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A Cooperative Vehicle Intelligence for Smart Transport Services

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ABSTRACT

Smart transport services seek to optimize the interaction between the vehicle and infrastructure for achieving high standards of protection, ease, and efficiency in-vehicle communication. To resolve the contradictions between the increasing need for wireless technologies for vehicles and the scarcity of spectrum capacity, short lifetime and bandwidth availability,and also to take advantage of emerging innovations in increasing traffic safety and productivity in smart transport services. a new cognitive radio (CR) and effective vehicle interaction spectrum management are needed. Therefore, a framework model for cooperative centralized and decentralized Spectrum bandwidth sensing in-vehicle networks is proposed to demonstrate the value of spectral efficiency. The designed architecture eliminates both spectral depletion and high mobility challenges. Besides, comprehensive analysis is carried out to measure the likelihood of energy optimization, link breakdown, and traffic regulation in Smart transport services.

Key words: Cognitive Radio, Co-operative Sensing, Infrastructure-2-Infrastructure,Vehicle-2-Vehicle, Vehicle-2-Infrastructure.

1.INTRODUCTION

The term‘cooperative’ implies where vehicles connect and the network, use wireless connectivity to enhance their visibility of the traffic conditions, and have the required safeguards [1–4]. CR's primary objective is extremely efficient communication at all times and wherever necessary to allow efficient use of radio services [5-8]. The few characteristics of CR are sensing of the spectrum, spectrum regulation, network accessibility, and spectrum distribution. Spectrum detection is essential, which is immediately attained until the main user utilizes it. The goal is to avoid main user intervention, and spectrum detection is extremely accurate. The cooperative vehicle communications system is safeguarded by reducing unnecessary traffic collision losses.

Security is a key advantage of cooperative traffic networks, the main benefits, such as avoiding congestion, finding the best optimal route by analysing data in real-time. The key benefit of this network is safety, there are many other advantages, they are eliminating congestion, identifying the best optimal route by processing real-time data, evaluating traffic behaviour, examining road efficiency and evaluating pedestrian flow patterns, etc.

The Dedicated short range of communication and IEEE802.11p and also Protocols for Small Range Communication like Zigbee, Wi-Fi is used for the communication. Furthermore, there is a significant rise in the usage of automobiles in a developed area like cities with lots of cars, leading to overcrowding, which may lead to the weakening of the communication. On the other hand, studies also show that the majority of the radio spectrum is still underused; they are too lengthily idle. In this case, CR will be an alternative to the spectrum overload problem [9]. Vehicle connectivity, the CR makes opportunistic use of the spectrum, along with the use of DSRC or other communication networks. CR is a completely novel research method in the vehicle network but some researchers are focusing on vehicle communications based on CR [10-12]. The analysis shows however that the CR network cannot be specifically extended to vehicle communication [5]. Therefore, when implementing the spectrum management mechanism for CR, consideration must be taken of cooperative opportunities. Unlike static CR situations, CR requires multiple cooperating vehicles in-vehicle interaction that can share information on the spectrum available. This encourages other cars to take appropriate corrective measures, depending on theproperties of the spectrum. Cooperative vehicle communication based on CR will also result in enhanced efficiency for different vehicle applications. Co-operative frameworks provide two types of communication. There are different modes of communication in cooperative frameworks such as Vehicle-2-Vehicle(V2V), Vehicle-2-Infrastructure(V2I), Infrastructure-2-Infrastructure(I2I) and Infrastructure-2-Vehicle (I2V) [13].

In the cooperative system, there are several disadvantages to making effective use of the infrastructure.

a) Development of an interdependent network in which several device numbers share their resources with less delay such as computational, storage, and spectrum capacity.
b) There is no consistent or reliable communication between the vehicles; it is wireless. Beyond mobility, we need to build a network that is unrelated to the existing networks.
c) Recollecting and sharing traffic-related data between various devices in real-time is a difficult job.

Reliability of the Data, less power consumption, safety, and efficiency in terms of cost are important restrictions in cooperative vehicle networks. Therefore, we are designing a framework model for a cooperative vehicle communication network to address the above limitations. Following Figure.1 show a representation of VANET cooperative interaction.

