

# QoS Routing Protocol (QoRP) to Enhance Road Safety in VANETs



Damodar S. Hotkar, S. R. Biradar

**Abstract :** Vehicular Ad Hoc Network (VANET) communication promises a vast array of applications ranging from road safety and driving comfort. Safety message broadcasting plays a significant role in highway safety in which the safety alert messages have to be delivered immediately to the vehicles located in the risk boundary area. Most of the current research attempt to select optimal relay for safety message rebroadcasting. However, relay selection models are not efficient, especially in a high-density VANET, as they cause a high delay in safety message delivery and lead to multiple accidents at the incident spot. To avert these issues, this work proposes a QoS Routing Protocol (QoRP) that aims to enhance the road safety in both sparse and dense VANETs.

**Index Terms:** Intelligent Transportation System (ITS), QoS Routing Protocol (QoRP), Road Side Unit (RSU), Safety assurance, VANET.

## I. INTRODUCTION

In recent years, the development of Vehicular Ad Hoc Network (VANET) has received more attention in Intelligent Transportation System (ITS), as it has the potential to provide safety and travel comfortably to the drivers and passengers facilitating communication among vehicles and Road Side Units (RSUs). The vehicles are equipped with on-board units (OBUs) to establish communication with other vehicles and RSUs[1][2]. The preliminary intention of VANET communication is to provide safety to the VANET users. The safety enhancement applications aim to assist drivers in handling unpredictable events or hazardous situations by broadcasting the safety messages such as an accident or collision warning, and weather conditions such as icy and foggy roads [3]. In a safety environment, a vehicle rapidly broadcasts safety information to other vehicles in the dangerous zone using dedicated RSUs. The geographic routing protocols, especially greedy routing protocols are the most desirable for VANET, as they allow the vehicles to select optimized next hop routers based on geographic information [4]. Due to the environmental factors such as obstacles and road intersections, it is a daunting task to provide reliable and timely communication in the realistic VANET environment. The performance of VANET routing

protocols drastically depends on the link availability and quality between the vehicles that communicate with each other. The link availability is a measure that assists in selecting the links that have a long lifetime to route the packets [4]. In the real time VANET environment, several factors such as vehicle speed, direction, and driver decision affect the link availability. The link quality guarantees to deliver the packets with high reliability by considering some Quality of Service (QoS) parameters. Most of the current works select reliable links based on distance measurement techniques such as Euclidean distance and signal strength. Euclidean distance leads the VANET to miscalculate the greedy nodes as closer nodes to sender node due to the restricted road topology, whereas signal based distance measure is likely to select the greedy nodes wrongly, because of the miscalculation of distance due to the presence of obstacles. Hence, it is crucial to develop a protocol that incorporates precise link availability and link quality measurements in router selection.

This work proposes a QoS Routing Protocol (QoRP) that improves the speed in safety message broadcasting

### A. Contributions

- The main objective of QoRP is to enhance road safety.
- The QoRP informs the drivers about accidents at the right time by allowing the vehicles to connect with other available networks even if there is no connection through RSU. Thus, it enhances the road safety.
- The simulation results show that the QoRP achieves better results in terms of safety assurance and overhead.

### B. Paper organization

The remaining part of the paper is organized as follows. Section II surveys the papers related to QoRP. Section III describes the system model of QoRP and Section IV briefly explains the overview of QoRP. Section V analyzes the performance of QoRP using various performance metrics. Section VI concludes this paper.

## II. RELATED WORK

The VANETs support a wide range of applications ranging from safety and driving comfort. Therefore, promising a stable and efficient QoS routing over VANETs is essential in real time vehicular communications. Efficient and reliable QoS based routing protocols [5] [6] are crucial to forward data packets within the required QoS constraints in the targeted regions and also to be adapting well to various applications. The work in [7] determines the key factors that affect the warning message dissemination.

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Another work in [8] provides a brief study of hybrid adaptive beaconing mechanisms presented for VANETs. The work in [9] presents a message broadcasting model in which the sender node chooses an optimal node as a relay among its neighbors to rebroadcast the safety messages. Hence, each node represents its mobility trend by maintaining its potential and variance acceleration values. Together with these parameters, the sender vehicle considers the current velocity of the vehicles to select the best relay node.

The work in [10] presents a time/location-critical (TLC) framework utilizes a Scalable Modulation and Coding (SMC) model for safety message distribution in VANETs.

The main aim of the framework is to guarantee safety message delivery to the vehicles in the intersection for taking timely decisions. The vehicles take location-based decisions to rebroadcast the safety messages. An Efficient Emergency Message Broadcasting (EEMB) has been proposed for VANETs [11]. The main objective of EEMB scheme is to avoid multiple accidents and to minimize the traffic jams caused due to accidents by rapidly disseminating emergency messages. In EEMB, the crashed vehicle selects the best relay to distribute the emergency messages in its area. Further, the relay node selects the best next hop relay node to rebroadcast the emergency messages. This process is repeated until the emergency messages reach the vehicles in the risky area. The work in [12] presents a Bi-Directional Stable Communication (BDSC) protocol that aims to achieve high reachability of safety alert messages by optimal relay selection.

