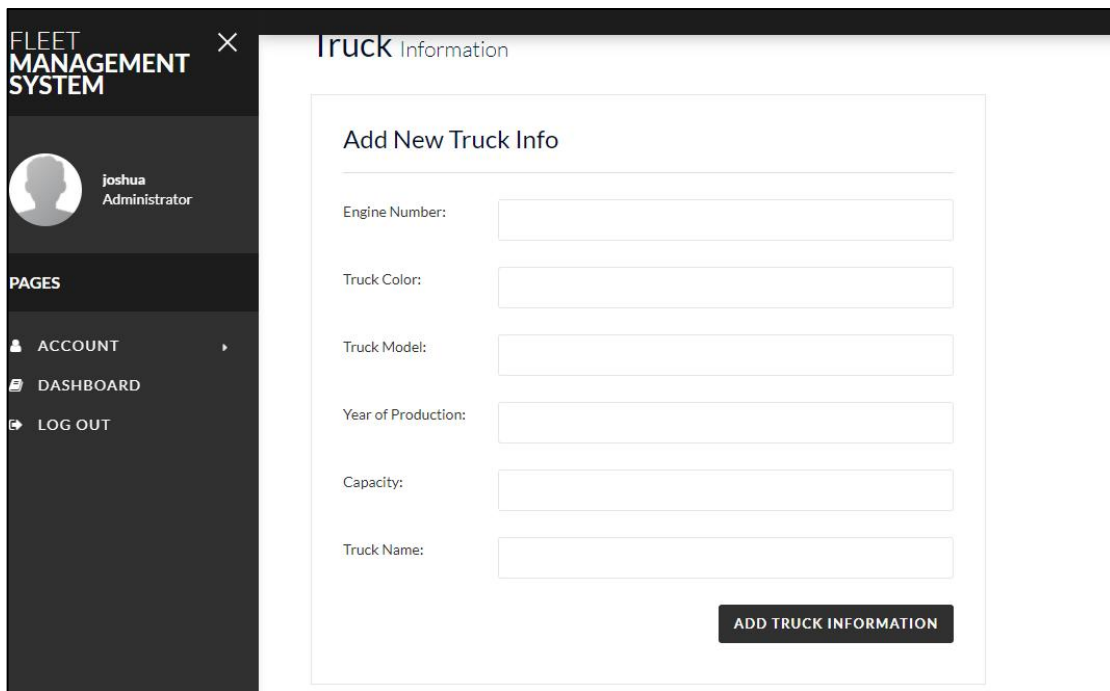


Figure 4.4 Truck registration page
 (Source: Ali, D. V., 2022)

All registered drivers can be seen from the system dashboard, the system will be able to display the driver's basic details, from this dashboard administrative users will be able to view driver's details, they can disable or delete drivers from the system, and they can edit driver's details on the system.

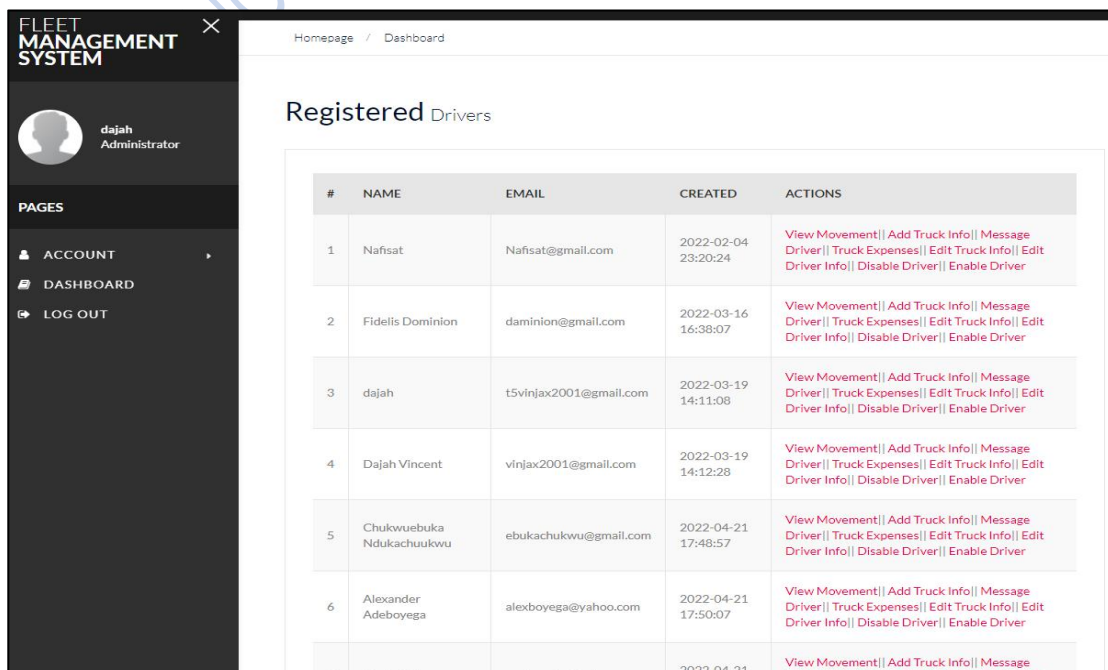


Figure 4.5 Driver's dashboard

(Source: Ali, D. V., 2022)

All driver's movement will be tracked using the global positioning system and coordinates will be sent on 10 seconds time interval to the fleet management system in the back office and the coordinates will be used to track whereabouts of the trucks and drivers.