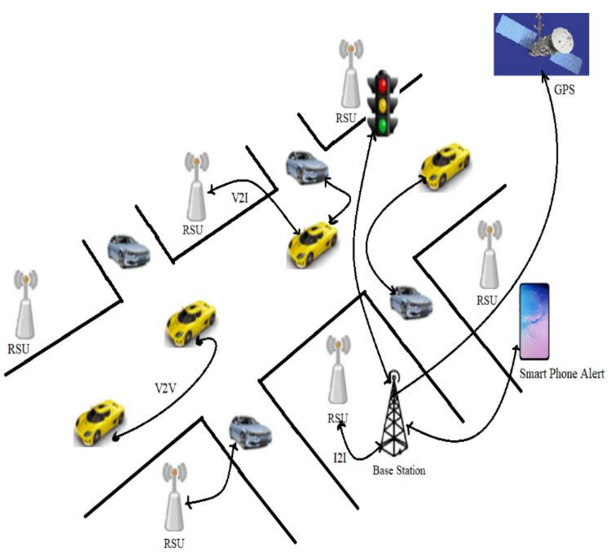

Figure 1: Co-operative Communication in Vehicular Ad-hoc Network

2. LITERATURE SURVEY

An Ad-Hoc Network for Vehicle is designed to ensure interaction between neighbourhood vehicles and nearby roadside equipment [3]. The key role is to send messages. The key goal is to improve the safety of the passengers [14-15].Under this specific situation, drivers would need to be motivated to comply and react between the vehicles and vehicle along with Roadside interactions [16].In [4] cooperative vehicle networks, highly dynamic nodes, challenging requirements for propagation and specific standards for deployment have to be tackled by Wireless access to the automobiles, and other communication nodes.In [9], a cooperative sensing analysis is performed to solve the problems of cooperation framework, cooperative profit, and overlap cooperation. The collaboration approach is specifically analysed by the co-operative sensing components, Cooperative models, sensing approaches, hypothesis evaluations, network monitoring and management, user choice, and knowledge base. The [16] Wireless Sensor Network framework for accessing information, in real-time network tracking of various tested entities within the area, and knowledge transmitted to the gateway nodes. [18] The properties of WSN are wide usage options for a cooperative system in the specific area of sophisticated entity detection and monitoring, with accelerated deployment, protection, and other capabilities. Future vehicles [19] can Interact through their surroundings by sharing data with the networks and devices around them. A Wireless short-range connection like Wi-Fi or Bluetooth enables in-car access and can be used by travelers, various devices, or the vehicle itself. The possible device efficiency enhancement was analyzed when Mobile Relay Node is included when Compared to the case where the systems are attached separately to the LTE network. [20] The microcontrollers play a crucial role in understanding the cooperative environment by personifying data through battery-powered everyday devices.

3. PROPOSED SYSTEM

Spectrum sensing plays an important role in the scope of the automobile, time utilization, and bandwidth utilization are the main constraints in automobile interaction. Many essentially various forms of spectrum sensing techniques in CR but particular are cooperative sensing techniques. Accuracy of sensing and the cooperative spectrum sensing performance are primarily applied to vehicle networks. In the vehicle scope, cooperative sensing is, a vehicle with CR communicates their sensing information with each other, and on decision-making,the system uses the sensing data provided by other vehicles. Vehicle users are called unlicensed/secondary users and can actively track, evaluate, and navigate the spectrum opportunities. CR coordinates its choices to a centralized system that enables the final decision to be used for the spectral resources. Through utilizing Cooperative Range Sensing, we can be able to predict the probability of mistake and false notification. Mutual spectrum sensing can be achieved in two circumstances: Cooperative distributed and Centralized sensing.

3.1 Cooperative Distributed Sensing

The user with CR makes decisions based on the cooperative distributed sensing method in the cooperative environment. In such a scenario only the last decision is circulated with a decentralized sensing manner. By using this we can reduce the network sophistication and which need very less bandwidth for the transmission of the data.

The network which consists of CR can have many users with CR, where each user with CR can send the data about spectrum which they sensed with other users with CR. In this system primary/main user(PU) is not currently utilize bandwidth. The available bandwidth is used by CR users and is often classified as a secondary user. Distributed spectrum sensing doesn't require an additional system which is an additional benefit. It must require the Centralised interface for fusion to perform the specific operation by the individual during the spectrum sensing that results in performance degradation. Also, the fraudulent user present on the CR network will misguide the neighbour through misconception. The distributed spectrum sensing is susceptible to the vehicle environment.

3.2 Cooperative Centralized Sensing

In cooperative centralized sensing each user with CR shares to DFC information about the existing spectrum consumption status. DFC then takes the decision. The Central system and remaining users receive the results from the CR user where it cannot decide about the status. In this sensing technique the optimum sequential spectrum sensing is used to increase the chance of identifying the Primary/main user and reduce the diminishing effect.

DFC controls three tasks within unified cooperative sensing.

1. DFC initially chooses an appropriate sensing spectrum unit and activates every CR participant to perform independent sensing.
2. CR users have reported their data about sensing through the control channel.
3. Eventually, DFC incorporates the sensing data gathered to identify the existence of the main user and distributes the decision to CR users.

In this sensing will be a potential solution for high mobility issues. Every vehicle with spectrum detection ability, often modified main spectrum repository system i.e. with decision fusion controller can be used to enhance spectrum sensing performance in cooperative vehicle interaction.

