

A CR-VANET Approach: Urban Eco-Route System Based on Air Quality

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Abstract

Cognitive radio (CR) is an emerging key technology in the recent times that allows versatile, efficient and reliable usage of available spectrum. Spectrum is a fixed band of frequencies that needs to be allocated to nodes that communicate via a wireless medium. It is expected that in the near future, all vehicles will act as intelligent systems and shall be equipped with radio communication interfaces. Vehicular Adhoc Networks (VANETs), acts as one type of mobile adhoc networks in which the cars are considered as the mobile nodes. This technology is gaining in popularity and with the popularity of Cognitive Radio Technology almost all vehicles in the near future will be set up with CR technology. In this paper we addressed the implementation of most helpful application for CR-based application for VANET vehicles. Clean air is assumed to be a vital necessity for living beings. However, pollution continues to make a serious threat to living beings worldwide. We proposed a topology with many number of Air Quality Monitors (AQM) in urban cities at each traffic signal. Our intention is to provide an eco-route planning system to vehicle users based on this air quality levels. We indicate each and every attainable route with colored lines based on this air quality levels and attainable values. Users conjointly access information through mobile application.

Keywords: *Cognitive Radio (CR), VANET, Air Quality Monitor (AQM), eco-routes.*

1. Introduction

Wireless sensor networks (WSNs) are devices that exchange data between two or more nodes. This is a most recently employed scheme and is used in several civilian application areas. There are also used in environment and surroundings observance, care applications, home automation, and conveyance traffic management[1]. One of the associated application of WSN, VANETS was recently developed. Vehicular communications plays crucial role in implementing

next generation energetic safety applications. Vehicular adhoc Networks (VANETs) devices are deployed in vehicles in order that these devices will exchange helpful data. This data exchange aims to increase vehicles and drivers perception by constructing a worldwide awareness of the surrounding atmosphere and also to specify the alternative paths. Data communication among these vehicles protects high data reach, which provides the driver a lot of latency to avoid unsafe things. With the increase of number of vehicles on the roads conjure concern on advanced road safety as with in-vehicle gratification. In this view we need to develop environment convenience services. Some specific examples that embrace applications are for safety, collision avoidance and traffic observation was stated in [2]. Vanets has become one of the best technology for vehicular communications.

WSN could be a technology that may be exercised in realistic time to search out the above decisive events. A WSN sometimes consists of geographically distributed sovereign sensors to watch real time applications like climatic conditions, noise, vibration, pressure, motion, CO, CO₂, pollutants or smoke being emitted from various sources and pass this information to the nearby base station[3]. In this present situation air quality index might increase in most of the cities in India. Air pollution has jumped to number five spot amongst the highest killers in India. As a result of significant traffic most of the respiration air gets contaminated. Principally CO emitted from vehicles pollutes air. Areas where vehicle traffic is more will results in contamination of air and dirt significantly effects the people in these areas with varied health issues.

VANET is an application of WSNs that has a fixed spectrum allocation of band like a dedicated communication short-range communication band (75 megahertz spectrum allotted in 5.9 GHz, unlicensed band, for example, 2.4 GHz is commonly used in science, medicine and industry(SMI)). As a result of increasing demands for wireless communication,

economical utilization of spectrum comes into existence. For addressing the stated challenge, Cognitive Radio intelligently and graciously allows VANET to access every license- exempt (i.e., TV unused spectrum channels) and licensed spectrum bands . The CR and VANET share certain common similarities within the manner that they operate during sensing operations area unit disbursed to collect data from the operational atmosphere and respond consequently as concluded in [4].

To evaluate the quality of each geographical space we develop an innovative paradigm where Vehicles collect air quality parameters and transmit those to the nearest base station .Based on the analysis of air quality parameters, system concludes final air quality index of each region. In the simulation system, each and every potential path is marked with varied colors

primarily based upon their AQI values. Supported by these color signs, user will simply ascertain the simplest AQI enabled path. In our work, we use the (V2I) vehicle to infrastructure. Each and every vehicle within the region of network can readily access the AQI information and obtain optimal path with AQI standing.

