A Hybrid Congestion Detection based Mobility Model for Vehicular Adhoc Networks

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ABSTRACT
Vehicular Adhoc Network (VANET) is a challenging and growing technology for smart vehicles. It is a network of connected nodes called vehicles. Sharing of information takes place between vehicle to vehicle, vehicle to roadside unit (RSU), RSU to RSU. Various network protocols govern the communication in VANET. Two intensions of VANET are sharing some critical information like road blockage, accidents on road, information about traffic jams etc among vehicles within a particular range and availing entertainment facilities like chatting, toll information, video streaming etc during a journey.

Here the communication is either between vehicle to vehicle or between vehicles to infrastructure. It is seen in survey that, due to traffic congestion there is a huge loose of fuel and valuable time. The time spent in traffic congestion can be spent in some productive works. The rapid growing technology of Internet of Things (IoT) made it possible to detect road congestion smartly before it stuck the vehicle in the congestion, so that the vehicle can be diverted in some other route to their destination. This paper proposes two modules one for congestion detection ANFIS based Hybrid Congestion Detection Based Mobility Model (CDMM) that makes aware the vehicle about the congestion on the route and followed by second modified ACO (Ant Colony optimization) module to follow an optimum route to the destination. Also PSO (Particle Swarm Optimization) algorithm is implemented to find optimal route to the destination. Both the modified ACO and PSO algorithms are compared to use the best one. After getting information about congestion a vehicle may transfer the same information to other vehicles to prohibit them to enter and get stuck into the jams.

Keywords
Wireless Sensor Network, Congestion Detection, Adaptive Neuro Fuzzy Inference System, Vehicular Adhoc Network, Sensors, IoT.

1. INTRODUCTION
A wireless network of moving vehicles is called Vehicular Adhoc Network (VANET). It is a special network of Mobile Adhoc Network (MANET). It is a current trend now to automate every small and large activity ranging from washing clothes at home to office automation. In the same way if transport system is automated, then it may save our time, life, fuel etc. In our busy life, time management is the prime aim of every individual. During travel to office, hospital, home, picnic or any event, less travel time and less travel cost is always desired. Out of various emerging Internet of Things (IoT) technologies, automatic transport system that is Vehicular Adhoc Network (VANET) is an important emerging technology.

Vehicular Adhoc Network (VANET) is an auto-configuring wireless sensor network which consists of vehicles as nodes, road side units (RSU), base station (BS). Communication in VANETs occurs in three ways, either it is vehicle to vehicle (V2V) or it is vehicle to Infrastructure like road side units (RSU) (V2I) or infrastructure to infrastructure (I2I). Driverless automobiles are equipped with onboard unit(OBU) which helps in communication in VANET. The onboard unit is consisting of Event Data Recorder, Global Positioning System (GPS), wireless transceiver that is a short range wireless interface, GSM to support communication in the network and a computational unit that plays a vital role in communication in VANET. These smart vehicles can be connected to internet through RSU. As soon as the OBU is switched on, it coordinates with the RSU and gets an IP address which is required for further communication. Fig.1 shows the structure of VANET and Fig.2 shows V2V, V2 RSU and RSU 2 RSU Communication.

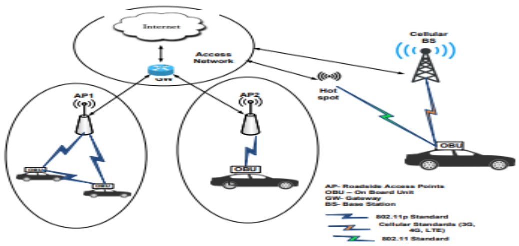

Fig.1. Structure of VANET

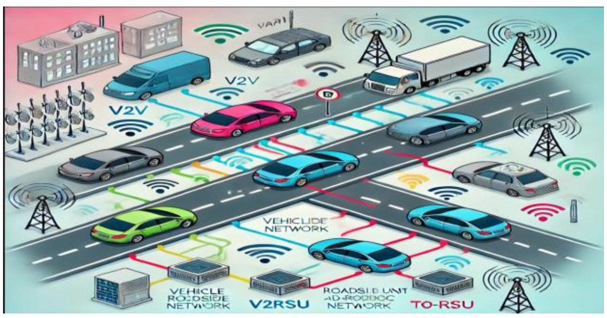

Fig.2. Communication in VANET

During V2V communication information like speed, direction, location, traffic information, driver behavior, road condition and some other required information are shared. V2I communication is intended to avoid motor crash, assist emergency vehicles etc. I2I communication provides facility for content sharing and its multi-hop communication characteristic extends the range of communication. All these features of VANET transform it to Intelligent Transport System (ITS).

Basically application of VANET may be classified into two classes. First being the safety application and second is user application. Safety application includes exchange of emergency information in V2V and V2I communication. This helps in reducing chances of accidents, Real time traffic notification, road hazard notification, post accident notification, forwarding collision warning messages, lane change warning messages, traffic vigilance are various safety applications of VANET. User application of VANET is for comfort and better travelling experience of user. It involves V2I communication to exchange information such as weather condition, location of nearest hospitals and restaurants. User application of VANET also includes playing video games, downloading videos, maps and other entertaining options.

