A Hybrid approach for Vehicle-to-Vehicle Communication System with Enabled Location Tracking.

Md. Al-Amin

A Thesis in the Partial Fulfillment of the Requirements

for the Award of Bachelor of Computer Science and Engineering (BCSE)

Department of Computer Science and Engineering
College of Engineering and Technology
IUBAT – International University of Business Agriculture and Technology

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Fall 2023

Letter of Transmittal

14 January 2024

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Subject: Letter of Transmittal.

Dear Sir,

I am pleased to present you my thesis report titled 'A Hybrid approach for Vehicle-to-Vehicle Communication System with Enabled Location Tracking' as required by IUBAT for the partial fulfillment of the requirements for the award of Bachelor of Computer Science and Engineering. It was indeed a great opportunity for me to work on this project to actualize my theoretical knowledge into practice.

Finally, I would like to express my gratitude to you for giving me this opportunity to pursue my studies in your renowned university.

Yours sincerely,

____

Md. Al-Amin
19303055

Student's Declaration

I thus certify that this thesis report titled 'A Hybrid approach for Vehicle-to-Vehicle Communication System with Enabled Location Tracking'; is my unique work. It has never been presented earlier or concurrently for any other purpose, prize, or degree at IUBAT or any other school, either by me or by any other student. I further affirm that there is no plagiarism or data fabrication, and that all materials utilized in this study and numerous sources have been properly cited.

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Supervisor’s Certification

This is to certify that the thesis report on "A Hybrid approach for Vehicle-to-Vehicle Communication System with Enabled Location Tracking " has been carried by Md. Al-Amin ID- 19303055 student, Department of Computer Science and Engineering, IUBAT-International University of Business Agriculture and Technology as a partial requirement to achieve Bachelor of Computer Science and Engineering degree. The report has been prepared under my guidance and is a record of work carried out successfully. To the best of my knowledge and as per their declaration, no parts of this report has been prepared for any other purpose, reward, or presentation. Now they are ready to submit the report.

I wish them success in their future endeavors.

Dr. Abhijit Saha

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Abstract

This thesis explores a pioneering hybrid approach for enhancing Vehicle-to-Vehicle communication systems by integrating local communication, long range communication and live location tracking system. The hybrid system aims to address the challenges of conventional V2V systems by combining the high-speed and secure data transmission capabilities of Li-Fi with the dynamic and resilient mesh network architecture. The research encompasses the design, development, and evaluation of this novel system, focusing on its ability to enable precise location tracking and efficient communication among vehicles. Results demonstrate the system's potential to significantly improve the reliability and effectiveness of V2V communication in dynamic vehicular environments, contributing to the advancement of intelligent transportation systems.

Acknowledgments

Select these texts and then type the text you wish to use. Acknowledge the people who helped you in various ways to complete this thesis report. Keep the format as it is.

Table of Contents

1 Introduction

Vehicular networks, also known as Vehicular Ad Hoc Networks (VANETs), constitute a wireless communication framework allowing vehicles to exchange information with each other and with roadside infrastructure or without roadside infrastructure Employing technologies like Dedicated Short-Range Communication (DSRC) or Cellular-V2X (C-V2X), these networks facilitate direct vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication. Vehicular networks are designed to enhance road safety through applications such as collision warnings and emergency messages or call, while also improving traffic efficiency with features like adaptive cruise control and dynamic route planning. Security and privacy measures are paramount, with encryption and authentication ensuring the reliability of exchanged information.

1.1 Application and challenges of VN

There are many core applications of vehicular network, among those Vehicle-to-vehicle (V2V), Vehicle-to-infrastructure (V2I), and Vehicle-to-Pedestrian (V2P) communications are mostly practiced in the research community.

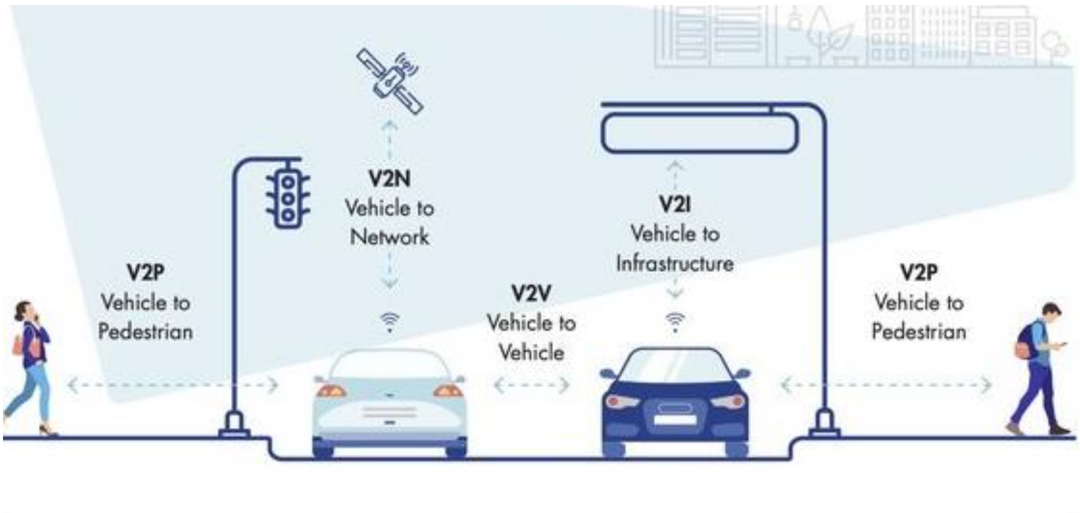


Figure 1.1 Vehicular Network

In current time there are many challenges in vehicular network as like Legal and Regulatory Issues, Public Acceptance and Adoption, Local vehicle live location sharing, Privacy of data of a particular transport-based industries. The V2V communication system enables the communication between *n* numbers on vehicles. V2V communication allow as to conduct the communication without any road infrastructure and keep our organizational or personal data secure.

1.2 Challenges of V2X (V2V)

In this research we mainly focused on the V2V communication method. We think that it is quit challenging to implement the V2V communication protocol in local transportation or industrial based transport system. We took the challenge to overcome some of the problem in the vehicular network system. Some mentionable challenges are Standardization, Interoperability, Scalability, Privacy Issues, Dynamic Traffic Conditions etc.

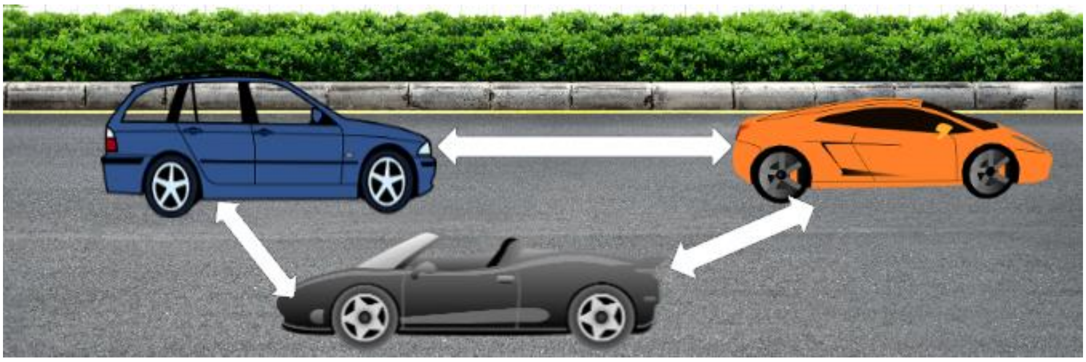


Figure 1.2 V2V Communication

I. Standardization

The lack of a universally adopted communication standard poses a significant challenge. Different manufacturers may implement V2V communication using different protocols, potentially leading to interoperability issues and hindering widespread adoption. We had tried to implement some universal protocols to balance the gap between multiple manufacturers. Our system can be connected with other organizational protocol with some internal changes and that can be done so easily.

II. Scalability

As the number of connected vehicles increases, managing the scalability of V2V communication becomes crucial. The system should efficiently handle a large volume of messages and interactions, especially in densely populated urban areas. We had tried to build our prototype in such a way, so that we can control large number of users by implementing or providing their own API.

III. Interoperability

Ensuring seamless communication between vehicles from different manufacturers and utilizing different technologies is crucial. Interoperability challenges may arise due to differences in communication protocols, hardware, and software implementations. As we discussed in the previous challenge, the connection between different manufacturers can be reduced by our proposed prototype.

IV. Privacy Issues

V2V communication systems gather and share information about vehicle movements and behaviors. Protecting the privacy of drivers and occupants while still providing valuable safety information is a delicate balance that needs careful consideration. And in our system, we tried to provide a centralized database (Interface) motivated from block-chain technology and without the device no one can easily found any data of a particular person or an organization.

V. Dynamic Traffic Conditions

V2V communication must adapt to dynamic and unpredictable traffic conditions. Ensuring effective communication in scenarios like heavy traffic, sudden lane changes, and complex intersections is challenging but crucial for safety applications. We tried to implement a real-time location tracking system in-build with our prototype. To ensure the visibility of the vehicle in any condition.

1.3 Challenges of V2X (V2I)

The Vehicle-to-Infrastructure (V2I) communication method faces many challenges such as Privacy, Investment, Public acceptance etc.

