V2X Communication for Message Transmission and Warning Detection

Parth Dixit, P Chandan Kumar

Abstract: Currently, the way that smart cars operate is that they have sensors all around the vehicle to identify and learn about adjacent objects. However, the precision of these sensors frequently has a relatively short range. Reliable long-distance data collection is becoming increasingly important as autonomous driving systems gain in popularity. The suggested remedy for this problem is a gadget that would be mounted on every moving vehicle. This gadget would transmit data about the car (size, speed, acceleration, position, heading, etc.) and receive data about nearby cars with comparable equipment. This eliminates the need for intelligent vehicles to guess what other vehicles are doing around them. Vehicles can instead get this information directly from other vehicles on the road and spend more resources monitoring/tracking non-vehicular objects and feed their information directly to an intelligent system for further complex decision making. This report mainly consists of collecting data for M2M communication and analyzing data for V2V based protocols; establishing simple V2V communication with software tool and sample data; code for V2V communication using CCA with the help of AoDV; design and simulation of hardware architecture in its application. The simulation is performed on an open-source software which is created on its latest release. The test cases run is in a simulated environment of nodal communication representing clusters of vehicles on the radar interacting with each other. These nodes have reactive protocols such as Co- operative Collision Avoidance (CCA) and Ad-Hoc On Demand Distance Vectoring (AoDV). These aim at providing early warning and message routing using unicast and multicast. The results presented in this report show that the through-put, network-life, energy consumed and distance between the nodes are crucial factors that help route message passing between nodes in a given Wireless Sensor Network (WSN). The results obtained from the project discuss WSN communication using AoDV and CCA, along with this the hardware application is built on the idea to transfer vehicle information such as acceleration and displacement using the ESP-32 control module to establish communication that validates the message transmission between these modules in offline mode.

Index Terms: V2V communication, WSN, CCA, AoDV, ESP- 32 control module

I. INTRODUCTION

Today, the average time an individual spends in motion lies between 60 and 90 minutes per day. The average Indian travels an annual distance of 8,000 to 22,000 km by vehicle which is equivalent to 27-33 km per day. Even if drivers attempt to avoid daily rush hour traffic, the circumnavigation of all suddenly arising traffic congestion is mostly impossible with current traffic management systems. To manage these challenges in the future there are three general solutions to this:

1) Extension of the current base capacity, e.g., increase in the number and size of highways.
2) Encouragement of alternative travel and land use concepts that require fewer resources, e.g., non-automotive travel modes.
3) Using the existing capacities more efficiently

The approach proposed in this report focuses on the third strategy. All of these three strategies reduce traffic congestion, but strategies for a more efficient use of existing capacities have the most effective impact, since they concentrate on the basic cause of the problems instead of only alleviating negative effects. A variety of alerts to the driver are possible thanks to the advanced driver assistance systems (ADAS) found in many cars. In an increasing number of situations, these systems even allow for partially autonomous vehicle control. Although the inputs will be over-the-air messages, the V2X system [1] will integrate with the ADAS system and function as an additional sensor. These inputs will be able to be used by the ADAS system in the same way as inputs from a nearby sensor. Vision systems for detecting objects in the vehicle's path have been one of the main focuses of ADAS. These systems are currently very advanced and are capable of detecting and even classifying different sorts of obstacles, but they are unable to see around corners. Known risks, whether permanent such as railway crossings or temporary such as road construction, could be equipped with V2X transmitters meaning that drivers would know about their presence before they could be seen, whether they're around the corner or hidden by fog [2]. V2X systems can improve comfort and convenience in addition to achieving their primary goal of improving safety. For instance, basic sensors in parking lots can find vacant spaces and use V2X technology to route vehicles there. Economy can gain from V2X as well [3]; as regions grow crowded, this information can be transmitted to the satellite navigation system to permit (or mandate) the vehicle to avoid the congested area. Similar to this, air quality sensors positioned in heavily pedestrianized areas can signal when the air quality has deteriorated and direct internal combustion engine cars to take an alternative route.