Density of smart vehicles is more in urban areas as compared to that in rural areas. So the probability of getting traffic congestion in urban areas is more in comparison to that in rural areas. Now-a-days Motor Vehicle Companies are developing smart vehicles which are equipped with various sensors to gather environmental information. Theses information helps the driver or the vehicle to reach at the destination with minimum time and cost and without human interventions. The vehicles in the network change their position very frequently. So the network is auto-configured at every instant of time. This makes VANET a challengeable research area. In urban areas, there may be road congestion due to manmade activities like strikes, road works, rallies etc or may be due to some nature's activities like rain, broken trees, damaged road etc. If emergency vehicles such as ambulance, fire extinguisher, police vans etc get trapped in such road congestion, it may lead to a serious loss of health and wealth.

This paper proposes two modules where first module, an Adaptive Neuro Fuzzy Inference based Hybrid Congestion Detection Based Mobility Model (CDMM) to detect road congestion and the second module finds the optimize route to the destination. GPS component in autonomous vehicle gives the current location of a vehicle. This current location is the source address and there is a fixed destination address for each vehicle. The continuous motion of the vehicle changes the network topology very frequently. There is a continuous flow of current location and destination address to each crossing BS. A Central Maintenance Database (CMD) stores and analyses data sent from vehicles and RSUs. The communication in VANET is wireless communication. A specific bandwidth of communication channel is assigned for the message transmission. Near a traffic jam, all the vehicles which are approaching towards the jam, are in a continuous process of receiving and sending messages to other vehicles. This may lead to high channel utilization. Due to high channel utilization there may be chance of loss of packets, and delay in packet delivery. The RSU at a very short regular interval of time sends these values to BS. BS uses an ANFIS to determine the congestion level on the route. Congestion is detected when the congestion level is higher than a threshold value on that route and a message regarding congestion is forwarded to RSU which forwards it to the vehicle. Initially all possible paths from a source place to destination place are recorded. The ANFIS module evaluates the congestion value for each path. Vehicles are assumed to be artificial ants with congestion value as pheromone level. As per ant colony optimization technique, more the pheromone concentration on a path, more is the number of ants following the particular path towards the food which is found to be an optimal path. Likewise, in VANET scenario, a variant of ant colony optimization technique is used in which, the evaluated congestion value is the pheromone value, but less the congestion level, more vehicles will follow the path to the destination. Congestion level is updated at regular interval of time resembles updating pheromone value. Also PSO algorithm is used to get optimum route to destination. Results of modified ACO and BFO are compared. This may resolve the mobility overhead on a congested road.

The paper ahead is organized as follows. Section 2 narrates the related proposed methods by different researchers in this area. The Section 3 and 4 describes the ANFIS mode, Ant Colony Optimization method and Particle Swarm Optimization algorithm respectively. Section 5 represents the proposed ANFIS model to find congestion on road and the vehicle is routed optimally using modified ACO technique also Vehicle is routed using PSO to the destination. Then Section 6 presents the simulation results of the proposed system. Finally conclusion is drawn in Section 7.

2. RELATED WORK

In paper [1], the authors have proposed a model in which a vehicle sends a message to RSU, BS and other vehicles in the same lane as soon as congestion is detected. Following this the vehicles approaching in this direction finds an alternate path to the destination by applying effective shortest path routing algorithm. The authors in paper [2] have used a proactive congestion control mechanism in which all paths between source and destination are found, average speed of a vehicle on that path without traffic, with less traffic and with congestion are calculated. Congestion is detected if the average speed of the vehicle is found to be less than the calculated average speed. Then a new path to the destination is selected. The authors of paper [3] have classified various congestion detection techniques into six major classification techniques and have discussed about closed loop congestion control and open loop congestion control mechanisms. In Next Route Routing (NRR) technique proposed in [4], a re-routing alarm is broadcasted to all vehicles approaching towards a congested road. NRR finds an alternate route based on routing cost function and sends it to the vehicle. A heuristic based minimum cost path algorithm is used to find an optimal path between a source and destination in a graph by the authors of paper [5]. This can be used to find alternate optimal path for a vehicle in VANET.

VANETomo a new approach was proposed by authors of [6], which infer transmission delay by using statistical Network Tomography (NT). This NT repeatedly measures the traffic on the network links and estimates the delay in the network without depending on internal nodes. In paper [7], the authors have proposed a Neuro-fuzzy optimization model that uses ANFIS to detect intra-cluster and inter-cluster faults in WSNs. The cluster head acts like a manager and detects intra-cluster fault using the proposed ANFIS model and performs data aggregation to identify the faulty nodes. The authors of paper [8] have proposed a congestion control framework that uses uni-priority event driven safety message in VANETs. According to the proposed technique, CCH communication channel is reserved for event-driven safety messages. Different congestion control schemes are compared on the basis of computational overhead, latency and throughput in paper [9] by the authors. The result of comparison is, congestion control in WSN for vehicular safety application technique performs well in terms of computational overhead, latency and throughput as compared to other existing techniques. The authors of paper [10] have proposed an efficient queue management technique to handle congestion in VANETs. This technique is named as Node Based Throughput (NBTH) which evaluates the throughput of a node.

