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Harmonization of vehicle location tracking and speed control systems in Addis Ababa city using open-source platforms

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Harmonization of vehicle location tracking and speed control systems in Addis Ababa city using open-source platforms

(TesfayesusYimenu, School of Civil and Environmental Engineering, Post Graduate Studies in Geodesy and Geomatics)

Abstract

The Internet of things (IoT), with real-time monitoring of assets, has become the order of the day in this contemporary world. One such application is vehicle tracking and monitoring in real-time. The number of frequent traffic accidents and car burglaries in Addis Ababa is mounting daily. It has become easier to monitor valuable assets, including vehicles, of an individual and organization, from tracking their exact location to monitoring associated assets like speed, fuel, or driver behavior because of modern technology. The traffic management agency (TMA) of Addis Ababa has started an initiative to grant a license to providers of such services that meet its mandatory standard. Almost all service providers have their systems and platform to monitor the location and check the speed limit of automobile owners and motorcycles. Consequently, dozens have already obtained the license and are in operation. However, using these so many platforms also have its disadvantage. They have different properties and focus. It has become overwhelming to TMA and other fleet managers to synchronize all the data from the various devices mounted on motorbikes, automobiles, and platforms. There is a pressing need for a centralized platform from which TMA and other fleet managers for a centralized platform from which TMA and other fleet managers can monitor service providers and vehicle and motorcycle owners. Therefore, this research project focused on developing and using a common platform for all integrators where TMA as a system administrator, will oversight the overall work. The licensed integrators, on the other hand, will deal with the routine work of dealing with end users. Open-source vehicle tracking platforms and affordable platforms were used to achieve the intended result. These open-source resources include Open-Source GPS Tracking System (OpenGTS) and other free software like Structured Query Language (MySQL) server database; open street maps and Apache Tomcat were utilized for synchronization of vehicle location tracking and speed control in Addis Ababa.

Keywords: IoT, Vehicle Tracking, GPS/GSM, Fleet Management, OpenGTS, MySQL Server

1 Chapter One

1.1 Introduction

The Addis Ababa Traffic Management Agency (TMA), has undertaken several activities in the past years to identify the problems that hamper traffic safety and smooth flow in the city and to find solutions. One of the tasks was to identify the most significant reasons for the city's frequent traffic accidents and build a speed-limiting system. (Traffic Management Agency, 2021) pointed out that traffic accident reports in Ethiopia indicate that speeding is one of the city's significant causes of traffic accidents. The construction of speed breakers somehow improved the number of traffic accidents that occurred in the past. Still, they did not reduce the risk of death and severe injuries as anticipated due to other causes. In the nine months alone in 2021, 356 people have been killed in road accidents and 1,200 seriously injured. In the two months of this same year, 42 people were killed in traffic accidents. According to the Addis Ababa Police Commission, speeding is one of the major causes of accidents. A total of 905,811 drivers have been charged and fined for traffic offenses during the months. Most of them are on the grounds of speeding (Abebe, 2022).

Furthermore, car theft is becoming rampant in the capital to complicate the smooth flow of traffic further. In nine months in 2019, Addis Ababa Police Commission recorded 211 car thefts in Addis Ababa. Out of the 211 stolen cars, 70 were not found at all, 102 were found with missing parts, and 39 were found while in use by the robbers. This trend is a global rife. The good thing is that technology is alleviating these complications worldwide (Tenaw, 2021).

Globally, the Internet of things (IoT) is more and more becoming a leading technology in this contemporary life. More types of equipment are being connected to the internet and each other. Real-time systems are being used for constant monitoring and effectively securing assets. IoT system provides vehicle control and navigation for the user. The IoT-enabled system avoids vehicle accidents and theft worldwide and makes life easier. The IoT-enabled approach can provide emergency communication and location tracking services in a remote car that meets a tragic accident or any other emergency. Vehicle tracking and speed limit technology is just one example.

