A Web-Interface based Smart Tracking of Overloaded Vehicle

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Abstract: Due to the development of road infrastructure and business trade, transportation of goods is increasing day-by-day. Each vehicle has its own configuration, size, power and capacity. However, heavy vehicles are often used to carry loads beyond their capacity. Therefore overloading is one of the major problems which affect truckers as well as other motorists and pedestrians going near-by. In order to provide a convenient solution to this problem, a web-based tracking system is proposed. A heavy duty vehicle which is overloaded and moving at high speed may cause the vehicle to loose balance while making turns along the roads. This problem may also cause the tire to burst, which in turn makes it difficult to control the vehicle. Communication module is interfaced with a microcontroller which takes data from global positioning system receiver to locate the current position of the overloaded vehicle. This unit is majorly controlled by an electronic control unit. A sensing element is placed at the axle point of the vehicle to concentrate on the total weight of the vehicle. A software study is done to extract the global positioning system data from GPRMC format. The proposed system is simulated and tested for semi-real data. The received data is transmitted to the control room user for further improvement in traffic regulation and road safety.

Keywords: Force sensor resistor GSM, GPS, Overloaded vehicle, smart tracking, Web-interface

I. INTRODUCTION

With the increase of business trade in the world, the transportation of goods is enormously increasing day-by-day. Moreover, there is also a great deal of competition among transport companies to transport goods from one region to another. To increase profitability per-trip, the goods are overloaded in various types of trucks and transported. As the fuel costs and toll charges increase due the road development, overloading in trucks are also increased, so as to reduce expenses for transportation. Overloading of vehicles lead to damage of roads, lack of safety for passengers/walkers nearby and the vehicle itself, resulting in several accidents [1].

Fig.1 shows the number of accidents that happened in India due to overloaded vehicles from 2015 to 2017.
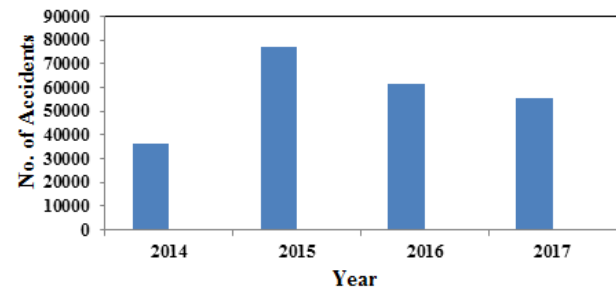

Fig. 1 – Accidents due to Overloaded Vehicle

Apart from the increased number of accidents, as per the Central Road Research Institute (CRRI) and the Indian Federation of Transport Research and Training, overloaded vehicles emit more toxic gases exponentially than a non-overloaded vehicle. For instance, if the vehicle is overloaded by 30%, nitrogen oxide emission increases from 3.17g/km to 119.2g/km as per a CRRI study. While considering pollution and unsafe driving, overloaded vehicles play a vital role. The Ministry of Road Transport & Highways, Government of India on 18th July 2018 released a report related to permissible safe axle weight of truck and is shown in Table.1

The authors have suggested a method for commercial vehicle weight enforcement for preventing the frequent damage of highway road infrastructure due to overloaded vehicles in India [2]. For efficient operation of trucks in road highways, low speed weigh-in-motion (WIM) and high speed weigh-in-motion technologies are proposed by the authors in [3]. To protect the road infrastructure and to find the overloaded vehicles in South Africa, a weigh-in-motion (WIM) scale is installed on the surface of the road [4]. To improve the tracking, WIM scale is integrated with automated number plate recognition cameras and screener lane. This reduces illegal activities in overloading. A portable cost-effective WIM system is introduced for periodic collection of vehicle load data and traffic volume in USA [5]. The best optimized location for installing WIM systems is suggested in [6].

The authors have proposed a web-based vehicle overloading management system integrated with weighbridges [7]. The data computerized in various weighbridges can be centrally monitored through regulatory bodies. To monitor the overloaded Tanzanian public buses, a case study is carried out in [8].

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The author proposed a Global System for Mobile Communications (GSM) modem based overload passenger monitoring module based on the scenario in Ethiopia [9]. This developed module can monitor and report the excess passengers in public transportation vehicles. A case study is done on Municipal solid waste collection vehicles by [10], to send the location of the vehicle and the amount of garbage collected to the concerned authorities. This study is done by implementing a system with vehicle weight sensor and automatic vehicle locator. A review of video surveillance systems used to detecting overloaded vehicles is given in the literature proposed by [11].

