Current Research on Congestion Control Schemes in VANET: A Practical Interpretation

Harjit Singh, Vijay Laxmi, Arun Malik, Isha Batra

Abstract: The change in lifestyle of human beings has increased the trend of purchasing multiple vehicles in same family. This has ultimately led to the hike in total number of on road moving vehicles. The prime concern including offering the best features to a vehicle is to offer a network that is non-congested even with this huge rise in vehicles. Therefore, a congestion control scheme is required in Vehicular ad hoc network (VANET) that ensures timely distribution of messages in the case of unusual activities or surprising events in network. Moreover, the congestion control scheme should also ensure that all the vehicles get correct information and will be able to access correct path in event of congestion. This research work focus on the existing controlling schemes for congestion in VANET. A detailed discussion is made initially on the existing schemes. Later, a comparative analysis is made on existing schemes by evaluating their performance on basis of computational overhead, latency and the throughput of packets. For simulating the network OMNeT++ is used along with SUMO. The results and discussions made at end help the novice to identify the best existing scheme for controlling the congestion in VANET.

Keywords : CITS, RSU, SUMO, VANET.

I. INTRODUCTION

Vehicular ad hoc network (VANET) is one of the specialized segments of Mobile ad hoc network (MANET) VANET contends to improve the vehicle networking by emphasizing on different facilities to be offered to the vehicles on the go. The vehicles moving on road ask for services like less congestion on road, safety related information, prediction of best path on the way [1]. Such type of smart applications is offered using Cooperative Intelligent Transport Systems (CITS). CITS tends to work in the direction that makes the journey smart for the vehicles. Considering the challenges of real-world including time and safety, one of the critical research areas in VANET is congestion control [2]. Congestion in the network is induced when the number of on road moving vehicles exceeds the actual competence of road. The major reason behind congestion is the dynamic topology and the

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varying speed and number of vehicles in VANET [3]. Therefore, a congestion control mechanism is required that will work in the situations of congestion on the road. Congestion Control works on offering equal number of resources to the vehicles moving on the road even in the situation of heavy traffic or congested roads. Resources in this context refer to either introducing an entirely new path to some vehicles or to alert the upcoming vehicles on the congested road segment about the congestion [4-6]. A scenario representing the different types of communication that can undergo in VANET scenario and the components for VANET are represented through Figure 1.
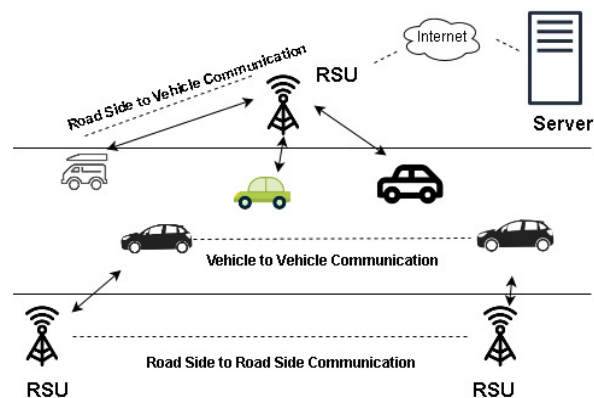

Figure 1: Components Required for Shaping VANET

As shown in Figure 1 above, components needed in operation of VANET include: Road Side Unit (RSU), Vehicles moving on the road are also part of VANET, and finally a centralized server is maintained at the back end where data is maintained after collecting from different RSUs on the road. Three types of communication is possible in VANET scenario namely (i) RSU to RSU, (ii) RSU to Vehicle and (iii) Vehicle and Vehicle. Therefore, information can be shared among RSU and vehicles in any way. Considering the congestion control mechanism to be opted on the road, whenever a vehicle feels congestion on the road it can notify it to the nearest vehicles as well as to the RSU to whom it is connected at that span of time. This information gets floated to all other vehicles on the road to notify them about the real situation of the congestion [7].

Messages that flow in the network are categorized in three: Data messages, Event based messages and the periodically generated messages. Data messages are the ones that carry the actual data from one end to another in VANET. Data can be the path information, the location of vehicle. Event based messages are the most critical ones in the mechanism of congestion control.

