Design Of A Road Traffic Monitoring And Report System

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***Abstract*— Road traffic is an essential part of our daily lives. This is why it is important to have a Traffic Monitoring and Report System (TMRS) that will empower the commuter to make better choices as they commute daily. The system will keep commuters updated about the traffic situation along their desired routes. Often times during the peak periods of the day, most routes within the Calabar metropolis are always congested due to heavy traffic causing commuters to spend so much time on the road before getting to their destinations. The aim of this study is to design a traffic monitoring and report system to enable commuters avoid traffic congestions and use routes that will take them to their destinations on time. A survey of some intersections within the Calabar metropolis was done to study the level of traffic within these peak periods. A survey of some hardware components and software was carried out. The TMRS was designed and tested on an iterative fashion. The result shows that the colour codes used to represent traffic conditions on the routes are easy to understand. The system will be able to provide users with the required information about the road traffic situation and enable the commuters to make informed decisions on the appropriate routes to take to their destinations. With the report from TMRS, the user will know what the level of traffic is ahead of him/her, and can decide his/her route. The system will serve as a very vital tool for reducing traffic congestion in the city, especially during peak periods. It will enable commuters to commute freely and get to their destinations on time.**

Keywords—Intelligent Transport System; Traffic Monitoring; Real Time System; Traffic Congestion; Commuters

I. INTRODUCTION

Traffic Monitoring and Report System (TMRS) is a traffic analysis program that empowers the commuter to make better choices as he/she commutes [1]. Traffic monitoring system means a logical method for the gathering, study, summary, and maintenance of road traffic related data.

Traffic reporting on the other hand is the near real-time distribution of information about road conditions such as traffic congestion, detours, and traffic collisions. Traffic reports, especially in cities, may also report on major delays to mass transit that does not necessarily involve roads. In addition to periodic broadcast reports, traffic information can be transmitted to GPS units, smartphones, and personal computers [2].

A Traffic Monitoring System (TMS) is an important element in an Intelligent Transportation Systems (ITS), especially in a developing country with a mixed traffic flow of vehicles including motorcycles and cars. Traffic flow varies at different times of the day, therefore the adoption of the TMS for an adaptive control of the traffic light timing is very essential [3].

With the availability of this type of systems, commuters will no longer be left to guess the traffic situation along their route of interest. This will affect the lifestyles of the daily commuter as the frequent worry about the unknown traffic situation will no more exist. It will help the workers to be prompt and punctual, and students to become the early birds to school and no longer miss their morning classes. Businesses will begin to flourish as all loose ends where profits were lost become tied. Based on the discretion of the commuter in choosing an alternative route when the desired route is inaccessible, the traffic situation of the area or city will be well distributed. The punctuality or lateness of workers, students, and business men, to a great extent will no longer depend on the traffic situation. Emergency cases, especially medical ones, will be taken care of without hindrances.

This study is an attempt to design a system that will help commuters to get up to date information on the traffic situation so that they make informed decisions on the route to commute and avoid delays as they try to get to their destinations.

II. LITERATURE REVIEW

A. *Speed Limit for vehicles*

Speed limit can be defined as the maximum speed allowed on a particular road. This directive is given by the government through the road/vehicle enforcement agents to the road users for them to adhere to. The following speed [4] in table I are those for different types of vehicles in Nigeria. The advantage of these speed limits is to reduce over-speeding, which mostly leads to accidents. Road users are required to adhere to these speed limits strictly to avoid penalties by the law. The speed limits listed are dependent on the condition of the road, and nature of the terrain.

TABLE I. Speed Limits for Vehicles

TYPES OF VEHICLE	BUILD-UP	HIGHWAY	EXPRESSWAY
MOTORCYCLES	50	50	-
PRIVATE CARS	50	80	100
TAXIS AND BUSES	50	80	90
TANKERS AND TRAILERS	45	50	60
TOW VEHICLES	45	45	40

The speed limit for motorcycles is 50km/hour on build-up roads, 50km/hour on highways, and nothing is given for expressway. The speed limit for private cars is 50km/hour on build-up roads, 80km/hour on highways, and 100km/hour on expressways. The speed limit for taxis and buses is 50km/hour on build-up roads, 80km/hour on highways, and 90km/hour on expressways. The speed limit for tankers and trailers is 45km/hour on build-up roads, 50km/hour on highways, and 60km/hour on expressways. The speed limit for tow vehicles is 45km/hour on build-up roads, 45km/hour on highways, and 40km/hour on expressways (see Table I).

