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Cluster Based Energy Efficient Optimal Relay Selection Strategy for Multi Hop Reliable Cooperative Communication in Vehicular Communication

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Abstract: Due to the inherent mobility of each node in a Vehicular Network, routing is the primary concern. The mobility enhances the dynamic character of the vehicular networks, which is reflected in controlling of traffic overhead. Consequently, attaining steady end-to-end communication connections is crucial to the success of routing strategy and a kind of mobility of node data. A RCCR (Reliable Cluster based Multi Hop Cooperative Routing) technique based on velocity, distance, and connection quality was offered as a solution to these issues. This method determines the optimum network settings that balance Quality of Service (QoS) requirements with mobility restrictions. By choosing cluster heads and Multi-Point Relays (MPRs) while taking mobility restrictions and quality-of-service requirements into account, it increases the scalability of routing. Each pair of nodes' connection quality is calculated using the suggested method's combination of strength of signal and distance characteristics. To guarantee steadiness, dependability, and longevity of the route, we choose the relay cars using the greatest possible QoS value. To improve Packet Delivery Ratio (PDR) of a multi-hop network with acceptable End-to-End transmission latency, heuristic limits of multi-point relay selection approach by taking into cluster-head coverage area, account link quality, and distance from source vehicle are addressed. Additionally, we optimized and acquired the ideal number of cooperating cars in each hop in an effort to reduce total energy usage. Finally, simulation results show that suggested approach outperforms in terms of throughput, network life time, packet delivery ratio and energy consumption compared to the Cluster-based Adaptive Cooperative Algorithm (CACA), Adaptive Optimal Relay Selection (AORS) and cooperative multi-hop vehicular to vehicular (Coop V2V). Proposed approach improves the network throughput by 225% network lifetime by 40%, energy efficiency by 48.8% compared to the AORS approach.

Keywords: Routing, Optimal relay selection, Energy optimization, Cooperative multi point relay, Quality of service.

1. Introduction

Communication between cars, infrastructure, and road side units (RSU) must be secure in the future of ITS. Parking, accident response, and traffic congestion are just some of the user-friendly applications that have benefited from IoT integration in vehicular communication [1]. Considering these applications, the third Generation Partnership Project (3GPP) is looking for ways to boost current system capacity and incrementally expand data rates as part of 5G standardization project. To mitigate negative impacts of multipath fading and signal depletion, vehicle cooperative wireless [2] is one of primary areas of focus for 5G research. Similarly, cooperative relaying may boost the efficiency of a CVN as a whole when included into the system.

Few significant difficulties have emerged with introduction and growth of ITS for next-generation vehicular communications. To begin, the transmission power rises with propagation distance because of the fundamental problematic aspects of their channels, such as signal fading, path-loss, angle spread, and delay spread [3], and the arbitrarily time-varying nature of the signal degradation parameters. Second, delay plays a crucial role in providing warning signals amid significant traffic congestion and accidents. To improve service quality provided to end users, advanced vehicular communication requires fast data transmission rates with low latency.

Using vehicle-to-infrastructure (V2I), device-to-device (D2D), and vehicle-to-vehicle (V2V) wireless communications, MANETs provide traffic information [6-8]. This information may then be used to select and route vehicular communication relays. DSRC (Dedicated Short Range Communications) [9] and multi-hop routing protocols [10] work toward the same end by creating a reliable channel for cars to communicate with one another. However, this presents difficulties for packet transmission owing to the dynamic nature of network architecture. Most MANET routing techniques fail to guarantee network topology throughout the routing process. Network architects must take into account the larger control message size required for route formation and the subsequent rise in the vehicle processing cost. Incorrect route selection, which may decrease network lifespan and lead to connection failures [11], is a potential outcome of the highly dynamic situation.

The clustering strategy, which investigates a compromise between mobility and service quality limitations in order to enhance network stability, is one of the most interesting solutions given to deal with the scalability challenge [12]. Reducing the number of relay nodes is one goal of the well-known proactive routing technology known as Optimized Link State Routing (OLSR), which utilizes a MPRs (Multi-Point Relays) [13] strategy to do so. Core concept of OLSR is to use control signals sent from nearby nodes to choose a leader from a group of neighboring vehicles. However, in a highly dynamic setting such as a Vehicular Ad hoc Network (VANETS), mentioned protocol fails to address the node mobility restrictions, leading to frequent disconnections, overhead of network, and a significant loss in network lifetime [14]. As a result of the additional a network collision, control overhead occurs, wasting valuable resources of network [15]. QoS limitations were identified by several researches [16] as the crucial component to enhance capabilities of routing techniques and mitigate impact of VANET's high-dynamicity environment. Information about network resources should also be reviewed [17, 18] in order to ensure that requirements of vehicular communication applications are met. Other than picking neighbor with the highest reachability of link level, it is a significant issue to include the capacity of clustering in multi-point relay selection technique to maintain network connection and choose speedy alternate pathways in cases of link failures.