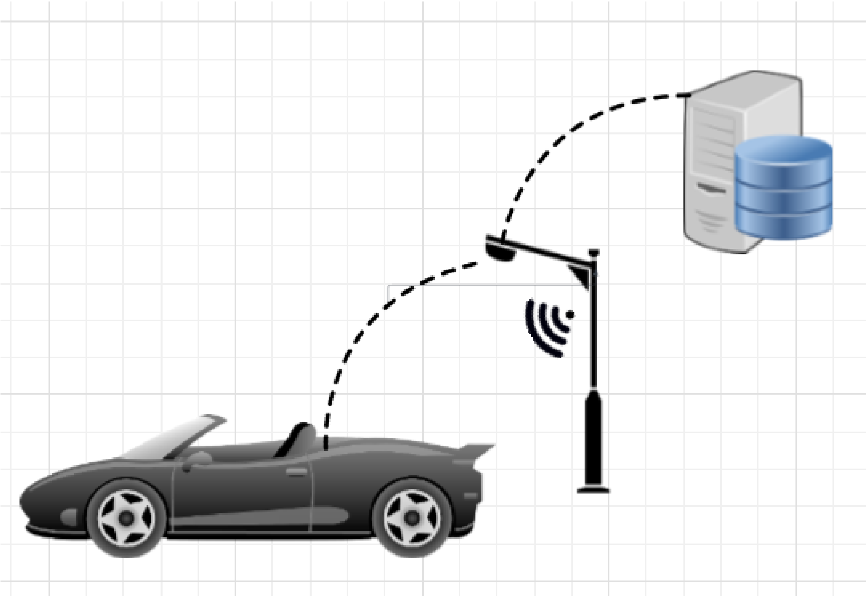


Figure 1.3 V2I Communication

I. Standardization

Lack of standardized communication protocols poses a significant challenge. Different regions or infrastructure providers may adopt different standards for V2I communication, leading to interoperability issues and hindering seamless communication between vehicles and infrastructure.

II. Security Concerns

V2I communication involves the exchange of sensitive information, including location data and traffic patterns. Ensuring the security of this data is crucial to prevent unauthorized access, data breaches, and potential cyber-attacks on the infrastructure.

III. Infrastructure Deployment

The deployment of V2I infrastructure, such as roadside units and communication beacons, can be challenging due to cost, regulatory hurdles, and the need for extensive coverage. The lack of a widespread and standardized infrastructure hinders the broad implementation of V2I communication systems.

IV. Funding and Investment

Establishing a comprehensive V2I communication infrastructure requires significant financial investment. Governments, private entities, and other stakeholders must collaborate to secure funding and allocate resources for the deployment and maintenance of infrastructure.

V. Maintenance and Upgrades

Over time, V2I infrastructure will require regular maintenance and upgrades to ensure its effectiveness and compatibility with evolving technologies. Establishing sustainable maintenance plans is crucial for the long-term success of V2I communication.

1.4 Challenges of V2X (V2P)

The Vehicle-to-Pedestrian (V2P) communication method faces many challenges such as Accuracy of data, Urban Environment, Public acceptance etc.

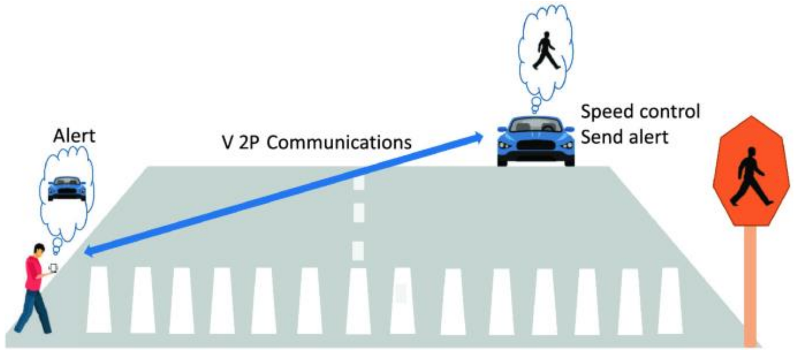


Figure 1.4 V2P Communication

I. Accuracy and Reliability

V2P communication systems need to accurately detect and communicate the presence and intentions of pedestrians in real-time. Reliability is essential for timely warnings and responses, especially in situations where pedestrians may be obscured from a driver's view.

II. Urban Environments

Urban settings present unique challenges, such as crowded sidewalks, complex traffic patterns, and various types of pedestrian movements. Designing V2P systems that can effectively operate in dynamic and densely populated urban areas is a significant challenge.

III. Public Awareness and Acceptance

Educating the public about the benefits of V2P communication and ensuring acceptance of the technology are vital. Achieving widespread adoption requires addressing concerns, building trust, and demonstrating the positive impact on pedestrian safety.

1.5 Motivation

The modern era witnesses a profound surge in vehicular traffic, accompanied by an alarming rise in road accidents and fatalities. In response, there's a pressing need for innovative solutions that leverage advancements in technology to enhance road safety and mitigate the severity of accidents. This thesis endeavors to address these challenges through the development of a sophisticated vehicle-to-vehicle communication system integrated with robust location tracking capabilities. The motivation behind this project stems from a deep-seated concern for public safety and a recognition of the pivotal role technology plays in shaping the future of transportation. By harnessing the potential of mesh networking, sensor technology, and long-range communication modules, our system aims to establish seamless communication channels between vehicles within proximity, facilitating real-time sharing of critical accident data. Moreover, the incorporation of GPS technology enables precise tracking of vehicle locations, empowering authorities with invaluable insights for efficient emergency response and accident management. Furthermore, our system isn't confined solely to accident detection and emergency response; it also caters to proactive safety measures. Through the implementation of intuitive user interfaces and dedicated emergency messaging functionalities, drivers can communicate vital information swiftly, ensuring timely interventions in hazardous road conditions.

In essence, this project aspires to contribute significantly to the ongoing efforts aimed at revolutionizing road safety standards, fostering a safer and more secure environment for all road users.

1.6 Problem Statement

The existing infrastructure for vehicle-to-vehicle communication systems lacks robustness in facilitating real-time accident detection and dissemination of critical information. Current systems also struggle to integrate seamlessly with centralized databases for comprehensive accident data sharing. Furthermore, there is a need for enhanced location tracking capabilities to ensure efficient emergency response in diverse transportation settings, including local transportations, industrial transportations, and personal vehicle usage. Addressing these challenges requires a holistic approach to develop a hybrid communication system that seamlessly integrates short-range mesh networking for local vehicle clusters, long-range data transmission to centralized databases, and precise location tracking mechanisms. Additionally, the system must accommodate diverse emergency scenarios, empowering drivers to communicate distress signals effectively while ensuring compatibility with emerging technologies such as Li-Fi for enhanced driver alertness.

1.7 Objectives

This thesis endeavors to overcome the limitations of current vehicle-to-vehicle communication systems by developing a multifaceted hybrid approach tailored to address the distinct needs of local transportations, industrial transportations, and personal vehicle usage. The primary aim is to design and implement a resilient communication system capable of real-time accident detection and seamless dissemination of critical information within local vehicle clusters, while also establishing a robust integration mechanism with centralized databases to enable efficient sharing of accident data across diverse transportation settings. Additionally, the objective includes the enhancement of location tracking capabilities through GPS technology, ensuring precise and reliable emergency response in varied operational environments. The thesis seeks to empower drivers with specialized interface features for effective communication of distress signals in different emergency scenarios. Furthermore, the research explores the feasibility and potential benefits of emerging technologies such as Li-Fi in augmenting driver alertness and safety in short-distance communication scenarios. The effectiveness and performance of the developed system will be rigorously evaluated through comprehensive testing and validation procedures to ensure its suitability for real-world deployment.

2 Literature Review

Our approach towards building up a V2V communication network is based on both short-range data communication through vehicles and also long rang data communication with a central data set. We have tried to implement an accurate location tracking system which will be enhance the capability of our system. Some specialized keys for emergency messages are implemented. The automatic emergency calling feature will ensure the instance action if any accident occurs. We have reviewed some previous research about V2V communication network. Three most relevant research papers, those helped us to do our research are following:

Automatic Vehicle Accident Detection and Healthcare Unit Notification using IoT Technology with ESP32. (Jnana K.P., 2022), Implementation of a WiFi-based V2V-V2I Communication Unit for Low-Speed Vehicles. (A.Q. Nguyen, 2021), A Li-Fi based Collision Avoidance System for Vehicles Using Visible Light Communication. (M. Yuvaraju, 2021).

2.1 Automatic Vehicle Accident Detection and Healthcare unit Notification using IoT Technology with ESP32.

The paper discusses about the population and accident ratio and for solve this problem of the proposed an accident detection and an emergency notification system. This paper mainly discusses about the system which is developed using IoT technology with the integration of ESP32 Microcontroller, Smart Sensors, GPS, GSM and Blynk Application to detect accident and to send immediate notification to the nearby healthcare centers and emergency contacts for the rescue operation.

2.1.1 System model

The figure 2.1 shows the block diagram of proposed system

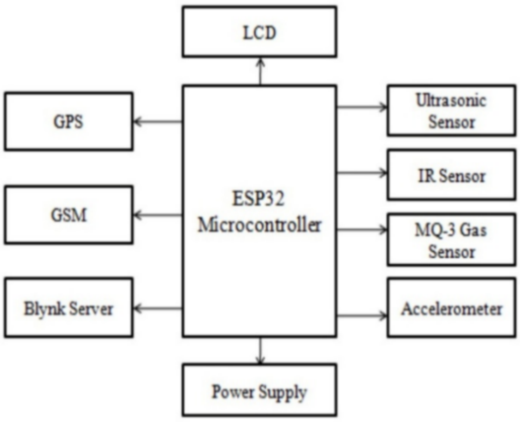


Figure 2.1 Block Diagram of proposed System

2.1.2 Working Procedure

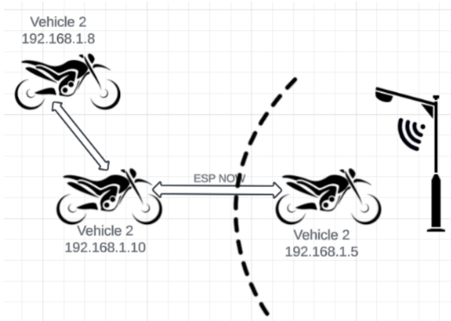
A prototype model is implemented by incorporating ESP32 microcontroller and various sensors. ESP32 has inbuilt Wi-Fi module. The considered Ultrasonic, IR, MQ-3 Gas sensors are connected to the microcontroller. GPS and GSM Modules are also interfaced. The system is basically based on one certain application called 'Blynk'. In this system ESP32 Dev board is considered. Auth token is generated which is unique identifier required in order to connect the selected hardware to the smartphone. The system is connected to the Blynk with the connection mode Wi-Fi. The application contains various widgets and these widgets are added according to the requirement. When the power supply is provided to the system it starts to operate. As soon as the system is in 'ON' mode it is simultaneously connected to the Blynk application through Wi-Fi. During the operating time of the system the information starts flowing through the sensors. The sensors detect the various conditions and based on that it triggers warning which is displayed manually on LCD. The system based on one application and the system is not optimized as per observation. Personal data or corporate data can be used by the third-party companies. Used one in-build (ESP32) microcontroller which creates time complexity to process multiple data at a moment.