One of the major issues is sensing accuracy based on secret PU. While CR as some constraint and work is in the early stages, it would have a huge impact to implement CR in cooperative vehicle communications which rise the demand for vehicle applications by the customer. By using CR can improve the efficiency of sensing and also improve the versatility of the spectrum in vehicle speed and vehicle position. One of the difficulties in the CR-based vehicular communication system requires a huge infrastructure.

4. WORKING VIEW OF THE SCHEME PROPOSED

Throughout the cooperative vehicle network the cooperation form is V2I and I2I. To demonstrate the value of cooperative vehicle networks, a hardware study is conducted to evaluate the efficiency of the V2V, V2I, and I2I interaction networks. The centralized network of existing frameworks capable of gathering and processing all the data from different sources and making the correct decision. The base station is considered as a central system in the proposed system and also it is responsible for transferring the data to the multiple linked devices in real-time.

Communication protocols such as Zigbee and Wi-Fi is used for various patterns between vehicle and infrastructure. The main attention is to avoid the collision and congestion between two or more vehicles interaction as a result it would improve the safety of vehicles in the scenario like lane transition and heavy traffic flow on the road. Recognition of the vehicle location and restriction of the speed if any vehicle reached to speed limit in the interaction between the vehicle and infrastructure. The real-time traffic alerts updating across the smartphone and base station is the main focus in the case of communication between the infrastructures.

In the proposed model consists of various modules that all are responsible for their functionalities in the communication. The main functionality of the central base station is to gather and analyse all information in the built system model and provides the necessary assistance for smart vehicle navigation. In the centralized system where the base station directly connected to the traffic signal and wireless CCTV camera. The connection network has the functionality to transmit real-time information to the base station. The vehicle will choose the optimal option in terms of lane choosing after collecting the information in the cooperative environment, travel costs by avoiding road congestion or construction of the roads. I2I connectivity will come into existence in case of an emergency event, by sending warning messages about congestion or collision to the smartphone user. The Proposed framework model mainly focusing on the reliability of the data and delay in the time which in turn reduces the sporadic as well as unreliable connection. The system specification consists of various modules like the vehicle, traffic signals, base station, and camera. Figure. 2shows Cooperative Communication System Architecture for the Proposed System.

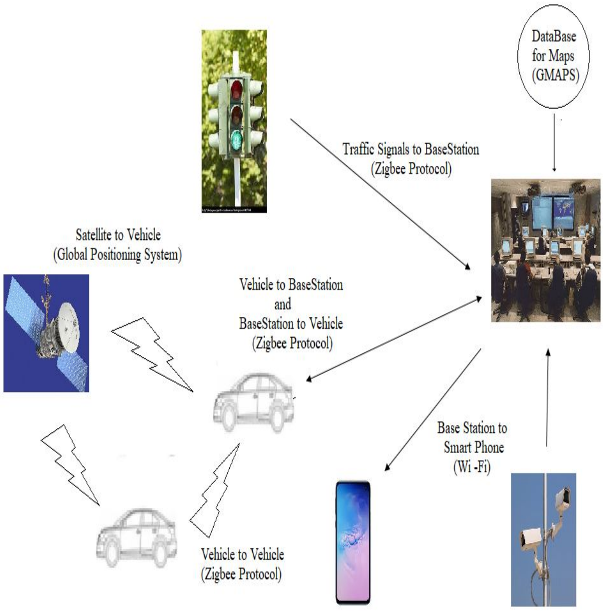

Figure 2: Cooperative communication system model at ITS

4.1 Vehicle

This module can be divided into three components i.e. Control system, Communication System, and sensors for events.

4.1.1 Control System: The controller controls the module for the vehicle's communications system and event sensor for different alerts. It main consists of40 pin microcontroller chips i.e. Atmage 162V, where it has two ports for serial communication among that one port is used for connection using ZigBee protocol, and another port is used for communication using Global Positioning System.

4.1.2 Communications System: The communication system uses GPS and Zigbee. The main feature of GPS is used to track any vehicle's location data, in this case GTPA01 is used for the monitoring sensitiveness along with that it also shows the specific position of the vehicle by longitude and latitude. The Zigbee protocol is used for communication with serial peripheral Interface where it consists of both transmitter and receiver composed by the microcontroller powered module CC2500 and RFM 73.it is operated at the frequency of 2.4GHz along with it uses both broadband and unicast communication. The main design concept behind Zigbee is that transmitter feeds an encoded data signal that modulates into RF waves that are in turn fed into the antenna. These RF signals are radiated by the transmitting antenna into the air. In the same way the receiver demodulates the RF signals in turn back into the transmitter. Zigbee acts as a coordinator for the end devices.

