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Congestion Control in Vehicular Ad Hoc Networks (VANET) Using Meta-Heuristic Techniques

K.Ravikumar [1], T.Vishvaroobi [2]
Assistant Professor [1], Research Scholar [2]
Department of Computer Science
Tamil University, Thanjavur – 613010
Tamil Nadu – India

ABSTRACT

In VANET, various boundaries such as high flexibility, in elevation rate of topology changes, restriction of bandwidth, etc., play an important role for reducing presentation in these networks. Qualities of Service policies have been used to recover the presentation of VANET. One of the important parameters in Quality of Service is Congestion Controller. The congestion control is used to ensure safe and reliable announcement architecture. Three types of approaches are available for congestion control which consists of broadcast power control, packet broadcast frequently control and packet period. Heuristic techniques can be used to define heuristic rules and finding possible and good enough solution to some glitches in reasonable time. According to heuristic's welfares, we are motivated to use these methods in congestion control to generate efficient VANET. This work is aimed to improve congestion control with heuristic techniques to reduce the traffic announcement channels while considering reliability supplies of submissions in VANETs. The simulation results have established that meta-heuristic techniques features significantly better presentation in terms of packet loss, throughput and delay associated with other blocking control procedure within VANETs.

Keywords:-Vehicular Ad hoc Networks (VANETs), Congestion Control, Quality of Service (QoS), Transmission Power, Transmission Rate, Meta-heuristic, Tabu search.

I. INTRODUCTION

Vehicular Ad hoc Networks (VANETs) are presented as a wireless announcement technology in transference system. VANETs are calculated to improve roadway protection and traffic efficiency that are diminished road dangers for drivers, customers and ramblers. Communication in VANET can be established among nearby automobiles or between vehicles and infrastructures that are called Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) infrastructures, respectively. V2V communications take place among On-Board Units (OBUs) that each vehicle is equipped with one OBU, and V2I infrastructures occur amongst Road - Side Units (RSUs) and OBUs, as shown in Figure 1. VANETs can be applied for safety applications like security on the roads, and non-safety requests such as traffic optimization, infotainment, parking organization and toll payment.

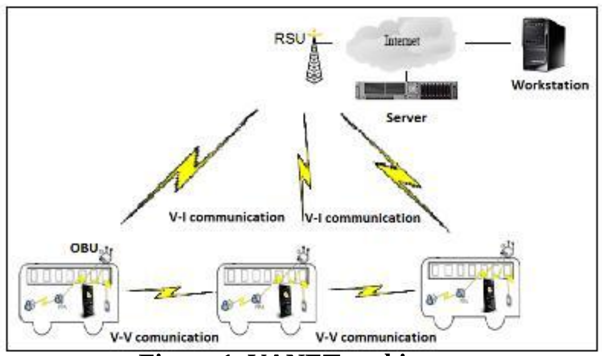

Figure 1. VANET architecture

VANETs are characterized by high flexibility, high rate of topology fluctuations and high variability in node density. These physiognomies lead to some challenges in direction-finding, scalability, data distribution, security and totally cause performance discount in VANET. Qualities of Service (QoS) policies have been used to recover the performance of VANET [1, 2]. One of the important operations for enhancing QoS parameters, such asdependability and delay, is congestion control in the networks. In other words, the mobbing control is used to ensure safe and reliable announcement without delay.

Due to energetically topology change and frequently direction break, controlling the congestion must be done with dispersed and self-organized methods. Some of proposed congestion control strategies in VANET compose of broadcast power, broadcast rate and prioritized messages scheduling. In each strategy, many limitations, such as message incidence, packet size, vehicle density, and so on must be considered in VANET environments, that increases number and time of calculation for controlling congestion [3].

The main objective of this paper is to design an efficient overcrowding control strategy to reduce the traffic announcement channels while considering dependability requirements of submissions in VANETs. More specifically, this paper suggests a suitable method to control broadcast rate and transmission range for announcement channels. It is structured as follows. The related attempts is introduced; the projected method is explained; the competence of this method is studied and finally, in accomplishes.