2.2 Implementation of a WIFI-based V2V-V2I Communication Unit for Low-Speed Vehicles.

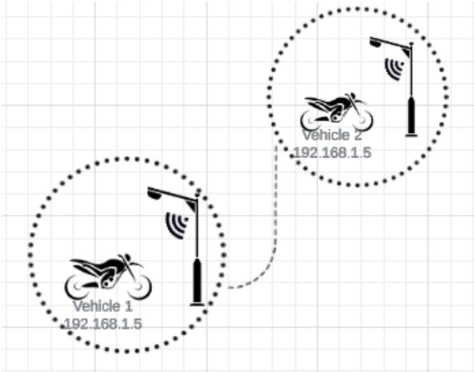
The paper discusses about the Wi-Fi based prototype of V2V-V2I communication unit for low-speed vehicles. They describe some of the common use cases of the system in various situations. Vehicles such as motorcycles, bikes, and UAVs usually move at a lower speed than automobiles. It is also difficult for them to be equipped with an expensive DSRC module. In this paper, a WIFI-based V2V-V2I communication unit was developed for low-speed vehicle

2.2.1 System Working Procedure: procedure in different situation

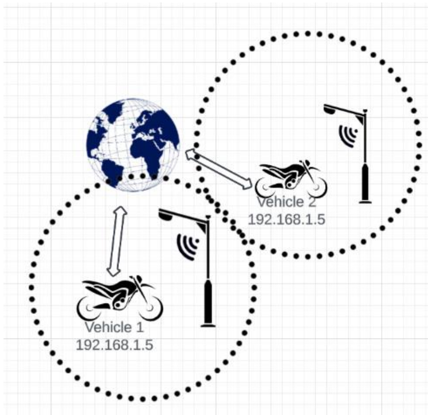
Scenario A. Direct V2V communication via



Scenario B. V2VV2I Communication via ESP



Scenario C. V2I communication when a vehicle travel from one RSU to another one



Scenario D. V2V-V2I communication between vehicles at different RSU locations

Figure 2.2 System Based Scenario in different situation

2.2.2 Working Procedure

Working process is described by the use case: V2V-V2I Communication via ESP-MESH protocol: In this case (Fig. 2.2, when a vehicle (for example, vehicle 1) is moving inside the coverage of an RSU, it is connected to that RSU and set for the ESP-MESH protocol and is ready to become a mesh point to extend the RSU network. Therefore, other vehicles (for example, vehicle 2) that are outside the coverage range of the RSU can connect to the RSU network through a mesh connection with vehicle 1. Then vehicle 2 can transfer data to the RSU via vehicle 1. So, both V2V and V2I communication are established. Vehicle 2 then becomes another mesh point of the RSU network to extend it much further (for example, vehicle 3). The system based RSU and low speed vehicles. The road side unit has to be maintained some automated system or human. The system did not integrate the module into a large number of vehicles to evaluate the operation of a full-mesh V2V-V2I network.

2.3 A Li-Fi based Collision Avoidance System for Vehicles Using Visible Light Communication.

The paper discusses about the lack of drive concentration while driving a car. So, proposed they the system with that motivation. The paper mainly about the method to avoid collision between vehicles at both ends (front and rear). This communication method is value effective with the capability of high-speed data rate. They have also the aim for reduce the air frequency from the digital signals.

2.3.1 System model

The figure 2.3 shows the block diagram of proposed system

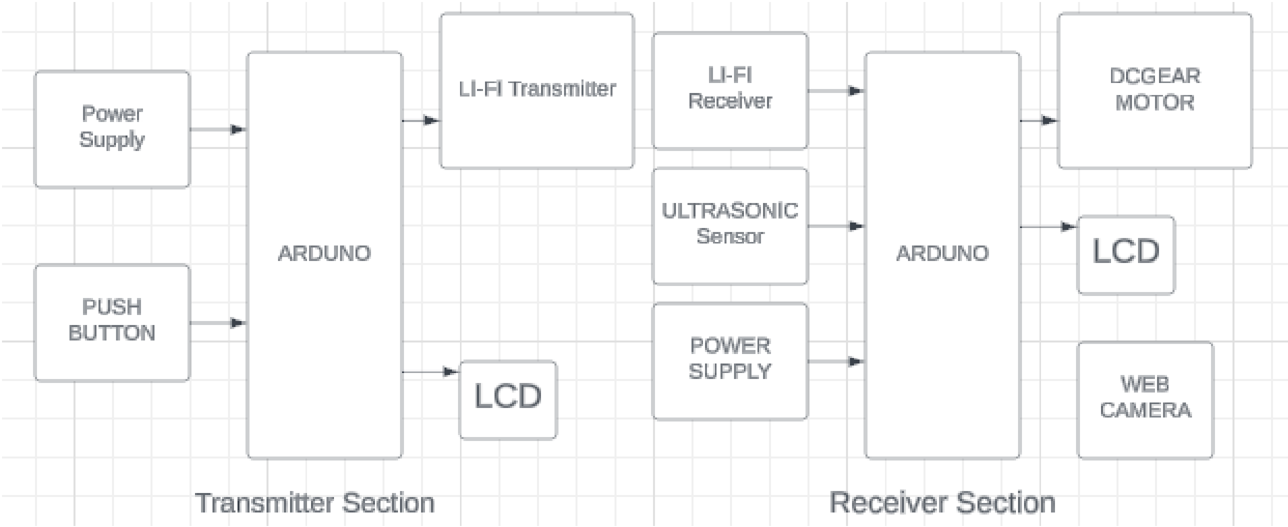


Figure 2.3 Block Diagram of the Proposed System

2.3.2 Working Procedure

The system is based on two section transmitter section and the receiver section. The transmission section having LED light source and the connected with the ARDUINO (ATmega MCU) and an LCD display. The receiver section has the solar panel (Li-Fi receiver) Ultrasonic sensor, webcam and they are controlled by the ATmega microcontroller. When the receiver receives a signal from the sensors through microcontroller, it will alert the driver to be safe. The system fully depends on the light source and light receiver. The light from other source can give errors in the result and can give false data output. They are not having any data communication frame (8 bit or 16 bit). There is no predefine instructions for light capturing

3 Methodology

3.1 Industrial transport network(V2V) scenario:

Figure 3.1 Industrial based V2V communication

In this scenario, we can see an industrial area with their transport connectivity (V2V) with each other. The admin can also manage the information from the factory to give instruction to the drivers.

3.2 Local transport network(V2V) scenario:

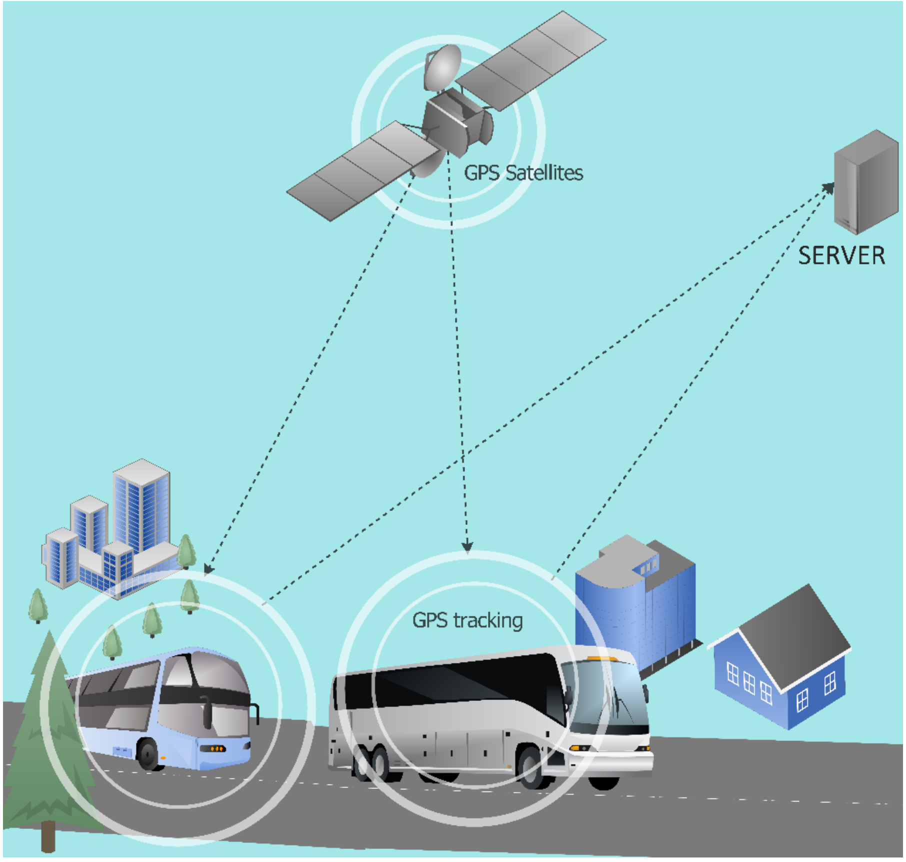


Figure 3.2 Local transport V2V communication

In the scenario, we can see a visualization of local transport vehicles. They are connected with each other, without any road-side unit, they are sharing their location through satellite and sharing the information in a centralized server. The server is connected manageable by the drivers as well as the admin of the particular transport company. Our prototype also can also be implemented in the three-wheelers local transport. Which can be used in Bangladesh as well as in this sub-continent. The vehicles are also having the LIFI technology for short rang accident alert system. The local transport system is having the emergency key in our prototype to send emergency