The system will be able to save the drivers route and calculate on a daily basis the distance and mileage covered, these details will be used to calculate drivers' efficiency, trucks efficiency, fuel consumption, cost and many other variables.

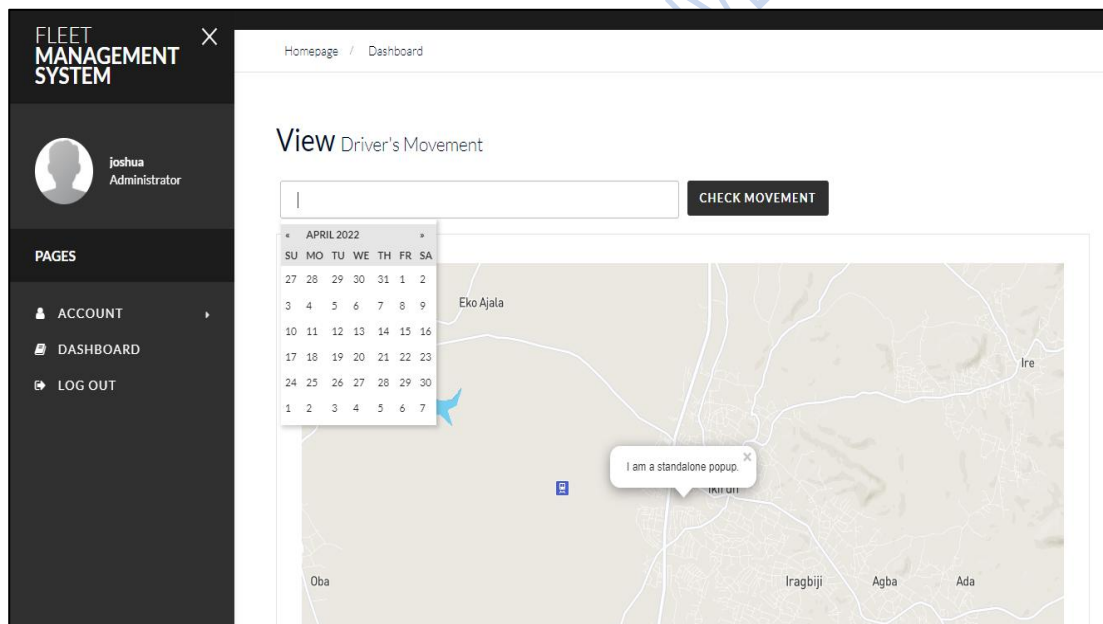


Figure 4.6 Screen shot of driver movement on a map

(Source: Ali, D. V., 2022)

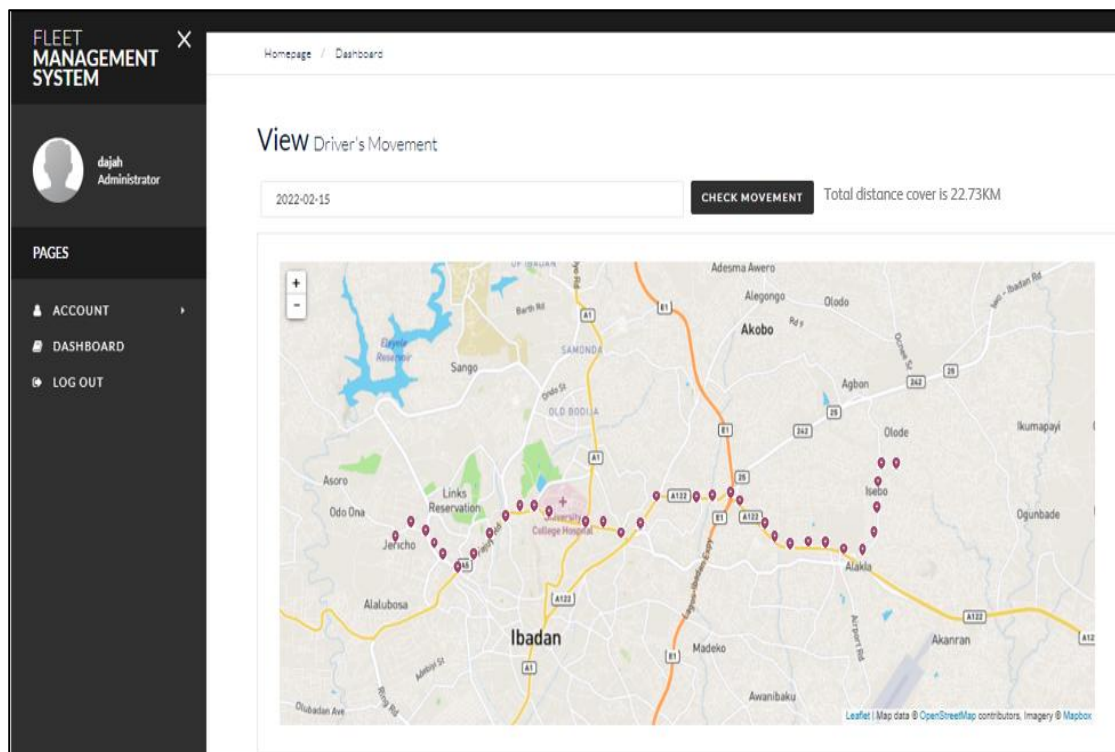


Figure 4.7 Screen shot of driver movement on a map and distance covered

(Source: Ali, D. V., 2022)

The drivers and truck movement are monitored on 60 seconds basis and coordinates are sent to a database for tracking actual location of the drivers, this system is designed to monitor the distance covered by the drivers, mileages covered per trip or at a specific time interval.

