A Novel Inter-Vehicle Communication Exploring Wide Range Traffic Collision Prevention with Cognitive Radio Technology

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Abstract: Smart cities, speeding vehicles and human losses due to accidents are also emerging with the same pace as that of technological advancements. The proposed system of advanced Inter vehicle communication explores techniques of cognitive radio concepts. We analyze the nature and specifications of inter communicating vehicles and acquire the moving data from them. Later, a link distance evaluator is introduced for determining the number of vehicle from transmitting device and receiving device. As the essential component, frequency spectrum is limited; it results in the need of optimized systems to access the spectrum called cognitive radio. In order to transmit exact data among vehicles without noise and any inference, a unique address identification methodology is assigned for efficient communication from one vehicle to the other vehicle is proposed in this system.

Keywords: - Inter- Vehicle networks, Cognitive Radio concepts and Delay reduction to avoid accidents

1. INTRODUCTION

Inter vehicle transmission system is an emerging field of networks where vehicles exchange data with nearby vehicles. The data started includes collision – traffic ratio, safety measures and so on. Inter vehicle transmission is in this way can become a boon to owe modern society to avoid traffic and collision prevention of accidents is the predominant goal of this inter vehicle transmission systems which make extensive use of cognitive network concepts. The proposed system is formed in such a way that end product will alarm the vehicles driver or operator to receive alarming messages in case of any risk and in worst case the driver may stop the vehicle at current position to avoid big accidents. This inter vehicle system converts every moving vehicle into a wireless devices. Thereby, huge accidents and further property and life loss can be prevented effectively.

2. CONVENTIONAL INTER-VEHICLE COMMUNICATION SYSTEMS

In order to acquire the data of vehicle which are out of line of sight, configure mote accession system and wireless protocols are followed. Then a distance – length evaluator is introduced which manipulates every data uniformly thereby when keeps as changing its sensitivity may remain constant. Even though this process succeeds in getting data beyond line of sight, it is defeated as it could not get data from all the directions. Because of this, the traffic is reduced but not accidents of vehicles. Conventional systems started off with vibration sensors, followed by transferring data such as high speeding, chances of collision and even tracked routes. The one drawback was Line of Sight issues and all Omni-directionality as the vehicles can come from any direction and it became difficult to analyze such behaviors. These issues are rectified in the proposed system.

3. PROPOSED SYSTEM OF INTER-VEHICLE COMMUNICATION

In this work, a working prototype of transmission among neighborhood vehicles exploring cognitive radio networks. Using this proposed system, the vehicles driver will get enough data about its nearby vehicles moving closer to it. The transmitted parameters of this proposed system includes velocity, acceleration and feasibility to stop. This information is rapidly shared among the speeding cars. Also a wide range of traffic collision prevention strategy will be incorporated where each vehicle is modeled into separated nodes. In order to investigate these nodes and making them split into multiple user channel, cognitive protocols are utilized.

Recent trends in luxury as well as normal cars have many great features with super sensors which can identify geographic features, velocity, pressure wheel, safety and security alarms. Having these features in mind, the information from vehicles is acquired in real time. They act as devices which both transmitter and receiver with the help of cognitive radio technique.

Sensing happens in two ways namely preliminary course and fine sensing. In the first phase, spectrum holes are detected when cognitive radio senses the surrounding environment. As soon as spectrum holes are detected, this cognitive radio performs fine sensing for identifying the availability of initial user. Also cognitive radio fixes time duration for executing the fine sensing phase and to communicate acquired data to the receiving device. The entire time duration of cognitive radio is split into time for sensing and time for transmitting.

Due to heavy traffic and more loads, delay occurs between these two times. Therefore it is necessary to have an optimized sensing for increasing data throughput and to decrease the noise levels.