2. Literature Survey

Many vehicles that are moving are not solely setup with global positioning system (GPS) or any other navigation system. The main concern is to create environmental awareness and to avoid collision with vehicles. Transmission systems are involved to improve the performance of vehicles and users convenience.



Figure 1: Classification of VANET

Vehicular communications may be categorized into Vehicle-to-Vehicle (V2V) communication and Vehicle-to-Infrastructure (V2I) communication. V2I consists of Vehicle-to-Roadside (V2R) communication which uses cellular technology for communication in-between the roadside units (RSU) and the vehicle's onboard unit (OBU). In V2Vcommunications, a Vehicular Adhoc Network (VANET) is equipped among the vehicles to exchange the data.V2Vcommunications are comparatively advanced and difficult as estimated to V2R and V2I communications. V2I communications have plenty of data to be exchanged within the centralized servers linked to the internet from different accessible networks and technologies.

In [5] the authors proposed to configure sensor nodes at various locations to captivate the environmental information and pass on this information to the near by moving cars that are equipped with the sensor nodes. Some thresholds are fixed and based on this they

proposed how to communicate with the near by nodes with less over head and how to reduce the message communications among the peer nodes. In[6] the authors stated that with the advancement of technologies there should be a mechanism how to route the traffic in terms of emergency and when they simulated significant amount of efficiency was achieved. In the coming future all traffic signals will be equipped with this sensor nodes at busy junctions and automatically the traffic will be routed at junctions where there is need for traffic control when emergency vehicles are approaching. Cognitive radio [7] is the upcoming technology that takes cares of sharing spectrum among primary and secondary users whereas the purpose of VANET is to share the traffic information with neighboring nodes in terms of emergency and rescue. In [8] authors stated that Wireless sensor networks place a key role for monitoring the environment. Air pollution is a major hazard for human existence. To minimize the effect of

air pollution ,experiments have been carried out where some sensor nodes are deployed at distances of 300m from one another and they share the information with the nearby devices or users .These sensors will monitor the effect of NO₂,temperature,CO and humidity levels in a particular route and pass on the information to the nearby smart device. Based on the gathered data from these sensors the drivers will take decision whether to follow that same route or to take an alternative route. In[9] the authors performed a comparative study and concluded that in the recent times due to effect of increase in pollution and global warming it is difficult to be available with clear oxygen. The primary concern that was put forth was to monitor the indoor environment and the levels of CO₂ in indoor environment. The experiments were carried out indoor to monitor the CO₂ levels and to report them back to the devices or sensors with the levels of CO₂ are effecting in that particular location. This can be very much helpful for real time monitoring and electing to the nearby sensor nodes in a complex environment.

In our projected paradigm we implemented V2Icommunication where all cars will be acting as nodes and RSU acts as knowledge server. V2V communications are self-organizing in nature and will be carried out with or without roadside aiding units. With the rapid increase in demand for spectral accessibility, cognitive radio has become a key area,

for the wireless communications and network's analysis community. Cognitive radio is an upcoming technology that increases the performance of existing radio by desegregation Artificial Intelligence (AI) by using Software Defined Radios (SDRs) [10].

Cognitive radios as intelligent radios will autonomously create selections using gathered data concerning the Radio Frequency (RF) surroundings through model based reasoning and they additionally learn, plan and decide according to their past expertise as described in[11]. Experiments were conducted in [12] using CR enabled device which adjusts its operational parameters to its environment. CR technology mainly uses radio, sensor, LE optimization (Learning Engine) tools, and a reasoning engine.

The CR's Cognition Cycle consists of four phases: Observe Analyze, Reason, and Act. Cognitive Radio searches the vacant spaces from the primary users and finds the best spectrum and allocates to the secondary users. The CR-VANET's Cognition Cycle encompasses a lot of comparisons with that of the CR; however some variations are a result of the character of high-mobility in the vehicular environment. Maximum vehicles are rigged with steering systems, and thus the location as well as quality prediction based on the present direction of motion may be used for Cognition.