4.2.2 The Mobile Application Screens

The mobile application was develop using flutter, it is and open-source software development platform that is wide use and accepted for development of variety of cross platform mobile applications.

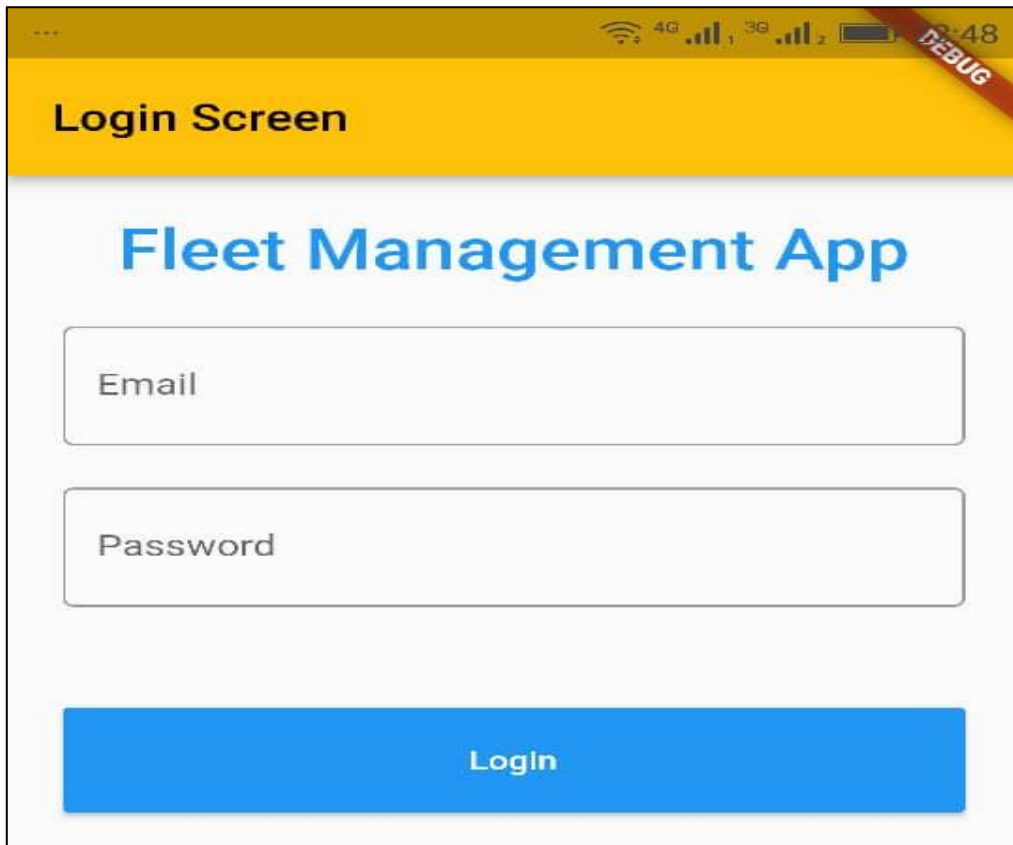


Figure 4.8 Mobile application login page

(Source: Ali, D. V., 2022)

The mobile can only be accessed using appropriately permitted user name and password, by so doing only users that have been registered into the web application by the system admin can log on to the mobile application. And if an unauthorized person tries to logon to the mobile application, the system will deny the person access.

