An Efficient Algorithm to Reduce the Broadcast Storm in VANETS

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Summary
VANET (vehicular ad hoc network) refers to the case networks designed for vehicles. Such networks are established among the vehicles which are equipped with communication tools. Within these networks, vehicles are regarded as the network nodes. On time and on schedule transmission of data is of high significance for these networks. In order to accomplish the objective of on-time data transmission, specific electronic equipment is embedded in each vehicle which maintains ad hoc communications among the passengers. Information about traffic, road signs and on-line observation of traffic status can be transmitted via these networks; such data makes it possible for the driver to select the best route to reach his destination. If there are not any infrastructures, two broadcasting approaches can be considered: overflowing and rebroadcasting. The overflowing approach leads to heavy traffic. Hence, the challenge we face is to avoid the broadcasting flood. In this paper, an approach for the management of the broadcasting flood is proposed based on fuzzy theory. The proposed method is assumed to have better performance and efficiency than any other approaches in terms of crash rate, the rate of message success and delay

Keywords:
Broadcast, fuzzy theory, infrastructures, traffic, vehicular ad hoc network.

1. Introduction

VANET is considered to be the case vehicular network which is established among the vehicles which are equipped with means of communication. Since each vehicle plays the role of a node in these networks, each node can be regarded as the source of data, destination for data and network router. VANET can be considered as an efficient tool for improving and enhancing the safety of roads. That is, alarming messages are transmitted among the vehicles which are present in the network to inform them about the possible traffic barriers on their way [1]. Hence, it can be contended that data transmitting in VANET has a remarkable security function [3]. In these networks, the vehicles equipped with the required tools are able to establish specific short-range communications (DSRC1) with each other on the frequency of 5/9 GHZ. This special short-range communication which has a range of 1000 meters establishes high speed communication for intelligent transport applications (ITS2) among vehicles. It has been applied in the fields of public security, traffic management, broadcasting alarm messages and messages which indicate the presence of emergency vehicles in the surrounding area [1]. Case vehicular networks are divided into two areas: security functions like crash alarms and alarms about locations which are under construction. The second category of functions for these networks includes non-security functions such as functions about the traffic status and functions for convenience and comfort. Namely, in case there is a car crash on the highway, urgent data will be soon transmitted so that all the other vehicles on the highway which are in the danger can be informed about it. As mentioned above, the second category of functions is related to the controlling of the vehicular traffic. In this category, the advantage taken from VANET is to improve the efficiency of the traffic system [3]. Different scenarios or communication patterns should be considered with regard to data transferring in VANET. Replacement of nodes, very high density within the network, differential topology of the urban traffic jams and rural traffic and the need for the data about the speed of different vehicles moving on motorways have transformed VANET into a challenging and hard network.

With regard to the issue of data broadcasting in VANET, the vehicular network includes lots of data sources and data users and within the network each vehicle is regarded as both a data source and data user at the same time. A variety (2) of functions such traffic management and the analysis of different situations are considered for them. The main objective behind data broadcasting is to use the network resources to meet the informational needs of all the users as much as possible. Each vehicle which is

Manuscript received September 5, 2024
Manuscript revised September 20, 2024
https://doi.org/10.22937/IJCSNS.2024.24.9.19

involved in VANET produces periodical reports about the traffic status [3]. Data transferring among the vehicles depends upon the hypothetical architecture of the network. In case there are infrastructures and road-side units, two data broadcasting approaches can be employed: placement-based approach and inspection -based approach. In the former approach, data are broadcast to every vehicle. This approach is appropriate for public data. However, according to the latter approach, a method of question-answer is used which is appropriate for broadcasting special data [9]. If there are not any infrastructures, two other approaches can be used for data broadcasting: overflowing and rebroadcasting. The former approach produces the message about heavy traffic. Hence, the main challenge we encounter with in this approach is the broadcasting flood. Also, in the rebroadcasting approach, we deal with two challenges: 1.The choice of spots for rebroadcasting data and 2. The guarantee that the chosen nodes will be involved in rebroadcasting of data [5].