II. RELATED WORKS

Meta-heuristic methods can be used to find high excellence solution in sensible time for this kind of problems. According to these benefits of meta-heuristics, we are interested to use these techniques for regulatory congestion and for making efficient VANET [4]. We propose a meta-heuristic method based on Tabu search algorithm to solve the problem of controlling congestion in VANETs. We select this technique due to Tabu search thoughtfully continued the search until obtain a near optimum solution; it also avoids tricking in local smallest, has much simpler concepts than other meta-heuristic algorithms and is more general for solving optimization problems.

One of the main aspects of VANETs is to uphold the productivity system operation and to increase the wireless channel announcement reliability. The congestion control methods were considered to control channel load and to upsurge the performance of wireless channels. There have been three mobbing control strategies in VANET which are collected of: a) broadcast power control that control range of broadcast in channels, b) broadcast rate that control the rate of packets, and c) scheduling messages in various channels based on their urgencies. In this section, we present some procedures belonging to these approaches.

Proposed the technique [5] which is modified transmission rate based on obtainable bandwidth. Priority is assigned to each packet according to utility and size of packets. The assessed priorities were then used to control transmission rate. Neighbor nodes need to conversation their context information together for distribution available bandwidth that generates a high message overhead in the system.

In presented a new approach that baptized Fair Power Adjustment for Vehicular environment (FPAV) algorithm. FPAV is focused on the control communications which includes beacons and safety-driven messages. Beacons broadcast periodically information packets amongst nodes, while safety-driven messages communicate some packets when an event occurs in the VANET. This algorithm limits the load of beacons and provides broadcast power based on the compactness of vehicles in environment which makes communication overhead. Also, FPAV reserves a wedge of bandwidth for event-driven communications that wastes the bandwidth in normal operation of VANET.

Distributed-FPAV (D-FPAV) was planned to solve some disadvantages of FPAV. D-FPAV controls broadcast range for the control messages animatedly. On the other word, D-FPAV decreases the range of beacon messages in overcrowding situations that is caused smaller probability of getting beacons in far distances [7].

Another method to control congestion was found by M. Torrent-Moreno et al. [8], that has used the max-min mode for handling broadcast power. The main substances of this approach are to increase the rate of message delivering and to decrease the delay of emergency messages. However, topology of network and physical information of nodes need to be working in the algorithm in order to achieve the substances.

Some approaches suggested for regulating safety messages, beacons and event-driven communications, based on their utilities. For instance, M. Bouassida et al. [9] suggested a dispersed congestion control that animatedly schedule packets in different channels based on their dedicated priorities. Some packet priority decisive factors are packet age, distance to an event, vehicle speed, the new area covered by a (re)transmission and message validity. The purpose of this approach is to guarantee that packets with high priority are sent without delay while other packets with low urgencies will be postponement. This research showed that can improve the performance of VANETs. However, this method operates in the same way for all safety communications and does not separate these communications to beacons and event-driven. As mentioned, the event -driven communications are more important than beacon messages and must be delivered with high dependability and on time. Also, delay of event-driven messages in the worse scenario is 50 ms that it is critical because safety communications need to distribute between national nodes within 20 Ms.

3. Proposed method

In order to satisfy dependability requirements in VANET applications, efficient bottleneck controls need to be designed. The use of meta-heuristic techniques leads to acceptable solutions with less time and cost. This paper is aimed to combine these meta-heuristic algorithms with congestion control approaches to improve the use of communication channels and enhance reliability in VANET applications. For tuning channel overcrowding in VANET communications, several limitations can effectively serve as mainly metrics.

These parameters are composed of broadcast rate, transmission range, packet size, vehicle thickness, vehicle velocity, number of lanes and communication frequency that are demonstrated in Figure 2. When the number of parameters increases, the amount and time of scheming would be too high. Therefore, due to the difficulty of procurement an optimal value for transmission rate and range in sensible time, this problem can be measured as an NP-hard problem. Meta-heuristic algorithms are general techniques to find an optimal solution in sensible time for NP-hard difficulties. The main algorithms of these techniques consist of Tabu Search (TS), Ant Colony (AC), Simulated Annealing (SA), Genetic Algorithm (GA), Mimetic Algorithm (MA), etc. [4]. In order to solve any problem with these algorithms, at first, encoding solution based on typical procedure, generating initial solution, and important conclusion condition should be considered. Then, the operation of producing the neighborhood solutions will be determined. Hence, we aim at obtaining broadcast rate and range via meta-heuristic procedures for satisfying dependability in VANET. Our proposed bottleneck control scheme consists of three phases:

i. **Make parameter combinations**: In the first step, dissimilar combinations of effective broadcast parameters are made by meta-heuristic measures. Values of these parameters are designated between illustrative values of defined standards for VANET.
ii. **Compare combinations**: In next step, these procedures must compare performance of different combinations fairly.
iii. **Select best combination**: Finally, meta-heuristic algorithms select optimal amalgamation with high performance. Criteria for choosing best combination are the most significant part that makes the conclusion condition for meta-heuristic algorithms. According to the main impartial of this research, the standard is lowest delay for bringing safety infrastructures.

In proposed approach, two units are considered for detecting and monitoring congestion, based on close-loop strategies for controlling bottleneck in networks [13]. Congestion circumstances are diagnosed within the announcement channels, in detection unit. Congestion discovery methods in VANET environments are self-possessed of event -driven and dimension methods. Event-driven methods are considered to be based on safety messages, particularly event-driven messages. Whenever one node detects event-driven letters, it considers the congested situation and directly controls the congestion to guarantee the bringing these safety messages. On the other hand, with dimension based methods, each node senses the channel to gain some restrictions such as channel usage level, number of communications queue and channel tenancy time. If the values of these restrictions are more than the predefined threshold, node detects the bottleneck in the communication channel [14]. In the proposed method, we consider channel usage level as the congestion detection parameter. Each node periodically senses the station and whenever the frequency usage is more than beginning 70% [15], it is considered overcrowding situation.

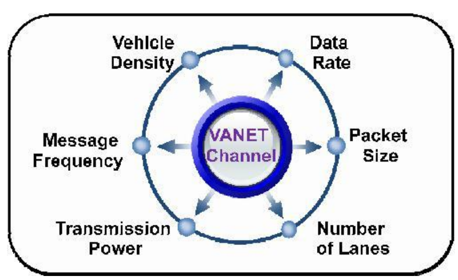

Figure 2. Influential parameters of VANET channel

In planned approach, two units are designed for noticing and controlling congestion, based on close-loop strategies for controlling congestion in networks [13]. Congestion circumstances are diagnosed within the announcement channels, in detection unit. Congestion detection methods in VANET surroundings are composed of event -driven and dimension methods. Event-driven methods are considered to be based on safety messages, especially event-driven messages. Whenever one node detect event-driven messages, it considers congested situation and immediately control the bottleneck to guarantee the delivering of these safety messages. On the other hand, dimension based methods, each node senses the channel to gain some parameters such as channel usage level, number of messages queue and channel habitation time.

If the values of these restrictions are more than the predefined threshold, node distinguishes the congestion in the communication channel [14]. In the proposed method, we consider channel usage level as the bottleneck detection parameter. Each node periodically senses the channel and every time the channel usage is more than beginning 70% [15], it is measured congestion situation.Controlling unit uses Tabu search procedure for tuning the transmission range and rate to control bottleneck, so that the operations of Tabu search will be discussed later. Based on the optimal explanation provided by Tabu search, the optimum transmission rate and range are set for message channel. The flowchart of Figure 3 illustrates the units of planned congestion control approach.

To find a near-optimal answer, the Tabu search must be adapted and new operations must also be clear based on our problem. First, the planned Tabu search has to generate initial solution with the present state of VANET. The present solution obtains influential parameters of VANET channel that are stated before. The initial solution develops as a best solution that is included of best delay, broadcast range and transmission rate. We insert best answers into Tabu list for avoiding of repeated solutions. Whenever the Tabu list is full, the oldest answer is removed as the new explanation is added. Neighborhood operations in proposed Tabu search generates exchange the values of each parameter between predefined limitations for each parameter that are acceptable in VANET standards. The cost meaning that we use for generate new answers is based on minimum delay that means we careful the one-objective Tabu search. The appendix contains a detailed analytical model of end-to-end delay in IEEE 802.11p-based VANET that we used as objective function. In each repetition, the candidate solutions are attained from the neighborhood solutions and the Tabu list. The best solution is selected based on smallest delay and then additional in the Tabu list. The pseudo code for Tabu search procedure in each node is presented in Figure 4.