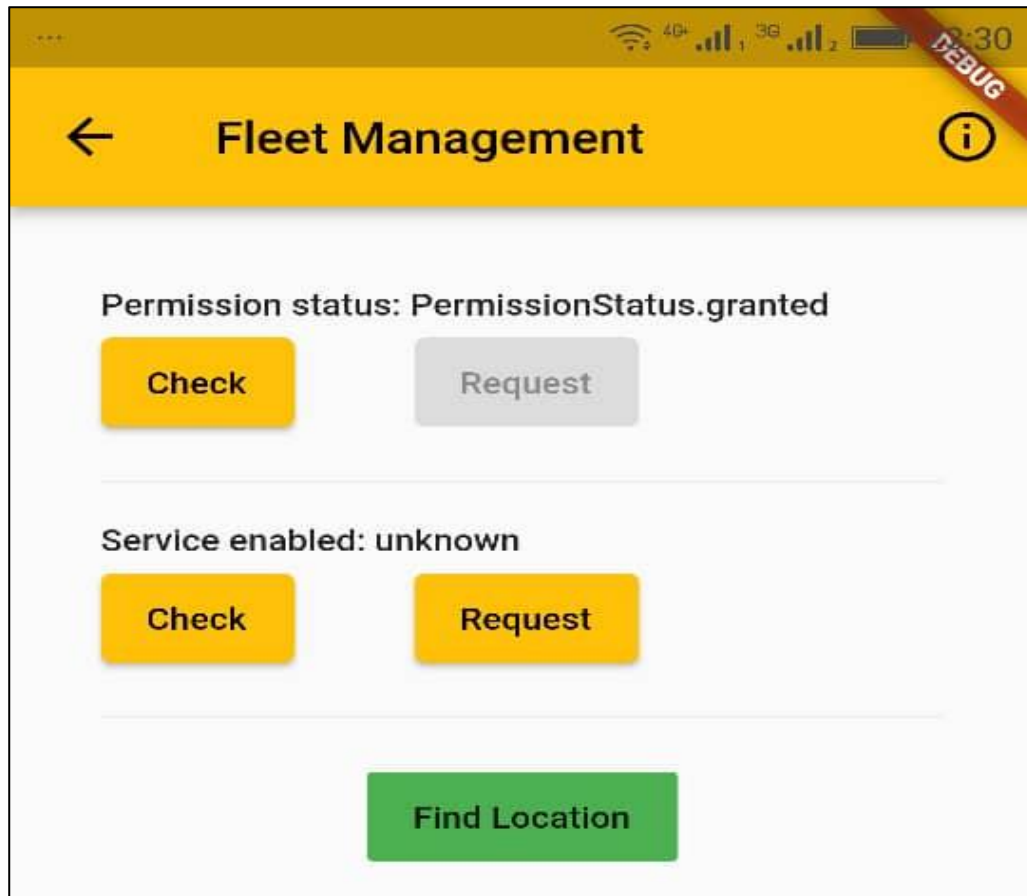


Figure 4.9 Mobile application access and services permission

(Source: Ali, D. V., 2022)

This is the snap shot of the user interface on the mobile application, drivers or users of the user interface will have to activate permission status on the application as well as the service enabler for the mobile application to start transmitting coordinates that will be used by the web application to track the whereabouts of the trucks and drivers on the map and this tracking is done in real-time.

4.2.3 Performance Testing

The improved fleet management system was developed and implemented basically using three programming languages. At the web application, HTML tags was utilized and powered by JavaScript. Flutter was used to build the mobile

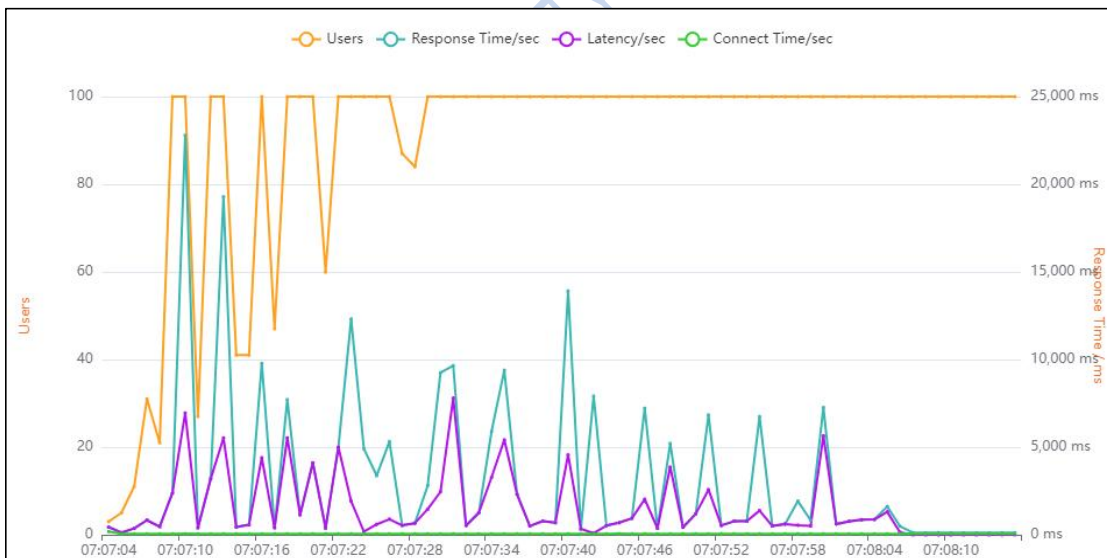
application. A total of 7683 lines of code (7.683×10^3 KLOC) was utilized to build this application both at the web and mobile application side.

Table 4.1 Table of programming languages and lines of codes

Programming Language	Lines of Codes
HTML	3296
JavaScript	3207
Flutter	1180
Total Lines of Codes	7683

(Source: Ali, D. V., 2022)

Below are the graphs of the system performance when checked using an online simulation software, it was simulated by pinging the system simultaneously with a number of users, this is done to see the system performance in terms of throughput



and response time.

Figure 4.10 Response time graph

(Source: Ali, D. V., 2022)

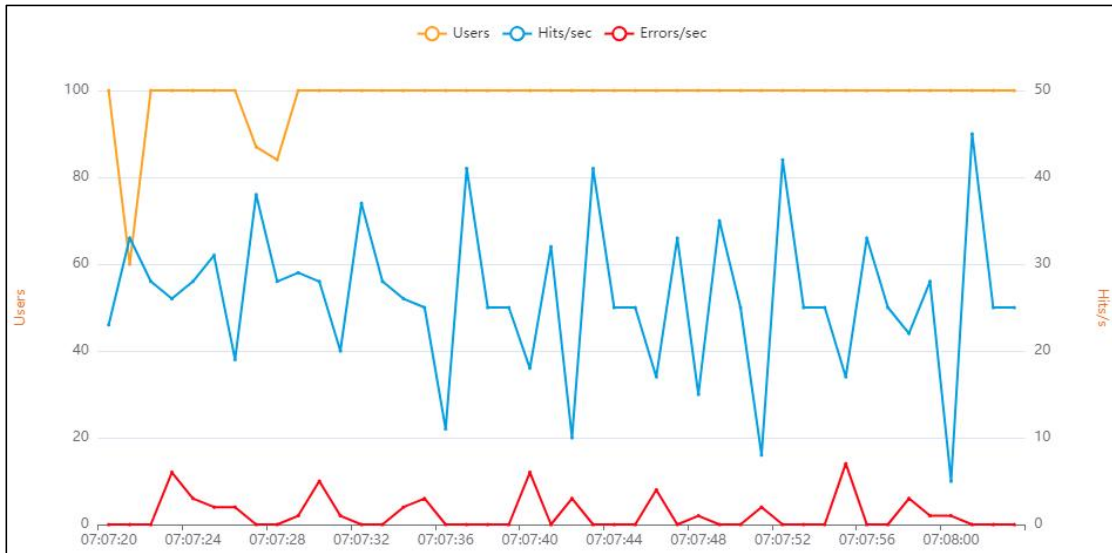


Figure 4.11 Response time graph against errors
(Source: Ali, D. V., 2022)

Below is the table of summary of the test result from the simulation software, generally, the table shows stability in the improved fleet management system.