Table 1. Permissible Safe Axle Weight

Axle category	Vehicle configuration	Weight (Tonnes)
Single Axle	Single Axle with single Tyre	3.0
	Single Axle with two Tyres	7.5
	Single Axle with four Tyres	11.5
Tandem Axles(Two axles separated with a distance of 1.8metres)	For rigid vehicles, trailers and semi-trailers	21
	For Puller tractors for hydraulic and pneumatic trailers	28.5
Tri–axles(distance between outer axles is less than 3metres)	For rigid vehicles, trailers and semi-trailers	27
Axle Row (two axles with four tyres each)	Modular Hydraulic trailers	18

To monitor/detect the overloaded vehicle, an integrated WIM system can be installed on the roads as suggested in the research articles discussed above. In this paper, a combination of a hardware system and an application (APP) termed Smart Tracking of Overloaded Vehicle (STOV), have been developed to detect the load at the axle point, track and locate while the truck bed is overloaded. Details about the system model are given in Section 2. Section 3 gives the information related to Proteus simulation. Section 4 shows the STOV prototype developed. The details about development of web based user interface (UI) and testing of the prototype are explained in section 5 and 6 respectively. Finally, section 7 concludes the paper.

II. STOV System model

Smart Tracking of Overload Vehicle (STOV) system model is designed around the AT89S52 development platform embracing the physical phenomenon shown in Fig 2. The function of the STOV model is to monitor the load at the axle point when the truck bed is overloaded. As the ignition switch is turned ON, the STOV model gets powered up and automatic load measurement is enabled through a sensing unit such as a force resistor element. A load sensor is used to acquire the load data at the axle point and equivalent electrical

signal is weighted to kick start the communication modules in the microcontroller for tracking and monitoring the vehicle.

Fig. 2 – Physical Phenomenon of STOV
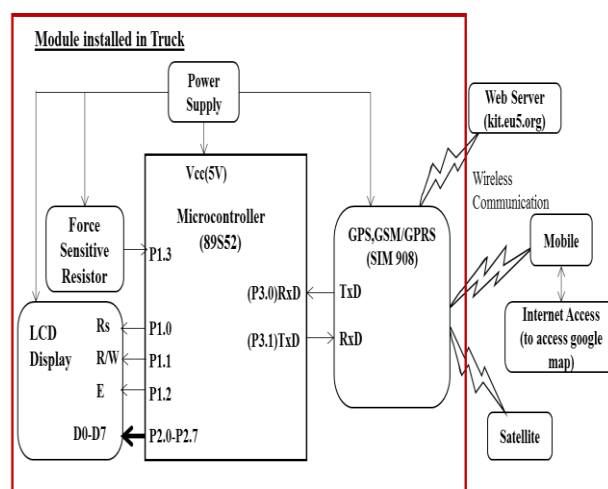
Fig. 3 – Architecture of Smart Tracking of Overloaded Vehicle System

The STOV model is composed of four parts: a sensing unit, a display unit, a microcontroller unit and a wireless communication module. The sensing unit can be a force resistor element or an axle sensor unit. Fig 3 illustrates the architecture of the STOV system. Details of the sensing unit and wireless communication modules will be presented in the following sections.

2.1. SENSING UNIT

Force sensor resistor (FSR) shown in fig. 4, is a two terminal device which has a resistance dependent on the applied force.

Fig. 4 – Force Sensor Resistor

The voltage equivalent of an applied force is studied by wiring the FSR with a measuring resistor in a voltage divider configuration. The output voltage is expressed by equation (1).

$$V_{out} = \frac{R_M V^+}{\left(R_M + R_{FSR}\right)} \qquad (1)$$

where R_M, V^+ and R_{FSR} represent the measurement resistor, 5V reference voltage and the equivalent resistance of the force sensing element respectively.
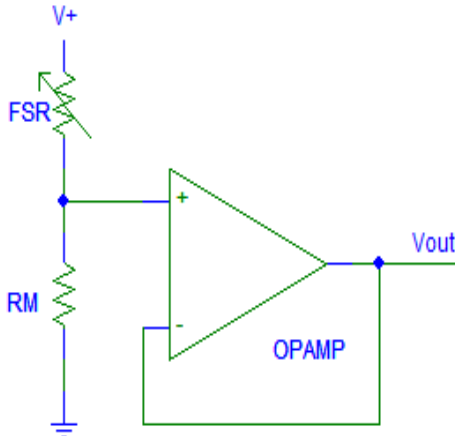

Fig. 5 – Voltage divider using FSR

On interchanging the values of R_{FSR} and R_M, it can be observed the output voltage will decrease with increasing force. The value of measuring resistor R_M is chosen carefully in such way as to maximize the desired force sensitivity range and to limit current. Fig 5 shows the force sensitive resistor tied to the voltage divider circuit.