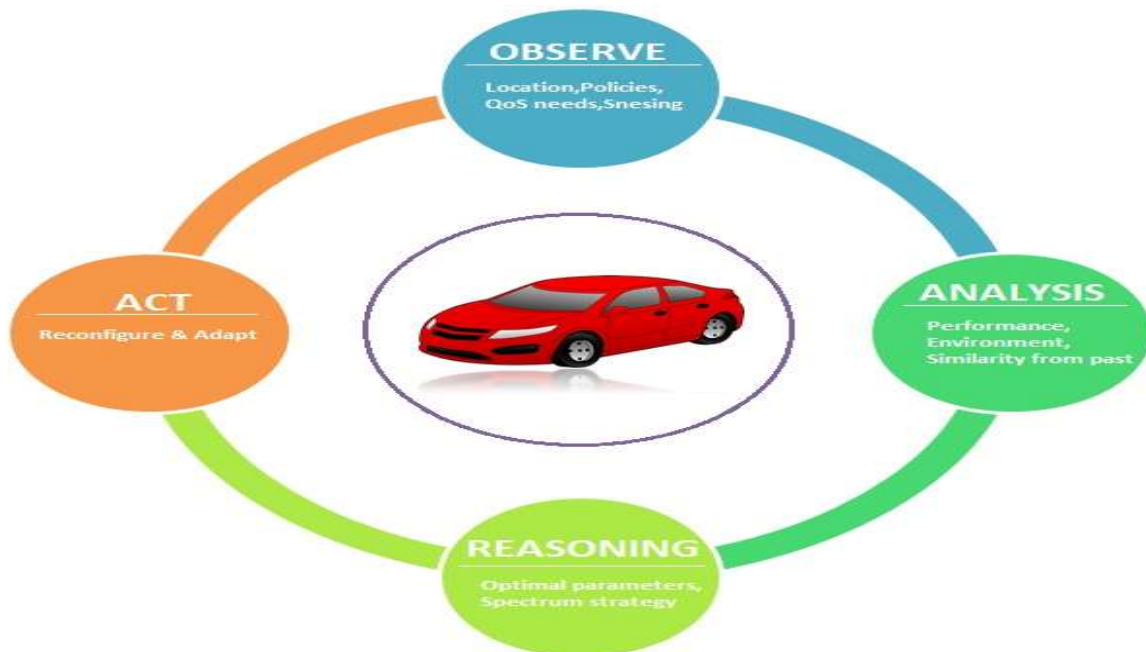


Figure 2: Cognition Cycle of CR-VANET

Currently, high-speed vehicles and varied outsized cars traverse through the road everyday. Advanced applications are needed for the improvement of safety

and potency of road setup and transport. This can change users to exploit vehicular networks in a very astute and safer approach was proposed in[13]. CR-

enabled VANETs will use extra spectrum opportunities by utilizing the unused TV bands consistent with the application's based on QoS requests. Whereas many studies in research are appending CR to cellular networks, wireless mesh networks and ad hoc networks, the analysis on implementing CR to VANETs continues to be in its primal stage. The specification of CR-VANETs are made up of vehicles with onboard units (OBUs and infrastructure units) along with base stations of

network suppliers. The authors in [14] projected many functionalities are required for CR-VANETs mirror for the primal design associated with completely different functionality blocks and protocols. For content issues in CR-VANETs, one approach performs content distribution using V2I communication, whereas V2V communication uses Cognitive Radio to interchange the missing packets as laid in [15].