Manuscript received on 12 July 2022 | Revised Manuscript received on 23 July 2022 | Manuscript Accepted on 15 August 2022 | Manuscript published on 30 August 2022.
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V2X relies on the formation of a mesh network between moving and stationary objects to provide the required coverage without the need to set up (expensive) transmitters particularly for the system [4]. However, designers must overcome a variety of obstacles to do this successfully, including:

It will be difficult to produce a global design given the various standards and frequencies being proposed for the mesh, unless multiple designs are produced. Overcoming the difficulties in creating a dependable radio transmitter/receiver for use in a modern vehicle's loud electrical environment, especially electric vehicles that have high voltages and currents present [5]. This problem is made worse by the rising use of mobile devices while driving. ensuring that the system remains secure and safe despite having external connectivity with regard to susceptible hacking or harmful interference. The networking within the vehicle presents still another difficulty (IVN). The use of many vision sensors as a component of an ADAS system has increased data rates and the amount of data that must be communicated, which makes it more difficult to achieve the low-latency communications required inside a V2X system [6]. Ethernet is generally accepted in the automotive sector as the finest option. Its widespread use in business, industry, and residential settings indicates that the technology is well understood and that a sizable ecosystem of parts, software, tools, and design resources is readily available, both of which will hasten and lower the cost of design. Deployment, however, will not be without difficulties, particularly ensuring that the implementation is not susceptible to the extensive EMI present in modern vehicles.

II. BACKGROUND

Communication between a vehicle and any entity that could affect or be affected by the vehicle is known as" vehicle-to- everything" (V2X). Vehicle-to-infrastructure (V2I), Vehicle- to-Network (V2N), Vehicle-to-Vehicle (V2V), Vehicle-to- Pedestrian (V2P), and Vehicle-to-Device (V2D) communications are all included in this vehicular communication system (vehicle-to-device).

V2X is primarily driven by concerns for energy conservation, traffic efficiency, and road safety. If a V2V system were adopted, it is predicted that there would be at least a 13 percent decrease in traffic accidents, leading to 439,000 fewer crashes annually. There are two types of V2X communication technology depending on the underlying technology being used:

(1) WLAN-based
(2) cellular-based.
(3) **Technological Overview** 1)802.11p (DSRC)

When two V2X senders are in range of one another, they form an ad hoc network known as a vehicular network. The original V2X communication relies on WLAN technology and works directly between cars (V2V) as well as between vehicles and traffic infrastructure (V2I) [6]. As a result, there is no need for any communication infrastructure, which is essential for ensuring safety in rural or underdeveloped locations. Due to its low latency, WLAN is especially well suited for V2X communication. It broadcasts Decentralized Environmental Notification Messages (DENM), Basic Safety Messages (BSM), and Cooperative Awareness Messages (CAM) (DENM). Signal Phase and Timing Message (SPAT), In Vehicle Information Message (IVI), and Service Request Message are further roadside infrastructure-related messages (SRM)[7]. Vehicles may be fitted with conventional radios to supplement the direct communication approach to cellular communication technologies, supporting V2N based services.

2) 3GPP (C-V2X)

Cellular V2X (or C-V2X), a more contemporary kind of V2X communication that makes use of cellular networks and is distinguished from WLAN-based V2X in Figure 2.1, is used to describe this technology. Due to C- advantages V2X's over WLAN-based V2X, numerous industry bodies, including the 5G Automotive Association (5GAA), have promoted it (without considering disadvantages at the same time) [8]. C-V2X is initially defined as LTE in 3GPP Release 14 and is designed to operate in several modes:

(1) Device-to-device (V2V or V2I), and (2)Device-to-network (V2N).

The V2X features are enhanced to support 5G in 3GPP Release 15. Both direct vehicle-to-vehicle communication (V2V) and conventional cellular-network based communication are supported by C-V2X. Additionally, C-V2X offers a path for upgrading to 5G-based systems and services, which indicates costlier and less compatible options than 4G-based ones. The so-called PC5 interface is used for direct communication (V2V, V2I) between vehicles and other equipment. A reference point known as PC5 is where two pieces of User Equipment (UE), such as mobile phones, can speak to one another directly over the direct channel. It is not necessary to communicate with the base station in this situation. The feature that defines the architecture of direct connection between UEs at the system architectural level is the proximity service (ProSe). The direct communication via PC5 is referred to as "side link" in the 3GPP RAN standards. The Public Safety-LTE, or PS-LTE, community's mission-critical communication needs were first described for the PC5 interface in release 13. The goal of the mission-critical communication was to make emergency rescue services or law enforcement agencies use the LTE communication even when the infrastructure is not available, such as natural disaster scenario. C-V2X enables the C-V2X device to connect to the cellular network in the conventional way using Uu interface in addition to the direct communication over PC5 and PC5[9]. The logical interface between the UE and the base station is referred to as Uu. Typically, this is known as" vehicle-to-network" (V2N). V2N is a special use case for C-V2X, as opposed to 802.11p based V2X, which only offers direct communication. While 3GPP defines the data transport features that en- able V2X, it does not include V2X semantic content but proposes usage of ITS-G5 standards like CAM, DENM, BSM, etc. over 3GPP V2X data transport features.