4.1.3 Sensor for Events: The keypad, alarm, and U SLOT sensor used in the events of the vehicle module. The keypad functions like a normal keypad of the computer system like whenever a key is pressed by the user an event occurs and an appropriate signal is a pass to the microcontroller in turn the microcontroller has transmitted those signals to other base station and vehicle. The alarm with aid of a drive circuit is an event trigger, activates an amplification signal, and consists of two switching transistors that control alarm ON and OFF functions. The alarm signal is either from the base station or any vehicle. The U SLOT sensor is a separate electric switch which is fixed in the relay that controls the DC motor. The magnetic field is created whenever the currents flow from the relay through a coil that attracts the lever and changes the switch states. U SLOT is a U- shape sensor which rotates the motor between the transceiver and the pulley fixed to the shaft turns and interprets with IR rays, once the pulse is generated, it is sent to the Signalling Condition Unit. This pulse rate is equal to the speed of the motor. therefore, the acceleration of the vehicle is activated, recorded, and transmitted. The potentiometer (POT) is utilized to enhance and reduce the speed of the vehicle. To display the information about the components, data, and the speed of the vehicle LCD screen is used.

Subsequent Figure 3 illustrates the functioning of the vehicle module.

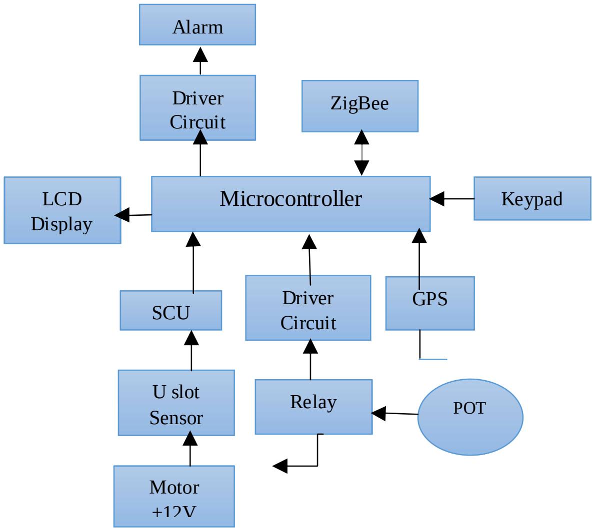

Figure 3: Vehicle Module

4.2 Traffic Signals

The Zigbee protocol is used between the base station and traffic signals for connection and communication. One element of I2I communication is the Traffic Signal module. It consists of the microcontroller which acts as a base station. There is a driver circuit at the traffic signal panel which uses the ULB 2803 IC for getting the correct signal or inverted one, similarly works as logical not gate. The Led light works as shown in Figure 4 while using the driver circuit. For its function, this panel uses an electric power supply externally.

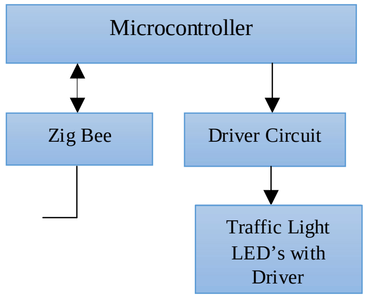

Figure 4: Traffic Signal Module

4.3 Base Station Module

In this framework where interaction between V2I and I2I exists. The functionality of this module similar to the working functionality of the vehicle module.

In the base station, the communications system plays a curial role; it can be described below.

1. Connection via ZigBee
2. Connection over Wi-Fi
3. Contact via RS232

For ZigBee communications, we use the same unit consisting of the Atmage 8 microcontroller-controlled CC2500 and RFM 73 module and interface like RS-232C and Wi-Fi in this module than Zigbee. Here UART-ETH-WIFI module is integrated with the Wi-Fi system. The Wi-Fi aims to connect smartphones with a built-in Wi-Fi system through port ID and IP address. By using the RS 232 interface is PC is connected in this module which is one of the telecommunication protocols used between the Data Terminal Equipment and Data Circuit Terminating Equipment for sequential network interconnection. The UART is IC which is used to convert from parallel to serial meanwhile the data also sending and receiving between the PC and Microcontroller. Figure. 5 shows that the base station works as an infrastructure where communication between V2I and I2I exists.

