IJCSE International Journal of Computer Sciences and Engineering Open Access
Survey Paper Vol.-8, Issue-1, Jan 2020 E-ISSN: 2347-2693

A Survey on Congestion Control Techniques for Ad Hoc Routing Protocol in VANET

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DOI: https://doi.org/10.26438/ijcse/v8i1.8489 | Available online at: www.ijcseonline.org

Accepted: 16/Jan/2020, Published: 31/Jan/2020

Abstract: A Vehicular Ad-Hoc Network uses moving cars as nodes to create a mobile network. VANET turns every participating car into a wireless router and allow cars to connect and create a wide range network. VANETs are developed for increasing the driving safety and comfort of automotive end users. It can provide wide variety of services such as Intelligent Transportation System (ITS) e.g. safety applications. Many of safety applications built in VANETs are required real-time communication with high reliability. The main issues are to avoid deterioration of communication channels in dense traffic network. VANET protocols have to face high challenges due to dynamically changing topologies. Many of studies suggested that suitable congestion control algorithms are required to provide efficient operation of a network. However, all congestion control algorithms are not applicable to event-driven safety messages. This paper discusses various existing congestion control algorithms in different congested scenarios. The effectiveness of congestion control algorithm is evaluated through the simulations using Network Simulator-2 (NS2).

Keywords: Ad-Hoc Network, VANET, Congestion Control, Routing Protocol, AODV, Network Simulator-2.

I. INTRODUCTION

Vehicular ad-hoc network (VANET) is an extended class of Mobile ad-hoc networks (MANETs). As a class of wireless ad-hoc networks, their nodes are self-organized and distributed. A VANET [1] technology uses moving cars as nodes to create a mobile network. VANET turns moving cars into a wireless router and allow them to connect approximately 100 to 300 meters to create a wide range network. VANETs can be called as a special type of MANETs.

VANETs present three unique features as follows [2]:

1. High mobility of nodes results in rapid changes in Network topology, and short life expectancy of routing.
2. With the changes of road condition, vehicle type, vehicle relative speed, wireless links are unstable.
3. The static shape of the road makes movement of vehicles limited, so vehicle trajectory is generally predictable.

VANET is the technology of building a robust Ad-Hoc network between mobile vehicles and roadside entities. As shown in Fig. 1.1, there are two types of nodes in VANETs; mobile nodes as On-Board Units (OBUs) and static nodes as Road Side Units (RSUs). An OBU resembles the mobile network module with a central processing unit for on-board sensors and warning devices.

The Road Side Unit can also be mounted in various centralized locations such as intersections areas, parking, or oil/gas stations. It can play a significant and effective role in many applications such as a gateway to the Internet.

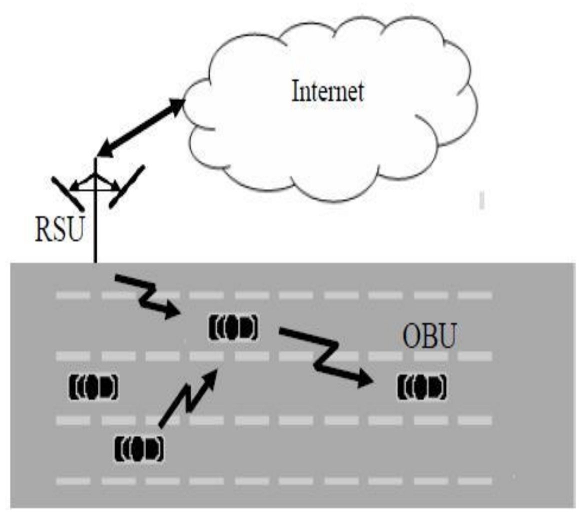

Figure 1.1: Node Types in VANET

In the past, wireless ad-hoc paradigms were implemented only in military applications [3]. However, advances in wireless devices and mobile computing, and the growth for ubiquitous computing, have led to exponential growth in the application and deployment of VANET. VANET applications can be divided into three categories: safety-oriented application, convenience- oriented and comfort-oriented applications [4].Safety-oriented related application look for the increasing safety of passengers by exchanging relevant information via vehicle to vehicle (V2V) and vehicle to infrastructure (V2I). Comfort and convenience applications improve passenger's comfort and traffic efficiency.

