DESIGN AND IMPLEMENTATION OF INTEGRATED INTELLIGENT CONTROLLER FOR PREVENTION AND DETECTION OF ACCIDENT USING IoT AND VANET ASSISTED COMMUNICATION

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Abstract-- The advancement of microelectronics and webbased communication are making a good space in various avenues of human comfort. Though the advanced transport systems prove to be a boon to mankind, the same has also been a disaster and tragedy when it comes to fatal accidents accompanied by huge loss of life and property. This loss is predominant when medical services and family members are not getting accidental information on time. The objective of this proposal is to design a working prototype of intelligent and integrated safety system to public and private vehicles in Oman, to prevent road accidents by alerting the driver under abnormal conditions and if incase of accident, the detailed information related to the accident is shared with the nearest hospitals, ROP stations and pre-stored numbers will be shared very quickly through Vehicular ad-hoc networks (VANET) in IoT Platform. This early detection is possible by continuously monitoring the important parameters of the vehicle through inbuilt sensors embedded with IOT (internet of things Technology) and this data is continuously compared with the standard information, the deviated values are shared to the main server through a cloud service. The location of the vehicle will be tracked consistently through GPS system. A GSM/GPRS system is used to send an alert message, if the location is a no network area, a RF module is used to transmit the alert information and is received by the moving vehicle having this system within the range of RF Module, and this is sent to the next moving vehicle and this process will continue like a chained seriesuntil the vehicle in the network area will receive this message. As soon as the message is received by the vehicle in network area, the alert message will be transmitted to the base station of the VANET

Keywords—VANET; Accident; RF Module; GPS System; Cloud Service

I. INTRODUCTION

Withholding towards the vicious development of technology, various autonomous systems have been envisioned. Inn South Asian region the number of vehicles is rapidly reaching up the highest level which is in accordance with the increasing population too. Traumatically Deaths and disabilities by accidents are reaching up in higher rates with each passing years. The survival rate after accident is very low as properemergency facilities are unavailable. In 2019, the number of deaths by road accidents in Tamil Nadu reached around 57,000. There is no means to find a latest technology that can completely revert the accidents and do not even materialize the exact area of occurrence. The life of the victim depends on the responses of the other people there. Sometimes due to the legal ramifications, people don’t even want to make themselves involved in recovery operation. The accidents are being notified to the their respective acquaintances only after a long period. The overall situation concludes that the reachability of the accident spot in a developed surrounding has become literally a difficult task. Hence, In this paper, an automatic accident detection and prevention systemusing IoT and VANET assisted communication is described. Real time information through messages will stored in the cloud services and will be sent to the base station of the VANET. In addition to this solution there is another case where there is less network availability, In such cases communication and exchange of information can be taken place by the RF Module through which the informative messages will be transferred to the next moving vehicle like a chained series.