Through its instant communication V2X allows road safety applications such as (non-exhaustive list):

1) Forward collision warning
2) Lane change warning/blind spot warning

3)Emergency electric brake light warning 4)Intersection movement assist 5)Emergency vehicle approaching
6)Roadworks Warning
7)Platooning

Using real-time vehicle notifications to relieve traffic con- gestion, vehicle-to-vehicle communication makes it easier to monitor and manage traffic, which is crucial for enforcing traffic laws. To redirect traffic, track vehicle positions, en- force speed restrictions, and modify traffic patterns, officials communicate with moving cars. V2V communication aids drivers in avoiding gridlock and maintaining a safe following distance from other vehicles. Drivers are able to have total control over their cars because to V2V communication. Timely warnings, such as the height of a nearby bridge, are very helpful for drivers operating large fleet trucks or transporting heavy cargo. By providing information about nearby vehicles, the technology may also help with safe parking techniques like parallel parking.

A. Communication protocols

1)IEEE 802.11p

A collection of standards created by the American Society for Testing and Materials serve as the foundation for WLAN-based V2X communication (ASTM). The ASTM E 2213 family of standards examines wireless communication for fast information sharing between moving objects as well as the underlying road system. This series' initial standard came out in 2002. In this instance, V2X communication was first described using the abbreviation Wireless Access in Vehicular Environ- ments (WAVE).

From 2004 onwards the Institute Electrical and Elec- tronics Engineers (IEEE) started to work on wireless access for vehicles under the umbrella of their standards family IEEE 802.11 for Wireless Local Area Networks (WLAN). Their initial standard for wireless communica- tion for vehicles is known as IEEE 802.11p and is based on the work done by the ASTM. Later on, in 2012 IEEE 802.11p was incorporated in IEEE 802.11.

After IEEE 802.11p became stable in 2007 and IEEE be- gan to establish the 1609.x standards family, which stan- dardises applications and a security framework (IEEE refers to this as WAVE) [10], SAE immediately began to specify specifications for V2V communication appli- cations. SAE refers to this technology as DSRC (this is how the term was coined in the US). The Technical Committee for Intelligent Transportation System (ITS) was established at ETSI concurrently and began developing standards for protocols and applications (ETSI coined the term ITS-G5). These regulations are all built on IEEE 802.11p technology.

Between 2012 and 2013, the Japanese Association of Radio Industries and Businesses (ARIB) specified, also based on IEEE 802.11, a V2V and V2I communication system in the 700 MHz frequency band [13]. In 2015 ITU published as summary of all V2V and V2I standards that are worldwide in use, comprising the systems specified by ETSI, IEEE, ARIB, and TTA (Republic of Korea, Telecommunication Technology As- sociation).

2)3GPP

In 2014, Release 14 of the 3GPP marked the beginning of cellular V2X (C-V2X) standardization efforts. LTE serves as the foundational technology for it. In 2017, specifications were released. LTE-V2X is a common name for this C-V2X functionality because it is based on LTE. Both direct communication (V2V, V2I) and wide-area cellular network communication are included in the range of functionalities that C-V2X supports (V2N).

Release 15 of the 3GPP continued the standardization of C-V2X to be 5G-based. As Release 15 nears completion in 2018, specifications will be released. In contrast to LTE-based V2X, the term 5G-V2X is frequently used to denote the underlying technology (LTE-V2X). Regardless of the precise generation of technology, C-V2X is the general name used to describe V2X technology using cellular technology.

In Release 16, 3GPP further enhances the C-V2X functionality. The work is currently in progress. In this way, C-V2X is inherently future-proof by supporting migration path to 5G.

In a small summary, the order to assess the efficiency of direct communication technologies between LTE-V2X PC5 and 802.11p from the standpoint of accidents prevented and a decrease in fatalities and serious injuries, research and analysis are conducted. The study demonstrates that LTE-V2X achieves superior levels of harm reduction and accident avoidance. Additionally, it shows that LTE-V2X performs better in terms of communication range and packet delivery success rates. Another link-level and system-level simulation result shows that the LTE-V2X PC5 interface may achieve lower signal-to-noise ratios (SNR) than IEEE 802.11p while still maintaining the same link performance in both line-of-sight (LOS) and non-line-of-sight (NLOS) circumstances.