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These type of messages are used to carry the information related to any unusual event occurred in the network. Last category of messages is the periodical messages that are generated and distributed after a regular span of time to the adjacent vehicles or the RSU and vice versa. Without many any distinguish in message type, each type requires the security check to be imposed on it. Therefore, security requirements always exist in the VANET scenario to prove the validity of the data. Otherwise, data from an unreliable source can make the network even more worse [8]. The security requirements in VANET are applicable in different domains of communication. The various security requirements in VANET are mentioned below:

- **Authentication:** Whenever a new vehicle enters in the network it needs to first authenticate itself to the RSU. Reverse authentication is also expected from the RSU. Before sharing any information among the peer the vehicles must authenticate. Authentication ensures that the data is from the valid user.
- **Confidentiality of Data:** Data sent as either event messages or any other information must be secure. Authentication ensures that data is generated from valid user but no one else is able to look over the information in transition is ensured using the confidentiality security requirement of the network.
- **Integrity of Data:** Not only data look over but the data alteration is also a serious concern to handle. Data being shared among vehicles must not be altered by any intruder, otherwise that may lead to the false information flow in network. For example, wrong information that a particular road segment is free when actually it is not may cause more congestion on that road segment. Integrity ensures that data is not altered by any unusual means.

Organization of remaining sections of the paper is as follows. Section 2, focus on the work related to existing congestion related concepts and the schemes that are already available for controlling the congestion. Section 3, discusses the different schemes for controlling the congestion by specifying the details on how the congestion is controlled using them. In section 4, existing congestion controlling schemes are evaluated on the network simulator OMNeT++ and SUMO considering computational overhead, latency and throughput as parameters. Last section 5 concludes the whole work done and how this work can help the researchers for future projects.

II. RELATED WORK

The work carried out in this research paper, initially highlights the work related to the field of congestion control. Numerous congestion control schemes already exist in literature. This work identifies the potential of most of those schemes and along with highlights the other critical issue related to congestion. In [9] author has author has stated that the scheme required for controlling the congestion works on distributing the available resources to all the moving vehicles in the network. In case, resources available are limited a congestion scheme tries to fairly distribute among the vehicles. Congestion control is a challenging mechanism in VANET as the vehicle density, speed on the road changes frequently.

In [10] author categorized congestion control mechanisms in two ways one is reactive and the other is proactive. The reactive kind of schemes work on dynamic reports obtained from the current network state. Therefore, the action is taken in a reactive scheme when the congestion has actually occurred in the network thus delaying the whole process of recovering from the congestion. On the other hand, proactive schemes works on predicting the congestion depending on the historical reports at a particular time instance. Therefore, a proactive scheme works on preventing the congestion in VANET.

In [11] author(s) have introduced a congestion controlling scheme that works on reducing number of messages transmitted on the road. A neighbor table is maintained at each vehicle in order to make decisions whether to keep message or discard if it is a copy.

In [12] authors have designed a scheme that is based on event driven generation of messages for congestion control. For doing this a value of threshold is fixed for the number of messages at a particular vehicle. Therefore, in case of the number of messages exceeding the threshold, the set of secure tag messages are blocked by the vehicle. Event driven message are given more priority over other periodic messages.

In [13] authors have proposed a local as well as centralized approach for controlling congestion in urban scenarios, considering more number of moving on road vehicles. RSUs are effectively used to find the congestion using k-means clustering algorithm of machine learning. Different clusters are formed in this scenario and whenever there is an event of collision, the vehicles are notified to either slow down or stop to avoid further congestion.

In [14] authors have worked on meta heuristic approach to control the congestion on the road. These types of techniques offer an efficient solution for the optimization of the traffic flow in VANET.

In [15] authors have proposed an improved congestion control scheme for VANET where simple way of congestion control is done by detecting the congestion before it actually occurs. This is carried using the basic AODV protocol for routing. The result in this work also concludes the efficiency of network is still maintained after congestion occurred due to preliminary steps taken.

In [16] authors claim that same channel is required for the transmitting the event based messages as well as the safety concerned messages. Assuming the more number of on road moving vehicles in VANET, the number of messages will also get augmented leading to congestion in VANET. Therefore, some priority channels are always required to flow these messages in the network.

Even after the existence of some may congestion control mechanism, still number of challenges persists in VANET and that is due to high movement of on road vehicles, dynamic altering topology and security concerns of vehicles on the road [17-18]. Next section compares some of the existing schemes for congestion control in literature and evaluates them in challenging situations.