II. ROUTING PROTOCOLS IN VANET

In the latest years, research has been conducted on improving the performance of the VANET routing protocols. To deal with the complexity of the routing protocols, VANET has become a vital issue for The Internet Engineering Task Force (IETF) and therefore a VANET working group (WG) is established by IETF. The role of this group is to be involved in the development of two routing protocols such as AODV and DSDV and so on.

The routing protocols for ad hoc wireless network should be capable to handle large number of hosts with limited resources, such as bandwidth and energy. A key challenge for the routing protocols is that they must also deal with node density, meaning that nodes can appear and disappear in various scenarios. Thus, all nodes in the ad hoc network act as router and must participate in the route discovery and maintenance of the routes to the other nodes. For ad hoc routing protocols it is important to reduce routing messages overhead in spite of the increasing number of nodes and their mobility. Keeping the routing table small is another important issue because when the routing table increases it will affect the control packets sent in the network and this in turn will cause large link overheads [5].

Ad hoc routing protocol

An ad hoc network is one that is formed instantly when devices connect and communicate with each other. Ad hoc networks are mostly wireless local area networks (LANs). The devices communicate with each other directly instead of relying on a base. Each device participates in routing activity, by determining the route using the routing algorithm and forwarding data to other devices via this route. An ad hoc routing protocol is a standard that controls how nodes to decide which way to route packets between computing devices in an ad hoc network.

Classification of Ad Hoc Routing Protocols

Routing protocols are divided into two categories based on how and when to discover the shortest path to the destination. Proactive routing protocols are table-driven protocols; they always maintain current up-to-date routing table by sending periodically control messages between the nodes which update their routing tables, when any changes made in the structure then the updates are propagated throughout the network. Reactive routing protocols are also known as on-demand routing protocols which is used to create routes when they are needed by the source node to maintain these routes [5]. In real life systems, energy consumption is a major issue , and the routing protocols affect the energy dynamics in two ways. First, the routing overhead affects the amount of energy which is used for sending and receiving the routing packets, and second, the chosen routes affect which nodes will decrease in energy faster [6]. Ad hoc routing protocols must operate in a distributed fashion to allow each node to enter and leave the network on its own, and should avoid data looping in the network. Proactive protocol introduces a large overhead in a bandwidth and energy consumption on the network. Reactive protocols trade off this overhead with increased delay, as the route to the destination is established when it is needed it is based on an initial discovery between the source and the destination. Following is a category of routing protocols in these protocols we are working on AODV and DSDV protocols.

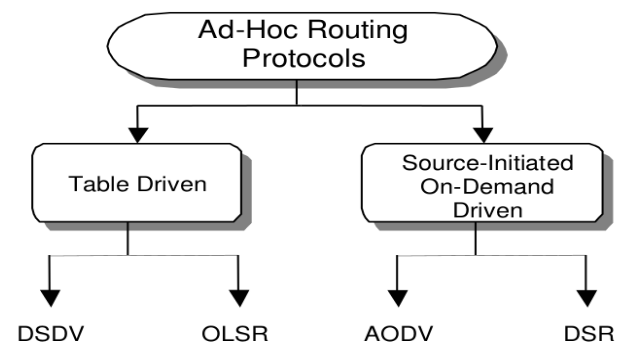

Figure 3.1: Ad hoc Routing Protocols [3]