In this paper, an idea is proposed for reducing the broadcasting flood by means of fuzzy theory. The rest of the paper is organized as follows: 1- subsection 2 concerns with the related literature review. Subsection 3 introduces the algorithm used for reducing the broadcasting flood. Subsection 4 reports the analysis of the experiments by the existing nodes and finally subsection 5 discusses the findings and concludes the study

2. Related Works

Various ways for avoiding the problem of broadcast storm. Overflow is an approach which can be used for data transmission in the case networks of vehicle in which there is not any backup infrastructure for communication. Due to the shared wireless medium, the overflow of the packets of data makes the contention and frequent collisions between adjacent nodes and this issue is called broadcast storm. There are two approaches which can address this issue:

Simple transferring which is limited to the timing and number of steps

Transferring based on the geographical map which uses the geographical information or map such as overflow and directional integration [1]. The approach based on timer via simple transmission method

The multiple protocols reduces the broadcasting surfeit and excesses since it assigns a shorter wait time before it rebroadcasts data to more distant receivers. The main objective of the multiple protocols is to achieve the maximal accessibility of data in the network [7].

Each vehicle holds an N series of neighbors and constantly updates it by means of the reports received from the data connection layer. Also, each vehicle relates the S series to the alarm message. Each time the system receives a message from the sender, it adds the identity of the sender to S. when the first message is received, S is started by means of the related sender and the system goes into one of these conditions:

Waiting for a second transmission and

Waiting for the neighbor.

If $N \backslash S \neq o$ ،the system will have neighbors other than the transmitter of the message and the receiver should go into the waiting condition for another transmission [4]. It is presupposed that the headline of the message includes the status and situation of the transmitter and the system which is aware of its own situation determines the wait time (WT) on the basis of the distance between d and transmitter so that the wait time for distant receivers is shorter. As indicated in Formula 1,

$$WT(d) = -\frac{MaxWT}{Rang} * \hat{d} + MaxWT \quad (1)$$

$$\hat{d} = Min\{d, Range\} \quad (2)$$

MAX WT : denotes the maximum waiting time,

Range: denotes the transmitting range and extent and

D: denotes the distance from the transmitter

It is clear that immediate transmission will result in heavy traffic in the channel. Thus, an attempt is made to force the receivers to go into the waiting state so that the traffic load would be relieved. When the system waits for the next transmission of the message, it will update the S and N series [4].

If N/S=0, hence, there will be not any new receivers in the short distance and the system will go into the waiting state for the neighbor. In this state, the system waits so that updating of N will happen and hence 0≠N\S. Then, the system will send the message [4]. Lee et al [10] have proposed a rebroadcasting protocol which is called efficient directional broadcasting (EDB)via directional antennas for urban VANET . When a vehicle carries out the broadcasting operation on motorways, only the receiver in the longest distance has the responsibility of rebroadcasting the message in the opposite direction. With respect to the topology of the VANET networks which is constantly changing, EDB makes decisions based on receivers to rebroadcast the packets with the aid of GPS. The receiver only has the responsibility of sending the packets in a direction opposite to the received direction . Having received a packet successfully, it waits for a while before it decides to rebroadcast it or not to rebroadcast it. At the meanwhile, the vehicle listens to the other relays of the same packet. The waiting time can be calculated through the following formula (3):

$$\text{Waiting Time} = \left(1 - \frac{D}{R}\right) * \text{maxWT} \qquad (3)$$

In this formula D stands for the distance from the transmitter which can be computed by means of the information about the transmitter's location which is included in the packet. R denotes the transmission range and extent. MAXWT is an adjustable parameter which can be adjusted with regard to the density of vehicles. In this EB algorithm, clustering is used to solve the problem of broadcasting flood in two-way motorways. This idea was proposed in two phases. In each phase, the operation of selecting the cluster head is carried out by the cluster head itself. In the setup phase, the nodes of the cluster head on both sides of the road are selected based on speed. In the steady state phase, a cluster head is selected in each route by the cluster head node on the basis of the best criterion.