3.3 Private community network (V2V):

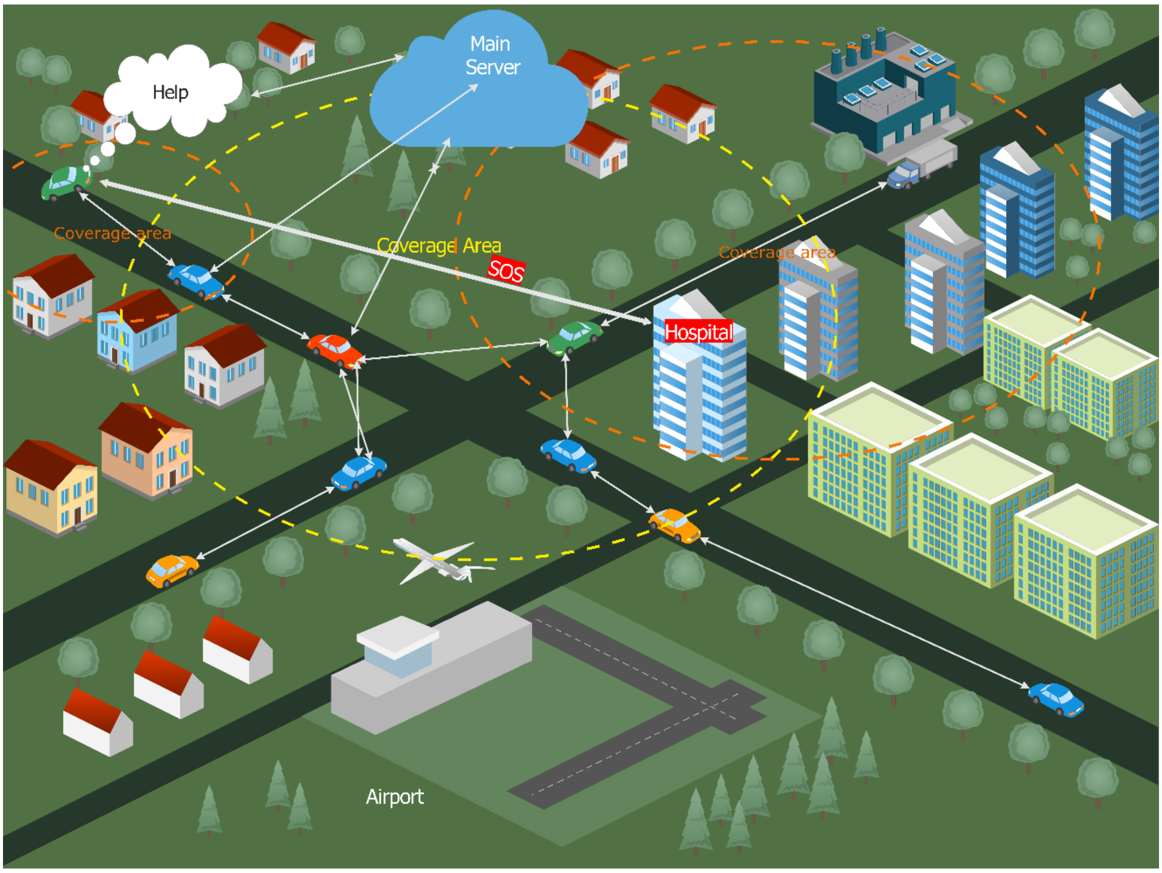


Figure 3.3 Private community network(V2V)

In this scenario, we can see a traffic situation inside a community. Every vehicle is connected with each other and sharing their status and live location. We can see the emergency call system in the scenario, when a car good accident, the surrounding vehicles within 100 meters are getting the message locally in the build-in screen and the out ranges vehicles and the admin in getting the emergency accident signal in the database. The community can also personalize our system for some vehicle. Any company can use our system to communicate with their service vehicles from any part of the country. The medicals services can integrate our system in their ambulance.

3.4 System Model

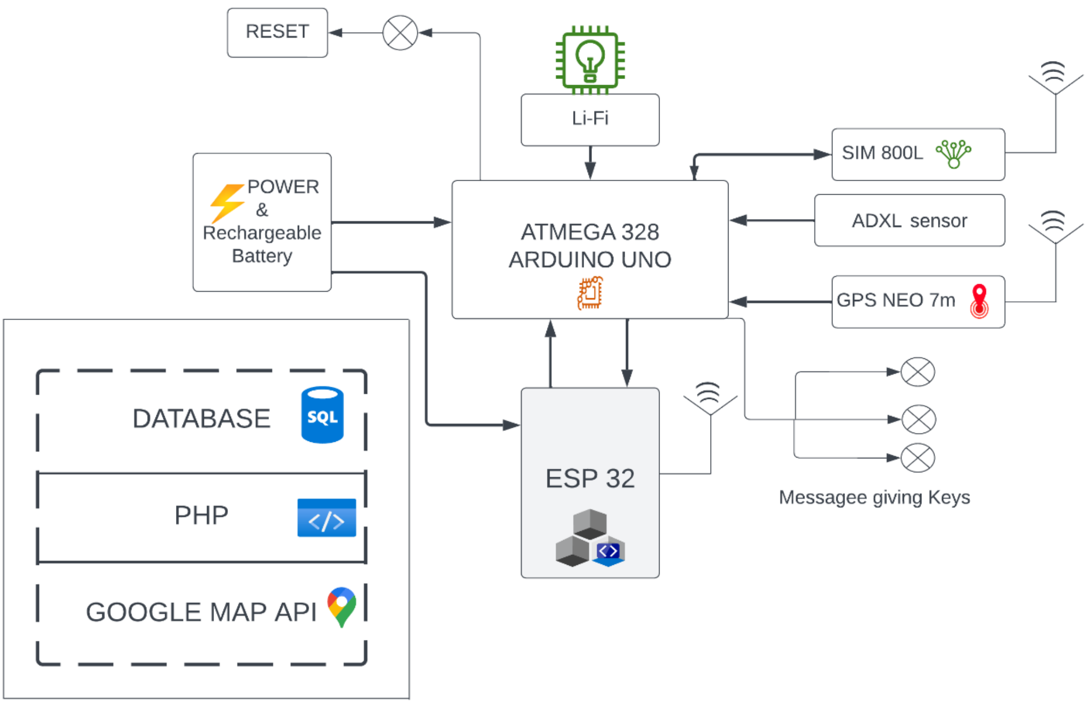


Figure 3.4 System model diagram (Functionalities)

The system model diagram visualizing the whole mechanism of our proposed prototype. The whole system is mainly based on three microcontrollers for different independent processes. The core MCU (Microcontroller unit) is ATmega328 MCU for several data processing for all the component on the PCB (Printed circuit board). The ESP32 microcontroller is playing the role of short-range data communication by creating Mesh-to-Mesh communication network. If the ESP32 module can get another system under 100 meters the accident data will be also shown in the LCD display attached with our proposed model as well as in the database. The SIM800L is for the long rang data communication and also for the automatic emergency calling feature. The SIM800L is also connected with the GPS Neo7m module for gathering location data. The proposed model is sending data in the server through SIM800L module. The accident will be detected by a ADXL345 module. It is also known as the gravity sensor for its acceleration measurement functionality. We had implemented specified keys for sending short messages to the data server which can be seen by another user or system admin from the database. The short messages can be helpful for the productivity and good services by a local transport company or industrial factories. A LIFI module is also implemented in the proposed model for primary alert of a nearby vehicles for the driver by vehicular light source. All the components are connected with the rechargeable power source, the power source can be supplemented by the vehicle power source also. The proposed system has a reset button to format all data from the register and start the processes again.

3.5 System Requirement

3.5.1 Hardware requirement

A. Components (Hardware required for prototype designing)

Figure 3.8(A) ATmega328P

Figure 3.8(B) ESP32

Figure 3.8(C) SIM800L

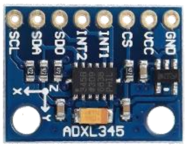


Figure 3.8(D) ADXL345

Figure 3.8(E) FTDI232

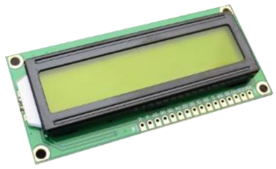


Figure 3.8(F) 16*2 LCD screen

Figure 3.8(G) XL6009 Booster Convertor

Figure 3.8(H) Solar cell

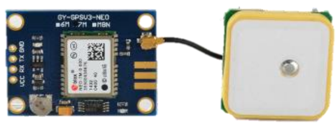


Figure 3.8(I) GPS NEO7M

Figure 3.8(J) Computer processor

Figure 3.8(K) 8 GB RAM

Figure 3.8(L) 128 GB SSD ROM

Figure 3.5 Hardware component in PCB

I. ATmega328P

The figure 3.5(A) shows The Atmega328P is a microcontroller chip developed by Atmel, now a part of Microchip Technology. It is part of the AVR family and is widely used in various embedded systems. The Atmega328P features 32KB of flash memory, 1KB of EEPROM, 2KB of SRAM, and includes a rich set of peripherals, making it popular for applications like Arduino development.

II. ESP32

The figure 3.5(B) shows the ESP32 is a versatile microcontroller developed by Espressif Systems. It features a dual-core processor, Wi-Fi, Bluetooth connectivity, and a wide range of GPIO pins, making it suitable for various IoT applications. Known for its affordability and performance, the ESP32 is widely used in embedded systems and DIY electronics projects.

III. SIM800L

The figure 3.5(C) shows the SIM800L is a GSM/GPRS module designed for mobile communication. It facilitates voice and data transmission, supporting SMS, Call, GPRS, and TCP/IP protocols. Operating in a compact form factor, it is widely used in embedded systems for IoT and networking applications.