A. Table Driven Routing Protocols

Table-driven routing protocols attempt to maintain, up-to-date routing table from each node to every other node in the network. These protocols require each node maintain one or more routing tables to store routing information, and they respond to changes in network topology by propagating updates through the network to maintain a consistent network view. The areas in which they fluctuate are the number of required routing-related tables, and the method by which changes in network structure are broadcast. The some existing table-driven ad hoc routing protocols are as follows [7].

a) Destination- Sequenced Distance-Vector Routing (DSDV)

The Destination-Sequenced Distance-Vector Routing protocol (DSDV) is a table-driven routing protocol based on the conventional Bellman-Ford routing mechanism [8, 9]. The improvements made to the Bellman-Ford algorithm include freedom from loops in routing tables. Each mobile node in a network maintains a routing table in which all the possible routes, and the number of hops to be recorded in the network. Each entry is marked with a sequence number assign by destination node. The sequence numbers enable the mobile nodes to differentiate old routes from new ones to avoid the formation of routing loops. These routing table updates transmitted periodically throughout the network to maintain table consistency. The large amount of network traffic that generated routes update for utilizing two possible types of packets. The first one is known as a full dump. This type of packets carries all the existing routing information and can need multiple networks protocol data units (NPDUs). Minor incremental packets are used to transmit that information which has changed since the last full dump. Each of these broadcasts should suitable to a standard-size NPDU, thus decreasing the amount of traffic generated. The mobile nodes maintain an additional table which store the data sent in the incremental routing information packets. A new route contains the address of the destination, the number of hops to the destination, sequence number of the information received regarding the destination, as well as a new sequence number unique to the broadcast [9]. The route labeled with the most recent sequence number is always used. When two updates have the same sequence number, the route with the smaller metric is used to shorten the path. Mobiles also keep track of the settling time of route that routes to a destination will change before the route with the best metric is received. By delaying the broadcast of a routing update by the duration of the settling time, mobiles can decrease network traffic and optimize routes by eliminating those broadcasts that would occur if a better route was discovered in the very near future [10].

B. Source –Initiated On- Demand Driven Routing Protocols

Source –Initiated On- Demand Driven Routing Protocols is the reactive type of protocol. These protocols create routes only when it is desired by source node. Route discovery invokes a procedure to find route after examined all routes. In other words, the protocol tries to discover a route only on-demand, when it is necessary. These protocols generate much less control traffic at the cost of latency, but it usually takes more time to find a route compared to a proactive protocol.

b) Ad Hoc on Demand Distance Vector Routing (AODV)

The Ad Hoc On Demand Distance Vector (AODV) is an extended version of DSDV because it typically reduces the number of required broadcasts by creating new routes on a demand basis instead of maintaining a complete list of routes as in the DSDV algorithm. The authors classify that AODV is a pure on demand route acquirement system, as nodes that are not on a selected path do not maintain routing information or participate in routing table exchanges. When a source node wants to send a message to the destination node and does not have a valid existing route to that destination, it initiates a path discoveries process to locate the other node. Source node broadcasts a route request (RREQ) packet to all its neighbors, which then forward this request to their neighbors, and so on, until the destination or an intermediate node with a “fresh enough” route to the destination is located.

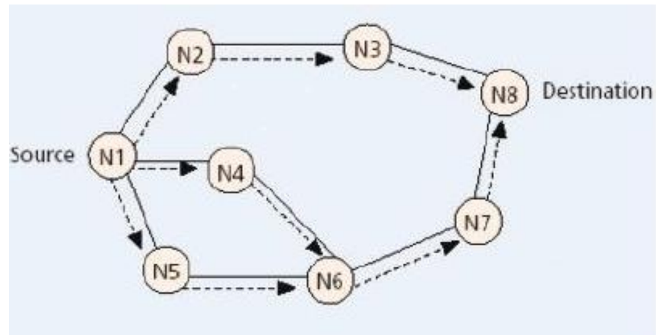

Figure 3.2: Route Discovery of AODV [11]

a. AODV uses destination sequence numbers to make sure all routes are loop-free and contain the most recent route information. Each node maintains its own sequence number and broadcast ID. The broadcast ID is incremented for every RREQ of the node initiates, and together with the node’s IP address, uniquely identifies an RREQ. Along with its own sequence number and the broadcast ID, the source node includes RREQ for the most recent sequence number it has for the destination. Intermediate nodes can reply to the RREQ only if they have a route to the destination whose consequent destination sequence number is greater than or equal to that RREQ.

