Abstract

Quality of service (QoS) guarantees in vehicular ad hoc networks (Vanets) is much more challenging due to the high mobility of its mobile hosts, multi-hop communications and contention for channel access. With the increasing demand for wireless communication technologies development of real-time and multimedia applications, there is a need to provide QoS guarantees, which results in a low number of admitted real-time and multimedia flows. Most of the current routing protocols for QoS ad hoc select only path guaranteeing bandwidth and do not deem throughput optimization. Typically, the QoS is measured in terms of throughput, packet loss as well as average delay for a liable bandwidth. In this paper, UDP Transport layer protocol is used as the real-time application to satisfy bandwidth requirement while optimizing network throughput and packet drop to provide QoS for nodes running the IEEE802.11 MAC. However, one of the DSRC’s seven-channel bandplan is used as the Data channel defined in the appropriate functions of the seven channels spanning 10 MHz bandwidth each. The results obtained through NCTUns simulator are used for analysis of throughput for UDP real-time traffic application.

Keywords: QoS Guarantee; real time traffic; throughput; VANETS
1. Introduction

With the increasing demand for wireless communication technologies and the need to improve the safety and comfort while driving, there a tendency to research on self-organizing, self-healing network. Vehicle ad hoc network (VANET) has emerged as the most popular and preferred network structure for Intelligent Transportation Systems (ITS).

VANETs are dependent on short-range wireless communication (e.g., IEEE 802.11) among vehicles (ElBatt, Goel, Holland, Krishnan, & Parikh, 2006). The Federal Communications Commission (FCC) has allotted 75 MHz in the 5.9 GHz band meant for accredited Dedicated Short Range Communication (DSRC) (Jiang & Delgrossi, 2008); which is geared towards maximizing bandwidth and minimizing latency. On the other hand, there are certain advantages from using V2V-centered VANETs compared to the V2I-centered VANETs these include: i) sufficiently flexible, ii) significantly less costly, iii) easily avoid the fast fading. For these reasons, we intend to focus on the V2V-centered VANETs.

WLAN standard IEEE802.11p was developed for the wireless access in the vehicular environment (WAVE), which is referred to as Dedicated Short Range Communication (DSRC). The physical layer from the IEEE 802.11p which is the recommended MAC protocol for VANETs (Jiang & Delgrossi, 2008). This perhaps suffers a huge amount of packet losses as a result of collisions as well as access delays viewed as common problems of contention-based MAC protocols. Its performance improves by using Time Division Multiple Access (TDMA) scheme (Yu & Biswas, 2007) to attain restructuring of TDMA slots with no central controls as well as to provide a reliable data dissemination in V2V communication. The entire bandwidth allocation of 75 MHz supports seven separate channels includes one control funnel (CCH) and six service channels (SCHs) including Ch172, Ch174, Ch176, Ch178, Ch180, Ch182, and Ch184, each spanning 10 MHz bandwidth. The data rate could be improved to 54 Megabyte per second with 20 MHz channels. Switching between the different bandwidth rates could be accomplished by altering the modulation schemes and channel code rate as shown in figure 1.

![Figure 1: Allocation of DSRC Channels](image)

Generally, QoS guarantees in wireless ad hoc networks for any distributed and real-time multimedia communication encounters a number of challenges, as specified by (Zhang, 1995). Therefore to guarantees the delay-bounded QoS is challenging once the VANET is in the contention-based (i.e IEEE 802.11 MAC) conditions, in which the packet delay and data congestion level increase because the vehicles contending for the common wireless media will get higher. Consequently results in higher collision rate and overhead. However, the clustering as with (Chen & Cai, 2005; Lin & Gerla, 1997) is an effective method to reduce the data-congestion and support QoS over wireless networks. An effective routing protocol however concentrate on optimally making use of the scare resources and should take loss rate, the bandwidth of the link, latency and channel diversity into consideration.

In this work, our main motivation is to design a QoS routing protocol for VANET using clustering approach. The algorithm for formation of clusters, as well as algorithms to maintain them in the presence of various network events is not under this research, scope, so we adopt (Ding & Zeng, 2009) with modifications. However, the V2V communication scenario is going to be designed as a clustering-based multi-channel ad hoc network; whereby all the vehicles within the communication range will self-organized into different clusters each that contains a cluster-head (CH) vehicle chosen as with (Ding &
Zeng, 2009) with an extension of CH Link Connectivity Duration. The CH is made to have dual transmission powers; chooses a short range transmission power to communicate with its cluster member and a long range transmission power to exchange information using its neighboring CHs.