IV. ADXL 345

The figure 3.5(D) shows the ADXL345 is a digital accelerometer sensor manufactured by Analog Devices. It measures acceleration in three axes (X, Y, and Z) and provides digital output via I2C or SPI communication protocols. Widely used in various applications, it is known for its high resolution and low power consumption.

V. FTDI FT232

The figure 3.5(E) shows the FTDI FT232 is a popular USB-to-serial bridge module, providing a seamless interface between USB and UART protocols. It enables communication between a computer and external devices with serial interfaces, facilitating data transfer and control. Widely used in embedded systems, it offers a reliable solution for bridging the gap between USB connectivity and traditional serial communication.

VI. 16*2 LCD Screen

The figure 3.5(F) shows the screen is used for showing small message.

VII. XL6009 Booster Convertor

The figure 3.5(G) shows the XL6009 Booster Converter is a voltage regulator module designed to boost input voltages efficiently. It features a wide input voltage range and is commonly used to step up lower voltages to higher levels, making it suitable for various electronic applications. With its adjustable output voltage and high conversion efficiency, the XL6009 is widely utilized in power supply and battery-powered device projects.

VIII. Solar cell

The figure 3.5(H) shows the solar sell is used for capturing the vehicles light source and give an alert to the driver.

IX. GPS NEO7m

The figure 3.5(I) shows the GPS Neo-7M is a compact and high-performance Global Positioning System (GPS) module. It features a MediaTek chipset, providing accurate and reliable positioning information with support for multiple satellite constellations. The Neo-

7M is commonly used in various applications, such as navigation systems, drones, IoT and networking devices.

X. Processor – Core i5 10th gen. or above

The figure 3.5(J) shows the 10th generation Intel Core i5 processor delivers exceptional performance, efficiency, and versatility for modern computing needs. With its quad-core architecture and hyper-threading technology, it offers seamless multitasking and smooth responsiveness for both work and entertainment.

XI. 8 GB RAM

The figure 3.5(k) shows the 8GB of high-speed RAM, this computer ensures smooth multitasking and effortless performance, empowering you to tackle any task with ease.

XII. 128 GB SSD ROM

The figure 3.5(L) shows the 128GB SSD ROM, delivering swift data access and ample storage for seamless multitasking and efficient workflow. Harness the power of SSD technology for quicker boot times and smoother performance in your daily computing tasks.

3.5.2 Software requirement

The following software-s and tools are required to developing the prototype:

- ✓ Windows 10 or above (OS)
- ✓ Ardiuno IDE (For configuring all the component and testing in the serial monitor)
- ✓ Proteus 8 Professionals (For designing the circuit diagram)

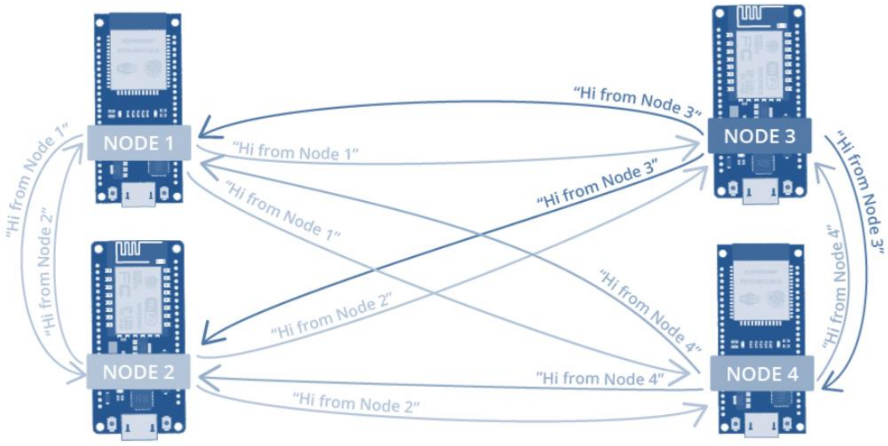


Figure 3.6 Mesh-to-Mesh network

The proposed model is based on painlessMesh library, painlessMesh is a true ad-hoc network, meaning that no-planning, central controller, or router is required. Any system of 1 or more nodes will self-organize into fully functional mesh. The maximum size of the mesh is limited by the amount of memory in the heap that can be allocated to the sub-connections buffer. The memory can be increased and we can control the limitation.

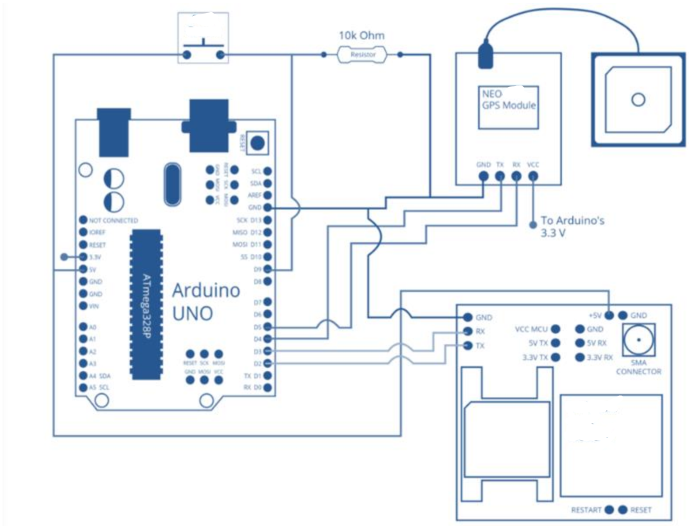


Figure 3.7 Connection between SIM800L and GPS NEO with ATmega 328p MCU

In our proposed system model the SIM800L will be connected with the GPS module to send the location information to the data server. To configure these two modules with the

ATmega328p MCU, we have to use Arduino IDE and their SIM800L code template to make connection with GPS module.

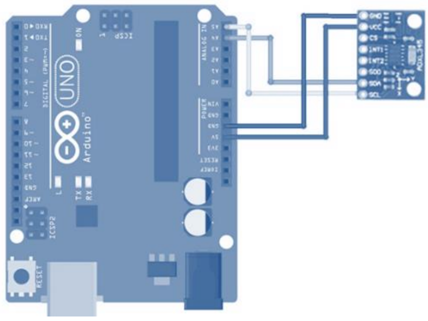


Figure 3.8 Interfacing ADXL345 with ATmega328p

In our proposed system model, the ADXL sensor (Accelerometer) will be connected with the ATmega328p MCU to send accident data to the mesh network within 100 meters and the data will also pass by the SIM800L module to send the data into the data server.

3.6 Flowchart

The following flowchart will show the working procedure of our system:

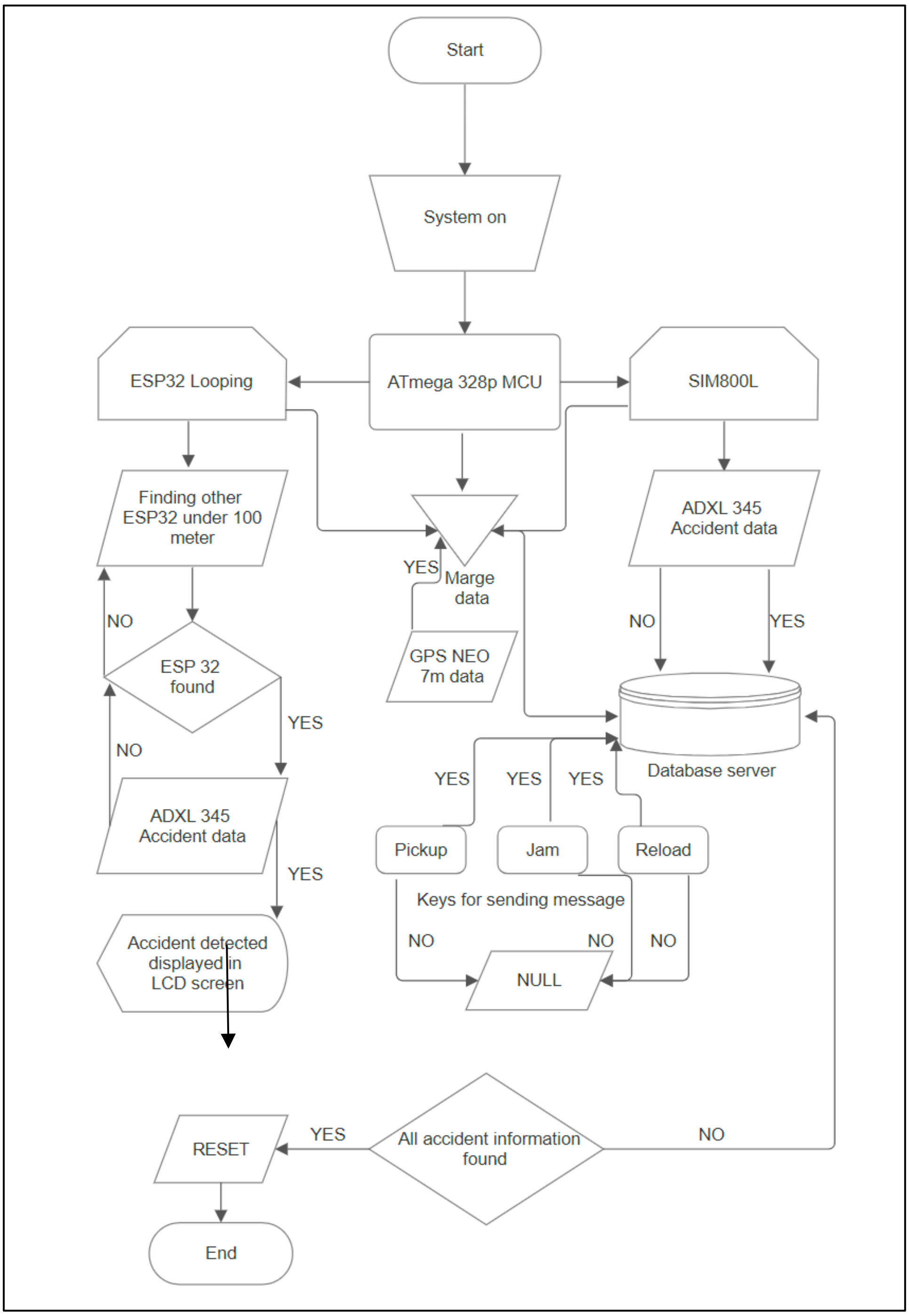


Figure 3.9 Flowchart of the system

In the above flowchart, we can see the flow of the processes of our prototype. The flowchart starts with the manual system on process. The main microcontroller ATmega328p get started along with two other microcontroller ESP32 and SIM800L. The main MCU connected with all other component as well as two other MCU of the system. The ESP32 keep looping for finding other node for passing signal and checking their condition. If the ESP32 get any other ESP32 module inside 100 meters, it will check the AXDL345 sensor data so that it can sends and receives an accident situation update to the other vehicle. If any accident detected it will show “Accident Detected” message in the LCD screen. The ESP32 is responsible for local Mesh-to-Mesh communication. The SIM800L will get the data from ESP32 through ATmega328p MCU and location data latitude and longitude from the GPS Neo7m. It will pass all the data to the centralized database for the system. The SIM800L automatically sends an emergency call to a number for taking instant action for the accident.