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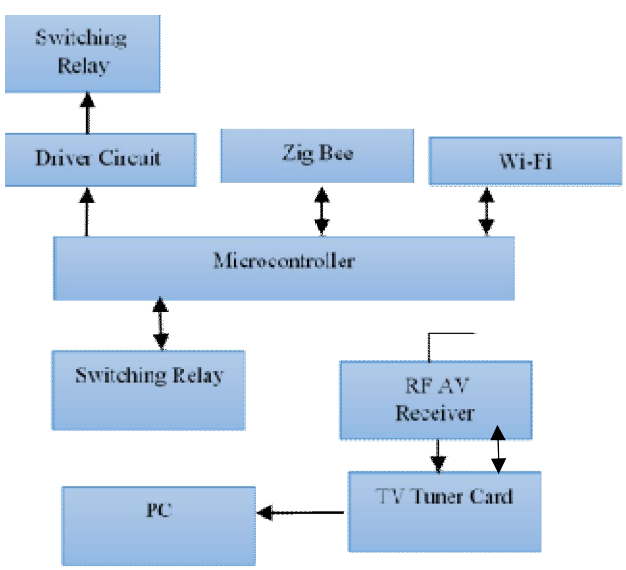

Figure 5: Base Station Module

As shown in Figure.7 There is a shifting relay in the base station. At a given time only two serial contactsare feasible in the Atmage 162V microcontroller. Even while we utilizing Zigbee, RS-232, and Wi-Fi serial communications. To differentiate between the serial communications a switching relay SPST (single pole single throw) is used. The relay is a mechanism powered by electric power. The current flow through the relay's coil produces a magnetic field that pulls a lever and changes the states of the switches and alsothe wireless camera is fixed to the base station for monitoring the traffic. As receiver RF AV is used inside this module and also it is connected to PC with the help of a TV tuner card.

4.4. Android Module

An Android software operating from Android version 2.3 to android versions 10.0 is built. Therefore, it could operate on any system. The base station connects with an android smartphone with a correct IP address and Port ID by using Wi-Fi connectivity.

The following Figure. 6 shows the Android module.

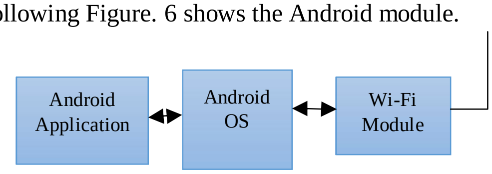

Figure 6: Android Module

4.5 Wireless Camera Module

A wireless camera is used to track and capture the traffic information. It is like a camera on CCTV. Capturing the visuals and transmitting through the RF-AV transmitter is a key feature of the wireless camera. An RF-AV receiver is used to collect the data at the base. The TV tuner card is used to connect the base station with a wireless camera. In the base station module the receiver function is specified.

5. DISCUSSIONS AND EXPERIMENTAL OUTCOMES

The following example is shown to demonstrate the variousdevices that communicate with each other to get the intended outcome that represents the operations of the cooperative vehicle network.

5.1 V2V Communication

Two main problems were tackled in V2V interaction, i.e. congestion control and collision avoidance. Such problems arise in high-traffic roads and during the lane change situation. TURN LEFT and TURN RIGHT is used to deal with lane changing scenario as seen in the test result in Figure. 7. This warning is shown to be an alert with an alarm so that the other vehicle will identify it. This alert technique would be useful during a lane change scenario to avoid the unavoidable accident.

Figure 7: Three Unique V2V communication outcomes

5.2 I2V Communication

During I2V communications if the vehicle speed reaches the maximum speed, the vehicle driver will get alert from the base station with speed restriction warning like Over Speed. An Alert is received in the recognition of a speed breach. After the vehicle's speed is reduced, the notifications like Speed in Range and No Restriction are sending to the vehicle and then the vehicle will move within the limited speed range. Figure.8 below shows the vehicle module results.

Figure 8: Three distinct speed-restriction outcomes

5.3. V2I Communication

Vehicle speed and vehicle location detection are the two main procedures for communicating infrastructure with vehicle.V2I communications mentioned two main problems, i.e. location data on the vehicle and vehicle speed is checked by the base station. The latitude & longitude values are calculated accordingly from the vehicle via the Zigbee protocol and with that value we can find a vehicle using Google maps. With every 2 s the alert should beep before the vehicle speed is reduced.

The base station interacts with an Android smartphone by two instructions. One accident has happened, and the other to heavy traffic. Com port is a communication port where the serial link is defined by specifying the port number. Figure.9 below Shows the application we developed on the base station for the vehicle and traffic monitoring.