Table 4.3 Throughput and response of the system

No. of Users	Ave. Throughput (Hits/Sec)	Ave. Response time (mSec)
50	24.39	1289.39
100	83.81	890.09
150	369.55	215.19
250	1028.59	134.83

(Source: Ali, D. V., 2022)

4.3 Comparative Analysis

This project work was done in order to improve an existing fleet management system that has been earlier implemented. Implementation strategies used by previous developer and state areas and specific improvement done in this work¹.

Their design was implemented on two key elements of the mobile platform: location services, which are mostly GPS-based, and basic telephone services, which

are primarily SMS-based. On the other hand, the client's smartphone can determine the bus's location via SMS or the internet. While our work is based on the implementation of dual GPS modules, one will be installed on a truck and the order will be stationed with the truck driver in the hone of a smart phone equipped with an android communication application that the driver can activate to send the driver as well as the truck location.

Their design was generally implemented for small and medium organization of not more than fifty users, while our design was tested for up to five hundred users, hence can be implemented for medium to large scale organizations. Their system is perceived to be volatile in terms of security and the use of SMS to send coordinates, while our work has an improved security as users are separated by admins and other users. Their coordinates were send every two minutes, but our system send the trucks coordinates every one minutes.

Endnote

1. Jahan Nusrath, Kamal Hossen, Muhammad Kamrul & Hossain Patwary. *"Implementation of a Vehicle Tracking System Using Smartphone and SMS Service"*. In 2017 4th International Conference on Advances in Electrical Engineering (ICAEE), pp. 607-612. IEEE, 2017.

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Chapter Five

Conclusion

5.1 Summary of Findings

The main purpose of this research work was to develop and implement an improved fleet management system for Nigerian breweries plc Ibadan, this system was so developed to overcome the manual system that was currently in use in the organization. After successfully implementing and testing this system, the major findings may be summarized as follows:

1. The use of dual GPS tracker, one on the vehicle or truck that is being track and the other is utilized on the android enabled mobile phone that is stationed with the operator of the vehicle. This dual functionality gives the system redundancy in case the mobile GPS tracker is tempered with then the one on the vehicle will still be functional.
2. A database was implemented that will be used to capture and save users of the system; it will also be used to capture details of all vehicles used in the organization. The system is also designed with varying access levels such that only trusted administrators can be able to carry out operations such as additions of trucks and users to the system, deletion and removal of users from the system.
3. It takes an average of 30 seconds to lookup a driver details from the system and make a decision instead of the manual systems that rely of manual books documents to save drivers details.

4. When using a 8GB RAM computer to run and access resource from the improved fleet management system, load testing from the system was done and the system maintain stability and data transferred from the system per request was 14. 1Kb.

5.2 Conclusion

This system, improved fleet management system could be used by anyone or organization who owns and operates a fleet and will like to keep track of each of their vehicles in real time, this makes it easy to monitor changes and get the real-time information on each vehicle in the fleet. This project application makes use of different API's to achieve the end result, for example the use of leaflet map that was infused into HTML text to display and present the current as well as the previous location of each vehicle, also the mobile application API that communicate and send signal from the drivers smart phone to the main office has to be implement with a location listener, it tracks the location of the smart phone and sends the actual location to the main office.

This project was implemented with some security features that allows each user of the system to communicate with the main office using unique user identification keys, this is done with the view to prevent fraudulent updates and unauthorized access to the computer system. Working in this project's end-to-end capabilities and interaction with an android app have helped me get a solid understanding of web application development.

5.3 Recommendation

Although this project and system was developed for and with data available to Nigerian breweries plc Ibadan. This system can be implemented in wide range of organizations that utilize fleet and vehicular equipment for their service. I also recommend government at all levels to enforce the use of this system to organization that maintain large fleets, this has far reaching benefits not only to the government or the organization itself, but systems like this can be further enhanced and used in calculating carbon footprint of an organization, cities and states at large, knowing this features gives stakeholder the right information to act responsibly.

5.4 Contributions to Knowledge

The contributions made by this project work can be summarized as follows:

1. Implementation of multiple API's such as the leaflet map to present the driver location on the web application, also android location listener API to capture and transmit driver current location. This is particularly important such that the project has to be developed to be compatible with different version of android devices.
2. Shows a mobile application implementation framework on a universal platform such as android by using development methodology and software engineering design principles within an IDE like android studio.
3. Providing more understanding in the area of web and mobile application development and a basis for more robust project development in the future.