B. Implementation of Software and Hardware Design Architecture

Vehicle-to-vehicle (V2V) communication is a relatively new and un-standardized inter-vehicle communication paradigm. V2V's primary advantage is that it communicates without using external networks like cellular networks. Its ad-hoc communication has a 1000 m range and a 360° view of the vehicles around it. V2V still has a lot of deployment issues despite the numerous advantages it provides.

The ability of V2V to address important safety issues in road traffic is highly rated by operators, which has raised interest in this technology.

C. Software simulation for WSN message communication in MATLAB:

As discussed in the previous chapter, the use of various toolboxes available in MATLAB helped design a simulated environment for multiple cars depicted as nodes that undergo random motion in every direction which is a part of the distance vector routing protocol which helps to identify the time taken and energy consumed for message transmission.

D. Simulating Environment

The area of simulation can be determined by the user that gives input to the required number of nodes and carry out the message transmission. The creation of road network requires the length and breadth inputs from the pre-defined user frame. **City Simulation** takes factors such as the total number of nodes, source node, destination that gives results in the form of **total distance, network lifetime, energy consumption and throughput** which will be discussed in detail in the next chapter. **Assigning RSUs** is an important part of this project which determines the total incoming message traffic from all the nodes and helps disperse the data with minimal packet loss transmission. This is a special wireless communicating device located on the roadside that provides connectivity and information support to passing vehicles, including safety warnings and traffic information [11]. This simulation contains 4 sub- modules and a mother module in between. This assignment is done by positioning them in a single matrix and deleting the blank nodes.

Ad-Hod on Demand Distance Vectoring is a protocol applied to understand the best possible route for its message propagation. User gives in the input of the source and destination node and using this the distance using:

$$\mathbf{dist = sqrt((nodersu(p,3) - nodersu(q,3))^2 + (noder\ su(p, 4) - noder\ su(q, 4))^2}$$

Performance Evaluation is the key aspect to this design as it helps determine the energy consumption, throughput and total distance the data packets can travel in a given area for optimum performance. The packet size considered here is **64 bytes** with data rates 4,6,8,10,12 and 14. The amount of Energy consumption per bit in the transmitter

$$Elec = 50e - 9$$

Amount of energy consumption for multipath fading;

Emp=0.0015e-12

Data aggregation energy;

EDA=5e-9

The energy loss calculation in transmitting packets at data rate:

$$\mathbf{E(f\ f\ ) = (\alpha 1 * datarate(f\ f\ ) * pktsize * 8) + (\alpha 2 * datarate(f\ f\ ) * pktsize * 8) * (totaldist)\alpha)}$$

The evaluation is performed based on the user input and its subsequent number of nodes which is given in Figure 4.1. Reactive protocols were not initially intended for the feature of high mobility during route discovery. Owing to the VANET's dynamic modification, this changes frequently due to break- downs that result in excessive broadcasting and flooding of the entire network in order to find new routes. Additionally, the initial routing takes some time, and this latency has the potential to drastically alter everything. Due to these factors, conventional reactive protocols are not entirely suitable for time-sensitive applications like cooperative collision avoidance (CCA). A significant class of safety applications on VANETs called cooperative collision avoidance tries to provide drivers using connection between vehicles (V2V). Reactive routing protocol Ad Hoc On Demand Distance Vector (AODV) [12] is capable of both unicast and multicast. Like all reactive protocols, AODV only allows nodes to send topology information when necessary. When a source has something to send, it first propagates an RREQ message, which an intermediary node forwarded until it reached the destination. If the receiver is either the node utilizing the requested address or it has a working route to the requested address, a route reply message is unicast back to the source. Networks are silent in AODV

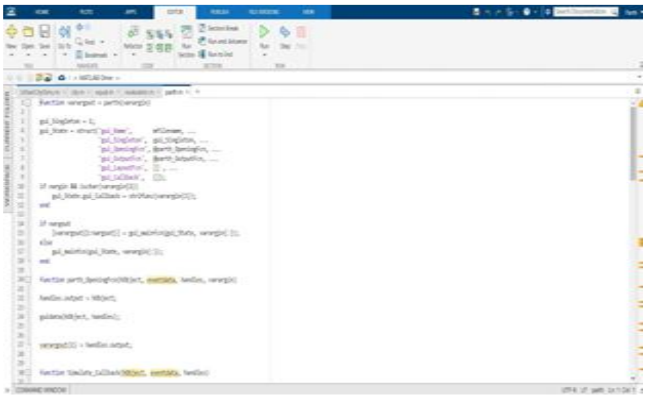

Fig. 1. MATLAB workspace overview

until connections are made. A connection request is published by network nodes that require connections. The message is forwarded by the other AODV nodes, who also note the node that made the connection request. As a result, they build a number of transitory routes to the node making the request which holds good in Figure 3. Sending a backward message