In paper [11], a type-2 fuzzy logic AI technique is used in Adaptive Congestion Aware Routing Protocol (ACARP) to detect congestion. This model finds congestion around each node by taking occupied bandwidth, quality of link and moving speed as input to the fuzzy model. The output congestion status determines the safe and reliable route for data transmission. The authors of paper [12] have presented the principal function blocks of a fuzzy controller. Here, gradient descent back propagation method and least-square method are used in the proposed ANFIS model. The authors of paper [13] have proposed a cluster analyzing technique which detects road congestion. The authors have compared the performance of Centroid based K-means , Object based FCM and FKM on the basis of data points and number of clusters. In paper [14], the authors have proposed an ANFIS based controller to model and simulate TCP/ AQM system. The ANFIS controller generates dropping probability as a control signal to the uncompensated system. The authors of paper [15] have presented a utility based congestion control and packet forwarding method for VANETs. Here for each node, the average utility value is calculated based on utility of data packets of the node. Available data rate is assigned to the node with proportional to priority.

The authors of paper [16] have proposed a neural network based model to detect congestion in Wireless Sensor Networks. The model takes number of participants, buffer occupancy and traffic rate as input and finds congestion level as output. The authors of paper [17] have proposed a cloud-based video trans-coding architecture that reduces downloading time of video and allows concurrent access of many users. The authors of paper [18] have analyzed various congestion control techniques in VANETs, packet dissemination in network and presented a framework for safe data transmission in VANETs. The authors have used channel busy time as metric for network load and have defined network performance of dissemination of safety messages. The proposed transmission control protocol in paper [19] has used communication rate and power for safe tracking processes. It is a transmission control protocol that has used a closed loop control concept to determine the wireless channel unreliability. The authors of paper [20] have presented a review on various aspects and researches on VANETs. The paper narrated various related protocols in physical layer, MAC layer, and network layer and about message safety. In paper [21], the author has proposed a Mamdani Fuzzy model to detect congestion level in urban area for autonomous vehicles. This detected congestion value may help to find alternate route to the destination. The author proposed a Sugeno Fuzzy model that can determine the traffic congestion on urban roads for an automated vehicle [22]. The proposed model has considered various input parameters such as average speed of vehicle, carbon dioxide level, carbon monoxide level, temperature, radio frequency intensity to find the level of jam at the location. The authors in [23] presented a vehicle ID-based congestion aware message (CAM) for beacon signals on the vehicle environment. Channel utilization, Vehicle Congestion Data (VCD) and Path Weight Computation (PWC) are used to determine best path for the vehicles. Connected Dominating Set (CDS) approach in [24] is able to adapt dynamic topology change of the network. It is designed to divert the traffic from high density path to low density sub path. It also takes care of reduced packet loss by constructing virtual back bone network with series of neighboring back bone nodes. The paper [25] proposed Ant based vehicle congestion avoidance system (AVCAS). The authors used ant based algorithm on segmented map to avoid congestion.

3. PROPOSED ADAPTIVE NEURO FUZZY INFERENCE MODEL FOR CONGESTION DETECTION AND RE-ROUTING

The Artificia Neural Network and Fuzzy Logic Controllers are being used in most of the control design system due to their speed and robustness properties. They do not need any mathematical model to represent the control system. Hence for designing and modeling more complex systems ANN and Fuzzy Logic are used which gives us appropriate and optimized results. Fuzzy Logic is a better tool for non linear and complex systems. The powerful capability of learning, adaptation and robustness of ANN made it to be applied in designing of various nonlinear and complex models.

The proposed model is based on Adaptive Neuro Fuzzy Inference System (ANFIS). This ANFIS is a combination of advantages and features of both ANN and Fuzzy Logic.

3.1 ADAPTIVE NEURO FUZZY INFERENCE SYSTEM

"Adaptive neuro fuzzy inference system" is a combination of neural network and fuzzy inference system. A neural network consists of input layer, output layer and n number of intermediate hidden layers. The Fuzzy inference system consists of input, fuzzification, rule based fuzzy system, defuzzification and output. Fig.2 shows structure of an adaptive neuro fuzzy inference system. The first layer is input layer which takes two inputs as there are two neurons or input nodes. The second layer is the first hidden layer that performs fuzzification on the basis of some membership function. Next hidden layer applies the rule based inference for the input values. Defuzzification is performed by the followed layer and finally output is generated.