The agency is undertaking several activities in the control and awareness-raising sectors to prevent this catastrophic event and make the city's traffic safer and more comfortable. For that reason, TMA is working to implement a speed limiting technology and vehicle location tracking systems to control traffic movement and reduce accidents in the city. The speed limiter, equipped with an integrated vehicle speed control module, reduces the amount of fuel or air entering the engine depending on the vehicle's condition and the vehicle's speed. The system is being realized using GPS technology as per a directive issued by the Bureau of Transportation to ensure enhanced mobility and movement of motorcycles and automobiles at the Addis Ababa city level. A further assignment for the Addis Ababa City Road Authority was to plan and fund "high-quality walking and cycling infrastructure." Additionally, the city began a speed control program in 2017, building infrastructure for speed limits and revising its speed limits to 50 km/h on arterial roads and 20 km/h on streets without designated lanes for unprotected road users (Abebe, 2022).

It is recalled that Motorcycle Licensing and Supervision Directive No. 02/2011 has set up the licensing and control system to reduce the number of motorcycles operating in and out of the Addis Ababa City Administration. The directive was organized into a fragmented service of motorcycles, giving licenses to those that meet the legal requirements for the free movement of passengers, goods, and mails, and private transportation (TMA/Traffic Management Agency, 2021).

The Agency is now granting licenses to companies those provides speed limiters and has their own control center and that meet the required standard (TMA/Traffic Management Agency, 2021).The Addis Ababa City Administration's Lion City Bus and Sheger Public Transport and Public Service Employees Transport Service Enterprise vehicles have installed the speed limiters, and other government institutions are following suit. It will then be applied to commercial transport service providers by developing guidelines and implementing performance systems (TMA/Traffic Management Agency, 2021).Previously, only the Federal Transport Authority had issued a license to install the speed limiters. Still, more recently, the Addis Ababa Traffic Management Agency has been issuing licenses to companies that install the device at the city level.So far, the agency has given licenses to dozens of system integrators for motorcycle tracking with GPS modules and those installing vehicle speed-limiting devices. They had started work in full swing. But it was not without challenges.

TMA needs to oversight the overall performance and requires a consistent platform across the board. TMA agreed with stakeholders that all the system integrators will continue to work with a single platform to be selected by TMA. (TMA/Traffic Management Agency, 2021).

Nonetheless, since various GPS tracking devices and systems or platforms are currently in use, it has made its usage unmanageable and inconsistent.

Faced with all these kinds of challenges, TMA has undertaken some steps building upon on the experience of other countries practice with many years of capability in vehicle tracking. There were practical initiatives by companies and even researches about using open-source platforms to mitigate the problem in many countries. There are many studies to design and implement low cost and open-source vehicle tracking system. However there is not any single study conducted in recent years in Ethiopia to use open-source platforms for use in vehicle tracking.

To mitigate the problem TMA is facing there needs to be a study aimed at assuaging the concern. Therefore, this research mainly focused on developing and using a common platform for all integrators. TMA will oversee the overall work, and the licensed integrators will handle the routine work. Synchronization of vehicle location tracking and speed control in Addis Ababa city using open-source and affordable platforms is necessary to achieve the intended result. Numerous initiatives have been carried out to use open-source and low-cost commercial platforms, as stipulated in the literature review. Also, specific efforts are still underway by TMA and stakeholders. The research result will partly contribute to helping the challenges TMA and other fleet management organizations face.

1.2 Problem Statement

There are dozens of motorcycles and vehicle fleet tracking service providers and integrators with GPS technology in Ethiopia, and the number is increasing. Currently, 55 vehicle locations and speed limiter providers have been given a license after verification (TMA/Traffic Management Agency, 2021).And about 30 GPS location device providers for motorbikes and installers have been granted licenses(TMA/Traffic Management Agency, 2021). These all work in Addis Ababa (the capital city), and the number continues. They are all primarily engrossed in importing and installing the devices. Even the government agency (Traffic management agency) required all vehicles manufactured after 2006 for Addis Ababa to have speed regulating mechanisms in place(Yilma, 2014). So many location-based service providers are being lured by the day. The operation began, and work commenced for a certain period until it was temporarily halted. Nevertheless, there is a problem facing the process.