b. During the process of forwarding the RREQ, intermediate nodes record their route tables the address of the neighbor from which the initial copy of the broadcast packet is received, thereby establishing a reverse path. If other copies of the same RREQ are later received, then those packets are discarded. Once the RREQ reaches to the destination or an intermediate node with a new route, the destination or an intermediate node responds by unicasing route reply (RREP) packet back to the neighbor from which it was received first, the RREQ (Fig 3.2).

c. As the RREP is routed back along the reverse path, nodes along this path set forward route entries in their routing tables which point to the node from which the RREP came. These forward route entries point out the active forward route. Associated with every route entry is a route timer which will cause the removal of the entry if it is not used within the particular lifetime. Because the RREP is forwarded along the path established by the RREQ, AODV only supports the use of symmetric links.

d. Routes are maintained as follows. If a source node moves, it is able to reinitialize the route discovery protocol to find a new route to the destination. If a node moves along the route, its upstream neighbor notices the move and propagates a link failures warning message to each of its active upstream neighbors to inform them erasure of that part of route [11]. These nodes give the link failure notification to their upstream neighbors, and so on until the source node is reached.

The AODV protocol is a flat routing protocol it does not need any central administrative system to handle the routing process. Reactive protocols like AODV tend to reduce control traffic messages overhead in discover new routes. In addition, AODV tries to keep the overhead of the messages small. If any node has route information in Routing Table about active routes in the network, then overhead of the routing process will be minimal. The AODV has great advantage in overhead over easy protocols which need to maintain a complete route from the source host to the destination host in their messages.

The RREQ and RREP messages are responsible for the route discovery, do not increase considerably the overhead from these control messages. AODV reacts quickly to the topological changes in the network and update only the hosts that may be affected by the change, using the RRER message. The Hello messages responsible for the route maintenance, are also limited so that they do not create redundant overhead in the network. The AODV routing protocol is a loop free and avoid count to infinity problem, which are typical to the classical distance vector routing protocols, by the usage of the sequence numbers [5].

III. LITERATURE SURVEY

Literature review presented here is for the vehicular ad hoc network taking various routing protocols under consideration. A routing protocol specifies rules for routers communication and distributes the information that enables them to select routes between any two nodes on a computer network. Routing algorithms determine the specific choice of route. Each router has a prior knowledge of networks attached to it directly.

"Congestion Control Techniques in VANETs: A Survey" [12] says that during the last years, Intelligent Transport Systems (ITS) experienced a great growth in both areas: academic and industrial. This aim to increase safety and comfort for users transport which essentially governed by Vehicular Ad hoc Networks (VANETs). In such networks, nodes represent smart vehicles that communicate either between themselves to exchange traffic information or with roadside infrastructure to request useful information. Therefore, the congestion control remains one of the most challenging problems of these networks. This paper surveys congestion control techniques which are divided into three categories: Rate adaptation, Media access control (MAC) and trajectory-based schemes. These provided its principle, its merits and, its limits for each technique. A comparative study with respect to some relevant metrics is given as well [8].