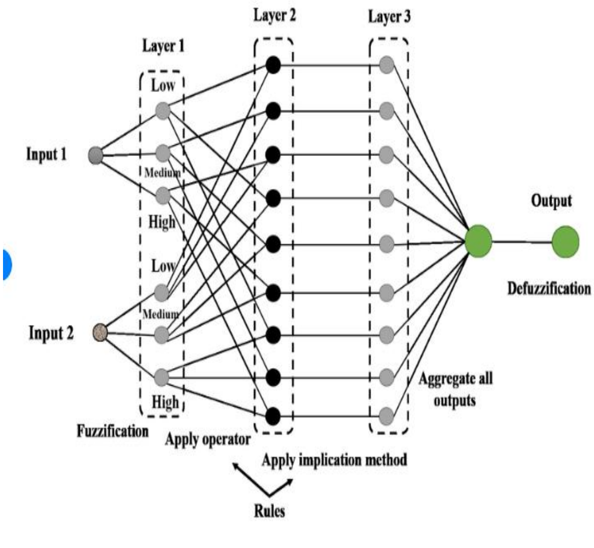

Fig.2. ANFIS Structure for two inputs

ANFIS is an intelligent controller and a tool designed by merging ANN and Fuzzy Logic. It is a neural network having features like adaptability of ANN and interpretability of Fuzzy Inference System(FIS). The advantage of using ANFIS to design complex system is, it has few adjustable parameters as compared to pure ANN, due to which it is precise and it works very fast. According to authors in [12], parameters of ANFIS are trained by hybrid learning method. Two types of parameter*s premise parameters and consequent parameters* are adjusted or tuned during the learning process of ANFIS. Gradient decent algorithm is used to adjust premise parameters and least square algorithm is used to tune consequent parameters. Training process continues by adjusting premise parameters and keeping consequent parameters fixed and vice versa. The decomposed parameters make ANFIS to get trained rapidly and learn fast. In ANFIS the first layer of nodes represent input variables and end nodes represent the output control gain. The intermediate hidden layer nodes represent the membership function and fuzzy rules. The operational logic behind ANFIS is it uses training process of ANN and decision making process of FIS.

3.2 STRUCTURE OF ANFIS

ANFIS works on three basic components, a rule base, which is consisting of fuzzy rules, a database having membership functions used in fuzzy rules, a logic mechanism, which inferences the rules to generate the output. ANFIS uses a Takage Sugeno models and hybrid learning algorithm. The hybrid learning algorithm for ANFIS is a combination of back propagation, gradient-descent and least-square algorithm.

In general ANFIS is based on feed forward neural network in which each layer performs a particular function on input signal [13]. Let us assume, the fuzzy inference system consists of two inputs x and y and a single output z. According to Sugeno Model there can be two IF-Then rules.

Rule 1: if x is A1 and y is B1 then f1=p1.x+q1.y+r1

Rule 2: if x is A2 and y is B2 then f2=p2.x+q2.y+r2

Here p1,q1,r1 and p2,q2,r2 are design parameters that are set during training period. f1, f2 are the outputs within the fuzzy region.

Adaptive neuro fuzzy inference system consists of five layers of neurons. Neurons of same layer, belong to same function family. The Fig. 3 represents architecture of ANFIS.

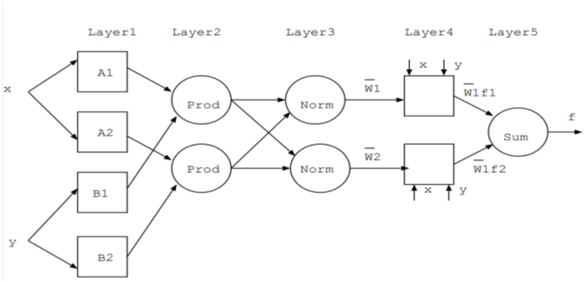

Fig. 3 ANFIS Architecture

Layer 1: First layer of ANFIS is input layer consisting of nodes or neurons. They take input and determine the membership function belonging to them. It is otherwise also known as fuzzification layer. The degree of membership of each input is computed by using the premise parameter set. The membership function $\mu_{Ai}(x)$ is bell-shape having maximum value 1 and minimum value 0. The formula of $\mu_{Ai}(x)$ is given in eq.(1),

$$\mu_{Ai}(x) = 1 / \; [1+\{((x-c_i)/a_i)^2\}^{b_i}] \quad (1)$$

The bell shape of the function changes according to the values of ***premise parameters*** a_i,b_i,c_i.

Layer 2: This layer is termed as “Rule Layer”. It consists of nodes which are nor adaptive in nature rather are fixed. The fuzzy AND operation is performed in this layer. As a result the output is product of all inputs from the first layer. So the output of this layer can be represented as eq.(2),

$$W_i = \mu_{Ai}(x) \text{ X } \mu_{Bi}(x), \text{ for } i=1,2 \quad (2)$$

Layer 3: The nodes of layer 3 are fixed nodes and termed as ***Norm***. Each i^{th} node of this layer calculates the ratio of firing strength of i^{th} output to sum of all firing strength of all fuzzy rules. The output of i^{th} node of this layer is represented by eq.(3).

$$W_i = \overline{W_i} / (W_1 + W_2) \text{ for } i=1,2 \quad (3)$$

The outputs of this layer are also known as ***firing strengths***.

Layer 4: Every neuron or node in this layer is an adaptive node and generates the output as a function of ***consequent parameters*** and the output function of the node is represented as in eq. (4).

$$\overline{W_i}\, f_i = \overline{W_i}\,(p_i\, x + q_i\, y + r_i) \quad (4)$$

Here $\overline{W_i}$ is firing strength from previous layer i.e layer 3 and p_i, q_i, r_i are consequent parameter set.

Layer 5: This layer has a single fixed node denoted as ***sum***. It is also known as defuzzifier layer. The node in this layer computes the output as a summation of all inputs from previous nodes by eq.(5).

$$\text{Output of ANFIS} = \textstyle\sum_i = \overline{W_i}\, f_i = \sum_i W_i\, f_i / \sum_i W_i \quad (5)$$

3.3 HYBRID LEARNING ALGORITHM OF ANFIS

The ANFIS system is trained using two passes of hybrid learning algorithm. In hybrid algorithm I i.e forward pass the algorithm uses ***Least-Square*** method to identify consequent parameters in layer 4. In hybrid algorithm II i.e backward pass, errors are propagated backward and the premise parameters are updated by Gradient descent method. The two passes of Hybrid Learning Algorithm in short is given in Table 1.