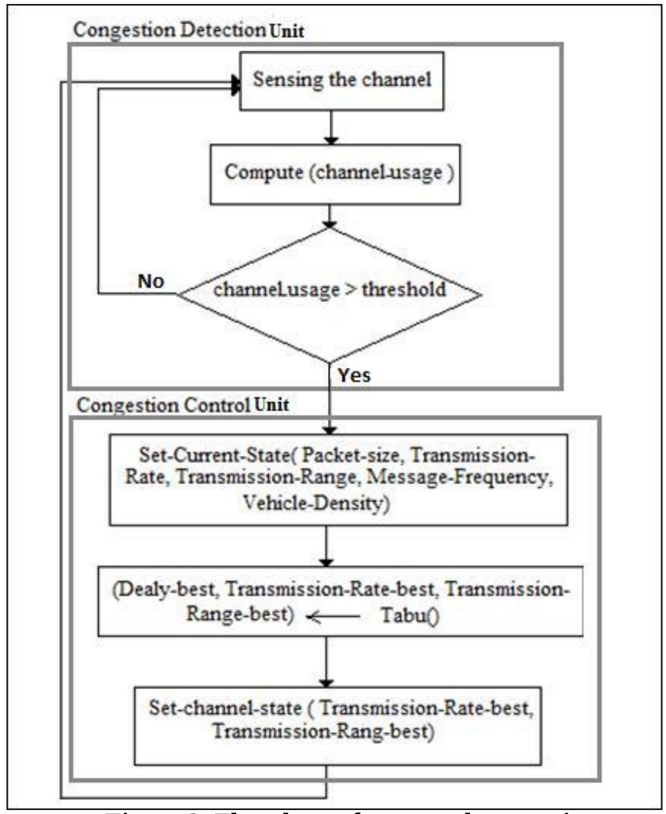

Figure 3. Flowchart of proposed congestion control approach

Input:

- Max Size of Tabu List
- Number of Iteration

Output:

S_{best} (Delay-best, transmission-rate-best, transmission-range-best)

1. $S_0 \leftarrow$ genInitSolution() // current delay based on current situation of node
2. $S_{best} \leftarrow S_0$
3. inserTabuList(S_{best})
4. $i \leftarrow 0$
5. while (i < Iteration) do
6. N(s) ← Identify (Neighborhood set)

// Changing the value of parameters between the predefined boundaries
7. T(s) ← Identify (Tabu set) // Tabu List
8. CandidateList(s) ← N(s) – T (s)
9. while (! empty (CandidateList(s)))
if (Delay($S_{candidate}$) < Delay $_{best}$)
S best ← S candidate
10. break;
11. End if
12. End while
// Update-Tabu-List
13. if (LengthTabu List < MaxSizeTabuList)
14. Add S_{best} to TabuList
15. else
16. Delete the oldest item in TabuList
17. Add S_{best} to TabuList
18. End while
19. Return(S_{best})

Figure 4. Pseudo code of Tabu search algorithm in proposed approach

IV. SIMULATION AND PERFORMANCE ANALYSIS

we evaluate the presentation of my proposed Tabu Search bottleneck control algorithm associating with the CSMA/CA that is MAC technique of IEEE 802.11p standard [16] and D-FPAV [7]. We considered a highway scenario with 6 lanes simulated with network simulator NS2Table 1 shows the limitations used in the reproduction. The criteria which are careful in this evaluation are as follows:

Delay: In this criterion, we appear to the required time amongst to deliver a packet from the source to the terminus.

***The number of packet losses*:** The amount of packet losses is a suitable criterion to estimate the system's performance.

Throughput: Average throughput measures of the regular rate of messages conveyed over a communication channel in a simulation time.