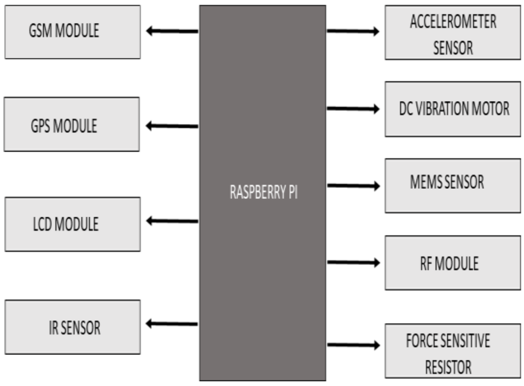

Fig. 1. Overall block diagram of the entire detection system

II. LITERATURE REVIEW

The proposed system deals with anautomatic accident detection system involvingvehicles which sends information about theaccident including the location, the time andangle of the accident to a rescue team like a firstaid center and the police station. Thisinformation is sent in the form of an alertmessage. But in the cases where there are nocasualties a switch is provided which can beturned off by the driver to terminate sending thealert message. A GSM module is used to sendthe alert message and a GPS module is used todetect the location of the accident. The GPS andGSM module are interfaced to the control unitusing serial communication.The accidentitself is detected using two sensors- MicroElectro Mechanical System (MEMS) sensor andvibration sensor. MEMS sensor also helps inmeasuring the angle of roll over of the car. A700 MHz microprocessor Raspberry Pi is used as the main highspeed data-processing unit. The vibrations aresent from the vibrating sensor to the controllerafter passing through an amplifying circuit.Similarlythe roll over angle is sent from theMEMS sensor to the controller. Certainly the sensor particularly IR sensor is also kinshiped in order to identify the drowsiness felt by the drivers at the earliest through the eye blinks. Accelerometer sensors are ICs that measure acceleration, which is the change in speed (velocity) per unit time. Measuring acceleration makes it possible to obtain information such as object inclination and vibration. This accelerometer sensor could read out the values at all the threeaxis points. The standard values from the sensors attached with these devices will compared with that of the present time readings and then the alert message will be stored through cloud service due to the fluctuations in the differing values of the sensors. The Road side unit will send the alert messages when the module and on board unit deviates from the original. This is just like a nodal network that acts to detect and activate the rescue system.

III. PROPOSED METHODOLOGY

The Project consists of Raspberry PI, Servo Motor, IR Sensor and Ultrasonic Transducer have been orderly shown with its complete usage and networking.

A. RASPBERRY Pi

The Broadcom BCM2835 SoC used in the first generation Raspberry Pi includes a 700 MHz ARM1176JZF-S processor, VideoCore IV graphics processing unit (GPU),and RAM, which has a level 1 (L1) cache of 16 KiB and a level 2 (L2) cache of 128 KiB. The level 2 cache is used primarily by the GPU.The previous version of V1.1 model of the Raspberry Pi 2 used a Broadcom BCM2836 SoC with a 900 MHz 32-bit, quad-core ARM Cortex-A7 processor, with 256 KiB shared L2 cache. The Raspberry Pi 2 V1.2 was upgraded to a Broadcom BCM2837 SoC with a 1.2 GHz 64-bit quad-core ARM Cortex-A53 processor, the same SoC which is used on the Raspberry Pi 3, but underclocked (by default) to the same 900 MHz CPU clock speed as the V1.1. The Raspberry Pi 3 Model B uses a Broadcom BCM2837 SoC with a 1.2 GHz 64-bit quad-core ARM Cortex-A53 processor, with 512 KiB shared L2 cache. The Raspberry Pi 4 uses a Broadcom BCM2711 SoC with a 1.5 GHz 64-bit quad-core ARM Cortex-A72 processor, with 1 MiB shared L2 cache. Unlike previous models, which all used a custom interrupt controller poorly suited for virtualization, the interrupt controller on this SoC is compatible with the ARM Generic Interrupt Controller (GIC) architecture 2.0, providing hardware support for interrupt distribution when using ARM virtualization capabilities.The Raspberry Pi Zero and Zero W use the same Broadcom BCM2835 SoC as the first generation Raspberry Pi, although now running at 1 GHz CPU clock speed.
The Raspberry Pi Pico uses the RP2040 running at 133MHz

Fig. 2. Raspberry Pi Board

B. IR SENSOR:

An infrared sensor is an electronic instrument that is usedto sense certain characteristics of its surroundings byeither emitting and/or detecting infrared radiation. It isalso capable of measuring heat of an object and detectingmotion. Here ,the IR sensor is used to detect the drowsiness of the driver. At first, the status of the driver will be analyzed by monitoring the eye blinks using IR sensor. The IR transmitter is used to transmit the infrared rays in our eye. The IR receiver is used to receive the reflected infrared rays from eye.Since, the output from the detectoris usually very small, hence pre amplifiers coupled withcircuitry are added to further process the received signals.

C. ACCELEROMETER SENSOR:

The Accelerometer module is based on the popular Freescale MMA7361 three-axis analog accelerometer IC , which reads off the X, Y and Z acceleration as analog voltages. The accelerometer is very easy interface to an Arduino Microcontroller using 3 analog input pins, and can be used with most other microcontrollers as well as the microprocessors.This module comes complete with 0.1" pitch pin headers soldered on, so it fits directly into a breadboard or prototype shield. This module's onboard voltage regulator allows for convenient operation at either 3.3 volts or 5 volts - a feature not found on the competitor's modules. The sensor board has 2x5 pin 0.1" pitch pin headers with two sensitivity modes specially ±1.5G and ±6G. The operation can be taken place at 5VDC & 3.3VDC.For linear free fall detection, 0G detect pin is preferred. The two desirable modes Sleep Mode and self test mode can be used to save on power and for easytroubleshooting. This sensor is designed in similar way that compensates with the temperature.