The remaining sections of the paper are arranged as follows; Section II presents the contemporary issues of QoS in Vanets. Section III states related works. Section IV describes the proposed QoS routing description. Section V shows a simulation experiment analysis. Finally, section VI concludes the paper.

2. Contemporary Issues of QoS Guarantees

QoS provisioning is really a challenge in VANETs because of their special features which lead to frequent routing path interruptions. The guaranteed service (GS) guarantees that packets are obtainable within the guaranteed delivery time, and does not be discarded due to buffer over flows. Various kinds of multimedia applications typically have extremely diversified QoS requirements in regards to data transfer rates and delay bounds and many others.

The majority of the current MANET routing protocols and QoS designs include difficulties for Vanets in addressing both of these needs due to the next reasons;

Several of them fail easily to capture and employ neighbor-availability information (described in sections IV). Typically, the QoS guarantee is derive in terms of throughput, packet loss and average delay for a given bandwidth allocation. Several schemes were suggested (Mauve, Widmer, & Hartenstein, 2001)(Zayene, Tabbane, & Elidoudi, 2009) for QoS guarantees in mobile ad hoc network (MANET). Therefore, the implementation of an appropriate network topology to satisfy the QoS needs has not been clearly determined. A distributed cluster-based multi-channel communications scheme in (H. Su, Zhang, & Chen, 2006) combines the clustering with contention free/- based MAC protocol. Thus, minimizes the data congestion under DSRC multi-funnel architecture for guaranteeing QoS real-time transmission of safety messages within the V2V.

2.1. Clustering

A collection of VANET nodes within a radio range can form a cluster area. Vehicles within the same direction into are group into the same clusters, each containing a cluster-head (CH) vehicle elected and some ordinary members (OMs). Cluster concept has successfully been utilized for MANET to get a better delivery ratio as well as to reduce broadcast issue (H. Su & Zhang, 2007).

VANET applications are able to use an extended range, Z, to utilize the control channel in order that a cluster-head can easily communicate with nearby cluster-heads for safety message disseminations, as well as a shorter range, z, for a service channel that is utilized for intra-cluster managements as shown in figure below;

![Node Neighbourhood Relationship](attachment:image.png)

Figure 2: Node Neighbourhood Relationship
For the reason that nodes exchange their status information through control channel, it will be feasible for node w to identify that x is within 2z distance. However, the neighbourhood relationship is constructed through the control channel which represents z-neighbourhood term. For instance, node w is known as 2z-neighbor simply because it’s within 2z distance. Conversely, to improve the stability of the CH in (Ding & Zeng, 2009), we modified the procedures by adding the CH Link Connectivity Duration (LCD); that reflect the stability of the link and its particular lifetime among two vehicles and is computed using the formula, from (Benslimane, Taleb, & Sivaraj, 2011):

\[
\text{LCD} = \sqrt{\left(\frac{\alpha^2 + \gamma^2 - 2 \alpha \beta \gamma \cos \delta \cos \gamma}{\alpha^2 + \gamma^2}\right)}
\]

(1)

Where

\[
\alpha = v_i \cos \theta_i - v_j \cos \theta_j
\]

(II)

\[
\beta = x_i - x_j
\]

(III)

\[
\gamma = v_i \sin \theta_i - v_j \sin \theta_j
\]

\[
\delta = y_i - y_j
\]

(\(x_i, y_i\), \(x_j, y_j\)), respectively is the Cartesian coordinates of the two neighbouring vehicles i and j and the have an inclination of \(\theta_i\), respectively \((0 < \theta_i, \theta_j < 2\pi)\) depending upon the x-axis and moving at \(v_i\), speed. R is the IEEE 802.11p wireless transmission range. We assume that the CH and source vehicle are adjacent, otherwise LCD is the minimum of \(\text{LCD}_i\) \((1<i<n)\), where n is the number of hops between the source and the CH. Routing from one node to another will consist of routing inside a cluster and routing from cluster to adjacent clusters. Therefore, routing in our cluster-based approach consist of the intra-cluster as well as inter-cluster communications.

2.2. Intra-Cluster and Inter Cluster Communication

Each node sends information to its cluster head. In our scheme as mention in section I, whenever a CH wants communicating with its cluster member, it chooses a short range transmission power to collect/broadcast safety messages over data channel using upstream-TDMA/downstream-broadcast method adopted. More so, the CH allocates the available data channels to the cluster-member vehicles for the non-real-time traffics. Therefore, each CH determines the TDMA frame structure dependent on the number of OMs within the cluster and also numbers of neighboring CHs. The time slots within a TDMA frame are designed for all of the OMs.