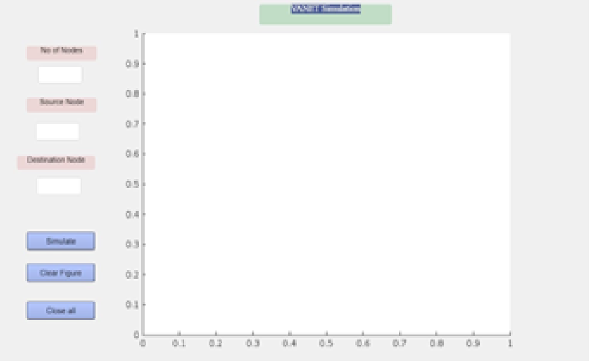

Fig. 2. AoDV simulated environment

across temporary routes to the asking node is done by a node that receives such messages and holds a route to the desired node. The route with the fewest hops across other nodes is taken by the node that made the request. After some time, the entries that are not used in routing tables are recycled. The process is repeated if a link fails, and the routing error is sent back to the transmitting node.

III. HARDWARE ARCHITECTURE IMPLEMENTATION

Communication between two vehicles has been implemented in various ways in the past. Currently V2V mainly works off the cloud or mobile network which requires good connectivity and hardware. The architecture implemented focuses on having a cost effective and simple system which does not require external network to work. For such implementation ESP-32 modules were chosen. The selected modules are then programmed using C/C++ for the desired function.

Retrieval Number: 100.1/ijeat.F37130811622
DOI: 10.35940/ijeat.F3713.0811622
Journal Website: www.ijeat.org

Published By:
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A. Communication Protocol

The mode of communication is through a protocol called ESP-now which is a peer-to-peer wireless connection-based protocol working at lower power without using any Wi-Fi or any other wireless technology. This protocol does not require a virtual handshake. Being developed by the parent company of the ESP-32 board, the protocol has capabilities of forming a network of modules communicating through short encrypted messages. This type of communication protocol is specifically helpful to achieve the mentioned objectives as transfer of only necessary data at short ranges and good speeds is desired. Each of the modules is assigned a unique MAC address to function which also helps in encrypting a closed network for specific applications.

B. Schematic Implementation

Implementation includes two modules of ESP-32 each having its own 3-axis accelerometer to identify movements of the module by continuously monitoring the three-dimensional co-ordinates which can be further used to calculate various attributes of the subject vehicle. Data recorded on one of the modules is immediately transferred and is shown on the OLED display of the second module and the data of the other is transferred to the first module similarly. Hence the changes triggered show up on the other module.

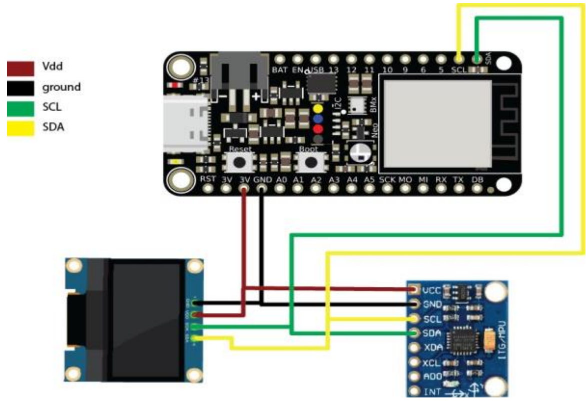

Fig. 3. ESP-32 Schematic

In 3 the connection between the ESP-32 module, OLED display and accelerometer is shown. External power is supplied to the ESP-32 module which further powers the display and accelerometer through the 3.3V port. This schematic will consist of a single module can be powered by the vehicle it is attached to, through a simple USB cable.