B. *Wireless Sensor Networks*

A wireless sensor network (WSN) is a wireless network consisting of spatially dispersed independent devices using sensors to observe physical conditions. WSNs have been used extensively with software applications to manage traffic situations on the road. [5] Built a Piezo-based traffic management system where the Piezo sensor was installed on the road to detect the different types of vehicles and their corresponding density. This work consisted of a mobile application that allowed users to see the traffic on different routes and hence choose the best option possible for hackle free ride. It was found to be very useful and effective in monitoring traffic, but the traffic report was given in micro-simulation, thereby making it a bit difficult to interpret at a glance.

A traffic flow control system that uses Wireless Sensor Networks (WSN) to control the traffic flow sequences is described in [6]. WSN is used as a tool to instrument and control traffic signals, while an intelligent traffic controller is developed to control the operation of the traffic infrastructure supported by the WSN. The study provided algorithms that are used in wireless controllers for traffic monitoring.

A model for real-time traffic control using the traffic lights is presented in [7]. Wireless sensors were deployed on the lanes and could detect vehicles' number, speed, and communicate to the nearest control station to forward any information. This additional level of report made this system deployable in other areas, like vehicular tracking and crime fighting by security agencies. Sing et al. [8] worked in the field of traffic surveillance using Wireless Magnetic Sensors. This model is supposed to work with the help of a Sensor Node installed where the vehicles are to be detected. A GPRS is used to forward the information further to some control system. This system went further in its traffic reporting, as it was able to distinguish between the types of vehicles on the traffic through the use of special devices. Global Positioning System is growing as an applicable product, which is used commonly nowadays. Traffic can be managed with the use of GPS. [9] Have shown the importance of using GPS/GIS systems in monitoring the traffic speed in urban areas. This was done by a study of the process that extracted the transportation information using GPS integrated with GIS technologies.

C. *Real time Systems*

Real time traffic control systems collect data in real time and analyze the data. The system uses this approach to control and monitor traffic. [10] Built up a dream based sensor that can sense the nearness of a vehicle in view of the pictures caught, naturally and continuously. The outcome was a system installed in the dashboard of vehicles to help vehicle users to know the separation of their vehicle from an obstacle close to the vehicle. [11] Describes the use of Transportation Incident Management Explorer (TIME) for visualizing real time and archived incident data collected. This study was able to report the traffic condition of the road in real time to the commuter.

The use of real time systems with image processing is described in [12]. The authors discovered in their study a method of controlling traffic, by control the signals in real time and operate them automatically according to the demand in traffic. [13] Investigated the issue of urban traffic signal control using a real time optimization model. The model was modified to take into account the traffic scenarios, the different types of vehicles in the area, as well as pedestrians. The technique was applied to a real case study in order to control road traffic and proved to be effective.

D. Micro-simulation of road traffic

Micro-simulation of road traffic is the use of computer models to show the movement of individual vehicles on roadways in a miniaturized fashion, showing the behaviour of each vehicle as it moves and the generalized traffic level. [14] used a continuum based macroscopic model to simulate traffic, concentrating on a large scale structure where traffic can be simulated in real-time. The model suitably handles lane changes, merges, and also changes in driving behavior due to changes in speed limit. This study demonstrated how a macroscopic model can be applied so that animating a great number of vehicles in a large-scale traffic network runs in an interactive rate. A simulation of the personalized behaviour of independent vehicles was carried out by [15]. In the simulation, all the cars correctly obeyed the laws of physics, such as acceleration and braking. Every car has some personality traits mimicking those of real drivers, such as how aggressive the car is, how attentive the car is to its surroundings, and how law-abiding the car is to traffic rules. This study helped road traffic law enforcement agents to check the behaviour of commuters and identify road traffic law breakers.

The design of a traffic simulation system that can be incorporated into an already existing crowd system, city, and road network was carried out by [16]. They built a traffic simulator which showed the immediate environment at an additional level of detail and realism, and was incorporated into devices that require accurate and intelligent automated backgrounds. [17] used the Dijkstra's algorithm in calculating alternative shortest routes for the road users to get to their desired locations on time. The Dijkstra class calculates the shortest route of the vehicle from the entry to the exit. The GetPath method in the Dijkstra class returns the vehicle shortest route, enabling commuters to decide quickly on the alternative route to use during a congestion.

D. Traffic Road Condition Monitoring System

Traffic road condition system is a road infrastructure monitoring system that observes the quality of roads and informs commuters or road construction agencies if the road is suitable to be plied on or if it needs maintenance. A system that uses wireless sensor nodes and magnetic sensors to form a single sensing unit was designed and described in [18]. These units were mounted on poles present on both sides of the road segment of interest. The sensing units were then mounted on vehicles. The outcome was a system that reported both road condition and traffic situation to the user. Erling et al. [19] built an in-car system that reads vehicle position every second using the Global Positioning System (GPS). It used an algorithm called the 'map matcher', which was able to use the positioning and a digital road map to determine the vehicles speed and to determine the road on which it is being driven. This system found useful application in vehicle tracking devices.