III. CONGESTION CONTROL SCHEMES IN VANET

Congestion control schemes that occur are divided in three main groups that are: Rate adaptation, trajectory-based schemes, and Media access control. In the class of rate adjustment we found mechanisms that control network stream rate to produce a fresh flow rate outside of the congestion zone. This section compares the different congestion control schemes based on different mechanisms of operation.

3.1 Dynamic Congestion Control Scheme in VANET [19]

Different sorts of various applications have been enforced, as schemes for giving security and solace in VANETs. Security applications depend on basic data, including mishap location and crisis messages, and in like manner they get incredible need inside systems. Various well-being emails are sent from roadside facilities, passageways or nearby cars, thus triggering a blockage of the mail channel. The easy transfer of safety app message remains a test for VANETs due to the telecommunications between different app messages. The correspondence channels have been more and more obstructed and cause overhead organization, misfortunes and problems with the scheme to be postponed. In order to gain an understanding of the problem of congested systems, the research in [19] suggested a dynamic control system for congestion (DCCS) to improve communication. The proposed scheme is categorized into two sub phases referred as congestion control and congestion detection. In such type of scheme one of the vehicles detects the congestion in the network or the road and starts working on the congestion control procedures in order to avoid the flow of congestion throughout the network.

3.1.1 Congestion Detection Phase

The congestion discovery technique examined incorporate self-started occasion based recognization, and neighbor-initiated occasion based identification. In this way, a channel assessment is embraced dependent on its use, presented considering the thought of practical calculating factors.

(i) Self-started occasion found recognition: Vehicle itself began occasion based location technique screens well-being messages and thus applies congestion control, at whatever point security messages begun from their side. For instance, the moment vehicle recognizes security information produced from its very own layer of application, it quickly dispatches information related to congestion control, because of unsurprising blockage.

(ii) Neighbor-initiated occasion based identification: The neighbor-started occasion based location technique screens wellbeing messages got from neighbor vehicles, and dispatches security information concerning congestion control. For instance, the moment vehicle gets diverse wellbeing information from neighbor vehicles, through time stamp estimations of the received messages it dispatches information concerning congestion control.

3.1.2 Congestion Control Phase

Certain free channels are required for disseminating congestion control messages in the entire network. Two sub methods are adopted for congestion control as stated in [20] namely- queue freezing using message generation based method and second is adaptive control method for congestion.

(i) Queue Freeing using message generation method: The origin vehicle of message will decide whether Media Access Control (MAC) queues will be freeze or not. Either a vehicle itself acts as origin or may be its neighbor act as origin. If vehicle is origin, MAC queues gets freeze for all the messages except the ones which are in queue containing safety messages. If neighbor is origin, then timestamp of message is compared with set threshold. If timestamp is greater than threshold, MAC queue not freeze, else it get freeze.

(ii) Adaptive control of congestion: A distinctive bandwidth reservation portion for safety apps is provided by the adaptive congestion control technique. Two types of schemes are used for this method, strictly level oriented methodologies and channel state oriented methodologies. Three distinct concentrations are defined within the level-based framework, including 30%, 70% and 90%, where a channel is allowed to drop. Following determination of the stage of a channel, the frequencies are determined by inspecting the channel's time calculation. The channel state is determined by the ±5 percent use of the canal within this range. In the case it records traffic above 5 percent, the channel is seen as growing.

3.2 Hybrid Congestion Control Approach [21]

The proposed hybrid approach given in [21] consists of majorly three sub phases- first is assignment of priority, second is detection of congestion and last one is controlling the congestion.

3.2.1 Assigning priority to messages

In this the MAC layer requires information to process the data from a vehicle at three rates (low, medium and high) as shown by its importance and earnestness. When some data is conveyed by roadside unit or by other vehicle or its implementation layers, their handiness, which provides three lines

(i) High-state Queue: It binds messages of high necessity, transmits these signals to multiple requirements. In the case of an incident, climate circumstances, and so on, this kind of signal is sent. The highest amount of need is assigned.

(ii) Queue of medium level: Bundles medium need emails. This message is sent to report an important opportunity.