In Figure 5, we study the standard of delay in delivering the data packet associating the network's density. It can perceptibly be seen that as the amount of the nodes in the network upsurges, the Tabu bottleneck control protocol has the lesser delay because in this protocol every vehicle with tuning the broadcast rate and range can decrease the delay when the network is congested. That means, with regulating transmission rate and range, we can reduction the packet losses and therefore the number of retransmissions, hence delay for transporting the packets to terminus reduce. In the two other protocols, a criterion delay is unavoidable, because of the needed time to process. But, D-FPAV just attends to beacon messages and reduces the beaconing range for controlling bottleneck, that it is not enough in inundation situation in VANET, hence the delay is more than our Tabu Search overcrowding control algorithm. Also, due to earshot the channel before sending the packets, CSMA/CA augmented the contention window size in congested situation that outcomes more delay.

In Figure 6, we plot for the average amount of packet losses versus varying amount of vehicles for different congestion control algorithms. This plot shows the development when we use the Tabu search in our instrument compared other congestion control algorithms. Our proposed procedure with handling the broadcast rate and range, in congested condition, can control the channel and causes to decrease the number of package losses and therefore causes to improve the reliability in the system. Whereas, in D-FPAV and CSMA/CA, controlling bottleneck via controlling beaconing rate and back off technique respectively, number of packet losses is more than Tabu Search bottleneck control that we propose. Also, in Figure 6, we can see when the automobile density upsurges between 50 and 200, the number of packet losses differs from around 5000 to 20000. Based on this viewpoint, we can conclude, increasing the vehicle thickness do not have many effects on amount of packet losses in proposed algorithm compare with another procedure. Therefore, it shows that our distributed procedure is scalable.

Table 1. Configuration parameters in simulation

Parameters	**Value**
Total road length	2400(m)
Number of lanes	6 (3 in each direction)
Number of vehicles	50,80,100,120,150,200
Vehicles speed	80-120 (km/h)
Transmission range	15-1000 (m)
Transmission rate	3-27 (Mbps)
Contention window size	15-1023
Bandwidth	10 (MHz)
Safety message generation rate	10 (packet/s)
Mac type	802.11p
Propagation model	TwoRayGround
Simulation time	120(s)
Simulation runs	8

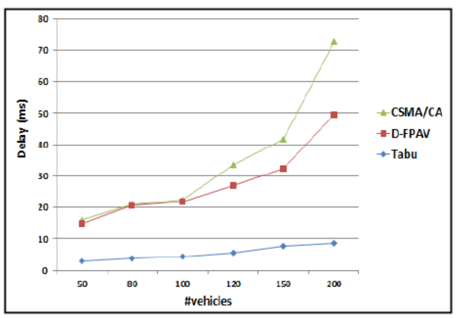

Figure 5. The average delay comparing the number ofvehicles in network

Figure 7 depicts the middling throughput as a function of the amount of vehicles for dissimilar congestion control procedures. This figure shows that the amount increases as the number of vehicles upsurges, due to, when the number of communicating nodes increases that leads to more transported packets. As well as, we find that the Tabu Search bottleneck control algorithm outperforms the other algorithms at all automobiles density.

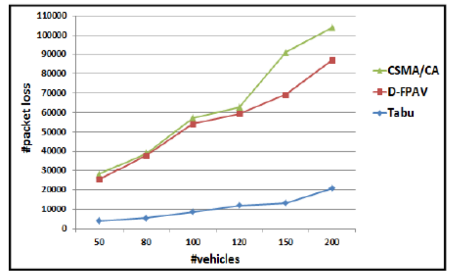

Figure 6. The number of packet losses comparing the number of vehicles in network

V. CONCLUSION AND FUTURE WORKS

In this paper, we considered the bottleneck control issues in VANET, and planned one congestion control procedure based on Tabu Search algorithm. Based on this dispersed algorithm, we control the transmission rate and range in vehicular networks that causes to improve presentation in these networks and increase dependability for safety applications. Also, the imitation results showed that tuning transmission range and broadcast rate via Tabu search can reduce delay and amount of packet losses. As well as, we conclude that at least 3.86% is enhanced the amount within VANETs when we control mobbing via Tabu Search instead of other congestion control procedures.In the future, we will suggest a multi-objective Tabu search procedure that consider delay, packet loss, and retransmission and jitter as functions in Tabu search procedure. Indeed, we are motivated to design a Tabu search algorithm for improving message preparation in the control and service channels based on predefined message priorities. The analysis for these developments will be established in the future.

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