When dealing with optimization, two inferences can happen with the signal sensed S[n] which is states as follows:

I_0: N[n] if the initial user is idle
I_1: gP[n] + N[n] if the initial user is active
Where
n= 1,2,… M
M = number of devices used
g= gain of channel
N[n]= Occurrence of noise (Assumed to have mean=0, Variability σ_n^2)
P[n]= Signal of initial user (With every sample whose value mean=0, Variability σ_p^2)

The detector at the receiver gets S[n] and manipulates the result delay, as given below,

$$Delay = \frac{1}{M}\sum_{n=1}^{M}(S[n])^2$$

Let us consider P_{est} denotes with estimation probability and P_{Pseudo} denotes Pseudo warning probability. P_{est} is the probability of identifying spectrum holes when they are available and P_{Pseudo} is the probability of spectrum holes being absent.
For estimating the spectrum holes, let the threshold value be V then

$$P_{est} = P\,[Dealy > (V|I_1)]$$

$$P_{Pseudo} = P\,[Dealy > (V|I_0)]$$

$$P_{est} = G[V - \mu_1/\sigma_1^2]$$

$$P_{Pseudo} = G[V - \mu_0/\sigma_0^2]$$

Here G(.) is the normalized Gaussian complementary function. Sample formula for P_{est} and P_{Pseudo} are given below,

$$M = \frac{1}{SNR^2}[\,G^{-1}(P_{Pseudo}) - G^{-1}(P_{est})\sqrt{2SNR+1}]^2$$

When considering for any time t,

$$Y = \frac{t}{SNR^2}[\, G^{-1}(P_{Pseudo}) - G^{-1}(P_{est})\sqrt{2SNR+1}]^2$$

The two special cases for inter vehicle communication are explained as follows:

Case (i):
Initial user being idle and cognitive Radio not crating Pseudo warnings, then the resulting data throughput measure is

$$T_0(Y) = \frac{Y_1 - Y}{Y_1\,(1 - P_{Pseudo})a_0}$$

Case (ii):
Initial user being active and cognitive Radio gives a data throughput as

$$T_1(Y) = \frac{Y_1 - Y}{Y_1\,(1 - P_{est})a_1}$$

When the above mentioned two cases are considered then the mean throughput of the proposed system is

$$T(Y) = P(I_1)T_1(Y) + P(I_0)T_0(Y)$$

We already have

$$P(I_1) = 1 - P(I_0)$$

Thus the optimized operation of cognitive radio is as given below,

$$\max P(I_1)T_1(Y)$$

Such that

$$P_{est} \geq P'_{est}$$

The final probability of estimation must have value more than 0.9 for better results through the proposed system.

4. COGNITION CYCLE

Adapting to the radio atmosphere, the respective transmission parameters are evaluated in real time. This is offered as adaptive operation in open spectrum known as cognitive cycle. There are three stages in this cognitive cycle namely,

Sensing - Identifies the band of spectrum, explores data and detects the hole in spectrum if any.
Analysis - Detected holes are then analyzed for certain characteristic parameters.
Decision - This stage forms the rate at which data is transmitted, mode of communication and channel bandwidth.

Cognitive cycle process is followed by identification of spectrum band. As the process is real time, it keeps an updating time and space values to acquire data changes from surrounding environment.

5. INFORMATION PROCESSING IN PROPOSED SYSTEM

A. FORMULATIONS AND PROTOTYPE PROCESS

The technique used in proposed system is to estimate available bandwidth in finding frequency. The devices make use of their frequency for the above mentioned purpose. Thus the delay in throughput can be optimized in order to avoid interference and power utilized.

Signal to noise ratio to determine RMS value,

$$SNR_{db} = 10log_{10}\left(\frac{\sigma_S^2}{\sigma_N^2}\right) = 20log_{10}\left(\frac{\sigma_S}{\sigma_N}\right)$$

The operating principle of the system is depending on a novel push – pull strategy where the channel of cognitive radio is estimated by

$$\hat{r}[K] = \frac{1}{l}\sum_{n=0}^{l-1} y[n]\, y[n-K]$$

where l represents length of available samples

When additive Gaussian noise is considered for K=0, interference is correlated and for K≠0, they are uncorrelated with each other.
To put it simplified,

$$r[K] = \begin{cases}\sigma^2 \; for\; K = 0 \\ 0 \; for\; K \neq 0\end{cases}$$

Just like any other communication system, the extracted data from each vehicle is modulated in analog form i.e. message signal which can take either sinusoidal form or square waveform.