3.7 Testing Environment

We had developed two prototypes for our propose system for V2V communication. As the system will be attached with our vehicles, so we needed two prototypes for testing the communication in local network, long range communication and for all other applications of our system.

Table 3.1 Components used to build each prototype:

Serial	Component Name	Component Price	Process responsibility
01	ATmega 328P	900 BDT	It is the main microprocessor for the prototype to process all data
02	ESP32	650 BDT	It is responsible for short range data communication and a supporting microcontroller

03	SIM800L	345 BDT	The SIM800L module is attached for passing the data to the database and to give emergency calls
04	ADXL 345	400 BDT	The ADXL345 acceleration measurement sensor is for measuring the position of the vehicle as x, y and z axis wise to detect accident.
05	I2C	95 BDT	Inter-Integrated Circuit used for passing and receiving data between the devices and the microcontroller.
06	16*2 LCD Screen	215 BDT	The LCD panel used for showing local accident information.
07	XL6009 Con.	290 BDT	As the prototype is powered by lithium battery, the XL6009 booster convertor used to convert the low voltage to high voltage of suitable voltage for the prototype's components.
08	Solar cell	350 BDT	Solar sell is the part of LIFI module, used for capturing close light source and short-range alert.
09	GPS NEO 7m	990 BDT	The GPS NEO 7m is used for the live location tracking system and it's also sent the location latitude and longitude to the database server.
10	FTDI 232	520 BDT	This component is used for make connection to the computer for testing. It is a popular USB-to-Serial bridge module. We can test the whole module in the Arduino IDE's serial monitor by connecting us with computer.
11	Mechanical Key	50 BDT	The kyes are used for sending specific message to the server to notify traffic

			information, passenger count and industrial load unload messages.
12	PCB	400 BDT	The printed circuit board is designed for place all the component in one board and make a single module.

3.7.1 Parameter list to designing PCB:

Table 3.2 Parameter list to design PCB

Serial	**Parameter name**
01	ATmega328p footprint
02	ESP32 footprint
03	Crystal oscillator footprint
04	SIM800L footprint
05	GPS module footprint
06	PCB layout footprint

3.7.2 PCB Designing:

We designed the Printed circuit board using the Proteus-8 professional (CAD connected) software.

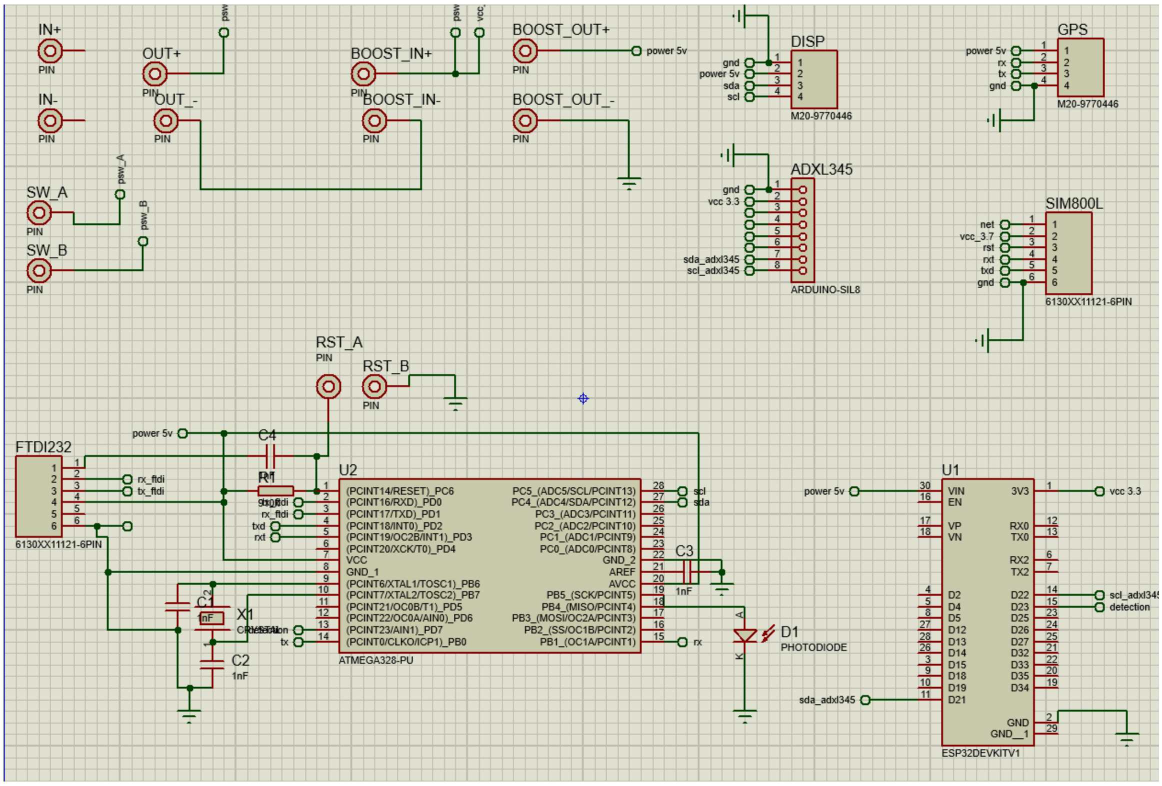


Figure 3.10 Schematic diagram of the PCD componets in Proteus software

The figure 3.10 shows the schematic diagram of the PCB components. It is visualizing the pin connection, I/O direction and a top-level view of the prototype.

We had used the specialized footprint for each component to make the printed circuit board.

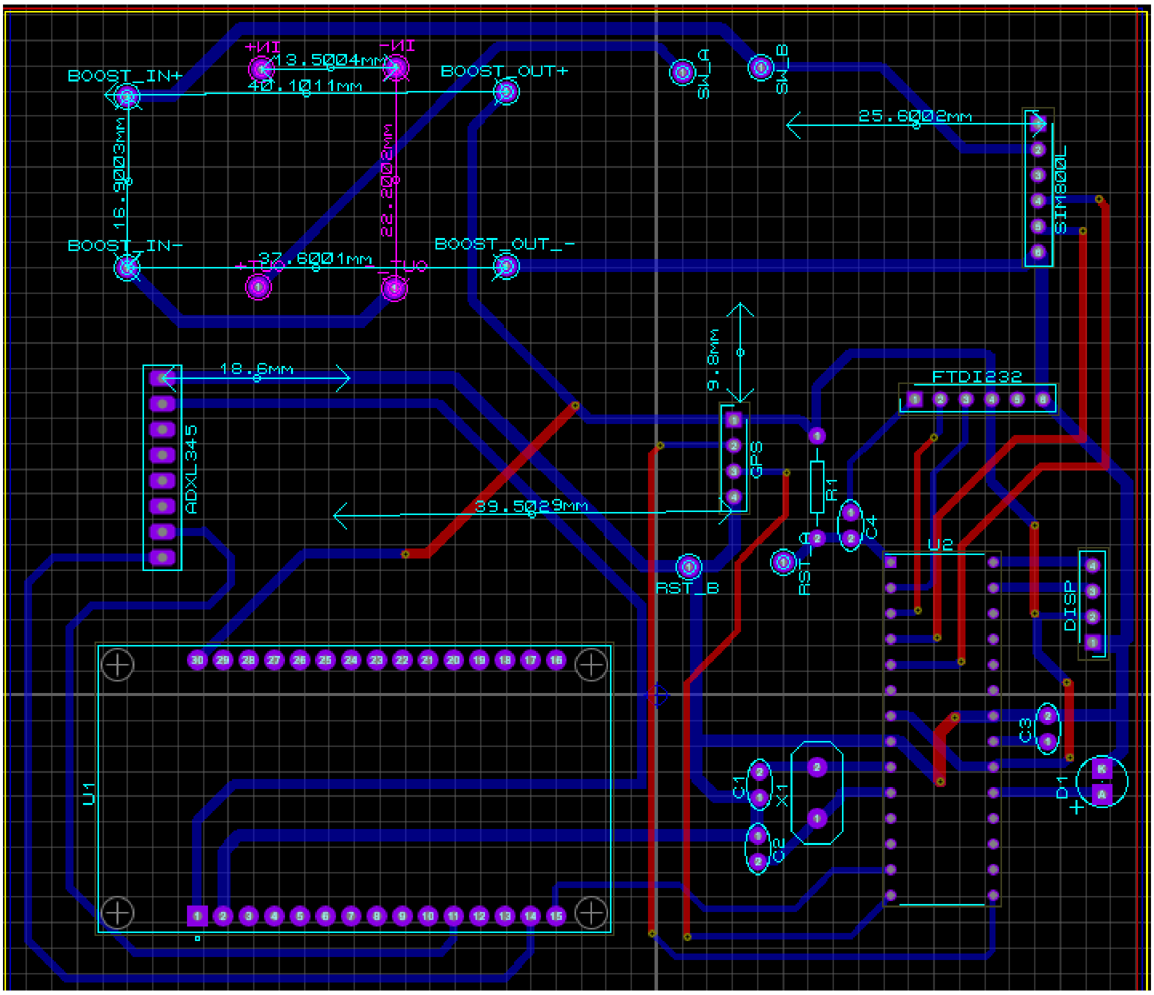
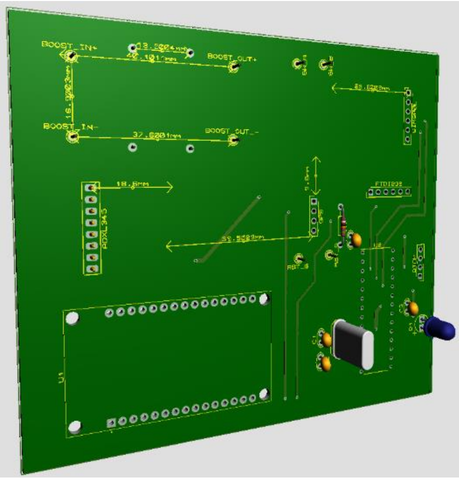