Table 1. “Two passes of Hybrid Learning Algorithm of ANFIS”

	“Forward Pass”	“Backward Pass”
“Premise Parameters”	“Fixed”	“Gradient Decent”
“Consequent Parameters”	“Least-Squares estimator”	“Fixed”
“Signals”	“Node outputs”	“Error Signals”

4. ANT COLONY OPTIMIZATION ALGORITHM FOR OPTIMAL ROUTE

Ant colony optimization technique is based on biological phenomenon of ants. Real ants search for food with a shortest distance from their nest. While travelling in the path they release a chemical substance known as pheromone on the path. Other ants follow these pheromones and the shortest path is reinforced with more pheromones as it is travelled by more frequently.

4.1 BASIC PRINCIPLES OF ACO

ACO simulates this behavior using artificial ants in a mathematical model. The algorithm can have two components:

i) Pheromone Trail : It is the virtual pheromone which is updated based on the paths taken by the artificial ants.

ii) Heuristic Information: Problem specific information guides the ants towards more suitable solution.

Initialization Steps:

1. Initialize Pheromone Levels: Pheromone levels on all edges are initialized with a small positive value.

2. Initialize Parameters: Number of ants, pheromone deposition rate parameters are initialized

Construct Solution:

1. Ants deployment: Artificial ants are placed at start.

2. Each ant creates a solution incrementally and choose the next step based of a probability function. The probability considers both pheromone level and heuristic information.

The probability P^k_{ij} of ant k moving from node i to j is given by equation (6),

$$P_{ij}^{\,k} = ([\Gamma_{ij}]^{\alpha} [\eta_{ij}]^{\beta}) / (\sum_{l \in N_i^k} [\Gamma_{il}]^{\alpha} [\eta_{ij}]^{\beta}) \qquad (6)$$

Where,

τ_{ij} is the pheromone level on edge (i,j),

η_{ij} is the heuristic value,

α and β are parameters that control the influence of pheromone and heuristic, respectively,

N^k_i is the set of feasible nodes for ant k when at node i.

Update Pheromone:

To simulate pheromone deposition, pheromone level is updated as follows in equation (7),

$$\tau_{ij}=(1-\rho)\tau_{ij} \qquad (7)$$

where ρ is evaporation rate.

After getting a suitable path from nest to food, all ants follow the same path and release pheromone on this path given by following equation (8)

$$\Gamma_{ij} = \Gamma_{ij} + \sum_{K=1}^{m} \Delta \Gamma_{ij}^{\,k} \qquad (8)$$

where $\Delta\tau_{ij}^k$ might be proportional to the inverse of the tour length traveled by ant k.

Optimal path is searched and pheromone is updated till a pre defined number of iterations or until a stopping criterion is met.

In the proposed technique ACO is a modified because in real scenario, higher the concentration of pheromone higher is the probability of selecting the path but in VANET, the congestion value is periodically calculated by ANFIS model and updated in BS's CMD. This congestion value plays the role of pheromone that it attracts vehicles to follow the route where pheromone or congestion concentration is low. Decrease in congestion level on road refers to evaporation rate. The modification in ACO algorithm is, less the pheromone value or congestion at a particular instant, the greater is the probability of selecting the path by the vehicle.

Let there are n number of routes from a selected source to destination. Then the probability of selecting i^{th} route out of n routes is given by equation (9).

$$P_i = \Gamma i / \sum_{i=1}^{n} \Gamma i \qquad (9)$$

Here Γi is the congestion level on i^{th} path to the destination. As it resembles the pheromone concentration, less the concentration of pheromone more is the probability of selecting the path and it may be the shortest route to the destination which may be the optimal solution. At regular interval of time congestion level is calculated by ANFIS model and update value is stored in CMD. Based on this congestion value vehicles choose the path.

5. PARTICLE SWARM OPTIMIZATION ALGORITHM FOR OPTIMAL ROUTE

There are various optimization algorithms to find optimal solution of real world optimization problems. Metaheuristic protocol base PSO technique is one of the optimization techniques which is nature inspired technique and helps to find optimal solution of the problem. It is based on social behavior of birds or fish searching for their food. Here bird / fish is considered as particle. In each iteration, the distance and velocity of each particle is calculated and updated. Accordingly the birds follow the bird which is at least distance from the food and approaching towards an optimal solution.

In the proposed modified PSO technique each possible paths from source to destination are considered to be the particles. Each path has BS and initialized with initial congestion value and it is the fitness value for the path. ANFIS model determines the congestion level at each iteration personal best congestion value. Each pbest congestion value is updated in BS and a global gbest value is determined and updated in BS.

6. SYSTEM MODEL

In Urban areas, number of vehicles on road is increasing day by day. New models of vehicles are designed with wireless sensors and IoT due to which there is a possibility of connecting vehicles and communicating with each other vehicles. The roads in urban areas may be blocked by some human activities such as strikes, road maintenance, accidents or by some natural disasters such as storms, flood etc. For a smooth, time saving, low cost and comfort journey congestion should be avoided. But to avoid entering a congested path it should be detected first. Researchers have proposed various techniques to detect congestion and also post congestion remedies. Congestion control approaches may be proactive congestion control, reactive congestion control and hybrid congestion control. The paper proposes a proactive congestion control technique using adaptive neuro fuzzy inference system to detect congestion and applying modified ACO Algorithm to find an optimal congestion free path to the destination. The algorithm and flowchart are as follows:

Step 1: Start

Step 2: Initialize source and destination nodes

Step 3: R_iS_i is Road side unit at source and $R_jS_j$is Road side unit at destination

Step 4: Determine all paths between Source and Destination.