2.2. ATMEL 89S52 DEVELOPMENT BOARD AND SIM908 GSM/GPRS & GPS MODULE

Fig. 6 shows the development board of the AT89S52 microcontroller. This microcontroller was chosen owing to its reduced cost [12]. It is challenging to interface two communication Global Positioning System (GPS) and GSM/GPRS modules with one serial UART. Effectively giving importance to the physical phenomenon behind the application scenario, the delay time between the GPS and GSM/GPRS communication is exploited to achieve serial communications. For example once the load sensor data is positive for overload, the GPS will be activated to extract the vehicle Coordinate points in the navigation system and consecutively, an SMS is sent through GSM/GPRS module with a web link to the host mobile device with the help of a SIM card activated in the SIM908 Module.
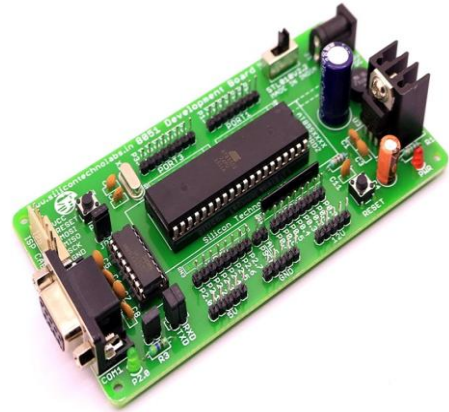
Fig. 6 – ATMEL Development Board

Fig. 7 shows the SIM 908 GPS and GSM/GPRS Module. The SIM 908 module consists of two UART ports. But a single UART is sufficient to enable the GPS and GSM/GPRS module simultaneously. This reduces the time to design as well as the cost to build a GPS related satellite navigation application [13]. Once the module detects the COM port, communication can be invoked using AT commands. Through AT commands the GPS Engine is switched ON to get the NMEA sentence. The GSM is controlled by the same UART by AT commands.

Fig. 7 – SIM 908 GPS and GSM/GPRS Module
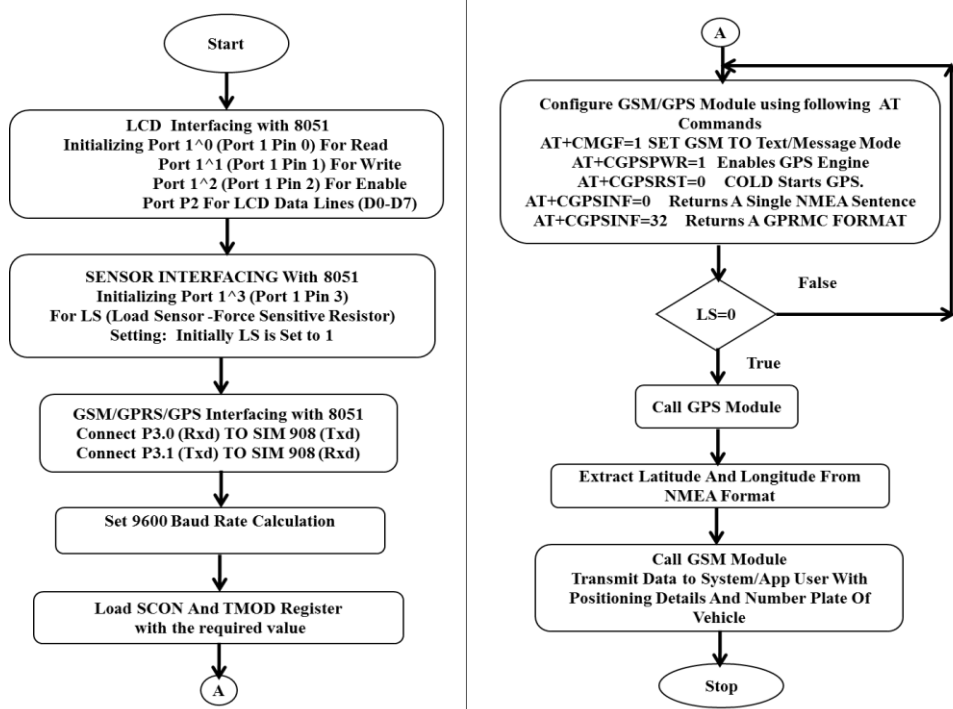
Fig. 8 – Detailed Flowchart of STOV