Figure 3.11 PCD layout in Proteus software

The figure 3.11 shows the PCB layout is showing the full view of the PCB by providing the exact graphic of the component. We can make the on-board connections of the components in this panel of the software.



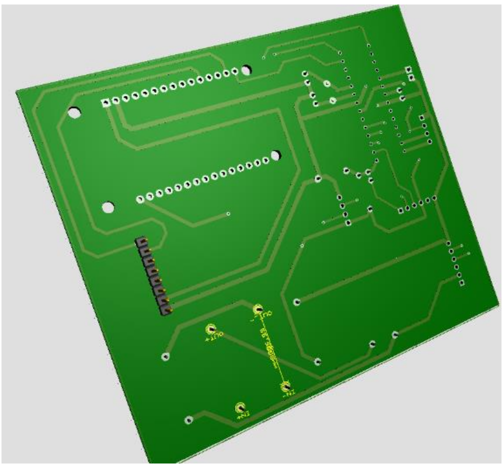


Figure 3.12 TOP and BOTTOM view of PCB in 3D visualizer

3.7.3 Configuring the component in IDE

We had configured the components in Arduino IDE (Programming Language C++)

Table 3.3 Libraries for configure the model using C++

Serial	Libraries
01	Painlessmesh.h
02	ArduinoJson.h
03	Wire.h
04	Adafruit_ADXL345_U.h
05	Adafruit_Sensor.h

06	LiquidCrystal_I2C.h
07	TinyGPS++.h
08	SoftwareSerial.h
09	AltsoftSerial.h

```
#include "painlessMesh.h"
#include <ArduinoJson.h> // Include the ArduinoJson library
#include <Wire.h>
#include <Adafruit_Sensor.h>
#include <Adafruit_ADXL345_U.h>
#define THRESHOLD 3.0  // Adjust this threshold based on your testing
#define BASE_VALUE_X 0.0  // Set your base value for the X-axis
#define BASE_VALUE_Y 0.0  // Set your base value for the Y-axis
#define BASE_VALUE_Z 9.8  // Set your base value for the Z-axis (gravity)
```

Figure 3.13 Parameters used to configure ESP32 and ADXL345

The figure 3.13 shows us the libraries we used to configure the ESP32 and ADXL345 module with the ATmega328p microprocessor.

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>


// Set the LCD address
const int lcdAddress = 0x27;  // You may need to adjust this

// Set the LCD size
const int lcdColumns = 16;
const int lcdRows = 2;
int buzzer = 11;
int button1 = 4;
int button2 = 5;
int button3 = 6;


// Create the LCD object
LiquidCrystal_I2C lcd(lcdAddress, lcdColumns, lcdRows);