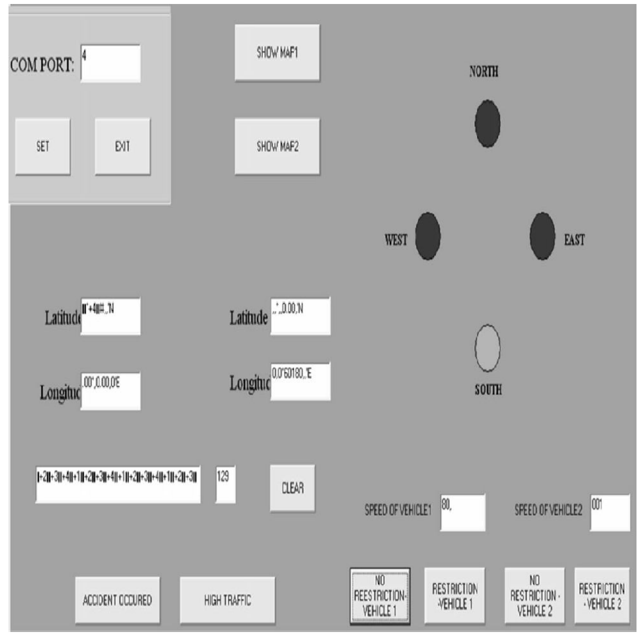

Figure 9: Traffic and vehicle monitoring at the base station

5.4 I2I Communication

To develop an understanding of the existing traffic condition, communication is used in I2I. The infrastructure consists of various components like a traffic signal, wireless camera, base station, and smartphone. Where traffic signals are controlled, they rotate in a clockwise direction after every 15s. The Base Station captures and tracks all the traffic through the camera along with that it also monitors various traffic signals. In case of any vehicle collision or dense traffic arises it sends a warning message to the user. When a collision occurs an Accident occurred is received and a warning from the base station is transmitted while there is heavy traffic" HIGH TRAFFIC'. 'Figure 10describes the Android mobile communication base station.

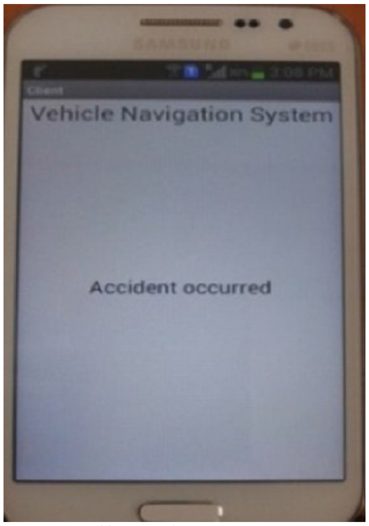

Figure 10: Traffic notification to Android app

6. QUANTITATIVE EVALUATION

First we quantify the quantitative evaluation of the parameter for energy, connection in the communication, and traffic management in the cooperative vehicle intelligence system. In this case we have discussed the efficiency of the energy with various systems, evaluate issues of failure of the link, and estimate the bandwidth of the link. The different data sets are used to test the optimization and performance of the new proposed system.

6.1 Optimization of the Energy

The multi-interface vehicle is taken for optimizing the energy. The specific interface for scanning is automatically chosen according to the application vehicle. While scanning the vehicle will take the random numerical value of the Base Station. In that application we calculate the scanning against the number of Base Stations.

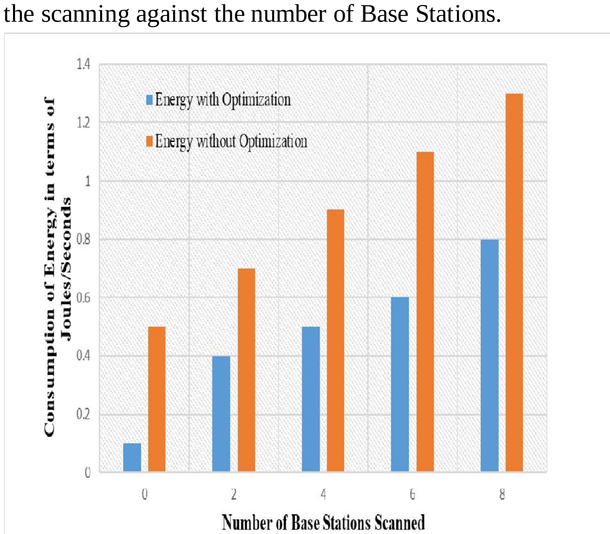

Figure 11: Energy optimization performance analysis

We estimate an application's overall energy consumption using all the interfaces. Finally, it estimates and illustrates the results in Figure.11. if the vehicle with high priority is requested it needs more energy to the lower priority application for speedy screening. Accordingly, if the application has high priority allocating a vehicle with the highest weight and vice-versa. For energy the numerical weights are considered from 0 to 1.0 so the proposed system needs considerably less energy than the present system because of the improvement of the regular scanning.

6.2 Probability of Connection Failure

At any given point of the time the base station provides services to a minimal number of the vehicles.

Therefore, to balance several vehicles efficiently in the base station require management of the traffic. If

The total number of base station connections reaches a maximum threshold; the base station will be accepting any connection request from the vehicle. In that case,the vehicle is not be provided with any information if that vehicle asks connection to the overloaded base station.

It is represented as

$$\mu = \mu + \sum_{i=1}^{N} vehicle_i \quad (1)$$

μ -> defines the number of connections on Base Station.

vehicle $_i$-> a new connection for Base Station

The Base Station is Specified with Markov chain with two states. In the first state if the connection is open and new, it will accept the new connections since it is empty. In the same way it will reject the new connections if no channels are available for that incoming connections. We can say that an open state comes first and a closed state comes next. Both state's probability depends on the vehicles coming and leaving from the connections respectively.