In each route, at any time, a cluster is formed and the nodes of the cluster head have the responsibility of managing the cluster. Each cluster will cover the lines of both routes, hence, the created packet will be transferred by the vehicle of the opposite direction which is moving at a high speed. After the formation of the cluster, the cluster head broadcasts the alarm message to all the members of the cluster. After receiving the alarm message, the nodes which are in the same direction as that of the cluster head send their own information to the cluster head to determine the next cluster head but the nodes which are not in the same direction as that of the cluster head receive the alarm message but they do not give any response to it. Gradually, clusters increase the distance between one and another. On the whole, only the cluster head node carries out the rebroadcasting operation. As a result, broadcasting flood is delivered and controlled by means of the distributed management [13]. The proposed method (Cluster-Based Efficient Broadcast) that has high efficiency and do better in contrast in propagation speed and propagated messages rate and finally it can prevent the occurrence of broadcast storm. The main idea of this method is using three parameters: rebroadcast possibility (Pij), Vehicle speed (V) and receiving order of messages by nodes. In the proposed algorithm all vehicles are equipped with GPS receiver and are aware of their position. Also the road is considered as bilateral and the algorithm runs on roads are unilateral. When an accident occurs, the accidental vehicle broadcasts a message in its broadcast area which includes a vehicle ID and also the situation where the accident was occurred. In Slotted p-Persistence Broadcasting Algorithm (SPB) [11] upon receiving a ESM a vehicle checks the ESM ID and rebroadcasts with the predetermined probability 'p' at the assigned time slot, if it receives the ESM for the first time and has not received any duplicates before its assigned time slot; otherwise it discards the ESM.

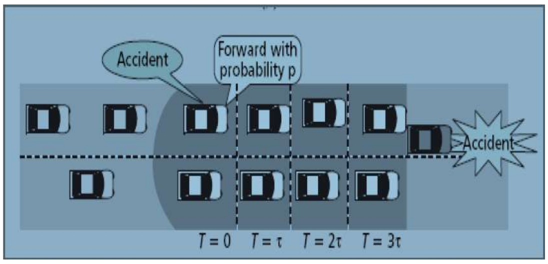

Fig.1. Slotted p-Persistence Broadcasting [11]

The drawback of both these schemes are: In dense scenario, multiple vehicles may rebroadcast the message simultaneously and causes severe collisions. In sparse network scenario it increases the waiting time [12]. Autonomic Dissemination Method (ADM) protocol delivers messages according to the message priority and network density levels. This scheme is based on (i) an offline optimization process and (ii) an online adaptation to the network characteristics. ADM allows each vehicle to dynamically adapt its broadcasting strategy with respect to the network density and priority of the message to send: ADM assigns high priority to emergency messages, medium-priority to road traffic messages and low-priority to comfort messages. This algorithm increases the efficiency of the broadcast process in terms of message delivery ratio, latency and interferences reduction and improves the robustness of protocols. In summary, the reviewed BSSAs use different methodologies to tackle BSPs. However, most of them rely upon GPS information alone to identify the farthest node(s). This poses severe drawback as GSP information may or may not be available and also may or may not be accurate.

This motivates to compare the reviewed BSSAs based upon certain qualitative abilities that could help to identify the issues and challenges with respect to identifying the next rebroadcasting node. This would motivate for an efficient BSSA that could possibly identify the best possible farthest node.

3. Proposed Method

In this paper, a new algorithm presented based on fuzzy logic for data dissemination to cover the weaknesses that previously proposed methods have been proposed. The criteria for selecting the vehicle is intended for broadcast as follows:

a) Vehicle that is farther away than the current cluster head more likely to be chosen as the next broadcasting vehicle and the Possibility is calculated as follows: Pi, j = Di, j / R [6]
b) The vehicle that its velocity is more, with more Possibility selected as the next broadcasting vehicle (Vij)

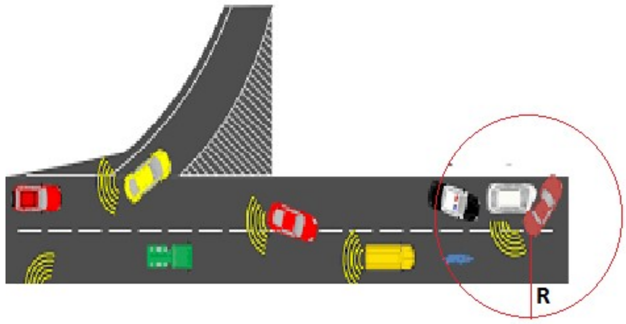

Figure 2. radio range of message diffusion

All of local connection states are stored locally on the state table. The application will perform fuzzy computation to select the right vehicle for broadcasting.
The parameters used in the algorithm are defined as follows:
Distance =, Dc ... Da, D b that is obtained for the above parameters
Velocity= Va, Vb, Vc,…
Da: distance of the vehicle A from broadcasting vehicle
Va: vehicle a speed

The proposed algorithm consists of two phases: Setup Phase and Steady-state Phase and both phases are explained in detail in the following:

Phase Setup:
Every vehicle that passes crash creates a cluster with the radius of its radio range. Crashed vehicle assumed as base station. Warning messages sent by the base station to all vehicles placed member of the cluster. Inside cluster vehicles that get this message, a response message is sent to the base station. The reply message contains ID and speed and direction of movement of the vehicle. The base station, according to the direction of movement of vehicles, is divided into two categories, and for each category of vehicles, the cluster head with more speed is selected. Cluster head is the same as broadcasting vehicle.