(iii) Queue of low level: It groups low desired messages, for example, intermittent messages or system look up messages. Considering the message size and the deadline, a scheduling algorithm runs to find priority of message. On the off chance that two inquiries touch base with a similar size, the one with the nearest due date first will be executed. On the off chance that two inquiries touch base with a similar due date, the one that has the littlest size first will be executed.

3.2.2 Detecting and Controlling Congestion

Two ways are identified by authors in [21] for congestion detection and control.

(i) Measurement-based traffic detection: The congested channel (CCH) is screened according to the package channel. If the number of emails in the lines exceeds the specified level, the CCH channel will be blocked. In our calculation, the congestion control shifts the signal transmission rate and then evacuates a message for a small need stage at any stage that the duration of the lines exceeds a specified threshold.

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(ii) Event-arranged congestion recognition: The blocking place depending on the occasion displays a safety signal displayed on the occasion and decides whether or not to send the congestion control calculation with a directed safety signal. So that a safety message with a basic postponement is sent by an occasion. Low and medium-level MAC transmission lines will rapidly be blocked and then high-need messages transmitted with a lower transmission range will take care of the need when receiving safe emails compared with other distant vehicles.

3.3 Congestion Control through Beacon Scheduling [22]
This scheme proposed by authors in [22], presents a congestion control scheme for routing the beacon related messages in event of congestion network. The concern is how to effectively use the available resources in congested scenario such that the beacon messages can be still floated in the network. Therefore, in [22] a context awareness scheme based on scheduling the beacon messages is proposed. The author proposed a TDMA-like transmission schedule considering the layer convention based on the CSMA–CA 80.02.11 MAC convention in order to open the schedule locally for beaconing. The proposed Plan is not a MAC convention that under the traditional TDMA based MAC convention is controlled by the single-vehicle schedule opening rule. The reason of proposed plot equally appropriates the reference points inside the distinctive vacancy by re-booking the following beaconing time. Along these lines, in our TDMA-like plan, a few vehicles possess a solitary schedule vacancy simultaneously.

3.4 Medium access control supported using Multi-priority in VANETs [23]
This proposed work in[23] uses an extraordinary packet transmission scheme, which characterizes both e-mails and beacon related messages. It uses a Markov Multi-need procedure to improve the channel's use according to the system state. In order to lessen the likelihood of crashes during transmission it also implements the MAC plan p-determined. Furthermore, this calculation performs a technique that identifies some requirements as the type of bundle indicates. ED Messages and Periodic Messages are subject to abnormal state requirements. It also runs a multi-needed Markov process for more efficient use of the channel as per traffic of system.

IV. RESULTS AND DISCUSSION

This section highlights the performance analysis of existing congestion control schemes based on their computational overhead, latency and throughput. Simulation is treated as a key apparatus for assessing the presentation of a system convention. In this manner, by leading simulation, the existing congestion control Schemes mentioned in section 3 are compared on computational overhead, latency, and throughput. System and traffic reproduction, both are a piece of broad simulation. For system and traffic simulation, OMNet++ and sumo test system are utilized individually. In Table 1 and 2, the parameters required for the system and traffic simulations are recorded.

Table1. Parameters for Traffic Simulation

Minimum Velocity	0 km/h
Maximum Velocity	120 km/h
Scenario	Random mobility

Dimension of space	1000m x 1000m

Table 2: Parameters for Network Simulation

Data Payload size	110 bits/packet
Physical link bandwidth	2Mbps
Range of RSU	280 m

4.1 Computational Overhead
It refers to the extra time a congestion control scheme takes to recognize and inform about this event of congestion counts to communication overhead. A congestion control scheme having less computational overhead is more efficient. Figure 2 shows the comparison of existing schemes [19], [21], [22], and [23] on basis of computational overhead. Computational overhead is estimated assuming varying number of vehicles. With more number of vehicles, more computational overhead will get imposed on the packets.
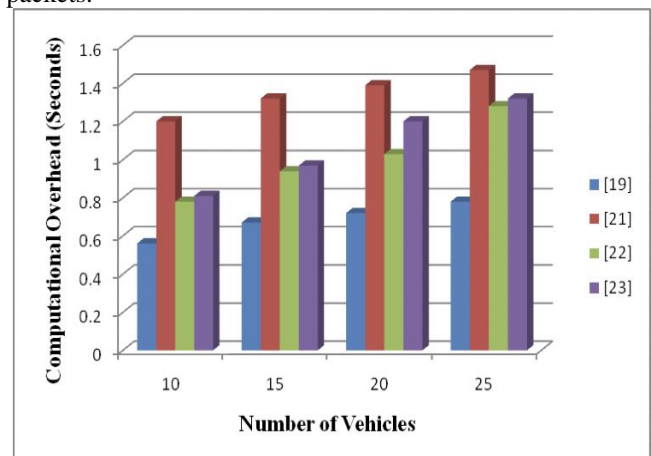