To prevent the Base station overloading we established threshold value for every Base Station is assigned called Connection threshold. Connection Threshold defines the total number of the connection for that threshold of the Base station. Whenever a new connection is arriving at the Base station, it checks with Connection threshold if the threshold value has reached then the Base Station will be accepting any channel request from the vehicle and it will block the new incoming connection.

6.3 Traffic Monitoring

In a cooperative vehicular environment, we evaluate the feasible probability of every arriving incoming connection to the Base Station. Therefore, every incoming connection probability is classified into three separate sets of data were 0.1 to 0.3 for the first set of data, 0.4-0.7 for the second set of data, and 0.8 to 1.0 for the third set of data. Data set 1 will be having a low probability of close state and, Data set 2 will be having average and Data set 3 will have the highest chance of close state. We evaluate all possible probabilities from set 1 on every channel of the base station. We evaluated the average possibility of blocking a base station if there is no channel available for the connection or when it is already in use and in the same way least probability for a set of data1. Figure.12 shows that possibility of incoming connection blocking is high in the data set 3 because at most all channels are occupied by others. Likewise, the close state is comparatively small for other remaining two sets of data. It is also stated that the chance of blocking is an increase in case of several incoming connections because most of the channels are occupied for newly arrived on to the base station and in that case channel move to the closed state.

The close state probability can be calculated from the below equation

$$P_{close} = \frac{P_C \times P_w}{1 - P_D \times (1 - P_C)} \quad (2)$$

Where P_C -> The channel probabilities are accessible or not. P_D -> Distribution of time holding. P_W-> The new channel has been accepted.

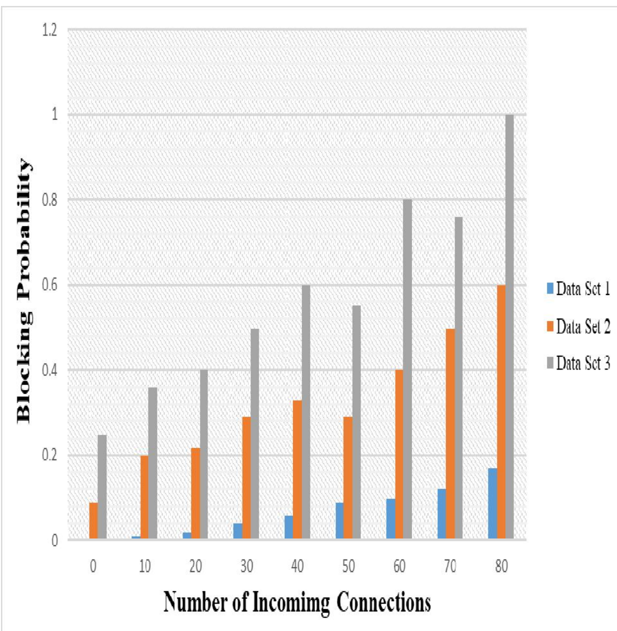

Figure 12: Performance Analysis of Traffic Optimization

7. CONCLUSION

For the cooperative vehicle intelligence, the new architecture for centralized and distributed spectrum sensing has been proposed. For effective communication using IEEE 802.15.4, Zigbee, and Wi-Fi protocols in between vehicles and infrastructures in ITS environments are implemented. Four primary processes were addressed during an investigation, i.e., controlling the collision, avoiding the congestion, vehicle location detection, and speed restrictions. The above process takes place without delay between multiple devices that we have successfully procured. Without any delay the process has been taken place between multiple devices. Also, quantitative analysis was performed to measure the probability of optimization of energy, link breakdown, and traffic monitoring in a cooperative intelligence environment.