Fig. 3. IR Sensor

Fig. 4. MEMS Sensor

D. MEMS SENSOR:

The MEMS (Micro Electro Mechanical Sensor) detects thesurplus vibration in case of accident with the help of 3-axis gyroscope and 3-axis accelerometer, activating the framework flow thereby sending the messages to the corresponding server. These sensors would store the factors like vibration, speed, humidity, temperature etc. This is connected with the accelerometer so that the speed of the vehicle can be directly proporational to the warning alarm (indicator).

E. DC VIBRATION MOTOR:

DC motors are in many ways the simplest electric motors. Most DC "brushed" motors operate in the same way. There is a stator and a rotor. The magnets on the stator and a coil on the rotor which is magnetically charged by supplying current to it. The presence of brushes (static, permanent mechanisms) within the motor, which propel the electromagnetic rotor forward. Utilizing a DC power source, very few controls are needed. Speed of the motor can be controlled by the amount of current reaching the coils from the battery to the commutator. If you reverse the leads, or wires, coming off of the motor - the motor will spin the opposite direction as it was previously.

Fig. 5. RF Module and the Vibration motor

F. RF TRANSMITTER / RECEIVER:

The RF transmitter transmits this serial data using radio signals. At the receiver side, the RF receiver receives the serial data. This serial data is sent to HT12D decoder IC which converts into 4 bit parallel data. The 4 data pins of decoder are connected to LEDs. Basically the RF modules are 433 MHz RF transmitter and receiver modules.

The transmitter draws no power when transmitting logic zero while fully suppressing the carrier frequency thus consume significantly low power in battery operation. When logic one is sent carrier is fully on to about 4.5mA with a 3volts power supply. The data is sent serially from the transmitter which is received by the tuned receiver. Transmitter and the receiver are duly interfaced to twomicrocontrollers for data transfer. The following are the characteristics of the RF Module..

- Receiver frequency: 433MHz
- Receiver typical sensitivity: 105Dbm
- Receiver current supply: 3.5mA
- Receiver operating voltage: 5V
- Low power consumption
- Transmitter frequency range: 433.92MHz
- Transmitter supply voltage: 3V~6V
- Transmitter output power: 4~12Dbm

Fig. 6. Wireless Transmitter and Receiver

IV. SYSTEM DESIGN AND IMPLEMENTATION

A. RASPBERRY Pi ADXL345 ACCELEROMETER SETUP:

The digital sensor communicates data over I2C and SPI interfaces. In any ADXL345 sensor module, pins for both interfaces (I2C/TWI and SPI) and interrupt pins are available. The sensor supports both 3-wire and 4-wire SPI. Raspberry Pi has both I2C and SPI interfaces, and either can be used to talk with ADXL345. The user I2C of Raspberry Pi is available at pins GPIO2 (Board Pin No. 3) and GPIO3 (Board Pin No. 5). GPIO2 is Serial Data (SDA) line, and GPIO3 is a Serial Clock (SCL) line of the I2C1. These I2C pins are internally pulled up to 3.3V via 1.8 k ohms resistors. So, the I2C lines of ADXL345 can be directly connected to the user's I2C port of Raspberry Pi without the need for any external circuitry. ADXL345 requires an operating voltage of 2.5V that can range from 2.0V to 3.6V. It consumes approximately 30 uA for a data transfer rate of less than 10 Hz and around 140 uA for data transfer rates above 100 Hz. The ADXL345 sensor can be supplied 3.3V supply with common ground from the Raspberry Pi itself, while the I2C channels can be directly connected without the need for any external pull-up circuit.