Table 2 Serial Control (SCON) Register format

Bit	7	6	5	4	3	2	1	0
Format	Serial Mode-0	Serial Mode-1	Serial Mode-2	Receive Enable	Transmitted 9th Bit	Received 9th Bit	Transmit Interrupt Flag	Receive Interrupt Flag
Assigned Bit	0	1	0	1	0	0	0	0

Table 3 Timer Control (TCON) Register format

Bit	7	6	5	4	3	2	1	0
Timer	Timer-1				Timer-0			
Format	GATE	C/T	M1	M0	GATE	C/T	M1	M0
Assigned Bit	0	0	1	0	0	0	0	0

2.3. FUNCTIONAL DIAGRAM OF STOV

Fig.8 shows the detailed flowchart of STOV.

2.4. CALCULATION FOR SETTING UP TIMER (TH1)

To set the baud rate as 9600, the timer (TH1) is calculated using equation (2)

$$Baud\ Rate = \frac{2^{SMOD}}{32} * \frac{f_{occ}}{12*(256-TH1)} \quad (2)$$

where SMOD= Baud Rate Doubler, 'f_{occ}' represents oscillator rate and 'TH1' represents Timer-1 auto-reloaded value. Table 2 and Table 3 shows the serial control and timer control register format respectively.

Consider SMOD=0 and f_{occ}=11.0592MHz, then

$$9600 = \frac{2^0}{32} * \frac{11.0592 * 10^6}{12 * (256 - TH1)}$$
$$TH1 = 253\ (decimal) = FD(hexadecimal)$$

Algorithm: Communication Link Establishment

Step 1: TMOD register is loaded with value of **20H** (use of timer 1) in mode 2.

Step 2: TH1 is loaded with one of the values to set baud rate for serial data transfer (**TH1=0xFD**).

Step 3: SCON register is loaded with value of 50H which indicates serial mode 1 where an 8 bit is framed with start and stop bits and is shown in Table.2.

Step 4: TR1 is set to 1 to start timer 1 as shown in Table.3.

Step 5: Until data transmission is DONE the SBUF register waits till TI flag is made 0.

III. SOFTWARE IMPLEMENTATIONS

Fig. 9 shows the proteus simulation of STOV by connecting GPS, GSM/GPRS and LCD display module. The necessary devices for modelling STOV are placed at various point and the terminals are wired as per the circuit diagram. Steps followed in proteus simulation environment are:

Step 1: The force resistive resistor sensor is interfaced at port-1, pin 3.

Step 2: LCD data lines at port 2 of 8051.

Step 3: TxD pin of GPS module is connected to RxD (P3.0) of 8051.

Step 4: TxD (P3.1) pin of 8051 is connected to RxD of GSM module.

Step 5: TxD pin of GSM module is connected to RxD of Virtual terminal.

Step 6: A variable resistor is connected to the 3rd pin of LCD (VEE) to adjust the contrast.

Step 7: Using Keil μ Vision5 software, the program is executed and the program is loaded in the source file of target folder.

Step 8: The program is checked for errors using the "build all" option and finally a Hex file is created.

Step 9: Double Click on 8051 device and add the program hex file and then select OK.

Step 10: Double Click on GPS module and add the program file and then select OK.

Step 11: Double click on GSM module and add the program file and then select OK.

Step 12: Click on Run the simulation icon and system starts working with the sensor activation.

Step 13: When the sensor is activated, the data related to location can be viewed in the virtual terminal as shown in Fig.10.

Step 14: The google link which has to be communicated through SMS is shown in Fig.11.

Step 13: The data shown in Fig.11 will redirect to google map.

IV. HARDWARE IMPLEMENTATION

In order to implement the above system, Atmel 89S52 micro controller is used. Variation in resistance at the sensor node enables the controller to find the location of the vehicle and the data received from the GPS is sent to the control room user.

Initially the sensing element gives a digital output of 0V and when the truck is overloaded it automatically switches to 5V. This is passed on to the control unit and the microcontroller sends signal to the GSM module (SIM908) for finding the required location to spot the target. The data from the GPS receiver is extracted from GPRMC format and the required values such as latitude, longitude and speed are obtained. The data received are sent in the form of a link to the concerned user. A control room user can also track the overloaded vehicle using the webserver. Fig.12 shows the prototype of STOV.