Firstly, as per discussion with TMA, even though there are device-related challenges, the main defy is platform-related. All those speed limiters, GPS location device providers, and integrators [fleet management system providers] have their platforms given to them by device manufacturers. This has in turn, significant disadvantages related to inconsistencies. Nearly the details of each platform have its peculiarities and differences to others.

Secondly, most of these platforms have servers somewhere in China, India, or elsewhere and pose security issues as the data is not in our hands. The government agency or the providers have to some extent, no control over the security issues. (TMA/Traffic Management Agency, 2021) This means the whereabouts of every vehicle owner might fall under constant scrutiny. At least soon, the database and the server need to be installed locally for security issues.

Third, the fact that there is no standard platform that TMA cannot maneuver has stimulated corruption as service providers will install the devices for their customers to fulfill the requirements by TMA and do not care about monitoring afterward. Currently, what is being done is, the traffic management agency (TMA) will be given administrative passwords for each service provider and firm to monitor to ensure that vehicle speed is controlled. Controlling the vehicles this way alone is simply impractical.

Fourth, the platforms and client applications are not customized to the local conditions and languages. Especially most end users of the system, namely fleet owners and individual vehicle owners, are not conversant in English and need local languages for their day-to-day activities. Most widely used local languages like Amharic, Oromo, and Tigrigna are an added value. Customized mobile and web-based applications are imperative.

Lastly, TMA has focused on establishing speed control systems so far. TMA needs to implement a platform according to its need. The platform out there in the market has various emphases. The reporting format can be designed based on their need. (Tenaw, 2021). For all these reasons, the government has notably and temporarily suspended the speed-limiting services in Addis Ababa. This research, therefore, envisioned assuaging the challenges faced by fleet management organizations in general and traffic management agencies in particular about synchronizing all their efforts in one single platform using open source and low-cost platforms.

1.3 Objectives of the study

1.3.1 General objective

The main objective of the study is to develop a synchronized and central vehicle location tracking and speed limiting platform that can be used for monitoring vehicle tracking service providers and their activities in monitoring vehicle movements.

1.3.2 Specific objectives

1. To put in place a tracking platform on the local server for curbing security-related problems
2. To adapt platforms for all vehicle service integrators so that all will report against the exact requirements.
3. To customize the platforms to the local conditions and languages.
4. To tailor-made clients' mobile and web-based applications that take into account local needs

1.4 Significance of the study

Vehicle tracking systems enable the most basic form of vehicle tracking. These features include monitoring driver performance, vehicle performance and maintenance, fuel management, dispatching, alerts and notifications, theft prevention, and report generation. More features might be added, but that relies on the business providing fleet management solutions. TMA as the main agency in managing the vehicles and traffic flow in the streets of Addis Ababa would benefit greatly if there is a workable and efficient platform at hand. Other vehicle management and rental firms would also benefit lot. Some of the significant importance includes monitoring speed limiting and vehicle tracking service provision; vehicle and driver safety, and improving protection and asset tracking.

1.5 Limitations of the study

One of the limitations of the study's outcome is that, like most open-source applications and software, the utilized tools are made with inherent restrictions. Some of the open-source software and systems used in the research are OpenGTS for platform management and MSQL server as a database. These are not full versions and lack some functionality that a firm or an organization in the location service provision might require.

The free and open-source versions are made to handle data inflow with limited capacities and volumes of vehicles. A single install of the platform on a single server can only manage a few thousand of vehicles. Unless we use multiple computers on different servers, one server alone cannot take hundreds of thousands of data from vehicles in Addis Ababa daily. This would have cost implications.

1.6 Scope of the study

Addis Ababa’s metropolitan population is projected to increase like most Sub-Saharan African countries. Likewise, the number of vehicles and motorbikes is increasing by the day.

Handling the ever-increasing vehicles using only open-source platforms would be practically be difficult if not impossible. Although the open-sources platform may alleviate a considerable number of complications associated with control of vehicles, the scope of the research focused on handling a few thousand of vehicles per server.TMA may need to upgrade to full versions of the open-source platforms for better efficiencies.