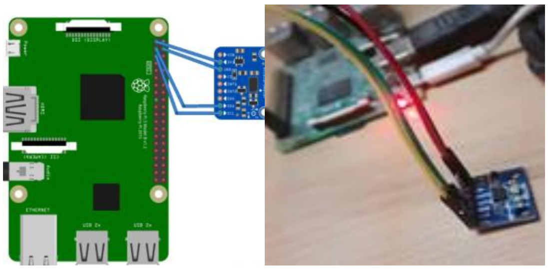

Fig. 7. Interfacing Raspberry Pi with Accelerometer Sensor

The I2C1 port of Raspberry Pi can communicate with data speeds up to 400 kbps. The ADXL345 sensor has a maximum output data rate of 3200 Hz or 3.2 kbps. So, the sensor can easily communicate with Raspberry Pi. The output data rate of ADXL345 can be set by writing to BW_RATE (0x2C) register. The I2C voltage levels of both Raspberry Pi and ADXL345 are 3.3V compatible, so there is no need for any logic level shifter between Raspberry Pi and ADXL345. The SDA and SCL lines of both can be directly connected.ADXL345 has an ALT address pin that can be hardwired to set the I2C address of this digital sensor. If the ALT ADDRESS pin is pulled high in a module, the 7-bit I2C address for the device is 0x1D, followed by the R/W bit. This translates to 0x3A for a write and 0x3B for a read. If the ALT ADDRESS pin is connected to ground, the 7-bit I2C address for the device is 0x53 (followed by the R/W bit). This translates to 0xA6 for a write and 0xA7 for a read.

B. VANET:

A vehicular ad hoc network (VANET) consists of groups of moving or stationary vehicles connected by a wireless network. Until recently the main use of VANETs was to provide safety and comfort to drivers in vehicular environments. This view is changing, vehicular ad hoc networks are seen now as an infrastructure for an intelligent transportation system with increasing number of autonomous vehicles, and for any activity requiring Internet connectivity in a smart city. Also, VANETs allow on-board computers of mostly stationary vehicles. The contents produced and consumed by vehicles has local relevance in terms of time, space, and agents involved, the producer and the consumer. Vehicle-generated information has local validity, a limited spatial scope, an explicit lifetime, a limited temporal scope, and local interest, it is relevant to agents in a limited area around the vehicle.

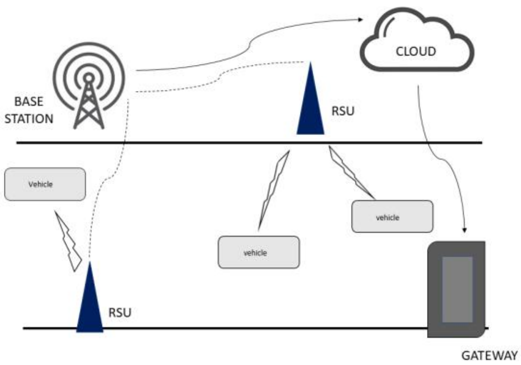

Fig. 8. Block Diagram of the Revelative Network

C. RASPBERRY Pi INTERFACED WITH VANET:

The operating system that run on the Raspberry PiZero W is a version of Raspbian, a distribution of Linuxported to the Raspberry Pi family of computers. Because the development took place on standalone computersrather than the Pi, for the Pi we selected a version ofLinux that did not provide a GUI, instead relying onthe command line to perform all necessary tasks. Theabsence of a GUI saves both processing power and spaceon the SD card.Once cross-compiled for the ARM, AllNet runsunmodified on the Raspberry Pi. The AllNetcommand-line utilities are available, and are sufficientfor our testing

D. FORCE SENSITIVERESISTOR (FSR):

Force Sensitive Resistors (FSR) are a polymer thick film (PTF) device which exhibits a decrease in resistance with an increase in the force applied to the active surface. Its force sensitivity is optimized for use in human touch control of electronic devices. FSRs are not a load cell or strain gauge, though they have similar properties. FSRs are not suitable for precision measurements. Force vs. Resistance The force vs resistance characteristics provides an overview of FSR typical response behavior. For interpretational convenience, the force vs. resistance data is plotted on a log/log format. These data are representative of our typical devices, with this particular force-resistance characteristic being the response of evaluation part # 402 (0.5" [12.7 mm] diameter circular active area). A stainless steel actuator with a 0.4" [10.0 mm] diameter hemispherical tip of 60 durometer polyurethane rubber was used to actuate the FSR device.