Fig. 9 – Proteus Simulation of STOV

Fig. 10 – Proteus output in latitude and longitude format

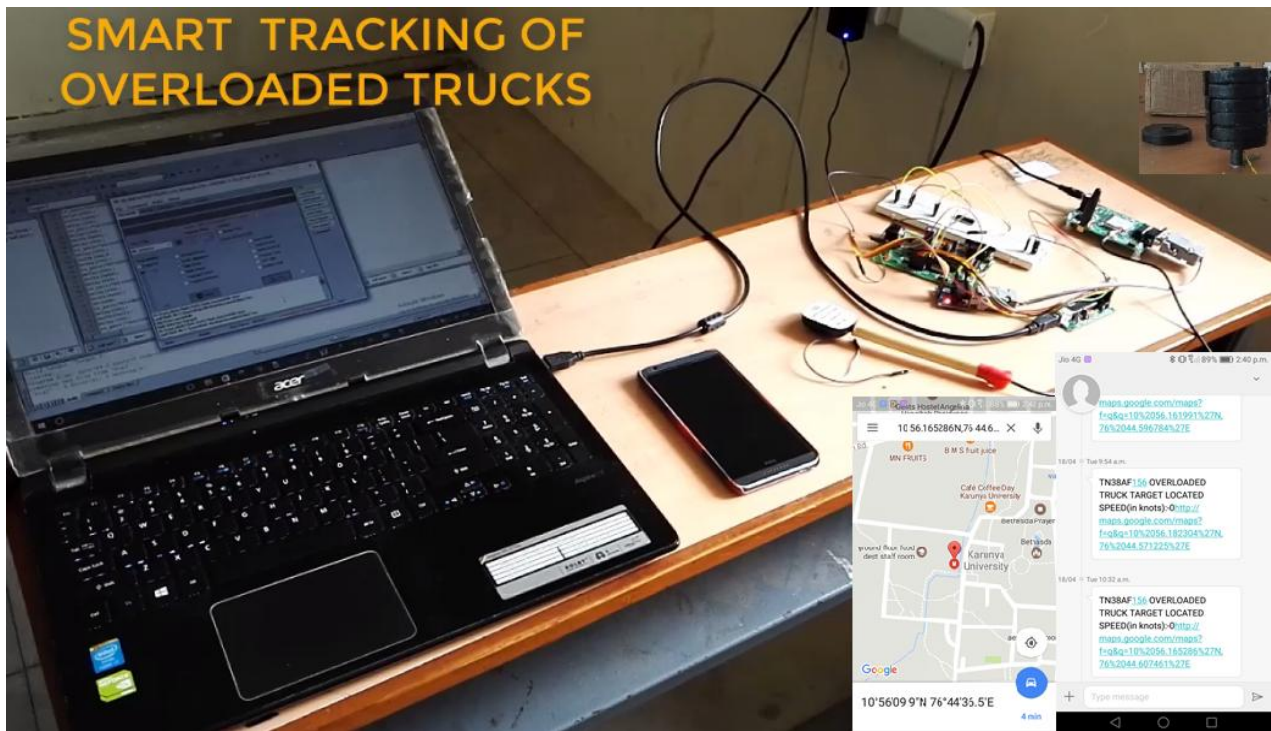**Fig. 11 – Proteus output in link format**

Fig. 12 – Prototype of STOV

The hardware consists of an LCD connected to port2 of the microcontroller and the GSM module which is connected to port3 of the microcontroller. A USB cable is used to supply electric power. This system can be also implemented by using the SIM900 module and sending GPS data to a group mail id. By using the above hardware connection, a perfect prototype of a fully function system is achieved.

V. WEB BASED UI DEVELOPMENT

To develop web interfacing, a free web hosting service is used. New web pages are created using htmlcss, javascript and php and run the same in the local host. The following steps are used to create a web interface for this work.

Step 1: Obtain the domain name and server, from the website www.freetzi.com

Step 2: After registration, domain name will be https://xxx.freetzi.com

Step 3: Upload webpages through filezilla software.

Step 4: Import the SQL file in the local database

Step 5: Place the API key obtained from the google developer API console (shown in fig. 13) into the local database.

<scriptsrc="http://maps.googleapis.com/maps/api/js?key=AIzaSyBfW2UkYooNah48WmYdbnSjf1A4T4iDQZI&sensor=false"></script> <script type="text/javascript" src="ajax.js"></script>

<!-- Initialize Map and markers --> .

Step 6: Now the system will start running.