REFERENCES

1. Higuera, J., Kartsakli, E., Valenzuela, J. L., Alonso, L., Laya, A., Martı´nez, R., et al. (2012). **Experimental study of Bluetooth, ZigBee and IEEE 802.15.4 technologies on board high-speed trains**. In IEEE Vehicular Technology Conference (VTC Spring) (pp. 1–5). https://doi.org/10.1109/VETECS.2012.6239971
2. Caballero-Gil, P., Molina-Gil, J., Hernandez-Goya, C., & Caballero-Gil, C. (2009**). Stimulating cooperation in self-organized vehicular networks**. In ACM proceedings of the 15th Asia-Pacific conference on communications (APCC) (pp. 346–349).
3. Sepulcre, M., Mittag, J., Santi, P., Hartenstein, H., & Gozalvez, J. (2011). **Congestion and awareness control in cooperative vehicular systems**. In IEEE proceedings (pp. 1260–1279). https://doi.org/10.1109/JPROC.2011.2116751
4. Singh, K. D., Rawat, P., & Bonnin, J.-M. (2014). **Cognitive radio for vehicular ad hoc networks (CRVANETs): Approaches and challenges**. Springer EURASIP Journal on Wireless Communications and Networking, 5(3).
5. Stiller, C., Farber, G., &Kammel, S. (2007). **Cooperative cognitive automobile**. In IEEE Proceedings of Symposium on Intelligent Vehicles, Turkey (pp. 215–220). https://doi.org/10.1109/IVS.2007.4290117
6. Ghandour, A. J., Fawaz, K., &Artail, H. (2011). **Data delivery guarantees in congested vehicular ad hoc networks using cognitive networks**. In International IEEE wireless communications and mobile computing conference (IWCMC) (pp. 871–876).
7. Akyildiz, I. F., Lo, B. F., & Balakrishnan, R. (2011). **Cooperative spectrum sensing in cognitive radio networks: A survey**. ACM Journal on Physical Communication, 4(1), 40–62.
8. Wang, J., Ghosh, M., &Challapali, K. (2011). **Emerging cognitive radio applications: A survey**. IEEE Communications Magazine, 49(3), 74–81. https://doi.org/10.1109/MCOM.2011.5723803
9. Felice, M. D., Doost-Mohammady, R., Chowdhury, K. R., &Bononi, L. (2012). **Smart radios for smart vehicles: Cognitive vehicular networks**. IEEE Vehicular Technology Magazine, 7(2), 26–33
10. Higuera, J., Kartsakli, E., Valenzuela, J. L., Alonso, L., Laya, A., Martı´nez, R., et al. (2012). **Experimental study of Bluetooth, ZigBee and IEEE 802.15.4 technologies on board high-speed trains**. In IEEE Vehicular Technology Conference (VTC Spring) (pp. 1–5). https://doi.org/10.1109/VETECS.2012.6239971
11. Kim, W., Gerla, M., Oh, S. Y., Lee, K., &Kassler, A. (2011). **CoRoute: A new cognitive any path vehicular routing protocol**. ACM Journal on

Wireless Communication & Mobile Computing, 11(12), 1588–1602.
12. Wang, Z., &Chigan, C. (2007). **Cooperation enhancement for message transmission in VANETs**. Springer Journal on Wireless Personal Communications, 43(1), 141–156.
13. Maurizio, M., & Vlad, P. (2011). **Cognitive radio communications for vehicular technology-wavelet applications**. In IEEE Symposium on communication and vehicular technology (pp. 1–6). https://doi.org/10.5772/14913
14. Yin, J. (2004). **Performance evaluation of safety applications over DSRC vehicular ad hoc networks**. In Proceedings of the 1st ACM international workshop on Vehicular ad hoc networks, USA (pp. 1–9). 01–01 Oct 2004.
15. Paul, A., Daniel, A., Ahmad, A., & Rho, S. (2015) **Cooperative cognitive intelligence for internet of vehicles**. IEEE Systems Journal. 8th April 2015 (available online).
16. Felice, M. D., Chowdhury, K. R., &Bononi, L. (2010). **Analyzing the potential of cooperative cognitive radio technology on inter-vehicle communication**. IEEE Wireless Days (WD) IFIP (pp. 1–6). https://doi.org/10.1109/WD.2010.5657770
17. Gloria Soatti, Monica Nicoli, Nil Garcia, Benoit Denis, Ronald Raulefs and Henk Wymeersch**Implicit Cooperative Positioning in Vehicular Networks** (2015)
18. Rawat, D. B., Treeumnuk, D., Popescu, D., Abuelela, M., &Olariu, S. (2013**) Challenges and perspectives in the implementation of notice architecture for vehicular communications**. IEEE International
19. Conference on **Mobile Ad Hoc and Sensor Systems, (MASS)** (pp. 707–711).
20. Saurabh, S., Chakole, V. R., &Suryawanshi, Y. A. (2013). **ARM hardware platform for vehicular monitoring and tracking**. In IEEE international conference on communication systems and network technologies (pp. 757–761).
21. Caballero-Gil, P., Molina-Gil, J., Hernandez-Goya, C., & Caballero-Gil, C. (2009**). Stimulating cooperation in self-organized vehicular networks**. In ACM proceedings of the 15th Asia-Pacific conference on communications (APCC) (pp. 346–349).
22. Ho, Y. H., Ho, A. H., Hamza-Lup, G. L. & Hua, K. A. (2008**). Cooperation enforcement in vehicular Networks.** In: International conference on communication theory, reliability, and quality of service (pp.7–12). https://doi.org/10.1109/CTRQ.2008.25
23. Alfred Daniel, Anand Paul ,Awais Ahmad **Cooperative Intelligence of Vehicles for Intelligent Transportation Systems (ITS)**2016