2 Chapter Three

2.1.1 Methodological Flow Chart

Vehicle tracking systems are being used by licensed location tracking service providers. The flowchart demonstrates the procedures. Tracking the position of a moving vehicle, such as a car, truck or other vehicles, is achieved in many cases using a geographical positioning system (GPS). GPS location tracking devices can be widely deployed to keep track of truck fleets to ensure that vehicles are properly used, and if stolen, they can be easily recovered. It has become very popular to use geographic positioning systems (GPS) to track the location of various objects. This includes automobiles and motorcycles. Some GPS devices use microcontrollers, while others also use GPRS/GSM technology as a networked way to access remote web servers. Various means, including in-situ visualization, have been used over the years to capture or visualize information captured by GPS, transmitted over networks, and displayed on platforms. The GPS tracker platform, which is the brain of the system, coordinates the activities of the GSM module and GPS receiver. The GPS receiver is used to receive satellite data from satellites. Through the GSM module, the coordinates are sent to the user/owner of the vehicle or motorcycle by SMS so that the vehicle could be tracked around the city and the real-time position could be viewed on the platform and client mobile application.

A flow chart illustrating this process is shown in Figure 9. Once the system is switched on, GPS obtained the location data from the satellite and sent it to the platform, which is the brain of the system. The platform is able to make the information available to users and vehicle owners in a number of ways. It displays the longitude and latitude on client mobile application for the driver of the vehicle. Moreover, the device sends the location information to the platform via a web server/web page. The administrator is also able to receive e-mail notifications.

2.2 Study Design

2.2.1 Primary Data, Interviewee selection criteria, sample size

The original data was gathered by visiting relevant offices in Addis Ababa, including government and commercial consultancy firms. Interviews with government officials and specialists are done to get insight into the current practice of tracing vehicles and motorbikes in the capital. The critical issues and challenges were documented. The reporting requirements from TMA's side to monitor and track vehicles were obtained.

There was a need to come up with a centralized platform. Henceforth this platform was designed, customized and employed as a result. The platform uses a free and open-source vehicle tracking tool that considers the needs of TMA and its stakeholders.

The research project was initiated based on the need identified by stakeholders in vehicle and motorbike tracking areas. The primary and immediate stakeholders were identified and are as follows.

- Addis Ababa Traffic Management Agency
- GPS Location and Speed Limiting Service Providers
- Fleet owners and managers
- Personal vehicle owners

The first task was developing an open-ended questionnaire to help grasp the gaps, opportunities, and challenges the sector faces. It was meant to be preliminary initial assessment questions regarding GPS location and speed-limiting services. A separate question was prepared for each group.