#include <TinyGPS++.h>
#include <SoftwareSerial.h>
#include <AltSoftSerial.h>

#define rxPin 2   //2
#define txPin  3  //3
SoftwareSerial sim800L(rxPin,txPin);
```

Figure 3.14 Parameters for configure SIM800L

The figure 3.14 shows us the libraries we used to configure the SIM800L module with the ATmega328p microprocessor.

3.7.4 The libraries we had used for configuring is listed below:

Figure 3.15 Testing the data communication in serial monitor of Arduino IDE

The figure 3.15 shows the we had tasted our proposed prototype by connecting with Arduino IDE’s serial monitor by FTDI 232 USB to Serial port.

4 Result & Discussion

4.1 Trail parameters

We had output (Result) of the prototype is many ways in many situations. The matrix of getting raw data of the prototype is:

- ✓ End-to-End time delay of sending automatic call, if any accident occurs.
  - The first matrix is the time delay of sending emergency to from the SIM800L to the hospital number. In figure 4.1 we used the matrix to draw a column graph with ten trails. We have made 10 accident situation and waited for the response from a demo number.
- ✓ Local Mesh-to-Mesh (ESP32) network connecting delay.
  - The second matrix is the time delay of sending accident information in the local mesh network within 100 meters. We had applied the matrix in figure 4.2 by trailing 3 times and every time we start from 5-meter distance and ends with 50-meter distance of two prototype. We had counted the time of getting the local network message by stop watch and get the time data.
- ✓ End-to-End data sending and receiving delay from the specialized messaging keys to database. Location information getting time on database server after the connection between Google map satellite and GPS NEO7m module. Accident detection status update time delay in server.
  - The third matrix have been taken for making combo graphs in figure 4.3. The matrix is made by 3 different data. The time delay for sending message from the specified key to the database, we had pressed the keys and count the time to send the short message to the database.
  - The time delay for sending location information from GPS NEO 7m module to the database through SIM800L module. We had set the prototype

in the open sky and count the time. After getting the satellite signal how much time needed to send the location data to the database we had counted.

- And after the accident, how much time need for sending the data from ADXL345 accelerometer to the database through SIM800L.

4.2 Graphical representation of the matrix:

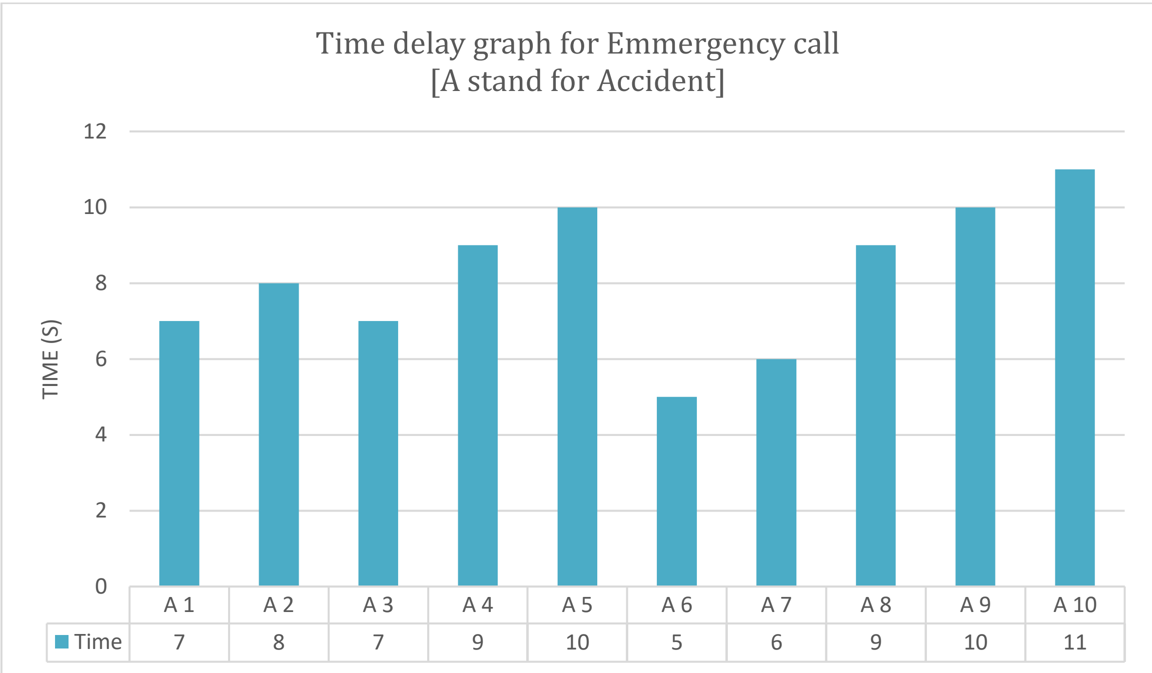


Figure 4.1 Time delay graph for Automatic call

The above graph we can see that, ten trail have been taken for one specific parameter (End-to-End time delay of sending automatic call, if any accident occurs). In the first trail, we can see system needed only 7 seconds to make the automatic call to the emergency number after the accident occurs. In the second trail it needed 8 seconds to make the call. In this way we took 10 trails to measure the average time delay of the calling function and the average time is 8.2 seconds.

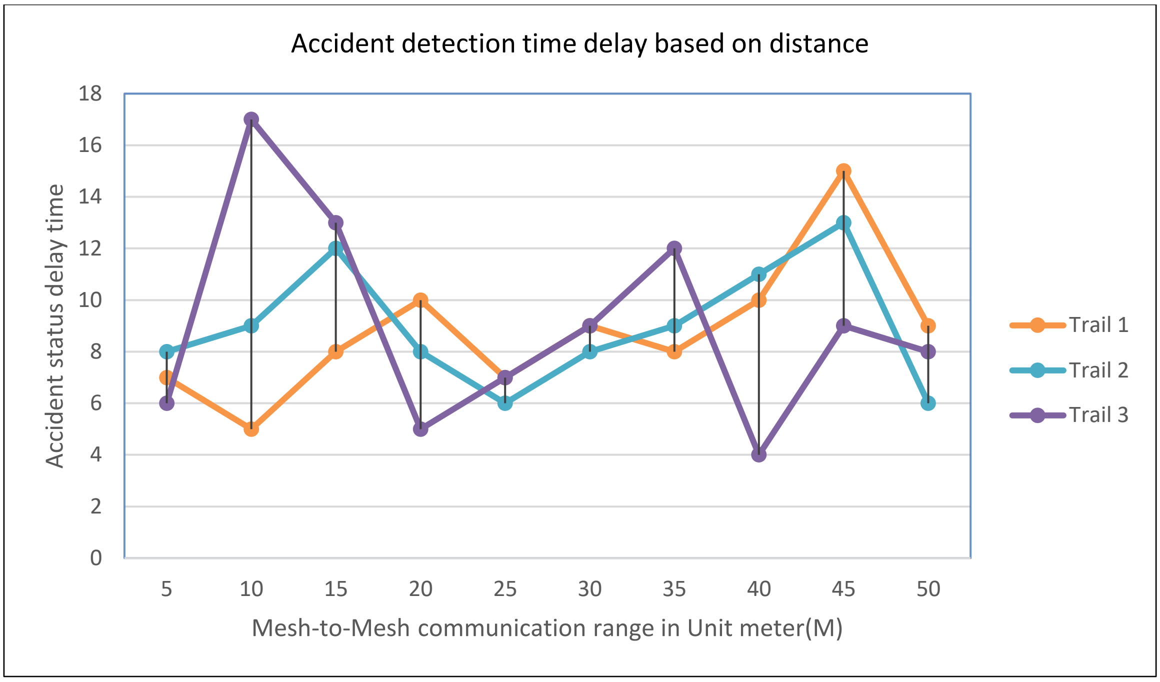


Figure 4.2 Accident detection time delay based on distance

The above line graph demonstrating the time delay of Mesh-to-Mesh communication based on the coverage area. We had made three trail seasons for this result within 50 meters. For each trail we had taken 10 approaches. The average time delay of first trail is 8.8 seconds. The second trail almost gives the same average time 8.4 seconds. In the last trail it had took 9 seconds on average to make the communication. So, we after calculating the three trails we got 8.73 seconds of delay of Mesh-to-Mesh communication.

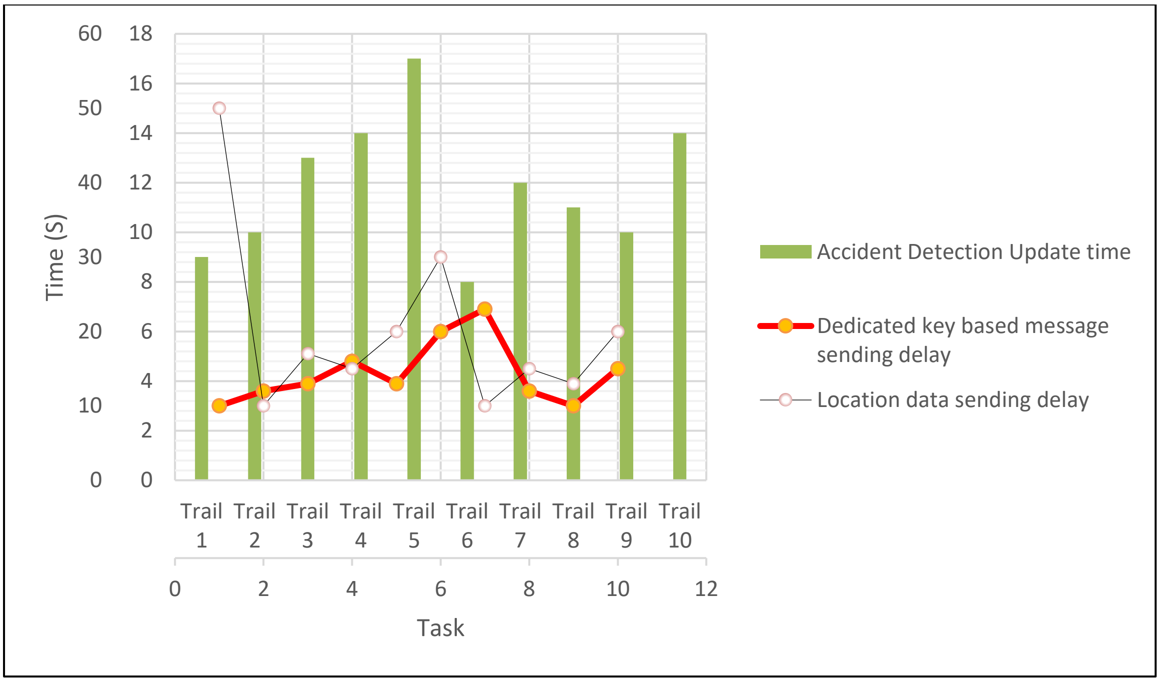


Figure 4.3 Time delay graph

The above figure is a hybrid graph made by Scatter graph, Line graph and column graph. The graph shows us the time delay of Accident detection update in server, dedicated key based message sending in server and location data sending on server.

Average time delay calculation:

Formula: Average = (Time in second / Number of trail) s

- Average accident Detection Update time:
    - (9+10+13+14+17+8+12+11+10+14/10) s = 11.8s
- Average dedicated key based message sending delay:
    - (10+12+13+16+13+20+23+12+10+15/10) s= 14.4s
- Average location data sending delay:
    - (50+10+17+15+20+30+10+15+13+20/10) s= 20 s

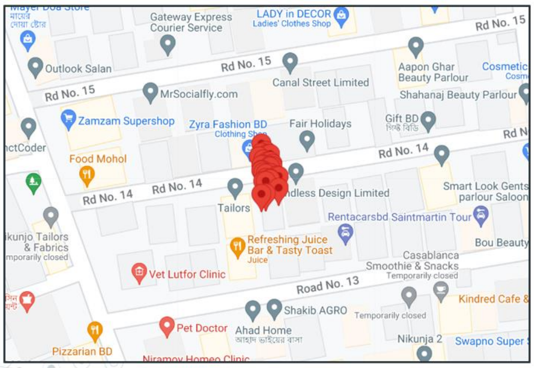
4.3 Result from the host server

Result of data communication through database

Latitude	Longitude	Status	Traffic	Pickup	Jamm
23.9248441	90.2453467	not	no_traffic	pick_please	no_jamm
23.9248441	90.2453467	not	no_traffic	pick_please	no_jamm
23.9248441	90.2453467	not	no_traffic	pick_please	no_jamm
0.0000000	0.0000000	not_detected	NULL	NULL	NULL
0.0000000	0.0000000	not_detected	NULL	NULL	NULL
0.0000000	0.0000000	not_detected	NULL	NULL	NULL
0.0000000	0.0000000	not_detected	NULL	NULL	stuck_on_jamm
0.0000000	0.0000000	not_detected	NULL	NULL	stuck_on_jamm
0.0000000	0.0000000	not_detected	NULL	NULL	stuck_on_jamm
0.0000000	0.0000000	not_detected	traffic_detected	NULL	NULL
0.0000000	0.0000000	not_detected	traffic_detected	NULL	NULL
0.0000000	0.0000000	not_detected	NULL	pick_request	NULL
0.0000000	0.0000000	not_detected	NULL	pick_request	NULL
0.0000000	0.0000000	not_detected	NULL	NULL	NULL
0.0000000	0.0000000	not_detected	NULL	NULL	NULL

Figure 4.4 Output from host server

All the output data from the different component comes to the host server to display the data from website.



Output from Google API key for live location tracking

Figure 4.5 Live location sharing in host server

The live location is sharing through Google map API key. Each movement of the vehicle will insert a pin in the map. The latitude and longitude of the live location will be shared on the host server database.

4.4 Discussion

In this research we tried to build a VANET based on V2V communication research area. We survey on different research area of VANET and tried to find out the reasons on failure of this research by other researchers to establish a real-life vehicular network in Bangladesh and different part of this sub-continent. After that we decided to work on V2V communication network without any external road side unit or dependency. We had tried to make our system user friendly with an aim of building a prototype and simple user interface. We had designed the prototype following some specific parameter that we had discussed earlier. We had built the user interface as a centralized server and tried to make it as simple as possible with aim that local transport, industrial transport and private communities can use the system easily. We have future aim to make the interface more user friendly with Android and IOS based application. The prototype can be more advanced with more research and technology in the future with machine learning algorithms and AI integration. We had tried to design every part of the system accurately and less error processes. The components of the prototype are also can be technologically compared by other advanced system. We tried to documented all the research work accurately. The results from the system are quite satisfactory at the end and we will continue our future upgradation for this research to make the prototype as a complete and preferable for real-time uses in local transport, industrial transport and community-based transport systems, which will be the ultimate success to conduct this research

5 Conclusion

In this research study, we tried to demonstrate the potentially of vehicular network specially the V2V communication in Bangladesh as well as the sub-continent. We tried to build a prototype by following a proper research methodology. We conducted several surveys to find out the gaps in vehicular network of the sub-continent. We had reviewed several recent research works in this area, tried to find out the limitations and tried to overcome the limitations. We build the system model and turned-out model in a prototype. The prototype is built by following some advanced parameters. In recent future we will be working on the Android and IOS based application to operate the system more easily. Already we are trying to interact with the user from the host server. We will upgrade the LIFI communication module and make it more functional. We have to conduct more research to initialize the full potentiality of LIFI technology by implementing data communication frame on solar call and comparing the predefine instruction for the light source. We will try to make a LIFI module Morse code-based modulation system as well. In near future we are aimed to build a complete hybrid system of vehicular network based on long range communication protocol and LIFI technology.

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