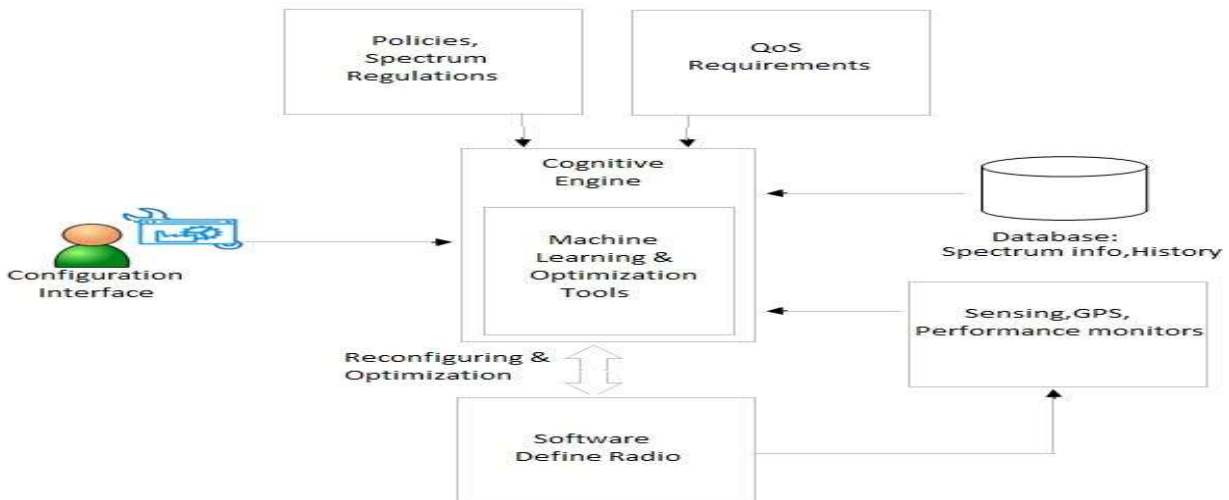


Figure 3: CR-VANET Functional Architecture

3. Art of Work

3.1 Prototype

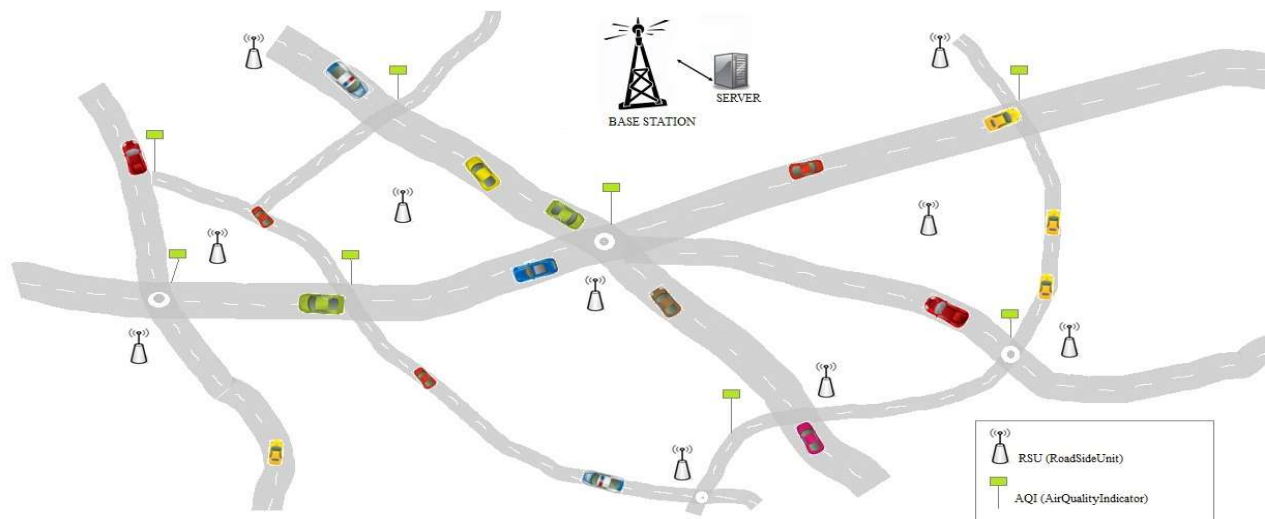


Figure 4: Prototype of Proposed System

The main functional blocks of our proposed system consist of Road Side Unit (RSU), Air Quality Monitor (AQM), Base Station (BS), and Server.