"Transmission Rate-based Congestion Control in Vehicular Ad Hoc Networks" [13] says Innovations in technology and, its rapid deployment in day-to-day matters has become the center of attraction for improving quality of life. In this context, Vehicular Ad Hoc Network (VANET) has become a promising topic in research community due to its various applications like safety, infotainment, traffic management application, etc. and supports for Vehicle-to-Vehicle (V2V) and Vehicle-to- Infrastructure (V2I) communication. To reduce the number of accidents, safety applications require effectiveV2V communication. Vehicles broadcast two types of messages, beacons and emergency messages, through the Control channel (CHH) of Dedicated Short-Range Communication (DSRC). Beacon messages include vehicle status like position, velocity, etc. that are disseminated periodically. With the increase in a number of vehicles, dissemination of safety messages becomes congested, for mitigation of which we analyze congestion detection schemes as well as congestion control. Effective congestion control algorithm involves incorporation of Decentralized Congestion Control (DCC) scheme using rate adaption on the lower layers of the protocol stack, i.e., Physical and Medium Access layer (MAC).The effects of congestion on vehicular safety can be controlled by designing a DCC algorithm including with priority model and transmission the rate of the beacon, which provides more reliable and timely reception of safety messages. DCC algorithm controls the congestion by maximizing the transmission the rate of the high priority safety messages. A novel approach is proposed regarding congestion control and performance is analyzed with respect to some indexes such as Packet-Delivery-Rate (PDR) and End-to-End (E2E) delay. The proposed scheme improves the PDR and E2E delay along varying traffic density.

"Transmit Data Rate Control based Decentralized Congestion Control Mechanism for VANETs" [14] says Vehicular Ad Hoc Networking (VANET) technology is becoming prominent in this era. It is defined to improve on the road conditions, and provide safety and different entertainment applications to end users in orderly and efficient manner. The idea of making everything connected in Internet of things (IoT) has evolved as a promising networking system and VANETs are one of the components of it. In this paper, we present a multistate active transmit data rate control based decentralized congestion control mechanism. The real-world scenario generated from SUMO is considered for simulation. Simulation results show that the data rate control mechanism performs better over transmit power control and without adaptation mechanisms

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"Queue Management Scheme to Control Congestion in A Vehicular Based Sensor Network" [3] says Vehicular Ad-Hoc Networks (VANET) is subsumed class of Wireless Networks. Sensors are utilized in vehicles for monitoring physical variables or environmental conditions with ease. The main task of each sensor incorporated is to collect respective data from the surroundings. The node which collects the data from the sensor processes converted it into meaningful information. In a vehicular network, such information is sent to other nearby vehicles for various purposes, such as indication of very close vehicles. The ability to route the packet to the next node is the foremost requirements of such vehicular networks. One of the main issues to be addressed in VANET is congestion. When a sudden burst of traffic is detected, the nodes need to forward it towards the destination. The node that is forwarding may also have some packets to be delivered from it. The outgoing packets and transitory packets lead to buffer overflows at a node which in turn lead to packet drops and finally degrades the overall network performance. Congestion control schemes are essential in such situations to increase network performance and ensure a fair use of the resources. This paper proposes a congestion control scheme distributed across the transport, network and MAC layers that can detect and avoid congestion in the network. It provides priority-based traffic scheduling with a dual queue scheduler which favors transitory packets. When congestion is detected based on the buffer occupancy, source sending rate is updated by the sink periodically with the help of dual queues and route the packets through less congested paths.

"Performance analysis of AODV and EDAODV routing protocol under congestion control in VANETs" [15] says Mobile nodes communicating in a wireless medium without a fix backbone infrastructure form an Ad-hoc network for VANETs which are characterized by their node movement and application scenarios. Routing protocols target to achieve minimum usage of network resources with less communication time. Due to fast moving vehicles, dynamic information exchange and relatively high-speed of mobile nodes, finding and maintaining routes is a very challenging task in VANETs. For these networks, packets travelling from sender to destination suffer huge packet loss, and long delay due to congestion occurring in intermediate nodes. In this paper, a performance analysis is carried out on an Early Congestion Detection and Control routing protocol called EDAODV and the Ad Hoc On Demand Distance Vector Routing protocol AODV which has no congestion control mechanism for a network. We have done our simulations in NS2 and the results are compared among these protocols for increased number of nodes.