5.5 Area for Further Studies

The following suggestions are made for additional research:

1. Other fleet management features can be implemented, such as geo-fencing. Geo-fencing can serve as an additional security architecture, this system is implemented such that administrators or user of the fleet management system can create virtual boundaries and restrictions through which vehicles cannot cross. It can be created using either RFID technology or with WIFI, depending on the implementation method, it can be designed such that push message notification will alert the system admin of a vehicle crossing the virtual boundary or taking informed automated action such as shutting down the vehicle engine for the admin to take action, this can save the company in the case of theft.
2. Leaflet JavaScript map library was used in developing the map presentation of this project which is lightweight and open source. In the future, a more advance system can be implemented using google map. Road designs, city and town locations, state boundaries, geographical characteristics, restaurant ratings, and satellite photos are available on google maps. Google maps has been in used for substantial amount of time with documentation support and user friendly API's, however this come with a cost.

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Appendices

Appendix A: Web App – The Code to Create Driver Account

```
public function createaccount()
{
    if (Auth::check()) {

        return view('createdriver');

    }else{
        return redirect()->intended('/');
    }
}

public function createdriver(Request $request)
{
```

```

if (Auth::check()) {

    if ($request->isMethod('post')) {

        //name:name, email:email, password:password, nok:nok, phone:phone

        $email = strip_tags($request->email);

        $name = strip_tags($request->name);

        $nok = strip_tags($request->nok);

        $phone = strip_tags($request->phone);

        $password = $request->password;

        if(!empty($email) || !empty($name) || !empty($password)){

            $mail = new Driver();

            $mail->email = $email;

            $mail->name = $name;

            $mail->nok = $nok;

            $mail->phone = $phone;

            $mail->reg_by= Auth::user()->id;

            $t=time();

            $hashword = $mail.$t;

            $hasded = md5($hashword);

            $mail->remember_token=$hasded;

            $mail->password = \Hash::make($password);

            $mail->save();

            return response()->json(array('msg'=> 1), 200);

        }else{

```

```
        return response()->json(array('msg'=> 'An error occurred while
creating the account, please try again'), 200);
    }

    }else{
        return response()->json(array('msg'=> 'An error occurred while creating the
account, please try again'), 200);
    }

    }else{
        return redirect()->intended('/');
    }
}
```

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Appendix B: Web App – The Code to Track Vehicles

```
public function getcoord(Request $request)
{
    if (Auth::check()) {

        if ($request->isMethod('post')) {

            //name:name, email:email, password:password, nok:nok, phone:phone

            $email = strip_tags($request->datet);

            $id = strip_tags($request->bpi);

            $dates = Positions::where('user_id','=',$id)

                ->where('created_at', 'like', '%'.$email.'%')

                ->get();

            $arr = array();

            $dist =0;

            $last_lat = 0;

            $last_long =0;
```

```

    $i =0;
    foreach ($dates as $date) {

        if($i != 0){
            $dist = $dist + self::distancec($last_lat, $last_long, $date->lat,
$date->long, 'K');
        }
        //
        $sarr[]=array( $date->lat, $date->long);

        $last_lat = $date->lat;
        $last_long =$date->long;
        $i++;
    }
    // unset($value);..
    //print_r($dates); json_encode($sarr,JSON_FORCE_OBJECT)
    return response()->json(array('msg'=> 1,'locations'=>json_encode($sarr),
'distance'=>$dist ), 200);
}
}else{
    return response()->json(array('msg'=> 'An error occurred, please try again'),
400);
}
}
}else{

```

```

        return response()->json(array('msg'=> 'An error occurred, please try again'),
400);

    }

}

```

Appendix C: Web App – Messaging Code

```

public function getmessages(Request $request)
{
    if (Auth::check()) {
        if ($request->isMethod('post')) {
            $admin_name = \Auth::user()->name;
            $admin_id= \Auth::user()->id; //driver
            $driver = strip_tags($request->driver);
            // Message
            $messages = Message::where('admin_id','=',$admin_id)
                ->where('driver_id', '=', $driver )
                ->get();

            $driverr = Driver::where('id','=', $driver)->get();

```

```

//dd($driverr);

return response()->json(array('msg'=> 1,'messages'=>json_encode($messages),
'admin_name'=>$admin_name, "driver_name"=>$driverr[0]->name), 200);

}else{

return response()->json(array('msg'=> 'An error occurred, please try again'),
400);

}

}else{

return response()->json(array('msg'=> 'An error occurred, please try again'),
400);

}

}

public function sendmessage(Request $request)
{
if (Auth::check()) {

if ($request->isMethod('post')) {

$driver = strip_tags($request->driver); // 'message',
'driver_id','admin_id','message_to_driver',

$message = strip_tags($request->message);

$admin_name = \Auth::user()->name;

```

```

    $admin_id= \Auth::user()->id;
    $smsmessage = new Message();
    $smsmessage->message = $message;
    $smsmessage->driver_id = $driver;
    $smsmessage->admin_id = $admin_id;
    $smsmessage->message_to_driver = 1;
    $smsmessage->save();
    return response()->json(array('msg'=> 1 ), 200);
} else {
    return response()->json(array('msg'=> 'An error occurred, please try again'),
400);
}
} else {
    return response()->json(array('msg'=> 'An error occurred, please try again'),
400);
}
}