In general, FSR response approximately follows an inverse power-law characteristic (roughly 1/R). Referring to Figure 2, at the low force end of the force-resistance characteristic, a switch-like response is evident. This turn-on threshold, or 'break force", that swings the resistance from greater than 100 kΩ to about 10 kΩ (the beginning of the dynamic range that follows a power-law) is determined by the substrate and overlay thickness and flexibility, size and shape of the actuator, and spaceadhesive thickness (the gap between the facing conductive elements). Break force increases with increasing substrate and overlay rigidity, actuator size, and spacer-adhesive thickness. Eliminating the adhesive, or keeping it well away from the area where the force is being applied, such as the center of a large FSR device, will give it a lower rest resistance (Eg. stand-off resistance). At the high force end of the dynamic range, the response deviates from the power-law behavior, and eventually saturates to a point where increases in force yield little or no decrease in resistance. Under these conditions of Figure 2, this saturation force is beyond 10 kg. The saturation point is more a function of pressure than force. The saturation pressure of a typical FSR is on the order of 100 to 200 psi. For the data shown in Figures 2, 3 and 4, the actual measured pressure 26 range is 0 to 175 psi (0 to 22 lbs applied over 0.125 in 2). Forces higher than the saturation force can be measured by spreading the force over a greater area; the overall pressure is then kept below the saturation point, and dynamic response is maintained. However, the converse of this effect is also true, smaller actuators will saturate FSRs earlier in the dynamic range, since the saturation point is reached at a lower force.

E. GSM MODULE:

For providing communication between the GPS, GSM and the allocated mobile number GSM SIM900 module is preferred. The name SIM900 says that, it is a tri band work ranging a frequency of 900MHz to 1900 MHz such as EGSM900 MHz, PCS 1900 MHz and DSC 100 MHz Receiving pin of GSM module and transmitting pin of GPS module are used for communication between the modules and the mobile phone.

F. GPS MODULE:

To find the location on the earth the whole is divided into some coordinates where the location can be easily captured by a module called GPS module. Here the GPS used is SIM28ML. This GPS module will find the location of the vehicle and the information fetched by the GPS receiver is received through the coordinates and the received data is first send to arduino and the information is transmitted to the saved contact through GSM module. The frequency is operated in the range of 1575.42 MHz and the output of GPS module is in NMEA format which includes data like location in real time.

G. LCD MODULE:

To display the numbers, alphabets and special characters an LCD module with 16x2 alphanumeric types is used. Using the higher bit data lines of LCD pins such as pin 11,12,13 and 14 are interfaced to digital pins of Arduino such as pin 8,9,10 in 4 bit mode. RS and E pins of LCD are connected to pin 12 and 13. To perform the write operation on LCD the read/write pin is connected to ground.

V. RESULTS, DISCUSSIONS AND SIMULATION

The Prototypic results and the simulation models with its inputs and parameters are discussed below…

A. RESULTS ON THE PROTOTYPIC MODEL:

The data is read from the sensors by the microcontroller and process the data. If there is any deviation from the normal value, the microcontroller sends an alert signal to the receiver end and calls for emergency. The deviated value will get displayed on the display of the device. The receiver end detects the case of emergency from the victims who are caught in the accident and rescues them through transferring the alert messages to the nearby base stations. Fig. 10. Shows the testing of the prototypic accident detection device showcasing the conclusive outturn.