For Inter-cluster communication, each node sends aggregated information to their neighboring clusters. Our scheme determines the transmissions of the real-time safety messages and non-real-time traffics amongst clusters to be over two different IEEE 802.11 MAC-based channels, correspondingly. The CH utilizes a long range transmission power when it wants to exchange information with its neighboring CHs.

3. Related Work

This section highlights major attempts in applying MANET routing protocols to VANET networks. Existing routing protocols in VANETs possess some difficulties in guaranteeing QoS. However, a QoS-aware routing protocol will need to guarantee satisfactorily a specific measure of overall performance. This could be accomplished through resource reservation and dedicated infrastructure.

The dynamic characteristics and infrastructure less of VANETs renders it challenging do resource reservation and guarantee QoS. Some measures to enhance the performance and efficiency in vehicular routing were proposed (Mo, Zhu, Makki, Pi ssinou, 2006) and provides quality route with higher
percentage of throughput. The work in (Gongjun, Rawat, & Bista, 2010) provides a routing protocol to enhance QoS in VANETs with regards to delay, response time and throughput. This scheme disseminates packets amongst the links which have longer expiration time. The routing selection and maintenance depend on the mobility of vehicles. More so, a routing algorithm for obtaining optimal QoS for highly dynamic VANETs is proposed in (Subramaniam, Thangavelu, & Venugopal, 2011).

4. Proposed QoS Routing Protocol Description

This section describes the basic idea of working procedures of our proposed scheme.

4.1. Protocol Procedures

In the proposed system, every vehicle is associated with one of the three potential state; Cluster Head (CH), gateway and ordinary member (OM). The propose protocol intend to exploit the cluster based approach for achieving optimal routes.

Typically, the QoS is derive in terms of throughput, packet loss and average delay for a given bandwidth allocation. Therefore, at present, our proposal would depend on two stages: neighbourhood availability information and QoS_route request.

4.1.1. Neighborhood Availability Information

It is executed in every node by utilizing two local information tables. Here the Node-QoS-Table preserves information in accordance with the actual node’s state are to be stored. As in (Yang & Kravets, 2007) a node’s bandwidth allocation is determined based on the network loads as well as the traffic classes of their neighbours. Consequently, to guarantee that a new flow can acquire its expected QoS without degrading the bandwidth allocation of existing flows, it's important to acquire traffic information at a node’s neighbours, classes of real-time traffic, average packet arrival rate and size of best effort traffic.

4.1.2. Route Request

The source node sends a request message and a frame to the CH node with feasible path QoS requirement over data channel as specified in (DING & ZENG, 2009). This perhaps would be executed as discuss below;

4.1.2.1. Source Node Algorithm:

In this algorithm, when the source node wants to send data packet to destination, to avoid wasting of resource, the source will search in its route cache and send packet if it has the location of the destination with QoS requirement, else will send QoS_RReq data packet to the CH and set timer.

4.1.2.2. Intermediate Node Algorithm

It is executed on receiving a QoS_RREQ packet (Aquino & Edwards, 2006) and consists in selecting the neighbouring nodes fulfilling the QoS constraints. Here the selection would be based on cost function including link stability, available bandwidth and link is computed for each neighbour; only CH with a cost value less than a certain threshold are forwarded the QoS_RREQ packet.

The CH maintains: Cluster table (addresses & geographical location of member & GW, QoS requirements). Upon receiving a Qos_RReq, algorithm 1 would be executed.
Algorithm 1: Cluster Head & intermediate node /* Here Source sends QoS-RReq to a cluster head*/
BEGIN
1. QoS_RReq (Source, cluster head) {
2. IF (Node == cluster head in the cluster) {
3. IF QoS_RREQ with the same {source ID, sequence number} received before THEN discard packet;
4. OTHERWISE, Node N decrement TTL by one.
5. IF TTL < 0, discards QRREQ packet. ELSE
6. IF node lifetime < threshold & allocate time slot to members
7. Compute Cost function from the source to this node;
8. { path available bandwidth Delay, Stability
9. IF route = True && QoS requirements = True && less stability value,
10. Node N records the available free slots in the slot array list of the QRREQ packet
11. Success triggers a QoS_RReq (each node knows location of the src & closest neighbor from QoS_RReq received)
12. Broadcast QoS_RReq
13. ELSE {
14. IF 9 = False, add address & location onto packet
15. Appends the address of this node to the route list, and re-broadcasts this QRREQ packet if it is not the destination
16. Broadcast QoS_RReq other cluster through gateway; END IF } }

4.1.2.3. Destination Node Algorithm
When the destination node received QoS_RREQ packet, the total cost of the path is calculated by the CH of the destination node. The node chooses the least costly path and sends to the source node a route reply packet (QoS_RREP) carrying this route along with the traffic type carrying the list of free slots to reserve for the selected path.