```

Appendix D: Web App – Truck Information

```
public function addtrackinfo(Request $request)
{
    if (Auth::check()) {
        if ($request->isMethod('post')) {
            $trname = strip_tags($request->trname);
            $trcapacity = strip_tags($request->trcapacity);
            $trofproduction = strip_tags($request->trofproduction);
            $trmodel = strip_tags($request->trmodel);
            $trcolor = strip_tags($request->trcolor);
            $trengineno = strip_tags($request->trengineno);
            $driver = strip_tags($request->driver);

            if(!empty($trname) || !empty($trcapacity)
|| !empty($trofproduction)|| !empty($trmodel) || !empty($trcolor)
|| !empty($trengineno) || !empty($driver) ){
```

```

        $truckinfo = new TruckDetails();
        $truckinfo->driver_id = $driver;
        $truckinfo->engine_no = $trengineno;
        $truckinfo->truck_color = $trcolor;
        $truckinfo->truck_model = $trmodel;
        $truckinfo->year_of_production = $trofproduction;
        $truckinfo->capacity = $trcapacity;
        $truckinfo->truck_name = $trname;
        $truckinfo->save();
        return response()->json(array('msg'=> 1 ), 200);
    }else{
        return response()->json(array('msg'=> 'An error occurred, Kindly check
your inputs and try again.'), 400);
    }
}
}else{
    return response()->json(array('msg'=> 'An error occurred, please try again'),
400);
}
}
}else{

```

```
return response()->json(array('msg'=> 'An error occurred, please try again'),
400);

}

}
```

Appendix E: Mobile App – Location Listener

```
import 'dart:async';

// import 'dart:convert' as convert;

import 'package:flutter/material.dart';
import 'package:flutter/services.dart';
import 'package:location/location.dart';
import 'dart:io';
import 'package:http/http.dart' as http;

// import 'package:dio/dio.dart';

class ListenLocationWidget extends StatefulWidget {

  const ListenLocationWidget({Key? key}) : super(key: key);

  @override
```

```
_ListenLocationState createState() => _ListenLocationState();  
}
```

```
class _ListenLocationState extends State<ListenLocationWidget> {  
  final Location location = Location();
```

```
  LocationData? _location;
```

```
  StreamSubscription<LocationData>? _locationSubscription;
```

```
  String? _error;
```

```
  getLocation() async {
```

```
    bool _serviceEnabled;
```

```
    PermissionStatus _permissionGranted;
```

```
    LocationData _locationData;
```

```
    _serviceEnabled = await location.serviceEnabled();
```

```
    if (!_serviceEnabled) {
```

```
      _serviceEnabled = await location.requestService();
```

```
      if (!_serviceEnabled) {
```

```
        return;
```

```
      }
```

```
    }
```

```
    _permissionGranted = await location.hasPermission();
```

```
    if (_permissionGranted == PermissionStatus.denied) {
```

```

    _permissionGranted = await location.requestPermission();
    if (_permissionGranted != PermissionStatus.granted) {
        return;
    }
}

_locationData = await location.getLocation();

Map<String, double?> personLocation = {
    "longitude": _locationData.longitude,
    "latitude": _locationData.latitude,
};
return personLocation;
}

Future<void> _listenLocation() async {
    _locationSubscription =
        location.onLocationChanged.handleError((dynamic err) {
            if (err is PlatformException) {
                setState() {
                    _error = err.code;
                });
            }
        });
    _locationSubscription?.cancel();
}

```

```

    setState() {
      _locationSubscription = null;
    });
  }).listen((LocationData currentLocation) {
    setState() async {
      _error = null;

      _location = currentLocation;

    });
  });
  setState() {});
}

sendlocation() async{
  _locationSubscription == null ? _listenLocation : null;

}

Future<void> _stopListen() async {
  _locationSubscription?.cancel();

  setState() {
    _locationSubscription = null;
  });
}

```

```

@override

void dispose() {
  _locationSubscription?.cancel();

  setState() {
    _locationSubscription = null;
  });

  super.dispose();
}

// @override
// void onInit() {
//   super.onInit();
//   timer = Timer.periodic(Duration(minutes:1), (Timer t) => getLocation());
// }

@override

Widget build(BuildContext context) {

  return Column(
    crossAxisAlignment: CrossAxisAlignment.start,
    children: <Widget>[
      Text(
        'Listen location: ' + (_error ?? '${_location ?? "unknown"}'),
        style: Theme.of(context).textTheme.bodyText1,
      ),
      Row(
        children: <Widget>[

```

```

Container(
  margin: const EdgeInsets.only(right: 42),
  child: ElevatedButton(
    child: const Text('Listen'),
    onPressed: _locationSubscription == null ? _listenLocation : null,
    // () {
    //   sendlocation();
    // } // _locationSubscription == null ? _listenLocation : null,
  ),
),
ElevatedButton(
  child: const Text('Stop'),
  onPressed: _locationSubscription != null ? _stopListen : null,
)
],
),
Row(
  children: <Widget>[
    Container(
      margin: const EdgeInsets.only(right: 42),
      child: ElevatedButton(
        child: const Text('Listen'),
        onPressed: _locationSubscription == null ? _listenLocation : null,
        // () {
        //   sendlocation();

```

```

        // }          // _locationSubscription == null ? _listenLocation : null,
      ),
    ),

  ],
),
],
);
}
}

```

Appendix F: Mobile App – Granting Permission for Tracking

```

import 'package:flutter/material.dart';
import 'package:location/location.dart';

class PermissionStatusWidget extends StatefulWidget {
  const PermissionStatusWidget({Key? key}) : super(key: key);

  @override
  _PermissionStatusState createState() => _PermissionStatusState();
}

class _PermissionStatusState extends State<PermissionStatusWidget> {
  final Location location = Location();

  PermissionStatus? _permissionGranted;

```

```

Future<void> _checkPermissions() async {

  final PermissionStatus permissionGrantedResult =
    await location.hasPermission();

  setState() {

    _permissionGranted = permissionGrantedResult;

  });
}