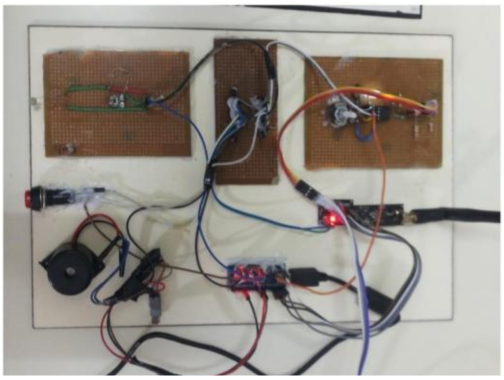

Fig. 8. Prototypic Top view of the system

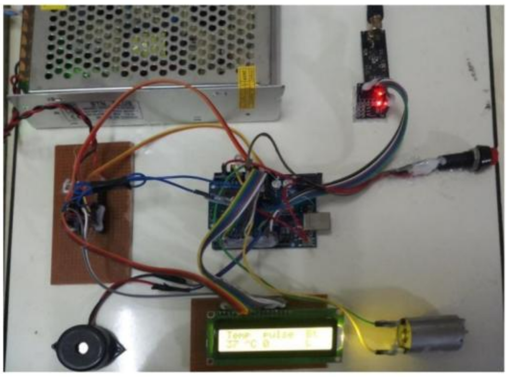

Fig .9. Consociation with the RF Module

Fig .10. Terminal Test with conclusive outturn

Fig .11. City Highwayconsideration for Simulation

Fig. 12. Vehicles movement in VanetMobiSim

Fig. 13. V2V and V2I Communication in NS2

B. SIMULATION MODEL:

In simulation model, let the representation "N" be the numberof nodes in the particular considered area. For simulation in VanetMobiSim andNS-2, we have considered a highway road particularly the City Highway and Sultan Qaboos Road in Muscat, Oman as in Fig. 11, including city scenario roadswhich is of length "L" and width of "B"hence the area will be defined by L*B. Initially the nodesposition and direction are allocated in the given area.Here two lanes have been taken in which vehicles in one lane move insame direction and other in opposite direction. Whenthe vehicles come near to the event the following nodeshould get slow down. The mobility factor is in between therange Smin to SmaxKmph. Realistic movement of vehicles andthe connectivity is as shown in Fig. 12 and 13.

C. SIMULATION INPUTS:

In order to illustrate some of the results of proposed work wehave considered the following simulation inputs (i.e.)N=25,Rangeof the vehicles = 250mts, Area = 3km * 3km, range ofthe RSUs= 1.5 km, length of the vehicles = 10mts, safetydistancebetween the two vehicles = 5mts, road type = twoway, speedof the vehicle S_{min}= 0 kmph to S_{max}= 20, 40, 60, 80kmph,packet size = 512 Kb of Constant Bit Rate (CBR).

D. PERFORMANCE PARAMETERS:

To analyse the ACO based routing scheme in VANETs withVanetMobiSim and NS-2 simulators, some of evaluationparametrics used are packet delivery Ratio, throughput,controloverhead, Cumulative density function of mean delay and Packet delivery latency.

_ *Packet Delivery Ratio (PDR):* PDR is defined as theratio of the total number of packets received out ofthe total number of packet sent. It is expressed interms of percentage. Fig. 14 explains the average packet loss attained by the underlying VANET protocol against RSADP. The density of vehicles on the road affects the packet count in a network, in high-density vehicle scenario more packets flow in a network and can result in packet loss. High packet loss cannot confirm delivery of emergency communication over a network, so need precise addressing. In proposed work, minimum packet loss recorded against the basic model of VANET.