### III. SYSTEM MODEL

The VANET is represented as a communication graph  $G(N, E)$ . The term  $N$  refers the number of VANET nodes that are separated into vehicles ( $V$ ) and RSUs. The term  $E$  represents the direct communication links between two vehicles  $v_1$  and  $v_2 \in V$ . Assume that each  $V$  is equipped with low-cost GPS, digital map, and navigation system for determining own geographical position, obtaining traffic information, and detecting the intersections position respectively. Each  $N$  has limited communication range ( $R$ ). The communication range of RSU ( $R_{RSU}$ ) is higher than the vehicle communication range ( $R_V$ ). The RSUs also have high computational and storage capacity than vehicles. The vehicles communicate with an RSU in single or multi-hop fashion. Each RSU determines the number of vehicles  $V \in R_{RSU}$  with its identity (ID) and location ( $l_v$ ). The road topology has several intersected lanes and the vehicles move across the straight and curved path in each lane. In safety mode, the vehicles communicate with other networks such as cellular, WiFi, and WiMax for effective safety message broadcasting..

### IV. OVERVIEW OF QORP

The VANET plays a major role in providing safety for the passengers. To improve routing reliability in data forwarding and enhance road safety. In safety mode, a vehicle in QoRP broadcasts the safety messages to other vehicles via RSU. In sparse networks, a vehicle is unlikely to connect with RSU always, and thus, it leads to reduce the safety level of the passengers. To avert this issue, the

proposed QoRP protocol seamlessly makes use of diverse networks such as cellular, WiFi, and WiMAX to broadcast the safety messages instantly, when there is no connection with the RSU. Moreover, the QoRP improves the speed in safety message broadcasting using diverse networks and also saves the human lives.

#### A. Safety mode

The tremendous growth of vehicles on roadside increases the difficulties in driving. Safety message broadcasting plays a significant role in alerting the vehicles in the dangerous zone. Most of the current work utilizes a blind broadcast scheme that leads to broadcast storm problem. To overcome the issues of blind broadcast, the restricted broadcast model limits the broadcast messages by selecting an optimal number of vehicles to retransmit the safety messages within the danger bound area. However, the constrained broadcast model leads to high delay due to the utilization of multi-hop relayers. In real time VANET, the drivers take timely decisions to react to the hazardous event, when they receive the safety messages. Hence, it is crucial to distribute the safety messages instantly and effectively within the dangerous zone for saving numerous human lives. The QoRP model exploits the advantage of RSU to assure quick delivery of safety messages to the vehicles that are in the danger zone.

#### B. Accident risk warning

Consider that the vehicles are equipped with multiple interfaces to connect to different networks. It is assumed that the vehicles also consist of a Global Positioning System (GPS) to determining its absolute position. The vehicles exchange their location information using periodic beacon messages, and an RSU sends beacons to the vehicles in its area. The vehicles comprise sensors to monitor the driving environment continuously. If a vehicle detects an accident, it has to report the accident to create awareness to the following vehicles for avoiding multiple accidents in the dangerous zone. Since the communication range of vehicles are limited and they require multi-hop relayers to distribute the safety messages effectively. Thus, it increases the distribution delay and leads to further accidents. To avert this issue, the QoRP broadcasts the safety messages through RSU that has a larger transmission range compared to the vehicles. Initially, the neighboring vehicles of a crashed vehicle check the RSU availability in its area. If any RSU is detected, the QoRP selects a neighboring vehicle that is in proximity to the RSU to send the safety message for alerting the vehicles in a dangerous zone. Thus, the QoRP minimizes the duplication in safety message forwarding. Otherwise, the vehicle switches its interface to connect with the different available networks such as WLAN, WiFi, WiMAX, and cellular network for reaching the RSU. Further, the RSU distributes the safety messages to the vehicles within the danger zone. Following Algorithm explains the safety message dissemination process of QoRP. Furthermore, the QoRP accomplishes fast and effective dissemination of safety messages over sparse and high-density VANETs.

**//Safety Message Dissemination Process//**

Aim: To quickly distribute the safety messages in the dangerous zone

Input: Neighbors of Crashed vehicle, Ncv

Output: Fast and effective Dissemination

Ncv do {Checks the RSU availability;

If (RSU is available) { Determines the proximity Ncv to the RSU using neighbor list;

Proximity Ncv do {Sends safety message to the RSU;

}

RSU do {

Disseminates the safety message in

its area; }

Else {

Proximity Ncv switches its interface;

Detects other available network to reach the RSU;

Broadcast safety messages through RSU;

}}

**V. PERFORMANCE EVALUATION**

The efficiency of QoRP is analyzed using Network Simulator-2.35 (NS-2.35). To analyze the performance efficiency of QoRP, it is compared with existing Bidirectional Stable Communication (BDSC) [12]. Table 1 shows the simulation parameter of QoRP.