5. Simulation experiments
The proposed scenario is implemented in NCTUns-6.0 (Wang, Chou, Lin, & Huang, 2010) simulation environment that provides a quick feedback loop in the simulation process. The traffic class considered in our simulation is UDP and also constant bit rate (CBR) as the data traffic of these protocols. Among the important parameters that should be tested for performance of any routing protocol is the throughput.

5.1. Simulation Model
Our simulation model network parameters that are used as default values unless of course otherwise specified are mentioned below. We present here a preliminary of result obtained in the urban situations have 100 nodes at random situated within the roads. Adhere to the DSRC’s seven-channel bandplan, we use Ch174 as the Inter-Cluster Data (ICD) channel as defined in (H. Su & Zhang, 2007). The parameters used in this simulation comprise of 100 nodes of IEEE 802.11p as MAC specification and the transmission area as well as the transmission range is 500m x 500m and 250m respectively. More so the packet size used is 1400 bytes (CRB as the traffic type) with data payload of 512 bytes/packet within the simulation time of 300 seconds and the nodes’ mobility speed is 0 - 18m/s using channel bandwidth of 3Mbps is used.

We simulated two scenarios by generating UDP packet flows with particular packets size distribution and inter- transmission time distribution. In the configuration file, UDP protocol is used as the real-time traffic using uniform distribution and inter-time distribution.
Scenario 1: based on a point-to-point transfer of a single message by the suitable vehicle CH (car head) in NCTUns within the transmission range.
Scenario 2: Using single hop broadcast (flooding) scheme which results degrading the network throughput, hence affect it performance.
5.2. Simulation Analysis

The performance shown in the graphs below is measured in terms of network throughput rate packet drop rate and collision rate for UDP protocol flow.

Two CBR flows are sent to have identical scenarios between hierarchical AODV where node are grouped based on their moving direction and AODV and to show clearly the bandwidth obtained using these solutions by considering throughput (Kb/sec) and simulation time (Sec).

Initially the vehicles broadcast the messages to get the information needed which includes position and speed of vehicles which in turn causes a small degradation around the performance as shown in fig 2. Below:

![Network Throughput using UDP Connection](image1)

![UDP Packet Drop Rate](image2)

![UDP Packet collision rate](image3)

The performance of each scenario was analyzed by generating a UDP packets flows with particular packets size distribution of 1400 bytes and 1000 bytes respectively. The throughput of the flows for both scenarios is dispatched in figure 3, where the simulation starts at 2 sec., and obtains a transmission of its target throughput (i.e. 1150 kbps) in scenario 1. More so, using the control channel for data transfer within a communication range, scenario yields a remarkable gain over scenario 2 because of its capability to prioritize and maintain real-time flows and thus achieved higher network utilization. Thus indicates increase in network utilization by allowing few real-time flows to be carried in the network.

For the packet drop and collision, UDP communication is simulated for the real-time application and also evaluated against the two scenarios. Fig. 4 (a) shows the packet drop rate with the increase of the number of mobile nodes contending for the same channel in scenario 2. This leads to higher packets drop rate as compared to scenario 1, due to the prioritizing the flows, thus as flooding increases in the network which decreases the network throughput. However, from figure 4 (b), it can be seen that less number of packets collide in scenario 1 which allow a reliable communication as the bandwidth is allocated with the defined data channel because burst of packet are generated that are sent with no specific link.

6. Conclusion and Future Direction

Based on the several issues arising in guaranteeing bandwidth in vehicular ad hoc network, enhancement scheme is proposed by utilizing clustering approach. Adhere to the DSRC’s seven-channel bandplan, we use Ch174 as data channel as defined in the appropriate functions of the seven channels spanning 10 MHz bandwidth. UDP protocol is used as the real-time application to satisfy bandwidth requirement to measure the network utilization. The results show that using the proposed scheme, the
network throughput measured and less packet drop rate are guaranteed for providing the quality of service for nodes running the IEEE802.11 MAC. We intend in future to exploit the multi-hop communication in intra-clustering for the enhancement of the proposed scheme in providing QoS over VANETs.

References


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