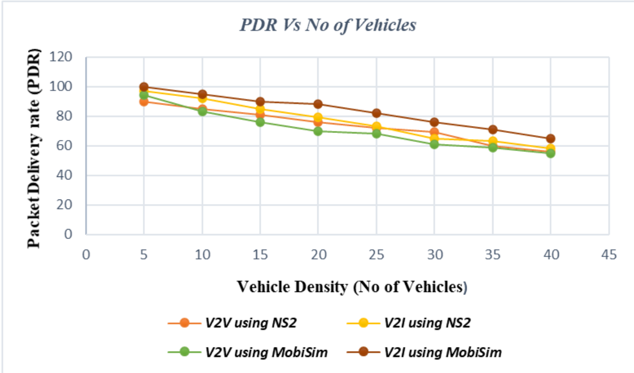

Fig. 14. PDR vs Vehicle Density

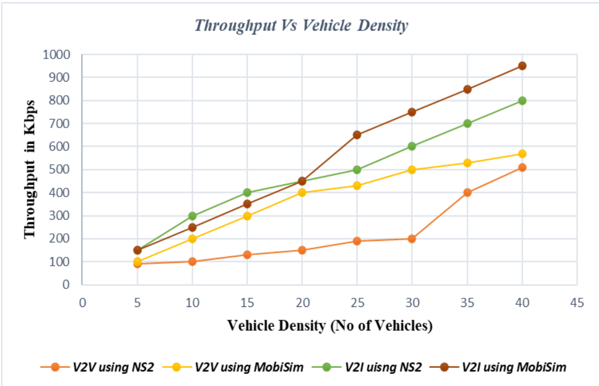

Fig. 15. Throughput vs Vehicle Density

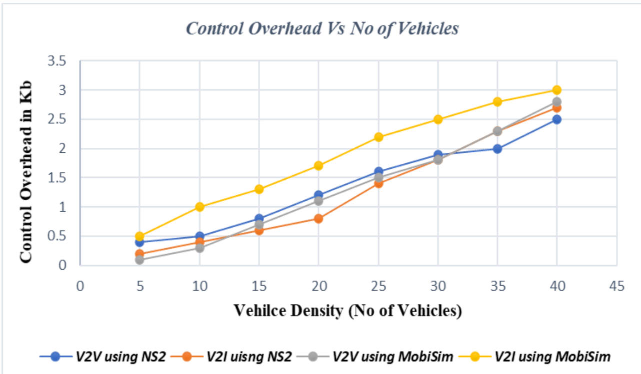

Fig. 16. Control Overhead vs Vehicle Density

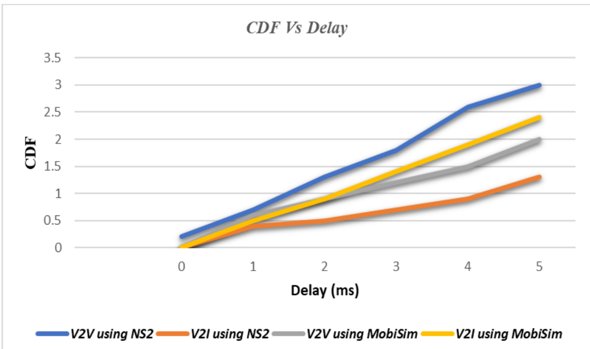

Fig. 17. Cumulative Density Function of mean Delay

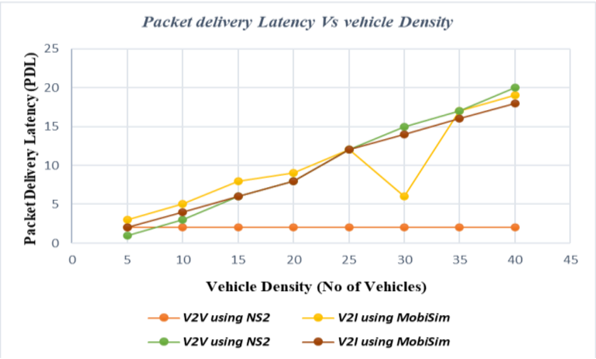

Fig. 18. PDL vs Vehicle Density

_ *Throughput:* Throughput is defined as the totalnumber of packets transferred successfully fromsource to destination in a given time period. It isanalysed in Kbps. Fig. 15. Gives the productivity of the system, which tells regarding the number of processed vehicles by the system during the analysis period.

_ *Control Overhead:* Usage of available bandwidth for control packets is considered as the control overhead.It is expressed in terms of kilobytes. Fig. 16. gives the number of packets received by each destination node in Vanet and NS2.

_*Cumulative Density Function:*Fig. 17. Shows the cumulative density function of the mean delay with four different densities 0.1, 0.2, 0.03, 0.05.

_*Packet Delivery Latency*: Packet delivery time or the Packet delivery latency is the time from where the first bit leaves the transmitter until the last is received. It is measured in milli seconds. In other words , packet delivery time is equal to the sum of propagation delay and the transmission time. Fig. 18. Shows that the V2V communication using NS2 is with the constant packet delivery time for the increased no of vehicles, whereas all the other framework outlets continuous increment.

VI. CONCLUSION

This system proves out the feasibility of automatic detection and prevention of accident system, significantly improving the time limit of servicing operations and saves the life of huge no of victims. The informative message will be sent to the registered number through GSM module. Using GPS module the location can be sent to the through tracking the system to cover the geographical coordinates over the area.Thus the proposed system can serve the humanity by a great deal as human life is very much valuable.

ACKNOWLEDGMENT

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