Real time data was used in a traffic management system to monitor current traffic flows in a network so that traffic can be directed and managed efficiently [20]. The authors discovered in their study a reliable short-term forecasting and monitoring model of traffic flow that is crucial for the success of any traffic management system. Sheng-Fuu et al. [21] describes an application of computer vision techniques to traffic surveillance. This study focuses on improving the efficiency of traffic flow estimation which include pedestrian flow and vehicular flow estimation.

E. Intelligent Transportation System (ITS)

Intelligent transportation system (ITS) is a traffic management system (TMS) with some embodiment of intelligence that provides road users with road traffic information and enables them to make smarter choices as they commute. The ADAS-equipped vehicles (Advanced Driver Assistance Systems) is a class of Intelligent Transportation System (ITS) described in [22]. Intelligent Transportation Systems (ITS) are becoming increasingly important elements in the traffic system. In the study, the author deployed ITS to interact with the vehicles in the traffic system in order to provide support for a more efficient utilization of the available traffic information. Zhiyong [23] built a traffic system that can respond to traffic demand and optimize online timing plans and then implement real time control i.e. be adaptive according to the traffic as demanded. AI methods like Fuzzy logic, neural networks, and evolutionary algorithms are being developed, which are used in traffic systems today.

A Complex Adaptive System (CAS) is an agent based system proposed by Clymer [24]. In the system, each agent adapts its behavior in order to collaborate with other agents to achieve overall system goals. It is also a way of using Artificial Intelligence in traffic system and apply the Fuzzy Classifier System. The fuzzy logic controllers provided considerable improvement in the efficiency of traffic junction's management. Purohit et al. [25] provided the use of genetic algorithms to optimize traffic signal timings in a traffic management system. They have developed an Emulator for representation of traffic conditions at an isolated intersection with a number of features like GUI developed with JAVA, random generation of vehicles, random vehicular direction, collision avoidance and traffic signals with fixed phase sequence. This gave the user a user-friendly environment to view the traffic situation of the area of interest.

F. Vehicle Routing

Vehicle routing is a system that calculates the optimized shortest or the best possible route for commuters to get to a desired destination. There are some proposed theories that aim for finding the shortest path in any typical traffic condition. LeBrun et al. [26] describes the VGrid. The VGrid is an ad-hoc networking and computational grid which can be formed by leveraging inter vehicle and vehicle-to-roadside wireless communications. They were able to propose a theory that aimed at finding the shortest path in a typical traffic condition. A traffic management approach using the behavior of ants to form an algorithm based on the algorithm of the ants is described in [27]. Through this study they were able to find a solution to the frequent occurrences of traffic jams. Charitha et al. [28] developed a tool for estimating the travel time in signalized urban networks, based on probe data. It is a self-learning tool and can be applied to basic networks description instead of a detailed modeling of the network structure. In the study, they were able to utilize a Bayesian system for estimating the travel time of vehicles along a road, thereby knowing the shortest path to commute.

III. Research Method

The methodology for this study includes a survey to understand the daily traffic behaviour at some routes given the daily traffic situations experienced at these routes within the metropolis of Calabar. A survey of hardware and other necessary equipment was also carried out. This led to the system design for the hardware and software components of the TMRS. The system was simulated and tested for results. The steps are presented next.

A. Requirement Gathering

A survey was carried out on some routes within Calabar metropolis. The aim of the survey was to find out why the traffic level varies at the various times of the day, and what category of commuters are found en-route at these times. Interviews were also conducted with the people who were commonly found en-route at the various periods of the day at the chosen routes. The survey and the interview provided data about people and the level of traffic on the selected routes in the city.

B. System Design

The traffic monitoring and report system design consists of two units: the monitoring unit and the report unit. The following sections describes the parts and functionality of the system as well as the simulation of the system to demonstrate the working of the system. The monitoring and the report units of the system are presented next.

a) Monitoring Unit

This unit comprises of a radar gun speed sensor used for reading the speed of moving vehicles across the intersection. A transmitter device (Wi-Fi) is used to send the information to the receiving devices at the user-end. A 30 by 40 inches, 220 Watt mono-crystalline solar panel and a 70 amp-hours / 3.5 amps battery which maintains steady power supply (DC) for the entire system's operation. The monitoring unit is shown in figure 1. The diagram shows a road intersection where the monitoring unit captures the speed of moving vehicles. The unit is installed by the road side at the intersection. The system is made up of the radar sensor, which senses the movement of vehicles across the intersection by emitting infrared rays in direct line-of-sight towards the center of the intersection. The next component is the microcontroller, which is the intelligent device that translates the output which the sensor gets from the moving vehicle into speed in miles per hour (mph). The radar sensor and the microcontroller are integrated into one device, called the radar gun. The system also has a wireless transmitter device, which sends the information (speed in mph), to the reporting unit of the TMRS wirelessly. There is also the solar power supply, which provides electrical power to the components by getting energy from the sun and storing (charging) it up in a battery.