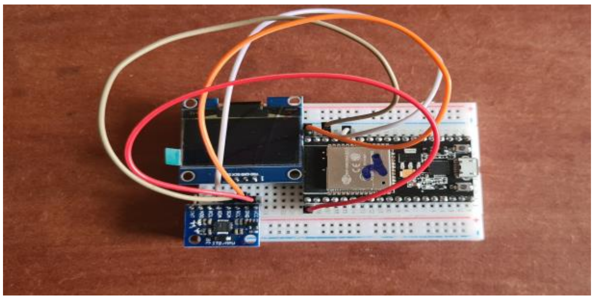

Fig. 4. Prototype of the schematic

Figure 4 shows the prototype on a simple breadboard with all the connections in place. Even when implemented on a breadboard using temporary cables the module is compact and portable.

IV. RESULT AND ANALYSIS

The results obtained from the MATLAB simulator discusses four main targets, namely:
1) Energy consumption 2) Throughput 3) Network lifetime 4) Total distance
The user gives a sample input of the total number of nodes in the simulation.
As a sample output shown in Figure 6 the total number nodes considered are **100** and the source node is **32** with the destination node being **79** as a frame of reference. The initial area simulation consists of random nodes with RSUs placed within their viscinity. In AODV, nodes find

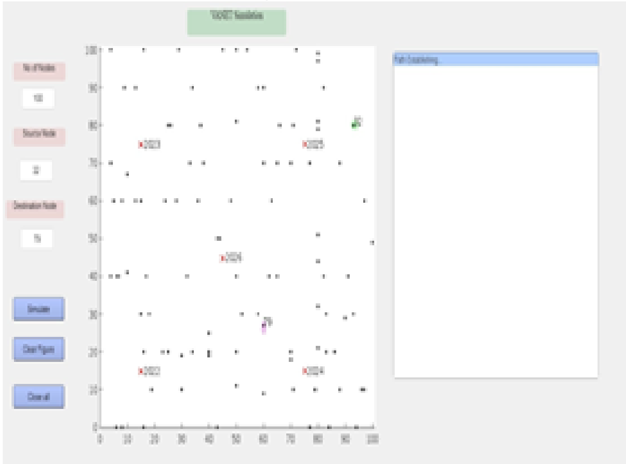

Fig. 5. WSN distance vectoring

pathways through cycles of requests and answers. By sending an RREQ message to all of its neighbors, a node seeks a route to a destination. A node broadcasts an RREQ message when it gets one but does not have a route to the intended destination. Additionally, it keeps track of a reverse route to the node making the request, which can be used to forward additional responses to this RREQ. Until the RREQ arrives at a node with a viable route to the destination, this process is repeated. This node answers with an RREP message (which could be the destination itself). Up until it reaches the initial requesting node, this RREP is unicast along the reverse-routes of the intermediate nodes. Figure 7 shows how this unicast messaging is processed.

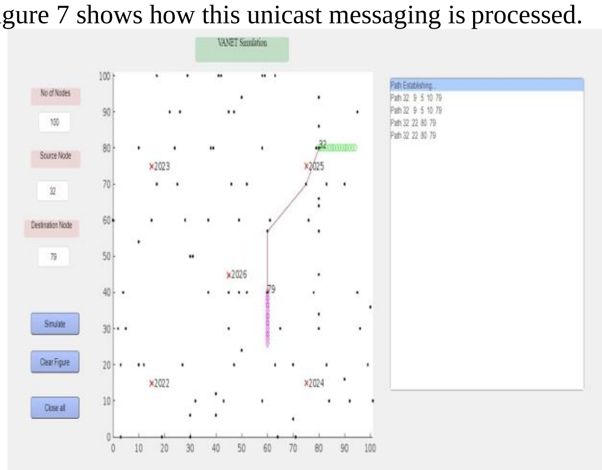

Fig. 6. Finding best possible path

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A. Cooperative Collision Avoidance

The conventional reactive protocols are not entirely suitable for time-critical applications like cooperative collision avoidance in their current structure (CCA) [13]. A significant class of safety applications in VANETs called cooperative collision avoidance uses vehicle-to-vehicle (V2V) communication to provide drivers an earlier warning. In order to investigate how two vehicles might coordinate their movements to avoid collisions and then retrace their original tracks, this study in- This introduces a novel approach of cooperative movement planning. Considering movement planning as a decision-making process helps to tackle this problem. The algorithm finds the proper steering motions that detects the distance given in Figure 8 for both cars at each time step when they are in danger of colliding so they can cooperate adjust direction to prevent crashes and return to their original course when the risk is reduced, things return to their original course. The position and orientation of the vehicles are used to characterize system states, and the kinematic limitations of the vehicles are taken into account when defining actions. After estimating the estimated value of potential target states that also satisfy the condition of the smoothness of routes, as well as the distances between and velocities of both vehicles, the system chooses appropriate motions.