Fig. 13 – API Key

A modified web server is created using a wamp server and it is made to have a public access to the authorized user. The API key is included to have a map integrated in the web page which points to the target using a red marker. Fig. 14 shows the fully customized app developed with various options and the app home page respectively.
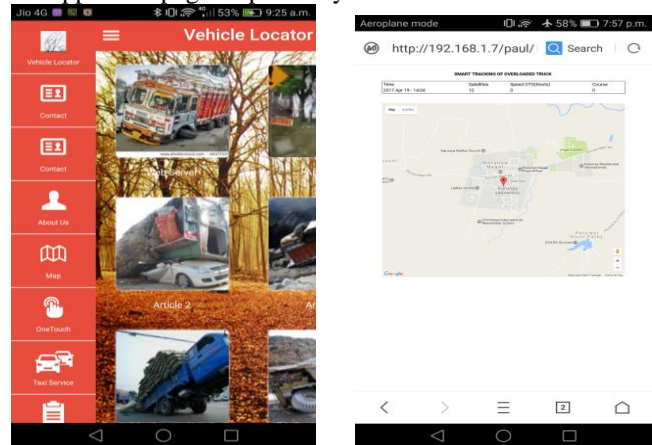

Fig. 14 – Fully Customized App   Fig. 15 – App to web server

Clicking on the icon where the web server url link is embedded, automatically directs the user to the browser and opens the web page as shown in fig.15. App created can be modified by an authorized developer. The web server is created with a user name and a password to restrict unauthorized user from entering into it, who may try to manipulate data at any time. Once a successful login is created, the user has full freedom to access the page. The web page displays the current location of the overloaded vehicle by locating red marker to the specified point (latitude and longitude).

VI. HARDWARE TEST RESULTS

When truck is overloaded above the set point, the sensor gets activated, thereby turning on the GPS which uses a satellite to obtain the current location of the target (overloaded vehicle). The location data is in the form of latitude, longitude and altitude. This data is sent to the control room (user) using GSM to the specified mobile number, with the number plate and speed of the vehicle over the ground is also mentioned.

Case A: If truck is loaded with the normal weight, sensor is set in deactivated mode is shown in fig.16.

Fig. 16 – Normal load with force sensitive resistor

Case B: When truck is overloaded above the set point as shown in fig.17, the sensor gets activated.

Fig. 17 – Heavy load with force sensitive resistor

Vehicle location and identification data with speed over the ground is obtained and shown in Table.4. The number plate of vehicle helps the control room user to easily identify overloaded vehicles. The SMS communicated to the authorized person is shown in Fig. 18. Speed of the vehicle is displayed in terms of knots.

Table 4 :Test Result based on force resistive sensor activation

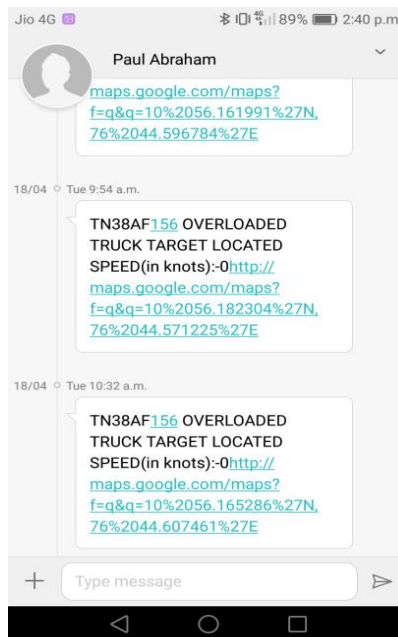| Load Sensor - Status Bit	Location Tracking-GPS	Communication Link-GSM	Message Details Web link
1	OFF	No Message	Not Applicable
0	ON*	Sends Message	TNXX AFXXXX OVERLOADED TRUCK TARGET LOCATED SPEED(inknots)>0http://maps.google.com/maps?f=g&g=10%2056.182304%27N,76%2044571225%27E

Fig. 18 – SMS Communicated

VII. CONCLUSION

An effective module for smart traffic management of overloaded vehicles is proposed in this work. It is useful to ensure safe and secure road transportation. In this work, the features of GSM and GPS modules are integrated for the best working of a STOV unit. The load weight of the vehicle is obtained using the sensors placed in the axle point and is applied as an input to STOV model for real-time overload prediction. The location of the vehicle is captured using the GPS module and the information about the overload along with the location of the vehicle is transferred to the control room. The performance of the proposed module is corroborated using simulation and tested with semi-real data.

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