The operation of this unit starts when it receives a trigger event from the processor in the radar gun, when a vehicle has crossed its line of sight. The radar gun sensor then measures the speed of the vehicle in the sensor's field of view. The sensor sends this data stream to the microcontroller for decoding. This information is usually collected at intervals and stored up on an SQL database server where the users can access them using an android device application. A Wi-Fi Module is used to broadcast the information so that the target devices, which are also Wi-Fi enabled can receive the information transmitted from the monitoring unit whenever the devices are within range. In cases where the streets are very lengthy, amplifiers could be mounted to boost attenuating signals to enable the receiving devices to receive the signals.

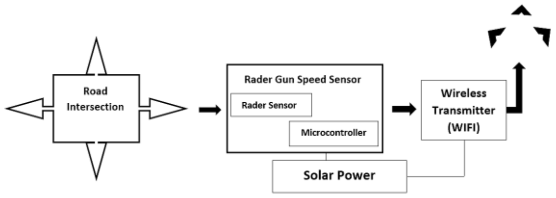

Fig. 1. The Traffic Monitoring Unit

b) Report Unit

This unit consists of a mobile device such as the mobile phone with a Wi-Fi connection and the mobile application. A Wi-Fi enabled device (receiver) is used to establish the client-server connection from the monitoring unit. The mobile application runs on the mobile device (client). Fig. 2 presents the structure of the report unit of the TMRS. The diagram illustrates the Wi-Fi as the receiver that takes input of data (traffic condition) transmitted wirelessly from the monitoring unit of the TMRS. The data is then passed to the android application within the mobile phone. The android application resolves the information into a colour code that depicts the traffic condition of the road at a given time. The colour is then presented to the user through the mobile application user interface. A red colour signifies heavy congestion, a yellow colour signifies mild congestion, while the green colour signifies "no congestion". Table II gives a summary of the vehicles speed and the traffic levels and the colours used in this study.

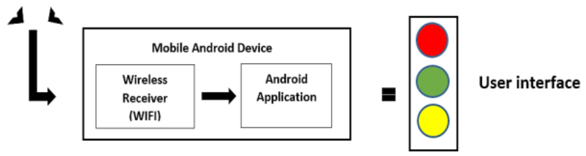

Fig. 2. Block diagram of the traffic report unit

TABLE II: Vehicle speed and traffic levels

	Vehicle Speed	Traffic Level	Colour displayed on the mobile application
1.	Less than 5 miles per hour (<5mph)	Heavy	Red
2.	Less than 15 miles per hour (<15mph)	Mild	Yellow
3.	Greater than 15 miles per hour (>15mph)	Low	Green

When the speed of the vehicle going through the intersection is below 5 mph, the traffic level is considered as being 'Heavy' (see Table II). This means that the road is very congested and there is no free flow of traffic. When the speed of the vehicles going through the intersection is below 15 mph, but above 5mph, the traffic level is considered as being 'Mild'. This means that the road is minimally congested and it is motor able. Lastly, when the speed of the vehicle going through the intersection is above 15mph, the traffic level is considered as being 'Low'. This means that the road is very free of congestion, that is, there is free vehicular movement.

Fig. 3 presents the flowchart that illustrates the program execution of the processes and conditions for the decisions that leads to the display of a particular colour code on the user interface of the mobile application.

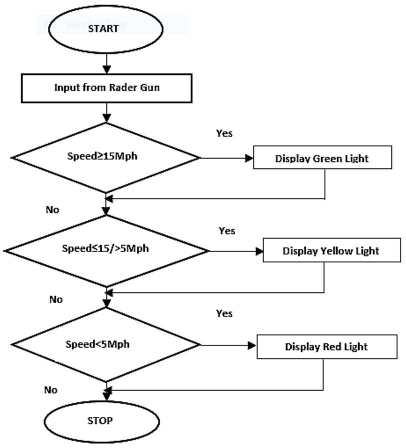

Fig. 3. Flow Chart of the Reporting System

C. *The Software System Architecture*

The software design for the traffic monitoring and report system consists of a number of packages like, Android, Java, PHP, and MySQL database. These packages function collectively to form the report and update part of the TMRS. Fig. 4 shows the system architecture for the system. The controller acts like the process which communicates back and forth with the database and updates information to the front-end. It is responsible for receiving the monitoring unit's input and acting accordingly. It acts like a bridge between back-end and front-end. The MySQL database serves as the back-end hosting the data. It provides data and methods that deliver information to the application. It is completely independent of how the application looks like. The Android application serves as the front-end or graphical user interface of the mobile application (Screens, buttons, views, table views), which the user operates to get information about the traffic situation.