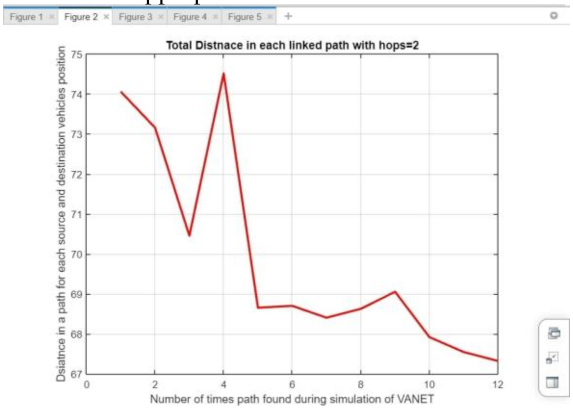

Fig. 7. Total distance in each path

Figure 9 highlights the energy used per node for each VANET scenario. The number of nodes is bigger and the collision avoidance approach necessitates more medium accesses (CSMA/CA), as seen in this figure, therefore energy usage rises as the network size increases. As a result, the nodes spent more time in the transmitting and receiving states. Al- though the maximum energy consumption by the two routing protocols occurred in scenario U2 and not the largest one, the energy used by the routing methods does not directly rise with the network size (U3). **Throughput** is another important parameter as the analyzed network results in Figure 10 shows that the shortest path has the highest throughput (i.e., Good

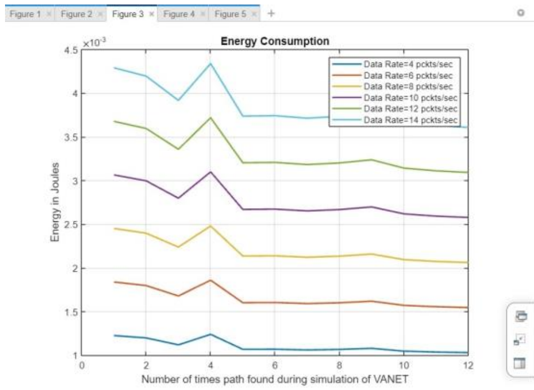

Fig. 8. Energy consumption

performance). As the transmission data rate increases, the throughput is enhanced. The vehicles may need to transmit the data to the cloud to be ready for request of other vehicles which request data from the cloud. This increases the distance of data transmission between the transmitter and the receiver. Therefore, the throughput decreases as comparing it with the same network that does not use cloud for relaying the data. The presented work is to be validated by implementing a prototype and get practical throughput. This will help to compare the simulated results by real measured value and enhance the contribution in the field.

Table I Energy Consumption Results

Result Pa- rame- ters	4 bytes	6 bytes	8 bytes	10 bytes
1	0.000988288	0.001482432	0.001976576	0.002470721
2	0.000892776	0.001339164	0.001785552	0.00223194
3	0.000870074	0.001305112	0.001740149	0.002175186
4	0.000856824	0.001285236	0.001713648	0.00214206
5	0.00085282	0.00127923	0.00170564	0.00213205
6	0.000858873	0.001288309	0.001717746	0.002147182
7	0.000876873	0.001315309	0.001753745	0.002192182

Table Ii Throughput Results

Result Pa- rame- ters	4 bytes	6 bytes	8 bytes	10 bytes
1	1.17E+11	1.75E+11	2.34E+11	2.92E+11
2	1.24E+11	1.85E+11	2.47E+11	3.09E+11
3	1.25E+11	1.88E+11	2.51E+11	3.14E+11
4	1.27E+11	1.90E+11	2.53E+11	3.16E+11
5	1.27E+11	1.90E+11	2.54E+11	3.17E+11
6	1.26E+11	1.90E+11	2.53E+11	3.16E+11
7	1.25E+11	1.87E+11	2.50E+11	3.12E+11

transmitting and receiving states during longer times. Users of Internet telephony applications may notice a significant decline in audio quality when there are excessive packet loss rates. According to the findings in Table II, forward error correction (FEC)-based error management systems make promising candidates for reducing the negative effects of packet loss on transmission quality. FEC methods broadcast redundant data together with the original data such that the lost original data can be at least partially retrieved from the redundant data. It is obvious that transmitting more redundancy increases the