3.1 Steady-state Phase:

The rebroadcasting warning messages were started after the setup stage that cluster heads were determined. To accelerate the broadcasting of warning messages, new cluster heads were proposed. This phase will consist of several rounds. In each period a new cluster head are chosen. Rebroadcast will be continued by the current cluster head until the next cluster head is set. So it may be varied at any time the number of Replay times by a cluster head. In this phase, cluster head selection is carried out and distributed and it is based on fuzzy theory and it is done as following

3.2 Fuzzy Choose a vehicle for the broadcast phase:

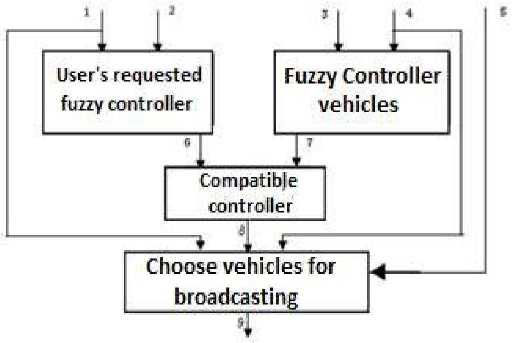

Fig.3. Controller structure of fuzzy

1. The required distance, 2.the required speed, 3 distance obtained by vehicle for broadcast, 4 speed obtained by the vehicle for broadcast, 5. The cost of the vehicle selection for broadcast 6. Result of fuzzy request, 7 vehicle modes for fuzzy broadcast, -8 fuzzy matching degrees, 9. Vehicle selected for broadcasting.

In the latter case, the 9 specifies that one vehicle among several vehicles is suitable for an application request. To dynamically changing network topology, controlling in an uncertain and non-implicit environment is estimated. Fuzzy logic as we know (*Pedrycz and Gomide, 1998*) has been proposed for solving obscure questions.

In this paper, the fuzzy controller is designed as shown in Figure 3. It contains three fuzzy controllers, and a selection of nodes model: Functional Requirements for fuzzy processing, fuzzy processing of selected vehicle parameters. Fuzzy coordination between the outputs 6 and 7, choose Nodes.

Fuzzy membership functions that can be used to solve problems are of two types. Triangular (x, a, m, b) and trapezoidal (x, a, m, n, b)

$$
\text{tri}(x;\, a, m, b) = \begin{cases} 0, x \le a \\ \dfrac{x-a}{m-a}, x \in (a, m] & a \ne m \\ 0, a = m \\ \dfrac{b-x}{b-m}, x \in [m, b) & b \ne m \\ 0, b = m \\ 0, x \ge b \end{cases}
$$

Fig.4. Fuzzy triangular membership function

$$
\text{trap}(x;\, a, m, n, b) = \begin{cases} 0, x \le a \\ \dfrac{x-a}{m-a}, x \in (a, m) \\ 1, x \in [m, n] \\ \dfrac{b-x}{b-n}, x \in (n, b) & b \ne n \\ 1, b = n \\ 0, x \ge b \end{cases}
$$

Fig.5. Fuzzy trapezoidal membership function

Fuzzy Logic Controller for Application request

In this case, the required distance and speed of application are the input variables[8]. Output is the result of fuzzy request according to linguistic rules. Controller design has two concepts. A fuzzy mapping of input variables and functions of their membership and the other is defined by the fuzzy rules.

According to the experience, distance request is divided into five classes: more low, low, and medium, high, higher. These fuzzy sets {R1, R2, R3, R4, R5} are shown in Table respectively.