3.2 Path Planning

The main criteria that laid foundation for the proposed model is graph theory. The proposed model of a graph with vertices and edges or arcs will compute the shortest path between two set of vertices. Dijkstra algorithm is typically used to compute it. This algorithm will realize the shortest path from a selected node to different nodes with time complexity $O(n^2)$ where n is the total number of nodes which are actively participating in this model. Its goal is to construct minimal spanning tree (whose cost is low) from the beginning to all different nodes recursively. This algorithm is usually used as a standard answer for comparing with different routing algorithms. There will be a specific format for recording the vehicle's driving info, the appliance to distribute period of time traffic info among communicated vehicles through the VANET, and additionally the movement to estimate the time traffic info of next geographical zone is first prioritized. Then the supported traffic information is distributed among vehicles which are accessed from Google Maps and then the routing formula is changed to recommend the simplest attainable routes. The network topology assists in planning routes with the shortest travelling time and based on air quality status. In VANET, the Road Side Unit (RSU which is used as access point by using wireless LAN Technology) allows vehicles inside its wireless transmission range to communicate with devices within the network infrastructure.

3.3 Air Quality Nodes

We design specific portable wireless Air Quality Nodes. In this model every node is capable of sensing numerous environmental parameters like temperature, CO, CO₂, humidity etc., and sends all sensing parameters from time to time to base station unit (BSU). At this BSU, based upon the received values it calculates air quality index (AQI) for each node. Nodes are mounted at every traffic signal for this purpose. Every node in this network is given a singular id to spot the standing of explicit region. All values of

node are stored at BSU. At BSU all records are updated to the web server also.

An air quality index (AQI) may well be utilized by government agencies to communicate with the general public. As a result of the AQI increase, a progressively huge part of the population is experiencing many health problems. Countries around the world maintain their own air quality indices that do not appear to be all reliable. Different countries in addition use different conventions for their indices like Air Quality Health Index (AQHI), Pollution Index (PI) and Waste Matter Standards Index (WMSI).

The Air Quality Index could be defined as a linear function (considered piece-wise) of the concentration of pollutants. At the maximum and minimum determined values by this function of AQI classes, there was a discontinuous jump of AQI by one unit. The equation used to convert the pollutant concentration to AQI is:

$$QI = \frac{I_{high} - I_{low}}{C_{high} - C_{low}} (C - C_{low}) + I_{low}$$

Where QI is the Quality Index of the Air,

C is the concentration of the pollutant,

C_{low} is the breakpoint concentration and it is $\leq C$,

C_{high} is the breakpoint concentration and it is $\geq C$,

I_{low} is the breakpoint index conforming to C_{low} ,

I_{high} is the breakpoint index conforming to C_{high} .

3.4 Road Side Unit (RSU)

All vehicle drivers travelling within the region are able to access the info from RSU. RSU provides methods to access air qualities standing. The RSU on every occasion takes the air quality values from BSU or internet server. When accessing this values if there is over one signal points then the air quality of that specific region is evaluated by computing its average.

3.1.5 VANET Simulators

Traffic flow Simulators will generate the required vehicular quality traces that can be utilized as an input to the network simulator. The network simulators will calculate and produce the components required in a wireless network periodically, like a detailed network structure of all nodes (cars etc.), transmission of packets and data traffic transmission channels [16].