Figure 2: Computational Overhead Comparison of Congestion Control Schemes [19], [21], [22], [23]

Figure 2 above concludes that the computational overhead of scheme in [19] is less as compared to other existing congestion control schemes considering the varying number of vehicles.

4.2 Latency
Latency is estimated as the time consumed by a packet to reach its destination. A congestion control scheme having less latency is more efficient as in event of congestion the packet gets delivered in less time. Figure 3 shows the comparison of existing schemes [19], [21], [22], and [23] on basis of latency. Latency is calculated assuming the varying number of vehicles. With more number of vehicles, more latency will occur in network due to generation of more number of packets in the network.
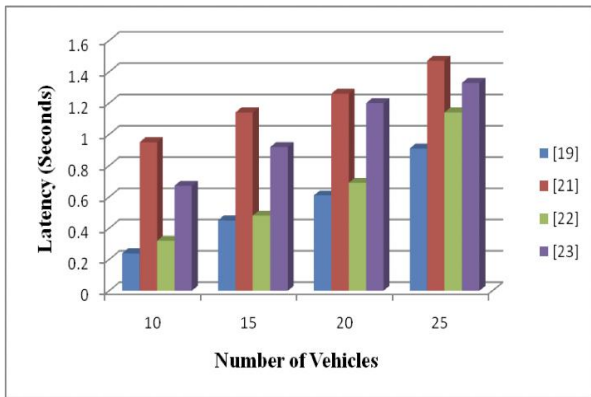
Figure 3: Latency Comparison of Congestion Control Schemes [19], [21], [22], [23]

Figure 3 above concludes that the latency of scheme in [19] is less as compared to other existing congestion control schemes considering the varying number of vehicles.

4.3 Throughput

Throughput is number of packets that are generated from source in a particular interval of time. . A congestion control scheme having more throughput is more efficient as even in the event of congestion the packet are generated in high number. Figure 4 shows the comparison of existing schemes [19], [21], [22], and [23] on basis of throughput. Throughput is estimated assuming the varying number of vehicles. With more number of vehicles, more number of packets will be generated in the network leading to high throughput.
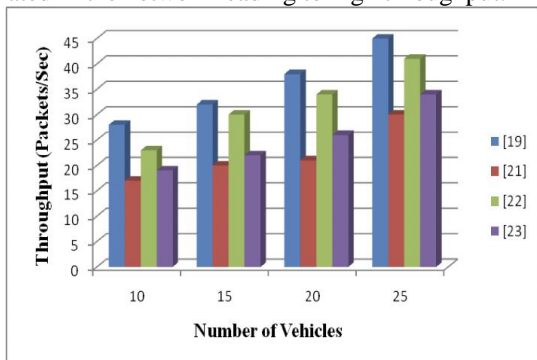

Figure 4: Throughput Comparison of Congestion Control Schemes [19], [21], [22], [23]

Figure 4 above concludes that the throughput of scheme in [19] is more as compared to other existing congestion control schemes considering the varying number of vehicles.Therefore, from the results and discussion made above it can be deduced that the congestion control scheme in [19] performs well over other existing schemes mentioned in [21], [22], and [23] in terms of computational overhead, latency and throughput.

V. CONCLUSION

This research work not only highlights and discusses the existing congestion controlling schemes in VNAET, but focus on practical evaluation of these schemes also. Existing schemes stated in [19], [21], [22], and [23] are compared by executing them on OMNeT++ and SUMO. Result concludes that out of these existing schemes, the dynamic congestion control scheme proposed in [19] performs better than other schemes in [21], [22], and [23] considering computational overhead, latency and throughput as parameters. Scheme is [19] offers high throughput and posses less computational

overhead and latency. In future, this work can be extended to incorporate some different methods for maintaining queues in event of congestion in dynamic scheme to further reduce the computational overhead and latency and improve the throughput.

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