Step 5: For each path find channel utilization level, packet loss rate and delay in packet delivery.

Step 6: These values are forwarded to Base Station and input for ANFIS model to detect congestion.

Step 7: If congestion level> Threshold value

Track current location of the vehicle through GPS

Find all paths from current location to destination

Step 8: Apply Modified Ant colony optimization algorithm to find optimal path from current location to destination and Repeat step 5 to 6

Step 9: select the path having low congestion level and low travelling cost

Step 10: Follow the path to destination.

In the proposed model, it is assumed that near a congested road there may be more number of vehicles. Communication among the vehicles and road side units leads to high channel utilization, high rate of packet loss and delay in packet delivery.

Channel utilization refers to the fraction of time given to user to send the data. If n numbers of user are sending messages using a communication channel then channel utilization can be calculated as average of time slots using the channel.

Channel utilization is calculated by eq.(10) as follows,

$$CU = \sum t_i / n \text{ where } 1 \leq i \leq n \quad (10)$$

Where CU is average channel utilization, t_i is time for which channel is used by i^{th} user and n is number of users.

Rate of packet loss is calculated by eq.(11) as follows,

$$RPL = LP / SP * 100. \quad (11)$$

where RPL is rate of packet loss, LP is number of lost packets and SP is number of sent packets.

Packet delivery ratio is calculated by eq.(12) as follows,

$$PDR = RP / SP * 100. \quad (12)$$

Where PDR is packet delivery rate, RP is number of received packets and SP is number of sent packets.

The road side unit forwards these values to base station of that coverage area. The proposed ANFIS algorithm is run at base station taking channel utilization, rate of packet loss and delay in packet delivery as input values and produces congestion level which is compared with the experimental threshold congestion value. Congestion is detected if resulted congestion level is more than the threshold congestion level and immediately an alarm is sent to the vehicle through RSU to change the route to the destination.

After getting the congestion alarm, RSU finds, vehicle's current location using GPS. The current location of vehicle and destination locations is forwarded to base station. All alternative routes to destination from current location are determined. For each path, channel utilization, rate of packet loss and delay in packet delivery are calculated. Using ANFIS model, congestion level for all possible paths is generated. Modified Ant Colony Optimization algorithm is used to find optimal path to the destination. According to normal ACO algorithm ants follow the path with more intense of pheromone, where as in modified ACO algorithm congestion value is considered as pheromone. As the vehicle (ant) will follow the less traffic path so less congestion value (pheromone) is followed to get optimum path. The route map with less congestion and minimum cost is forwarded to vehicle to follow the new route.