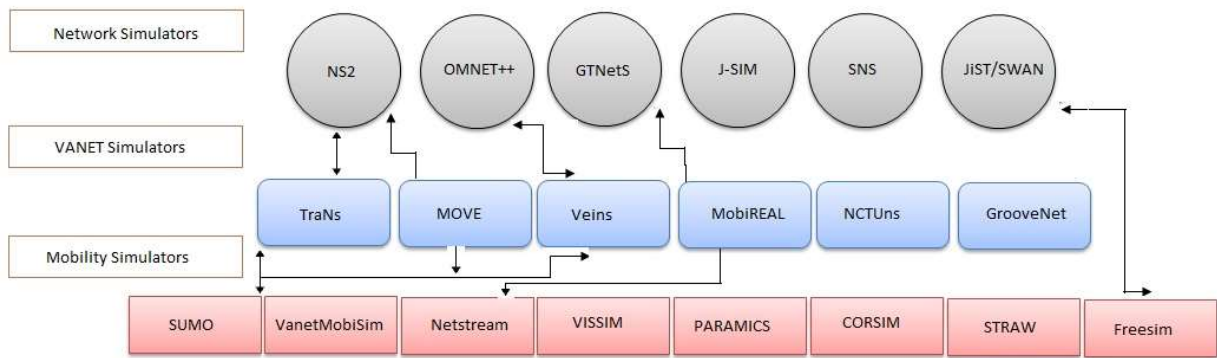


Figure 5: Taxonomy of VANET simulators

3.6 Trans Tool

We have chosen a Graphical User Interface (GUI) tool Trans to implement our planned work. TraNS (Traffic and Network Simulation Environment) is a GUI tool that incorporates network and traffic simulators for obtaining realistic simulations of the Vehicular Ad hoc Networks (VANETs). SUMO and ns2 are best suited tools for this monitoring. TraNS permits the data changed during a VANET to influence the behavior of a vehicle within the quality model.

4. Results

Series of experiments were conducted with real-time air quality values in TraNS tool. We obtain air quality

values of various traffic points at Visakhapatnam city located in India. Time to time AQI values of each traffic point are saved in database. For every user queried route by the user one or more short distance paths may be available from source to destination with their respective AQI values in Google maps. Based upon those results user can easily choose best path with good AQI. Paths are indicated with AQI index color scheme based on AQI values. After number of observations we attain nearly 87% accurate results. We project additional issues that we have identified as challenges for future enhancements.

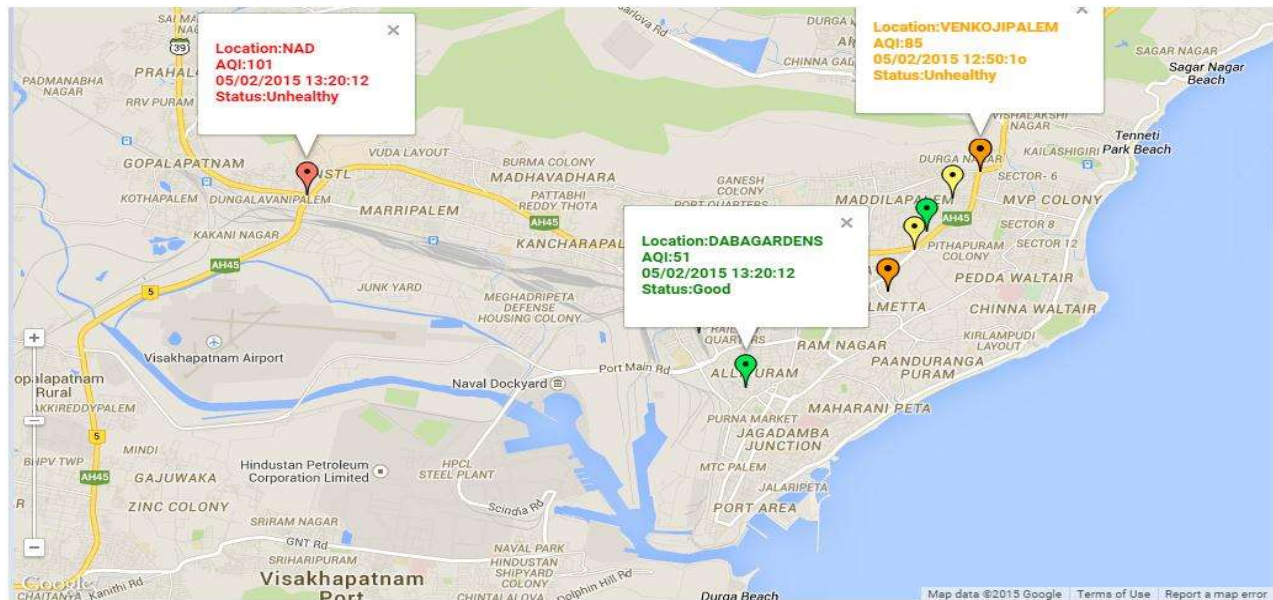


Figure 6: Visakhapatnam AQI Values of Each Geo-Graphical Area

The color scheme is used to easily identify the different levels in AQI from source to destination. According to the AQI parameters the color may vary.