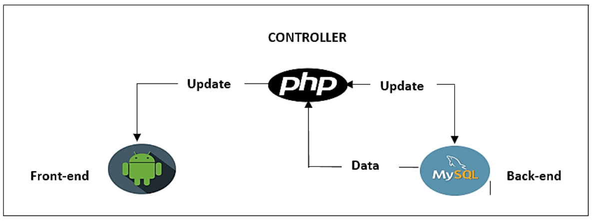

Fig. 4. Software architecture

Android studio was used in the development of the mobile application, and java programming language was used in its coding. Fig. 5 shows the various activity screens from the mobile application.

Fig. 5 shows the home screen of the android application. It has an input text area where the user is required to type in the name of the street for the traffic report. Fig. 5b shows the page where the user confirms that the street name entered is correct and available. Fig. 5c shows the case when traffic level is considered mild with the yellow icon and the user is informed that the traffic on this route is gradually building up. Fig. 5d shows the case when traffic level is considered low with the green icon and the user is informed that the route is free of traffic. Fig. 5e shows the case when traffic level is considered heavy with the red icon and the user is informed that there is a heavy traffic on this route.

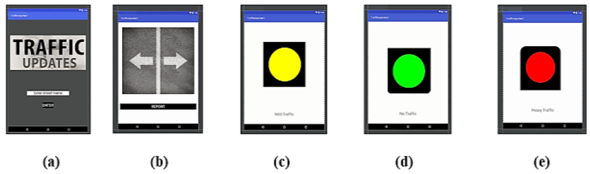

Fig. 5. Graphical user interface for the report system.

IV. Results And Discussion

The problem that led to this study is the growing levels of road traffic congestion in the metropolis of Calabar, during the peak periods of the day. In a bid to solve this problem, surveys to determine the actual number of commuters and the category of each commuter was carried out. The data collected from this survey are shown in the charts and tables available in this section. Some test tools were also implemented for the analysis of the result gotten from the survey, as will be shown in this section.

A. *Survey Results*

The survey was carried out using the quantitative approach. The interview method was used for the collection of the data needed for this study. The commuters were counted manually and interviewed verbally. The reason why the interview method was used is because commuters had no time to spare for other methods, like the questionnaire. The data collected was to provide a meaningful reason as to why there is always a congestion experienced at peak periods of the day in the metropolis of Calabar. This survey was necessary because, for us to solve the problem of traffic congestion, we must first understand it. Fig. 7 is a pie chart depicting the results gotten from the survey carried out. One objective of the study was to find out the types/categories of commuters found in the traffic. This is shown in the pie chart and is represented in percentages (%).

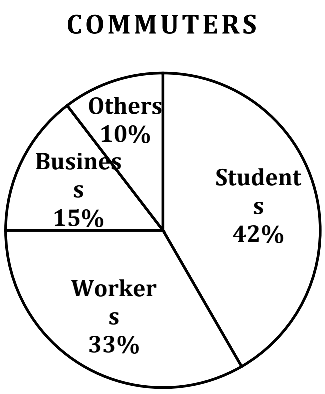

Fig. 6. A chart of categories of commuters

From the survey of the area, it was discovered that 42% of the commuters were students, and 33% were workers, while 15% were business people. Ten percent (10%) belonged to other category of persons. This findings explain the reason for the congestion experienced at the specific times of the day. The main reason why traffic congestion is experienced at the hours of the day between 7am – 12pm and thereafter, between 4pm – 6pm, is because majority of the commuters at these peak periods are either workers or students. It is so because workers and students activities begin and end within these periods and there is normally a rush to get to their destinations early. The chart in Fig. 7 depicts the traffic behaviour from survey carried out at selected intersections within Calabar metropolis. The vertical axis represents the traffic conditions, as shown in the box to the left of the chart, while the horizontal axis represents the time of the day.

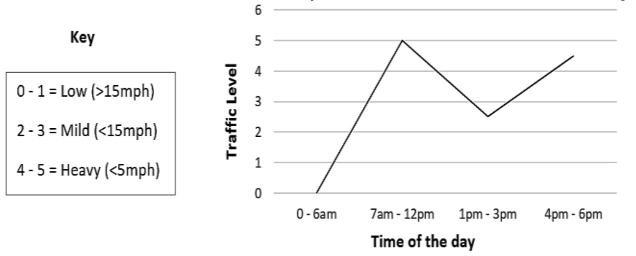

Fig. 7. The traffic behaviour

The information gotten from the survey carried out on some intersections within Calabar Metropolis showed that between the early hours of the day to 6am, there was little or no traffic. The reason for this is because during this period commuters are still at home preparing to leave for their respective endeavours. Between 7am and 12pm it was noticed that there was a sharp increase in the level of traffic, and this grew quickly to its peak, the highest traffic level for the day. This usually leads to a very heavy congestion, making it very difficult for commuters to find their way. Due to this, commuters tend to spend at least an additional 30 minutes to 1 hour to their normal commuting time. The rush on the roads caused other problems as motorist tend to clash with the law enforcement agents as they try to manoeuvre their way through the traffic illegally. Sometimes, in order to avoid the delay, some road users drop from the vehicles they boarded and go on foot out of frustration.