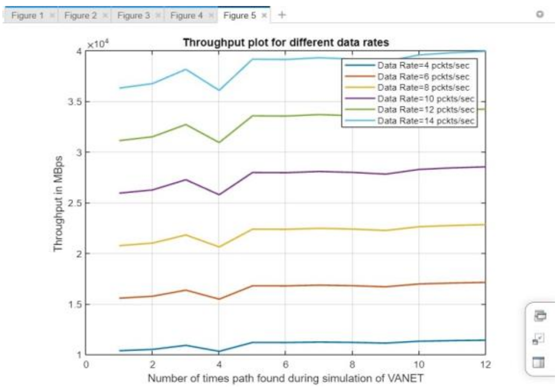

Fig. 9. Throughput Plot

B. Tabulation of results

As shown in table I, the energy consumption increases with the network size, principally because the number of nodes is higher and the collision avoidance method requires more medium accesses (CSMA/CA). Thus, the nodes were in likelihood of retrieving lost packets, but it also raises the bandwidth needs and, consequently, the rate at which messages are lost in transmission.

C. Hardware architecture results and Findings

Results obtained from testing the two prototypes are discussed in two aspects which are:

a. Latency 2) Range

Latency was pre-assigned at 500 m to maintain highest possible accuracy and very low failure rate. Lower latency of about 50-100 m is also possible. The change of co-ordinate from the sensor was visible on the display without any excess delay. Co-ordinates being displayed were a result of pre-defining a reference frame which is initiated as the the sensor turns on. The claimed range for the communication protocol used is about 200 m but the real-world use between various obstacles is found to be 80-100 m. As observed this range is found to be better than similar sized Wi-Fi modules which normally have a range of 20-40 m. The connection was found to be stable when tested in an environment with multiple mobile devices and strong Wi-Fi. Obstacles of various degrees also did not affect the latency while the range was affected a little. Using a reference frame and refreshing the module every cycle, stabilized the values quickly even after sudden stop and start movement. the desired form of V2V implementation. Test data from accelerometers was used to observe latency and range parameters for the functioning. Analysis of the simulation result parameters helps us arrive at the ideal data rate for high throughput and low energy consumption by the model. For the ideal data rate found the designed hardware system is verified for its latency and range figures to verify its possible application for the V2V simulation. The prototypes are then tested in various scenarios and are tested for different parameters to achieve the best performance.

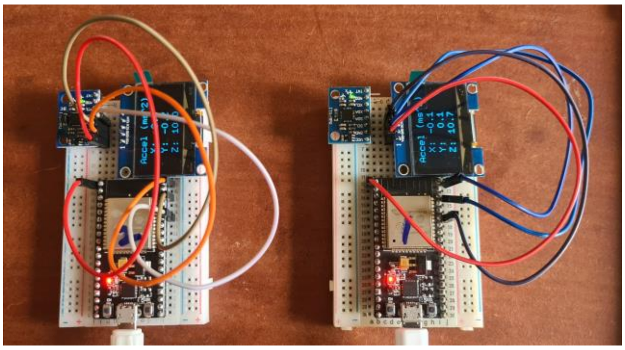

Fig. 10. Functioning of both the prototypes

Figure 10 shows both the modules displaying each other's three axis co-ordinates. Data of various sizes was tested and beyond the limit of 250 Bytes, the network started to struggle refreshing and displaying changes in time. Encrypted concise data is best suited for transmission between the prototypes. The module required a 2-amp current along with the 5-volt supply to function without issues. when supplied with higher voltage and lower current there was no damage found on the circuit instead there were no readings. Slightly higher currents were tested and it was found that there was no effect on the functioning.

V. CONCLUSION

Communication standards and models used in current generation of vehicles are not available in every model because of the implementation cost. Even when present, the current methods are based on services which will require the vehicle to be connected to an external server or platform acting as the mediator between two vehicles. Ideal solution devised was to design a low costing simple message transmission system which would act as a warning detection system functioning on an offline network efficient, effective, and fast for a short range. Simulation of the said system for a large fleet of cars and designing ideal hardware to implement the simulated system was observed. V2V communication code was built using CCA [13] with the help of Ad Hoc on Demand Distance Vectoring [12] on Matlab and simulated for result analysis under various situations. ESP-32 was identified as suitable hardware for

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Retrieval Number: 100.1/ijeat.F37130811622
DOI: 10.35940/ijeat.F3713.0811622
Journal Website: www.ijeat.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)