```

```

Future<void> _requestPermission() async {

  if (_permissionGranted != PermissionStatus.granted) {

    final PermissionStatus permissionRequestedResult =
      await location.requestPermission();

    setState() {

      _permissionGranted = permissionRequestedResult;

    });

  }

}

```

```
@override
```

```

Widget build(BuildContext context) {

  return Column(

    crossAxisAlignment: CrossAxisAlignment.start,

    children: <Widget>[

      Text(

```

```

Permission status: ${_permissionGranted ?? "unknown"}',
style: Theme.of(context).textTheme.bodyText1,
),
Row(
  children: <Widget>[
    Container(
      margin: const EdgeInsets.only(right: 42),
      child: ElevatedButton(
        child: const Text('Check'),
        onPressed: _checkPermissions,
      ),
    ),
    ElevatedButton(
      child: const Text('Request'),
      onPressed: _permissionGranted == PermissionStatus.granted
        ? null
        : _requestPermission,
    )
  ],
),
];
);
}
}

```

Service enabling

```
import 'package:flutter/material.dart';
```

```
import 'package:location/location.dart';
```

```
class ServiceEnabledWidget extends StatefulWidget {
```

```
  const ServiceEnabledWidget({Key? key}) : super(key: key);
```

```
  @override
```

```
  _ServiceEnabledState createState() => _ServiceEnabledState();
```

```
}
```

```
class _ServiceEnabledState extends State<ServiceEnabledWidget> {
```

```
  final Location location = Location();
```

```
  bool? _serviceEnabled;
```

```
  Future<void> _checkService() async {
```

```
    final bool serviceEnabledResult = await location.serviceEnabled();
```

```
    setState() {
```

```
      _serviceEnabled = serviceEnabledResult;
```

```
    });
```

```
}
```

```
  Future<void> _requestService() async {
```

```

if (_serviceEnabled == true) {
  return;
}

final bool serviceRequestedResult = await location.requestService();

setState() {
  _serviceEnabled = serviceRequestedResult;
});
}

@override
Widget build(BuildContext context) {
  return Column(
    crossAxisAlignment: CrossAxisAlignment.start,
    children: <Widget>[
      Text('Service enabled: ${_serviceEnabled ?? "unknown"}',
        style: Theme.of(context).textTheme.bodyText1),
      Row(
        children: <Widget>[
          Container(
            margin: const EdgeInsets.only(right: 42),
            child: ElevatedButton(
              child: const Text('Check'),
              onPressed: _checkService,
            ),
          ),
        ],
      ),
    ],
  );
}

```

```

ElevatedButton(
  child: const Text('Request'),
  onPressed: _serviceEnabled == true ? null : _requestService,
)
],
)
],
);
}
}

```

Biodata

A. Personal Data:

1. **Name:** Dajah Vincent ALI
- Permanent Home Address:** No. 3 redemptorist community Kulodi estate, Egbeda LGA Ibadan, Nigeria.
- Contact Address:** Nigerian Breweries Plc, Km 3 new Ife road, Ibadan.
- Email Address:** vincent.dajah@heineken.com or
vinjax2001@gmail.com
- Phone Number:** 08036776850
- 2: **Date of Birth:** 04th September 1983
- Place of Birth:** Jos, Plateau State.
3. **Nationality:** Nigerian
4. **Next of kin**
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B. Education Background with Date

i. Institution Attended with Dates

- i. Lead City University, Toll Gate, Ibadan Oyo State: 2020 till date.
- ii. Ahmadu Bello University, Zaria, Kaduna State: 2016 to 2019.
- iii. National Open University of Nigeria, Jabi, Abuja: 2009 to 2014.
- iv. Government Technical College, Bukuru, Jos Plateau State: 1999 to 2002.
- v. Pilot Primary School Heipang, Barkin Ladi, Jos Plateau State: 1989 to 1995.

ii. Qualifications with Dates

- i. MBA Human Resources Management: 2019.
- ii. B. Sc. Computer Science: 2014.
- iii. GCE: 2007.
- iv. NABTEB: 2002.
- v. First Leaving Certificate: 1995.

C. Working Experience with Date

Line Manager Packaging, Nigerian Breweries Plc, Ibadan, Oyo State. 2019 to till date.

Total Productivity Coordinator, Nigerian Breweries Plc, Aba, Abia State. 2018 to 2019.

Packaging Process Trainer, Nigerian Breweries Plc, Awo- Omamma, Imo State. 2016 to 2018.

Production Team Lead, Nigerian Breweries Plc, Amaeke Enugu, Enugu State.
2013 to 2016.

Machine Specialist, Nigerian Breweries Plc, Amaeke Enugu, Enugu State.
2003 to 2013.

Machinist, ATMN Bukuru, Jos Plateau state. SIWES 2001.

D. Award and Fellowship

TPM Bronze Award – 2015.

Federal Government Exchange Program Scholarship Award – 1995.

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CISCO Certified Network Associate

OSHA Certified Occupations Safety Professional

Institute of Brewing and Distilleries

F. Publications

Design and Implementation of a Security Database: a Case Study of Nigerian
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Impact of Reward System on Employee Performance: a Case Study in
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Signature

Date

University Compliance Form

This is to certify that that this thesis by Dajah Vincent Ali with Matriculation Number LCU/PG//002213 in the Department of Computer Science, Faculty of Natural and Applied Sciences, Lead City University, Ibadan is in full compliance with the approval of the University's format and style.

Signature

Date