"Analysis of Correlation between Vehicle Density and Network Congestion in VANETs" [16] says the Vehicular Ad Hoc Networks (VANETs) is an important part of intelligent transportation systems (ITS) which is a promising research area. The high mobility of vehicles when connected results in the dramatically changing network topology, it is difficult to design a protocol including congestion control mechanism, which is helpful to improve network performance in VANETs. Therefore, it is necessary to have a further study on vehicle density and network congestion. In this paper, we make a detailed analysis of the correlation between vehicle density and network congestion. By analyzing the vehicle density and network performance around the intersections, the results presents a worse network congestion and a lower throughput along with the high vehicle density, which promotes us to design an efficient routing protocol to solve these problems.

"Decentralized Congestion Control Algorithm for Vehicular Networks Using Oscillating Transmission Power" [5] Wireless Access in Vehicular Environments (WAVE) is a vehicle to vehicle (V2V) communications technology, which can be used to facilitate the deployment of safety applications for intelligent transport systems. Currently, the channel which is responsible for the awareness of other vehicles suffers from congestion even at moderate vehicular traffic densities. In this paper, a novel method proposed for adjusting the transmission power in a pattern which alternates between high and low powered transmissions. The proposed approach can be used both with and without existing rate control algorithms for V2V communication. Our simulation results demonstrate the advantages of the proposed approach in terms of both awareness levels and packet error rates

"An Infrastructure Based Congestion Detection and Avoidance Scheme for VANETs" [6] says in urban areas, traffic congestion is a challenging problem which creates many complications to travelers. Unattended congestion in roadways will cause long waiting times and affects individual economy. It also creates environmental issues and affects personal health. In recent years, the development of Vehicular Ad-hoc Network (VANET) provides a promising solution for handling the congestion in the roadways. In this paper, we adapt a VANET networking model and propose a novel congestion detection and avoidance scheme for urban areas. A lightweight histogram model is utilized to compute the congestion for every lane using an infrastructure-based system. By computing the probability density function for every lane, the proposed model predicts congestion in advance and the re-routing strategy is initiated on time. For optimizing the re-routing strategy, two different kinds of congestion avoidance scheme is proposed based on static and dynamic modeling. Various scenarios are created in the microscopic simulation environment and the effectiveness of the proposed algorithm is analyzed by measuring the average travel time. The simulation results show that the proposed model detects congestion in priori and initiates reroute strategy effectively.

"Non-Cooperative Beacon Rate and Awareness Control for VANETs" [7] says in vehicular ad hoc networks (VANETs), vehicles broadcast their status information in beacons periodically to make the surrounding vehicles aware of their presence. To maximize the level of awareness, a congestion control mechanism is necessary to avoid loss of beacons due to collision in dense traffic environments. In addition to congestion control, it is desirable that vehicles share network bandwidth in a manner proportional to their dynamics or safety application requirements. Current congestion control mechanisms have a number of issues including control information overheads, fairness, and awareness. In this paper, a beacon rate and awareness control mechanism based on non-cooperative game theory called non-cooperative beacon rate . The proposed algorithm is used to assign a beacon rate to every vehicle proportional to its requirements while ensuring fairness between vehicles with the same requirement. NORAC is compared with the two other known congestion control mechanisms. The simulation results show the efficiency and stability of the proposed NORAC algorithm in several high-density traffic scenarios. The results indicate its advantages in terms of fairness and congestion and awareness control over the other two algorithms.

IV. CONCLUSION

VANETs are the most prominent technology. It provides many new exciting applications for transportation safety by broadcasting safety messages among vehicles. We have surveyed various research papers on congestion control in VANET in different scenario. Specifically, the main focus is on transmission rate and transmission power control methods. Based on issues highlighted during analysis various techniques have been proposed to overcome issues and many are yet to be discovered .VANET would be able to provide effective communication between vehicles with further enhancement and evolution of new approaches.

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