The chart below depicts the AQI index with colors as well as health impact status.

Level of Health Concern	Index Value	Meaning
Good	0-50	None
Moderate	51-100	Unusually sensitive people should consider reducing prolonged or heavy exertion
Unhealthy for Sensitive Groups	101-150	People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.
Unhealthy	151 to 200	People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion
Very Unhealthy Alert	201 to 300	People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.

Figure7: AQI chart

5. Analysis

Figure 8 shows a normal scenario for a vehicle to travel at times of emergency and in normal times. Here the users who tried to give way to emergency vehicles will significantly increase the time to travel as there will be chance for collision.

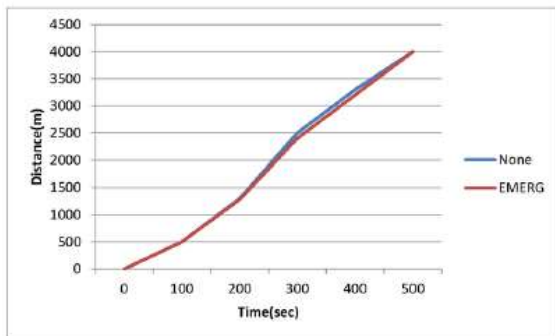


Figure 8: Distance vs Time

Figure 9 shows for each and every theory vs Simulation there are a little bit of variation in universe. Same scenario arises in the result also. Here we consider 10 vehicles for RSU unit. The information is in the form of packets which contains AQI status and various echo routes between the source to destination where there is an emergency significantly the time will increase for the vehicle to travel from source to destination.

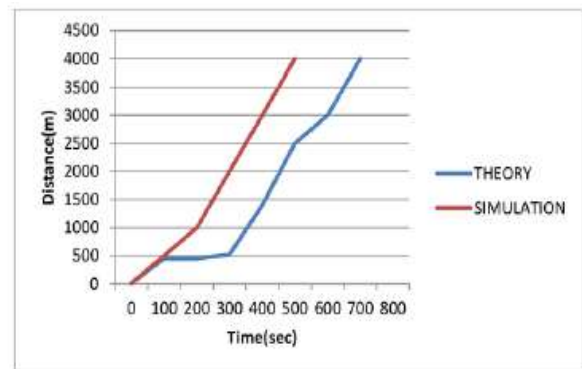


Figure 9: Theory vs Simulation

Figure 10 shows a sample scenario where the travel time is taken as reference and to see how much time a vehicle takes to travel between 2 point and normally what will be the average time for a vehicle to travel from one location to another location in various scenarios of PEAK HOURS+EMERGENCY, PEAK HOURS, NORMAL HOURS, NORMAL HOURS+EMERGENCY and general theoretical observations.

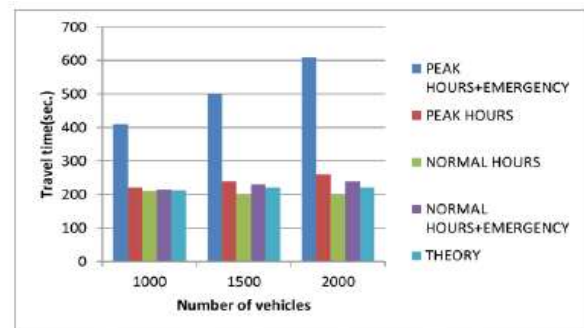


Figure 10: Travel time vs No of Vehicles

Figure 11 shows the experimental results obtained after setting up the sensor nodes at various locations and the effective time taken will be significantly reduced during emergency and normal times. As observed the time taken to reach to the destination

increases but still we can significantly reduce the effect of hazardous environment.