To process it, we have a carrier signal which is sinusoidal in nature. By proper fixing of frequency of message and carrier signal, waveform is obtained with the following prototype.

- Start
- Create inter vehicle system for a given road distance by fixing the vehicle approximately
- Mobility to each node is assigned after giving structure to each vehicle node
- Initiate a cognitive channel and prefix its channel parameter
- Perform transmission and reception of data from surrounding vehicles
- Stop

B. BLOCK DIAGRAMS OF PROPOSED SYSTEM

In the proposed system, each vehicle is interfaced with cognitive Transceiver which transmits speed, Temperature, Vibration, Alcohol, Distance, Tire calibration status intimation, which is transmitted to nearby vehicles travelling in all directions. The following figure represents the block diagram which gives the overall structure of proposed work where three vehicles and corresponding transceivers are used; six sensors are used for various parameters.

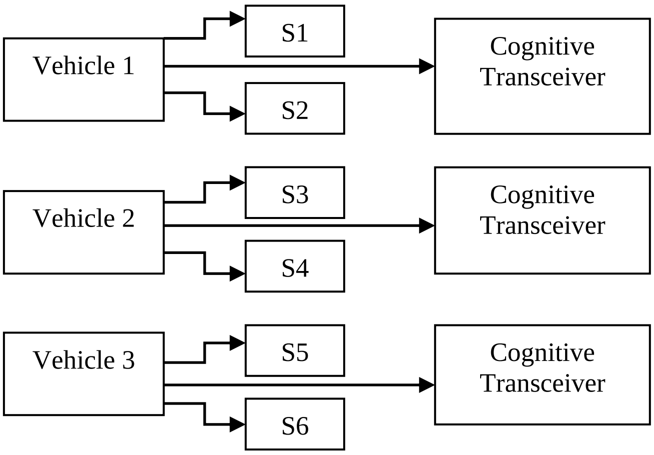

Fig-1: Inter-vehicle Communication Model

The prototype deals with three devices V1, V2 and V3 respectively Here the vehicle v1 consist of Ultrasonic and Speed sensor respectively the sensor information from Vehicle 1 transmits the Data to v2 and v3 each devices is spited with unique address respectively the vehicle 2 consists of Temperature and

ISSN 2515-8260 Volume 7, Issue 4, 2020

IR Sensor The real time value of the vehicle 2 is transmitted to V1 and V3 respectively. Similarly the vehicle 3 consists of Alcohol and Vibration Sensor the vehicle 3 transmits the information to v1 and v2 respectively. Here the output of the each device is viewed by LCD Display.

C. PROPOSED ALGORITHM

The following steps are involved in the proposed methodology:

- Step 1: Sensor from the device in the vehicle gets started and collects all the information of vehicle
- Step 2: Each device from the individual vehicle is assigned with the unique address.
- Step 3: Cognitive radio transceiver from the device starts to scan the channels.
- Step 4: The used channels from the particular area is said to be primary user and unused channels are authorized to use for secondary user.
- Step 5: The secondary user selects the unused channel from the available channels by analyzing noise and threshold level of all channels.
- Step 6: Device data is manipulated as packets and transferred to another vehicle using cognitive channel.
- Step 7: Similarly the information is received from all direction of vehicles simultaneously by differentiating unique address detection method.
- Step 8: The packet is decoded in the form of information and available to the user.