2.2.2 OpenGTS Vehicle tracking platform Development Process

The overall process is summed up in the following Figure 8

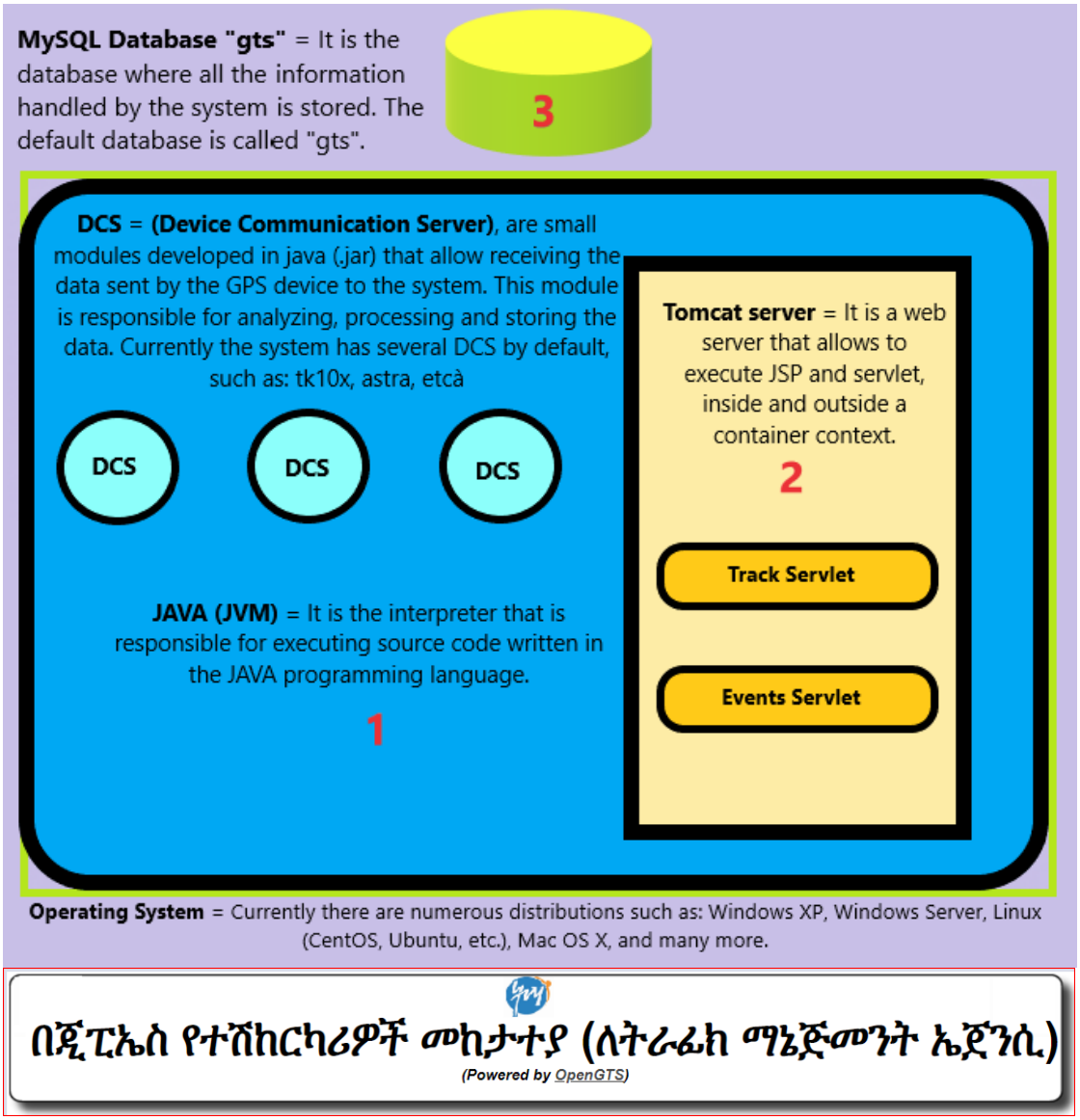

Figure 1: OpenGTS Vehicle tracking platform Development (TMA)

2.2.2.1 Deployed Localized Version of OpenGTS

Since the platform is open-source, it was made possible with an excessive effort to localize the vehicle tracking system in Amharic, where both system integrators and vehicle owners can fully utilize its potential. Over seven thousand lines of code were translated within the configuration file and deployedto make it happen. The picture below shows whatIt looks like on the login page.

The official Amharic name of TMA and its logo are shown on the login page. This is where the agency and service providers inputtheir account and username.

Figure 1: Localized Version of OpenGTS

Main

The main home (or homepage) is the main web page of a platform. It is the start page shown in Figure 11 when the application first opens. the home page is located at the root of the platform's domain or subdomain

As you can see, the functions are broken down into five main categories, Mapping, Reports and Administration, and System Administrator. Each of the tabs corresponds to the appropriately named category of functions.