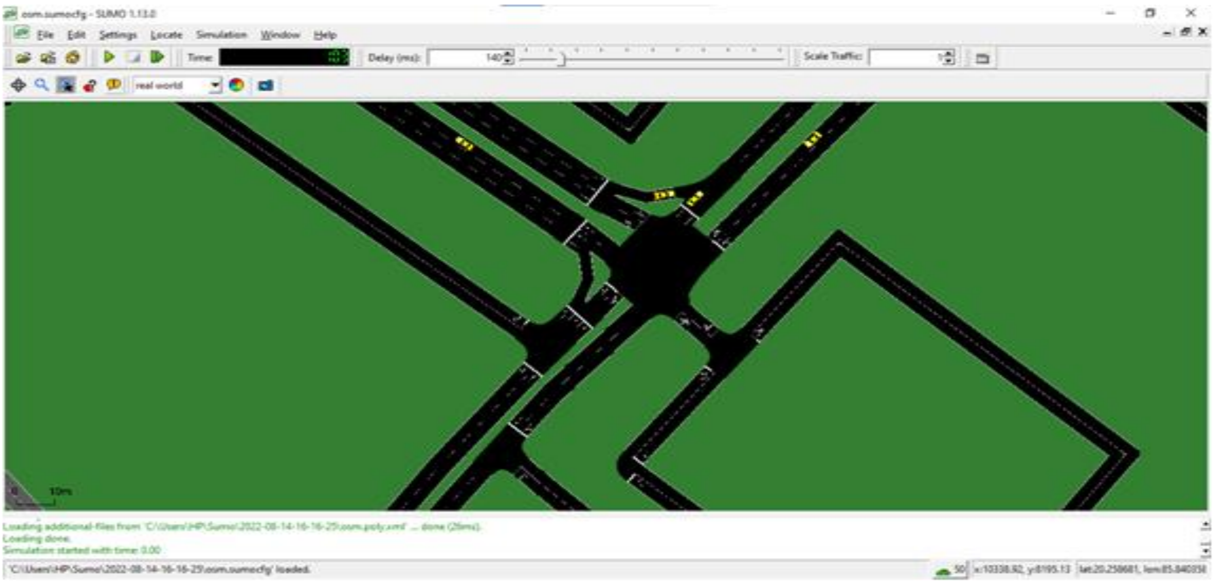

Fig 4: Simulation of VANET with 50 vehicles in SUMO

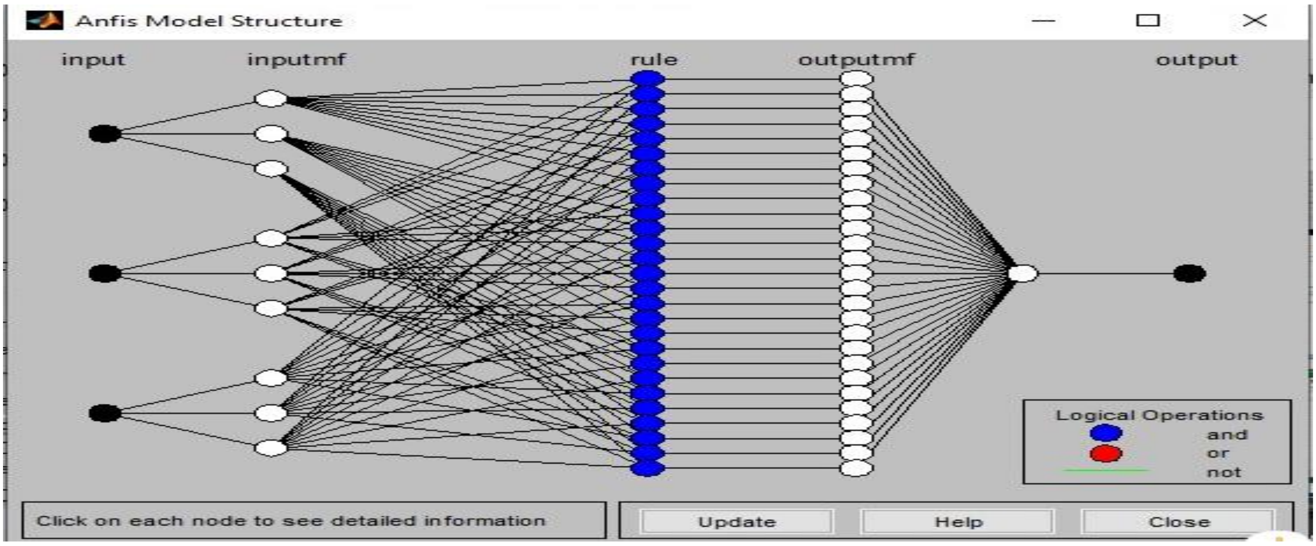

Fig.5. ANFIS model for congestion level

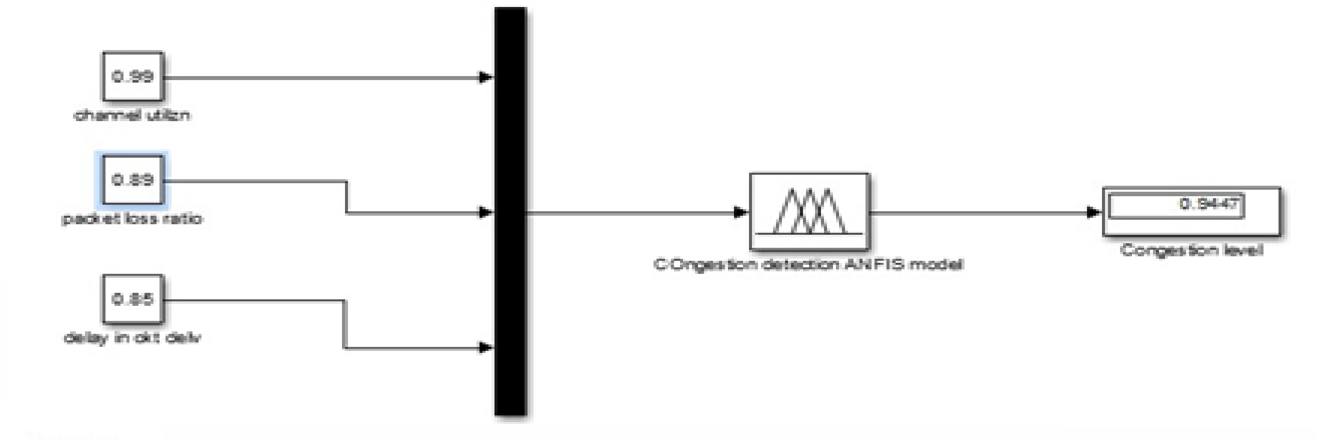

Fig.6. Simulink implementation of ANFIS model

7. SIMULATION RESULTS

A mobility model is generated using SUMO as shown in Fig.4 and this mobility model is integrated with NS2 simulator.

NS2 is an open source network simulator. It uses C++ and OTcl languages for simulation of network. Channel utilization, rate of packet loss, and delay in packet delivery values are estimated from the generated mobility model. The proposed ANFIS model is designed using MATLAB 14. It takes these inputs and generates the congestion level. The VANET simulation parameters are noted in Table 2. The ANFIS model to determine congestion level uses fifty experimental values corresponding to channel utilization, rate of packet loss and delay in packet delivery for training the ANFIS model. Twenty five corresponding values are used for testing the ANFIS model.

Twenty five more values of channel utilization, rate of packet loss and delay in packet delivery are used to get result for congestion level. Experimental threshold value for congestion level is set to 0.6. The Fig.5 shows the ANFIS structure to determine congestion level. The Fig.6 shows the Simulink implementation of ANFIS model.