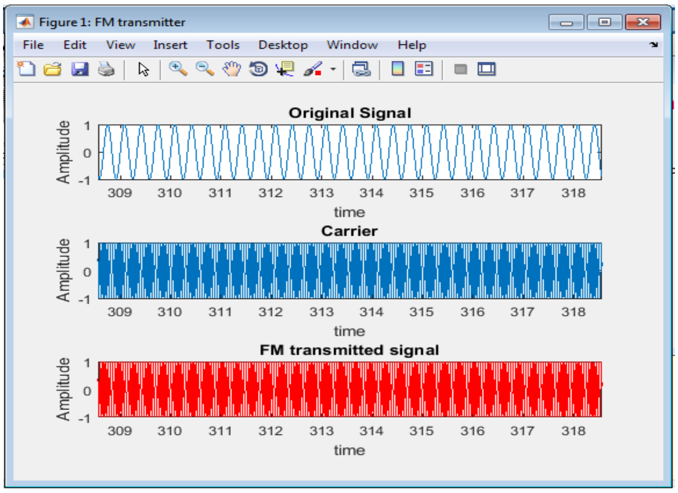

Fig-2: Inter-vehicle communication using cognitive channel

6. RESULTS AND INFERENCES

A. Cognitive wave form and channel selection for used and unused spectrum

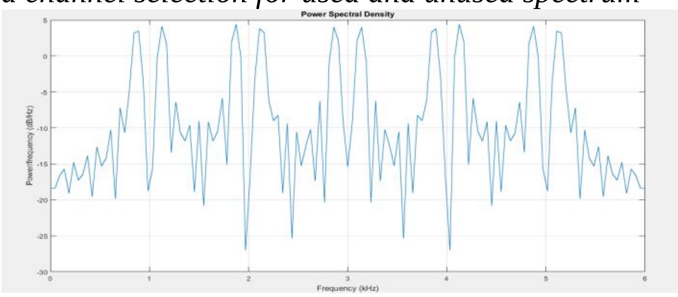

Fig-3: Cognitive channels for used spectrum

The above simulation infers that all the channels are utilized leaving no empty channels. Hence the vehicle users could not occupy the channels. It is known that when in such situation, the power utilized will be much more higher than the one with unutilized spectrum.

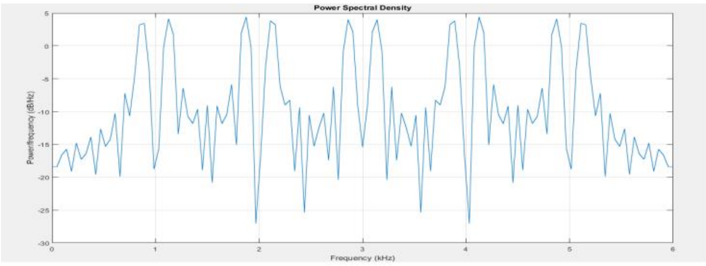

Fig-4: Used and unused spectrum for cognitive channels

The above simulation results prove that the empty channel has a very low power when checked with used channels. In the above result, first-third-fourth-fifth channels are used and second channel is unused.

B. Spectrum Sensing

Cognitive radio detects un used spectrum using spectrum sensing algorithm. Sensing spectrum is the most important factor of cognitive radio, which is mandatory step that needs to be performed for communication to take place. A number of schemes have been developed for detecting whether the primary user is present in a particular frequency band. Some approaches use the signal energy or some particular characteristics of the signal to identify the signal and even its type. Here we are optimising Matched Filter Detection using BPSK modulation. The main purpose of using BPSK modulation is to minimize bit error rate.

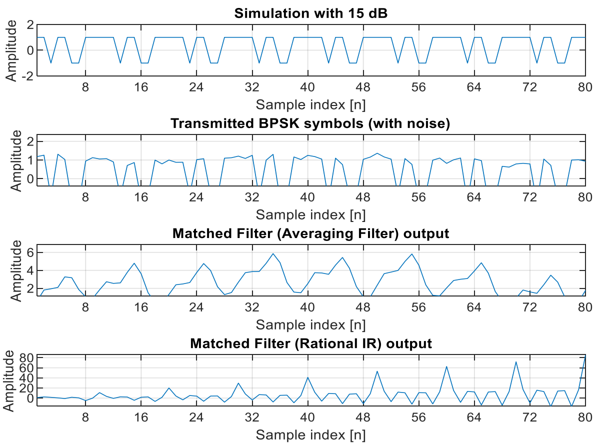

Fig-5: Simulation waveform for BPSK data transmission

The Simulation wave form describes Bipolar phase shift signal transmission here the digital signal from transmitter side is transmitted without converting digital form to analogue here the carrier signal is set to very high frequency and the digital pulse is directly induced in to it the wave form of the message and carrier signal is shown in figure 5.