Membership functions for distance request graphically shown in Figure 4. Figure 5 shows graphically the representation of the membership function for speed. Fuzzy rules among connoisseurs and experiences or other general rules were chosen. According to the rules, there is not enough research applications in vanet of fuzzy set .The use of rules depends on hard experience. So we generalize the theory of fuzzy rules we use to estimate.[15]

Description:

For Fuzzy decision for requirements to set factors that are:

F= { D is distance and (V) vehicles distance }

The evaluation set:

C = {(c5) less, (c4) low, (c3) average, (c2) high, (c1) more}

If the assessment Fi (i = 1, 2) can be equal to Ci fuzzy decision making matrix R (C1, C2) to be formed To show the effect of each parameter in the evaluation of fuzzy sets A = (A1P, A2) is used. A1 and A2 efficacy are required to determine the effect of speed. Here, if the operators are the result of triangular law will be evaluated as follows.

$$bi = \sum(ai * rij)(j=1,\ldots,m) \quad (4)$$

So that $B = A * R$ (5)

$$bi = \sum(ai * rij)(j=1,\ldots,m) \quad (6)$$

According to the general, the maximum value of the exact distance and speed required to return the corresponding fuzzy sets are required for example when requested distance is R1 and speed is S.

$$R = \begin{bmatrix} 0 & 0 & 0 & 0.2 & 0.8 \\ 0.9 & 0.1 & 0 & 0 & 0 \end{bmatrix}$$

A = (0.4, 0.6)

B= (0.54, 0.06, 0, 0.08, 0.32)

This means that Decision requirement sets, {R1, S} is the same method in all the language's rules as shown in Table 1.

Table 1: Fuzzy sets of distance

Fuzzy set	Function parameters
R1	[0,0,300]
R2	[200,400,600,800]
R3	[600,800,1000,1200]
R4	[1000,1200,1400,1600]
R5	[1400,1600,1800,2000]

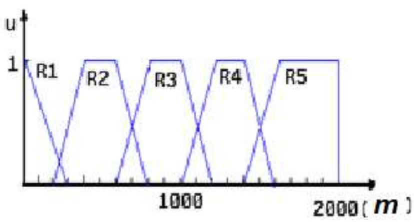

Fig.6. membership function of distance

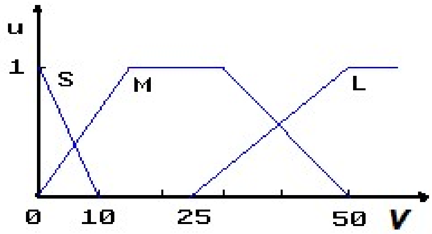

Fig.7. Membership function of velocity

Table 2: linguistic rules of fuzzy controller of application request

RB/D	R1	R2	R3	R4	R5
S	high	high	high	high	high
M	Average	Average	Average	Average	Average
L	lesser	lesser	Average	very	high

3.2.2 Broadcasting vehicle Fuzzy controller:

The controller will be responsible for processing the discovery phase and its structure is similar to the fuzzy traffic controller.[14] The difference is in input and output variables, input variables here are distance and speed.

3.2.3 Conformity controller

Control rules are based on the Conformity degree between fuzzy request results and question and result of selected state in the vehicle for fuzzy broadcast.

$$MD = \begin{cases} 1, & \text{Broadcast mode for the vehicle} \\ 0, & \text{Other wise} \end{cases}$$

If MD = 1 choice of a vehicle for broadcast is suitable otherwise it is invalid.

d) Choose a broadcasting vehicle

Among all the appropriate vehicles for broadcasting, the vehicle that is issued by an algorithm is selected. This algorithm will be as follows:

If the distance of broadcasting vehicle is greater than or equal to requested distance, program goes on to step 2. Otherwise, the program goes to the step 4.

If there are two or more vehicles with condition 1, the costs and a vehicle will be compared. The reduced costs will be selected. Then, the program goes to Step 3. Otherwise, the only available vehicle which satisfies the requirements will be selected as the result. If the vehicle has not been defined, the conditions this vehicle question cannot be accepted.

4. Conclusion

In this article, we evaluated some algorithms which reduce traffic storm and accordingly an optimization algorithm was proposed. This algorithm is based on fuzzy theory. This method consists of two phases. The first phase concerns with the vehicle selection to broadcast. The second phase concerns with the process of selecting vehicles for broadcasting which is based on the fuzzy controller. This algorithm is used for speed and distance parameters in order to determine the broadcasting vehicle which makes the perfect vehicle be selected for broadcasting.

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