Table 2. Simulation Parameters for NS2

Parameters	Values
Simulator	NS2
Simulation Time	50s
Traffic Type	CBR
No of Vehicles	10
No of streets	3
No of Stationary Nodes	5

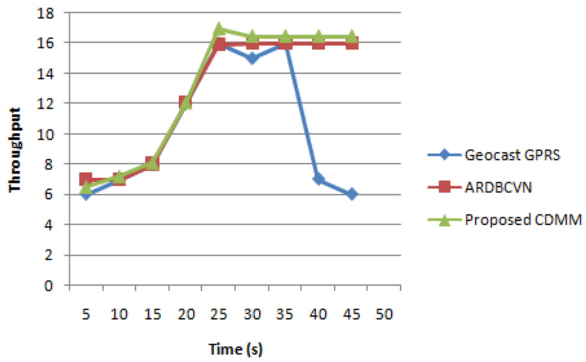

Fig.7. Comparison of CDMM with Geo cast GPRS and ARDBCVN

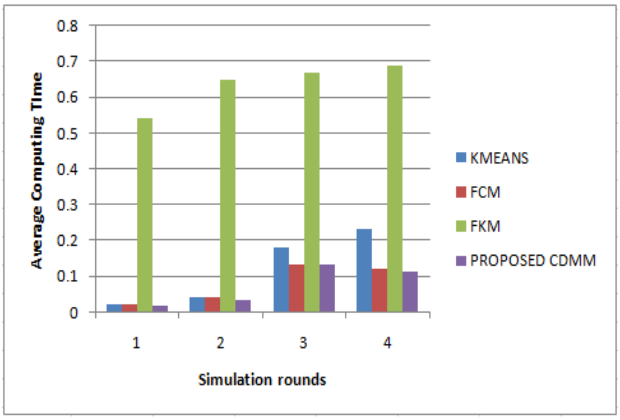

Fig.8. Comparison of Average computing time of CDMM with Other Techniques

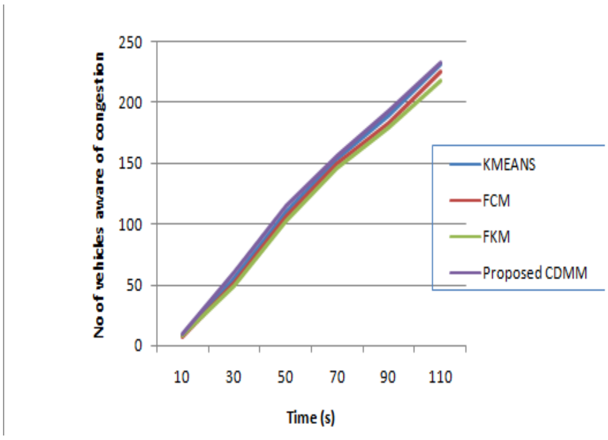

Fig.9. Number of vehicles awareness of congestion vs. Time(s)

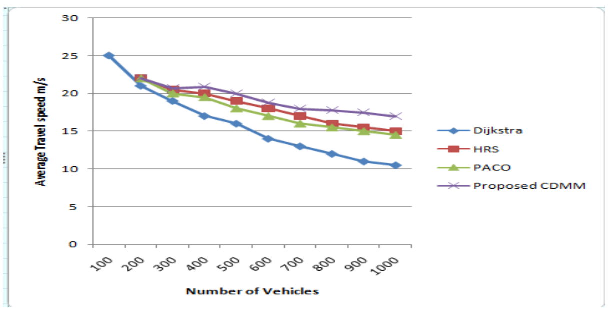

Fig.10. Number of vehicles vs. Average Travel Speed (m/s)

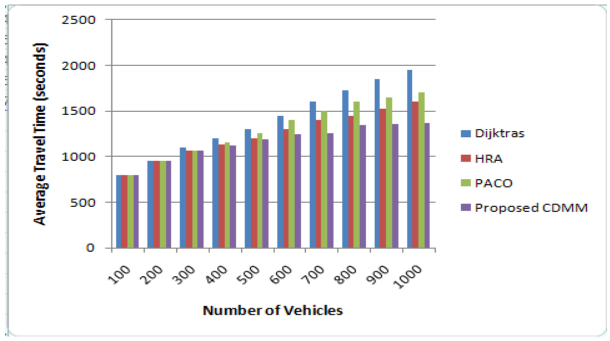

Fig.11. Number of vehicles vs. Average Travel Time (s)

8. CONCLUSION

The primary goal of VANETs is to provide a safe and comfortable journey.

Automatic traffic control is one of the issues of VANETs.For this automatic traffic control, high intensity of vehicles on a particular road due to some accidental or natural condition should be resolved immediately and provide a smooth running of vehicles. The paper proposes a Congestion Detection Based Mobility Model (CDMM) that frequently monitors, rate of channel utilization, rate of packet loss and delay in packet delivery to determine congestion by using an ANFIS model. As soon as congestion seems to occur, the base station transmits an alarm message to all vehicles approaching towards the congested path. The current location of all vehicles in the coverage area those are approaching towards congestion are tracked and an alternate path to the destination is suggested from the current location. This suggested alternate path has been tested to be congestion free and optimal one. The proposed mobility model may save the precious time of travelers which can be invested in other productive activities. This work may be further enhanced in future to take into consideration different types of road conditions, heavy snowfall in hilly areas causing road blockages etc. so as to find alternate routes to divert the approaching vehicles.

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