The reason for this sharp increase in the level of traffic is because of the number of commuters found on the road at these times. The traffic level gradually reduces till the period between 1pm and 3pm where a significantly mild level of traffic is experienced. The reason for this is because workers and students had reached their various locations and the traffic becomes light, reducing by about 75%. There is also a gradual build-up in the level of traffic as it approaches 6pm. The level of traffic grows relatively high at this period. But it does not get to the maximum level experienced between 7am and 12pm. The reason for this, is because students who are the most populated commuters return from school at different times of the day, leaving only workers, some business men, and few people belonging to other categories en-route at this period. There was also a significant drop in the level of rush due to less time consciousness by the commuters. Table III shows the results of the survey carried out to determine the reason why the level of traffic varies at the various times of the day.

TABLE III: Survey results for period 7am and 12pm

COMMUTERS	NUMBER OF COMMUTERS	NUMBER OF VEHICLES	TRAFFIC PERCENTAGE (%)
Students	167-210	33-42	42
Workers	132-165	26-33	33
Business people	60-75	12-15	15
Others	40-50	8-10	10
Total	400-500	80-100	100

From the interview conducted with commuters, it was discovered that the mean number of commuters found at the intersections within the hours of 7am and 12pm was between 400 and 500. Between 167 and 210 (mean number) students were seen between the hours of 7am and 12pm. Workers were the second highest number found at the intersections within the hours of 7am and 12pm. i.e., between 132 and 165 (mean number) of those commuting at these times of the day were workers. The third highest numbers of people found at the intersections within the hours of 7am and 12pm were business people. i.e., between 60 and 75 (mean number) of those commuting at these times of the day were business people. Other persons who do not belong to any of the aforementioned categories were between 40 and 50 (mean number) persons.

During the survey, students and workers were mostly commuting on commercial vehicles which took at least 5 people at once. Grouping 5 individuals into a single vehicle gives the mean number of vehicles at the intersection. Thus, within the hours of 7am and 12pm, between 80 and 100 (mean number) vehicles were en-route.

TABLE IV: Survey results for the period 1pm and 3pm

COMMUTERS	NUMBER OF COMMUTERS	NUMBER OF VEHICLES	TRAFFIC PERCENTAGE (%)
Business people	60-75	12-15	15
Others	40-50	8-10	10
Total	100-125	20-25	25

Also, it was discovered that the mean number of commuters found on the intersections within the hours of 1pm and 3pm was between 100 and 125. The traffic at these times of the day comprised of business people and the category of persons grouped under 'Others'. They both comprised 25% of the total traffic for all categories of commuters. Grouping 5 individuals into a single vehicle gives the mean number of vehicles at the intersection. Thus, within the hours of 1pm and 3pm, a mean number between 20 and 25 vehicles were en-route.

TABLE V: Survey results for the period 4pm and 6pm

COMMUTERS	NUMBER OF COMMUTERS	NUMBER OF VEHICLES	TRAFFIC PERCENTAGE (%)
Workers	132-165	26-33	33
Business people	60-75	12-15	15
Others	40-50	8-10	10
Total	232-240	46-48	58

Also, it was discovered that the mean number of commuters found on the intersections within the hours of 4pm and 6pm was between 232 and 240. i.e., individual commuters without the vehicles they were inside. The traffic at these times of the day comprised workers, business people and the category of persons grouped under others. These three categories of commuters comprised 58% of the total traffic for all categories of commuters.

Grouping 5 individuals into a single vehicle gives the mean number of commuters at the intersections. Thus, within the hours of 4pm and 6pm, we have between 46 and 48 vehicles en-route.

B. Data Analysis and Results

A simulation software tool was used to test the data collected from the survey carried out. The software was a typical model of the intersections being studied, and it provided input fields for the data to be entered. When the data is entered, the software simulates a typical intersection based on the input provided, and the traffic behaviour of the intersection is clearly depicted on the screen. This survey results was used in a simulation to determine why the traffic level varied as it did between the various hours of the day. The results of the simulation using an intersection simulation software is shown next (Fig. 8, 9 and 10). The intersection simulation software provides input parameters for the traffic light timing; the density range of traffic on each arm of the four intersecting roads; the direction probability for each vehicle and the number of input and output tracks for each arm of the four intersecting roads; and a graph showing the waiting time.