C. Efficient Data Transmission

The data is transmitted efficiently from Vehicle 1 to vehicle 2 by sensing unused spectrum and transmitting the data using BPSK modulation here from below image the data transmission of various field like speed ,engine temperature ,Distance and breaking ability is simulated and the cognitive wave form with noise reduction is shown.

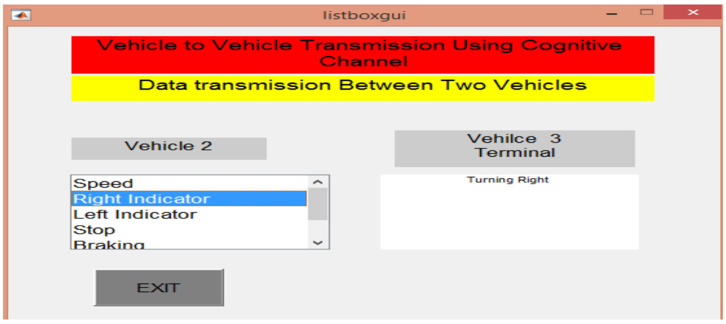

Fig-6: Data transmission between two vehicles

From the figure 6 it is shown that vehicle to vehicle data transmission interface which transmits and receives the parameter data to each nearby residing vehicle So while each parameter attains the threshold level alert is received.

D. Individual Vehicle Data

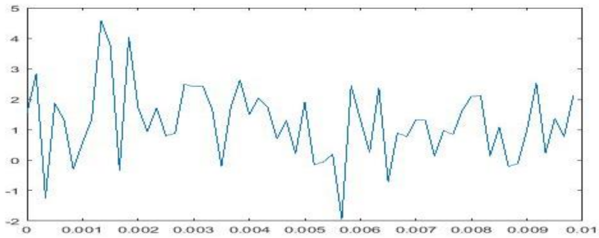

Fig-7: Spectrum Wave form for data transmission for individual vehicle.

The Cognitive system changes its frequency and bandwidth randomly on each cycle of the data so the above figure 7states the signal wave form for individual parameter of each vehicle.

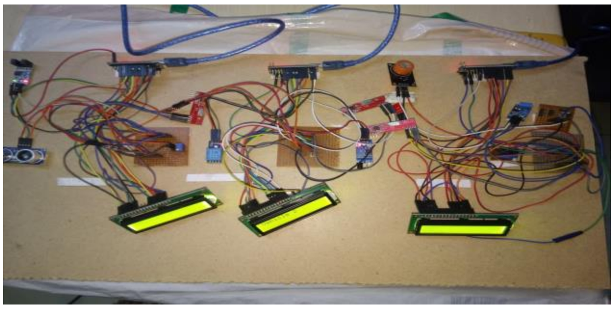

Fig-8: Final Prototype of Proposed System

The hardware and simulation of the vehicle 1 ,vehicle 2 and vehicle 3 is discussed and the hardware prototype of the project is shown in figure 8 and the transmission and receiving part of the each vehicle is transmitted and received using RF transceiver with Cognitive Induced System With each device is shown.

7. CONCLUSION

Thus in today's modern world, especially in urban areas, speeding cars and traffic accidents are a real concern for Government sectors and vehicle manufacturing organizations. They invest for enhancing research and development in this area of inter-vehicle communication system. This has significantly contributed in our proposed system which explores wide range traffic collision prevention. The proposed system is found to be more efficient when compared with its conventional predecessors as it has formulated delay variations and reduced delay to make it perfect for real time applications. As we cannot do any compromise in data transfer in such critical cases, this proposed system proves o be more efficient. Unique address identification, precise and exact information transmission without any interference is the major advantage of the proposed system.

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