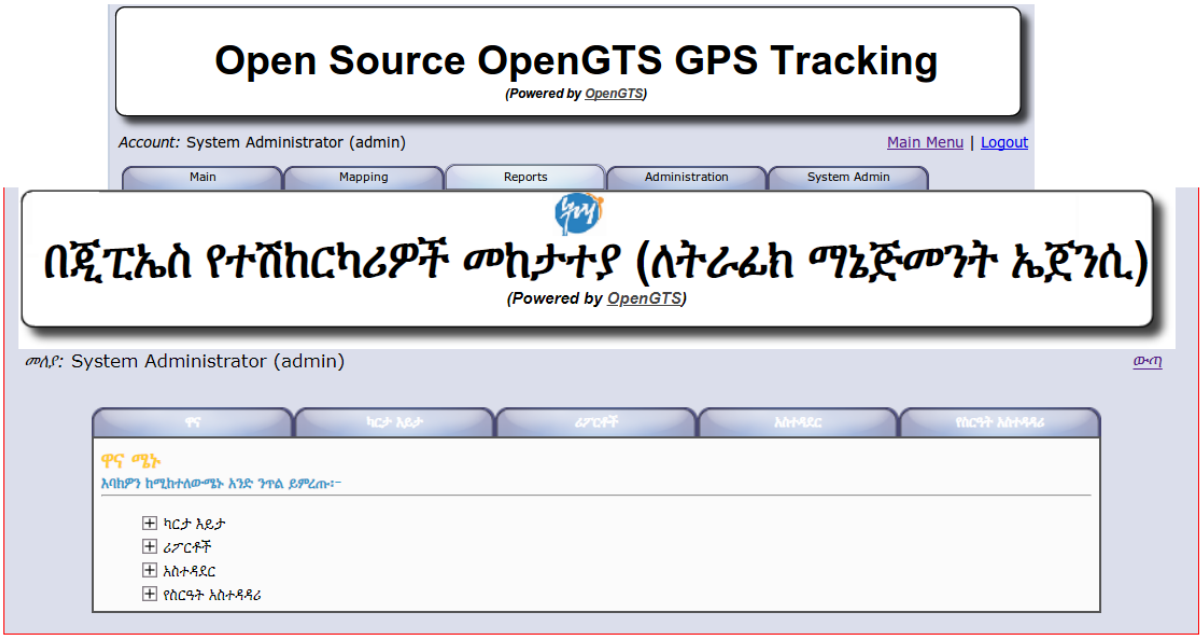

Figure 2: OpenGTS main tab

3 Chapter Four

3.1 Results and Discussion

Results

A workable synchronized and central platform was developed based on a free and open-source planform that can be used across all vehicle tracking providers, integrators, and traffic management agencies. The platform includes all the requirements of TMA as stipulated in the standard. All stakeholders can make full use of it as it enables them to monitor their clients in line with standard.

The main issue that necessitated the deployment of the platform on local server is the fact that personal data need to be handled locally. Consequently, it was made possible to set up the tracking platform on a local server which restricts security-related problems. The whereabouts of every vehicle owners as well as associated personal information would be under constant scrutiny if the server is not handled locally. On the other hand if the server fails or if the providers of such service outside of the country are not willing or interested to continue service all related information would be lost forever.

The set-up of the mockup platforms made it possible for all vehicle service integrators so all would report against the same requirements as demanded by TMA. While achieving the above, a customized platform was developed that adhere to the local conditions and languages. For a start, it was made available in Amharic. As more and more vehicle service providers and rental car and fleet management companies are joining the business, it would be of paramount importance to carry out their responsibilities.

Customized client's mobile applications are vital; the work is in progress and will be made available in accordance with the developed standard.

However this open-source has limited functionality and scope. The number of vehicles in Addis is increasing rapidly and cannot be handled entirely by open-source platforms. The research mainly focused what TMA can potentially do to centrally control vehicle location service providers. TMA may wish to go for a more advanced commercial platform.

Discussion

It has been stated earlier that there are, close to 1.2 million vehicles have been registered by the authority overall at both the federal and regional levels at the time of carrying out this research. And the numbers are mounting by the day. Motorcycles are the most often registered type of vehicle, according to total registrations, according to the Federal Transport Authority. Among the registered vehicles in the country, apart from motorcycles, Addis Ababa gets the lion's share of vehicles in Addis Ababa city.