**TABLE I.**

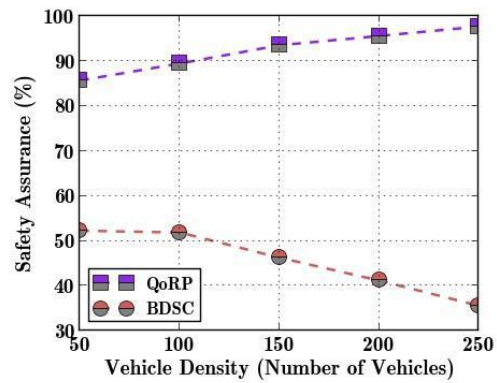
Simulation Parameters of QoRP	
Simulator	Network Simulator 2.35
Number of Vehicles	50, 100,150, 200 and250
Area	2000mx 2000m
Communication Range of Vehicles	250m
Communication Range of RSU	500m
Interface Type	Phy / WirelessPhy
Mac Type	IEEE 802.11p
Queue Type	Droptail /PriorityQueue
Queue Length	50 packets
Antenna Type	Omn Antenna
Propagation Type	Nakagami
Routing Protocol	QoRP, BDSC
Transport Agent	UDP
Application Agent	CBR
Simulation Time	400 seconds

**B. Performance metrics**

The efficiency of the QoRP is measured using performance metrics such as Overhead and Safety Assurance.

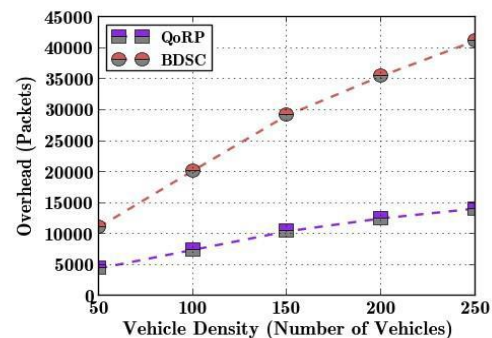
**Safety Assurance:** Percentage of delivered safety messages to the vehicles in the dangerous zone.

**Overhead:** It is the number of beacons used to preserve the vehicles in the dangerous zone.



**Fig. 1. Vehicle density Vs Safety Assurance**

Figure 1 illustrates the safety assurance results of both QoRP and BDSC by varying the vehicle density from low to high. The QoRP increases the safety assurance with increasing vehicle density, as the vehicles at the accident spot have better connectivity to reach the RSU. For instance, the QoRP enhances the safety assurance by 11.99%, when the vehicle density is varied from 50 to 250. Also, the QoRP exploits the advantage of RSU to quickly broadcast the safety messages to the vehicles and avoids multiple accidents in the accident zone. Unlike QoRP, the existing BDSC broadcasts the safety messages using vehicles as relays only. Hence, the relay node selection increases the computational complexity under high density scenario and also extends a delay in safety message delivery. Thus, it leads to multiple accidents within the dangerous zone. Moreover, the QoRP attains better performance than existing BDSC. For instance, the QoRP increases the safety assurance by 62.1%, when compared to existing BDSC, when the number of vehicles is.



**Fig.2. Vehicle density Vs Safety Overhead**

Figure 2 depicts the comparative results of the overhead of QoRP and BDSC. It clearly demonstrates that both the schemes slightly improve the overhead, when varying the vehicle density from 50 to 250, as they utilize a large number of safety messages under the high-density scenario. However, the overhead of QoRP is minimized, when compared to existing BDSC. The reason behind this is that the QoRP effectively reduces the duplication in message forwarding by utilizing the RSU as relay. Unlike QoRP, the BDSC exploits a huge number of beacons to select better relay for safety message rebroadcasting and attains high reachability of safety messages.





Thus, it increases the overhead and reduces the broadcast efficiency due to packet collisions. For example, the QoRP reduces the overhead by 65.8% less than that of existing BDSC, when the vehicle density is 250.

## VI. CONCLUSION

This work has proposed a QoRP protocol that maximizes the road safety over VANET. The RSU assisted safety message dissemination process assures quick delivery of safety messages and avoids multiple accidents in the risk area. Moreover, the QoRP improves the road safety in sparse and dense VANET scenarios.

The simulation results demonstrate the efficiency of QoRP by comparing it with the existing BDSC protocol. The QoRP maximizes the safety assurance by 62.1%, when compared to existing BDSC.

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