Fig. 8 shows the simulated traffic level based on Table III. In the process, data from all the categories of commuters shown in Table III is entered into the intersection simulation software. For each of the four intersecting roads, 20 to 25 vehicles is inputted as the average number from the mean number of 80 to 100 vehicles. The traffic light timing is set to 30 seconds, and the input and output tracks are all set to 1 track each. The simulation is done for a duration of at least an hour. It was noticed that the level of traffic rose exponentially as the number of congested vehicles continuously grew to an average of 264 per intersecting road. The waiting time also increased steadily, showing that commuters spent more time on the road than usual.

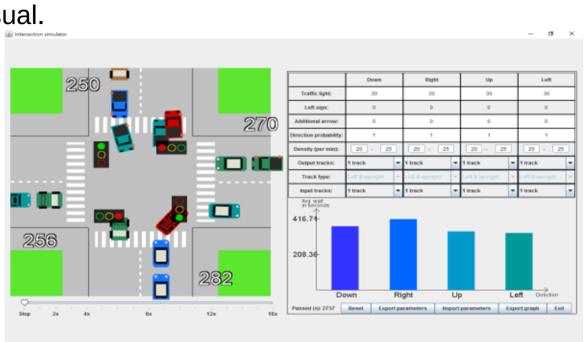

Fig. 8. Simulation output for the period 7am and 12pm

Fig. 9 shows the simulated traffic level based on Table IV. In the process, data from all the categories of commuters shown in Table IV was used for the simulation. For each of the intersecting roads, 4 to 5 vehicles is inputted as the average numbers from the mean number of 20 to 25 vehicles. The traffic light timing is set to 5 seconds, and the input and output tracks are all set to 1 track each. The simulation is done for a duration of at least an hour. It was noticed that the level of traffic remained steady, with no significant increase observed. The number of vehicles remained at an average of 1 vehicle per intersecting road. The waiting time also remained low, showing that commuters spent no extra time on the road than usual.

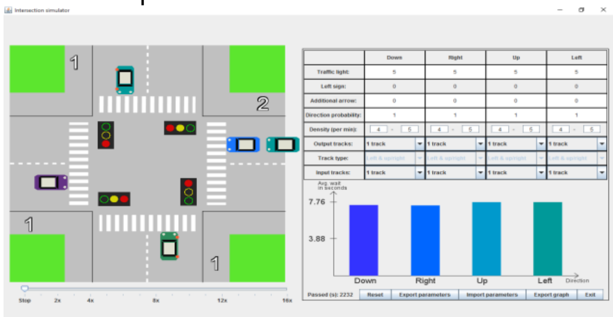

Fig. 9.Simulation output for the period 1pm and 3pm

Fig. 10 shows the simulated traffic level based on Table V. For each of the intersecting roads, 11 to 12 vehicles was inputted as the average numbers from the mean number of 46 to 48 vehicles. The traffic light timing is set to 10 seconds, and the input and output tracks are all set to 1 track each. The simulation is done for a duration of at least an hour. It was noticed that the level of traffic rose minimally to a steady level, with no significant increase observed after this. The number of vehicles remained at an average of 6 vehicles per intersecting road. The waiting time also remained low, showing that commuters spent a minimal amount of time on the road than usual.

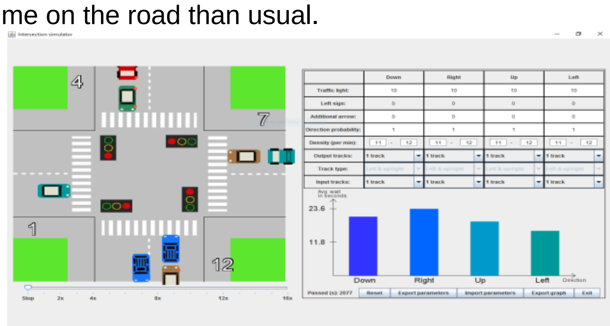

Fig. 10. Simulation output for the period 4pm and 6pm

C. System Simulation Results

A laboratory simulation of the traffic monitoring and report system was conducted using mobile phone application that performs the exact functions of the entire system. The monitoring unit model consisting radar gun (radar sensor and microcontroller) and the wireless transmitter were simulated using the mobile application that uses the camera of the mobile phone to perform the functions of the radar gun. The simulation was carried out to determine the performance and behaviour of the system before implementation on the road intersection. The results are presented next.

a) Monitoring unit

The controlled experiment consists of the mobile phone application on the phone and a car model with a board that served as the runway or road. The car model is pushed across the line of sight of the phone's camera. The phone camera captures the movement of the car model object as input to the application. The experiment is repeated several times with varied speed of movement of the car object. The application calculates the speed and sends it to the report system application on another mobile phone through the Wi-Fi transmitter on both devices. Fig. 11 presents the simulation output for the monitoring unit. The mobile phone is held parallel to the path where the car object passes through. The mobile camera captures the moving object (car model), the mobile application analyse and then displays the speed of the vehicle on the application screen as shown at (C) part of Fig. 11. The reported speed is sent to the report unit on another mobile device via Wi-Fi to the reporting unit. The report unit is shown in the next section.