In total, as of July 7, 2020, there are about 1,200,110 automobiles that have been registered nationwide as of the last fiscal year, as per the study. According to TMA report, Addis Ababa has registered about 630,440 automobiles, compared to Oromia's 204,026, Amhara's 106,434, and SNNPR's 118,424 vehicles. Despite small initiatives and early beginning in providing vehicle location service provision many results were observed. But it is far from adequate. There are many holes that need to be filled. Thus far there are no researches that were undertaken related to vehicle location tracking or platform development with particular focus in Addis Ababa. More need to follow, especially in areas that would consider the application and usage of geo-fences and geo-zones.

3.2 New Contribution of the research study

Some of the main new contributions of the research study, among other things,including

- A customized platform that takes into consideration of the needs of TMA has been installed on the local server
- The entire program has been prepared in the local language (Amharic), which required translating about ten thousand code lines.
- Geofences have been prepared in many selected regions of Addis Ababa, which facilitates accessible location and referencing of vehicles and places.
- New customizable reporting formats as per the requirement of TMA have been prepared.

4 Chapter Five

4.1 Conclusion

This study originally envisaged to develop a synchronized and central vehicle location tracking and speed limiting platform to monitor vehicle tracking service providers and their activities in monitoring vehicle movements. A demonstration and mockup of the established platform proved that using the platform, TMC can be able to monitor and oversee all the service providers for speed limiting and location tracking service providers. The details of how this was made possible and achieved are illustrated in the following sections.

- A workable synchronized and central platform was developed based on a free and open-source platform that can be used across all vehicle tracking providers, integrators, and traffic management agencies.

- It was made possible to set up the tracking platform on a local server which restricts security-related problems. The server for the mock platform is developed on local machines with no security threats.

- TMA to oversight the working progress of service providers and vehicle owners requires daily and monthly reports. The set-up of the mockup platforms made it possible for all vehicle service integrators so all would report against the same requirements as demanded by TMA.

- Especially most end users of the system, namely fleet owners and individual vehicle owners are not conversant in English and prefer local languages for their everyday activities. A customized platforms and client applications were developed that adhere to the local conditions and languages. For a start, it was made available in Amharic.

- Customized client's mobile applications are vital; the work is in progress and will be made available soon.

4.2 Recommendation

Based on the findings of this research work, the following recommendations are suggested:

- A mockup of the set-up platform proved that using the platform, TMA can monitor and oversee all the service providers for speed limiting and location tracking service providers. The number of vehicle owners is growing by the day as more and more cars are being imported. To make things worse, car burglaries and mischief are rising. And also implies that many firms are showing interest in getting a license from TMA to provide services. It is also the responsibility of TMA to oversight the process. With little means and resources to do this would be bound to fail. TMA urgently needs a synchronized and harmonized platform. Therefore, it is highly recommended that TMA set up a vehicle tracking platform on its server locally. Most vehicle and motorbike tracking service providers were mainly absorbed in installing devices. They gave little attention to what TMA requires of them in reporting and monitoring vehicle owners. Vehicle tracking service providers have a hard time dealing with various platforms. All platforms have their specific focus and peculiarities, making monitoring very difficult to monitor. Complying with the reporting requirement of TMA has also been problematic. Therefore, it is highly recommended that device providers also set up a central vehicle tracking platform on their server. Consequently, it is highly recommended that device providers also set up a central vehicle tracking platform on their server locally. Localized platforms would undoubtedly ease the pressure they are faced with. At best for a start setting-up an open-source platform like OpenGTS would alleviate the problem TMA is facing.

- Vehicle owners' and fleet managers' primary concern is ensuring their valuable assets are being used effectively and efficiently. They want to ensure that their drivers and vehicles in general and their assets, like fuel and car parts in particular, are safe and sound. Setting up a platform locally is indispensable to fled managers and highly recommended. Free and open-source platforms would benefit a lot to this regard.

- Taking care of the ever-increasing vehicles utilizing only open-source platforms would be for all intents and purposes be troublesome in case not incomprehensible. In spite of the fact that the open-sources platforms may lighten a significant number of complications related with control of vehicles, the scope of the investigates centered on taking care of many thousands of vehicles per server. TMA may have to be overhaul to full versions of the open-source platforms for better efficiencies.