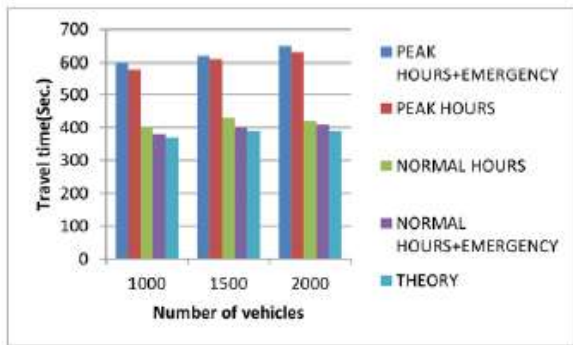


Figure 11: Travelling Time vs No of Vehicles

Figure 12 shows the impact of reducing the number of fatal incidents during this period when the nodes were installed. Although clean air is one primary factor for persons travelling in that route another criteria that was kept into consideration were the number of incidents that happened before the sensors were installed and after the sensors were installed. This also proved that there was significant variation in the number of incidents that occurred.

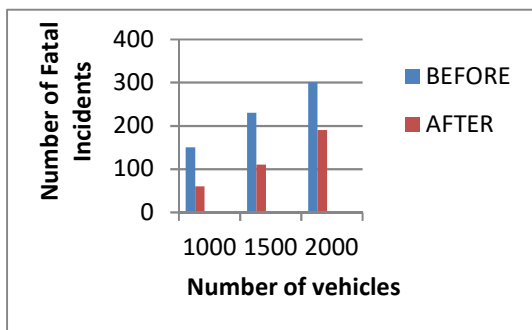


Figure 12: Number of Vehicles vs Number of Fatal Incidents on Average

Figure 13 shows a relative comparison of various prime and heavy traffic locations in Visakhapatnam where the sensors were installed and how this has significantly varied in the case of this Junction where the sensors were installed. A close monitoring was carried out at similar busy locations and a report was generated.

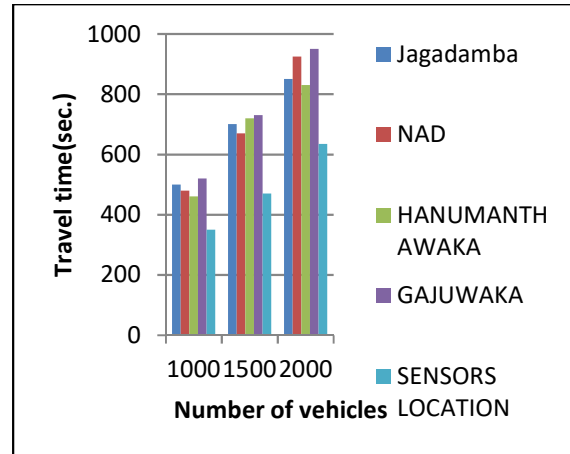


Figure 13: Number of Vehicles vs Travel Time at Busy Locations

6. Future Enhancements

Addressing security problems in CRVANETs is very difficult as neighboring vehicles will be changing with time. During mobility of vehicles on roads it gets very complicated to find a malevolent automobile that was intended to transmit pretentious reports of the spectrum which needs continuous detection and immediate correction. Additional issues that were identified and needs attention are dynamic spectrum allocation, redundant information for similar ways, and delay in received information from BSU to RSU. We wanted to deal with all these issues in our future enhancements. We also wanted to develop an android app for vehicle users as well as non-vehicle users who will get the pollution free eco routes at regular intervals for their region to ensure healthy living.

7. Conclusion

With the rising growth in CR technology and VANETs, many novel approaches are being developed day to day. In this work, we surveyed novel approaches and mentioned analysis challenges associated with the advantages of Cognitive Radio technology for Vehicular Adhoc networks (VANETS). Although CR usage in transport networks remains in the inception stage, CR-VANETs has the capability of turning into the most popular of CR applications within the near future due to a large client market for vehicular communications. However, the solutions planned for an all-purpose Cognitive radio networks can indirectly be applied to CRVANETs owing to their unique options that required to be thought of when coming up with the spectrum management solutions for CR-VANETs. We hope to address some of the issues in developing more advanced applications for CR-VANETs.

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