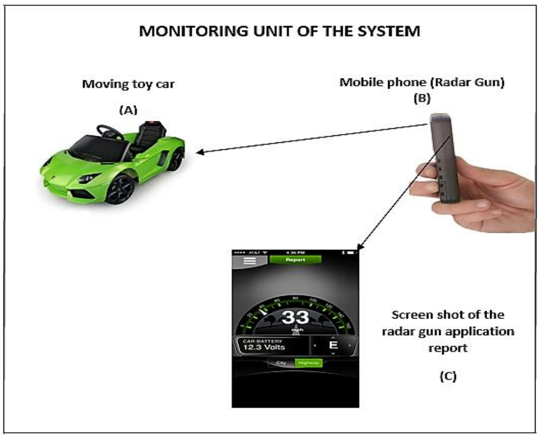

Fig. 11. Traffic monitoring unit Simulation output

b) Report unit

Fig. 12 presents the output of the traffic report unit. The reporting android device receives the information from the simulated monitoring unit through the Wi-Fi of the monitoring mobile device. The reporting device analysed the data received using mobile application. The reporting application displays the corresponding colour code signifying the traffic situation. The green colour code displayed in Fig. 12 signifies that there is no congestion based on the vehicle speed received. The reporting unit through the mobile application has demonstrated its potentials in providing the commuters the right traffic situation along the route they are commuting. This will help to reduce traffic congestions in the metropolis and enable commuters get to their destination on time.

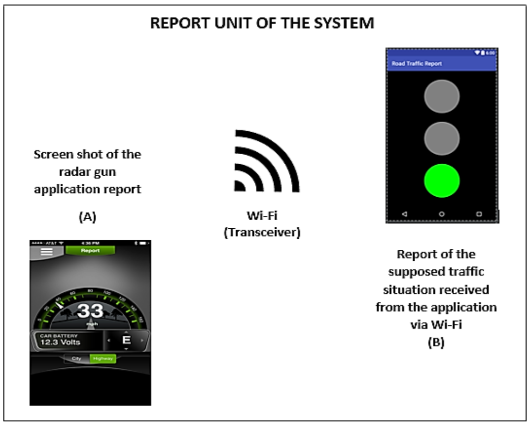

Fig. 12. Traffic report unit Output

V. CONCLUSION

Traffic Monitoring and Report system is a blend of street transport observatory and analysis systems, which cooperate to give continuous data to street clients for the administration of their driving. The major aim of the system is to help commuters avoid traffic congestion. During the study, it was shown that the level of traffic varies as a result of the number of commuters using the routes at the different times of the day. Congestion is experienced when a high number of commuters are using the route at the same time, while there is no congestion or minimal congestion when the number of commuters using the route is less. Road simulations are complex programs that have been researched for more than forty years [29]. This study is an attempt to show that if the system that was designed during this study is fully implemented along the traffic routes in the metropolis, traffic congestions can be avoided and commuters will save time and be more productive in their places of work during the day. The system results were simulated under a controlled experiment and with the involvement potential users. The output from the system is user friendly and easy to understand. The colour codes were chosen for the obvious reason that these are symbols that are already familiar to motorists and the general public with regards to traffic signs.

It was observed during the study that traffic situation within the city fluctuate during the day especially during peak periods when there high level of people commuting for their daily activities. Also, during high level of traffic situations, people behave in different ways due to high level of anxiety. The traffic monitoring and report system can help in this type of situation by providing traffic status information to commuters on the route they are about to commute. This information will cause the commuter to go for an alternate route to their destination. The anxiety and time wasting on traffic congestions would be avoided. In the long run the traffic situation in the city will improve. From this study, it is evident that the Traffic Monitoring and Report System is the way forward for road traffic control and improvement.

When an input is received from the monitoring unit, the application checks the value to know if the speed is greater or equal to 15mph. If this is true, the application displays a green colour code on the user's mobile screen. If the input is less than 15mph and greater than 5mph, the application displays a yellow colour code. This means that the traffic is mild and still not congested on the route. If the speed measure sent and received is less than 5mph and if it satisfies the condition, a red colour is displayed on the user's mobile screen. This informs the commuters that the traffic on the route is heavy and there is no free flow of vehicles.

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