However, effectiveness of Optimized connection State Routing operation is significantly impacted by the vehicle's movement and road obstructions, leading to frequent connection failures and a considerable control message overhead necessary to appropriately maintain routes. Vehicle nodes have a unique way of knowing the locations of their neighbors, therefore they can't quickly compute data transfers of next hops. These limitations reduce available data on mobility and route selection procedures, hence decreasing the message delivery dependability. To reduce unnecessary broadcast overhead, this project seeks to optimize the route selection procedure.

This study proposes a new cooperative routing algorithm based on reliable clusters to be used in automotive networks. By finding the sweet spot for the optimal number of collaborative cars, we can reduce the network's overall energy usage. In this approach, the optimal parameters are determined in order to strike a balance between portability and communication security. The suggested method takes into account capacity, connection quality, distance, and mobility, all of which contribute to Optimized Link State Routing's scalability. This technique uses distance and signal strength to rank quality of connection between every node pair. When determining the cluster head and intermediate cars, the greatest connection quality is prioritized to guarantee the reliability, longevity, and consistency of the route. By paying close attention to the cluster-head coverage area, distance from source, and connection quality, we may improve multi-hop PDR and therefore overcome heuristic limits of multi-point relay selection approach. Additionally, we optimize and achieve ideal number of cooperating cars in each hop in an effort to decrease overall energy consumption.

The work is projected as follows. The review of related works is presented in section 2. Network model of the considered cooperative vehicular communication is described in section 3. In section 4, proposed reliable cooperative routing method is presented. Energy consumption and optimization analysis presented in section 5. The performance enhancement with the projected algorithm compared with the related algorithms and their simulation analysis are explored in section 6 and the outline of the work is projected in section 7.

2. Related work

It was common practice to use multi-hop relay selection processes when dealing with MANET networks. However, standard techniques of communication in MANETs cannot be directly applied to vehicular communication because of unique qualities of a dynamic network. When it comes to the routing issue in vehicular communication, clustering is one of proposed solutions. It's been presented as a solution to the problem of scalability and service quality.

In order to handle difficulty of reducing number of intrinsic clusters of MPR set, the authors in [20] lowered number of intermediate vehicles locally, but only after all second hop neighbor cars were covered. Only in very dense networks will the benefits of this method become apparent. Inadequate selection also causes resource waste. Because of this need, the authors of [17] developed a Necessity First Algorithm (NFA) to deal with relay selection issue, which improves upon MPR selection strategy somewhat and introduces great performance. Time and effort may be needed to calculate Multi-Point Relay set. In order to lessen the burden of the control topology, [15] introduced the New Cooperative Algorithm (NCA) that uses fewer Multi-Point Relay vehicles. By taking into account the level of cooperation and connection reachability, this technique has decreased the number of CHs in the region. It divides the nodes into master and slave positions to get the lowest possible set. Algorithms like Cooperative Communication, NCA, and NFA were designed for MANETs but performed poorly on VANETs.

To help writers choose the most productive MPRs, [21] provides a system of weighted linkages. The best MPRs were chosen after careful study of the average latency and bandwidth factors. OLSR's performance grows tremendously with QoS, and it does so with little control overhead. On the other side, MANETs are the inspiration for this particular protocol. [22] proposes connection Defined OLSR (OLSR-LD), which takes into account connection quality while choosing MPR sets, to enhance routing choices under QoS constraints. Although this measure demonstrated improved performance over the baseline, it was unable to significantly reduce the number of connection failures or lost packets. The authors of [23] detail a method for reducing network overhead. Authors have taken into account connection quality, link stability, and vehicle mobility level to enhance the relay selection method, hence increasing the routing's scalability. Most of the critically important data sent between nodes is exploited via the specified paths. The PDR performance of the network has been enhanced. However, the quality of service metric was not taken into consideration while choosing relay trucks.

In [24], the capacity of discovering signalling pathways was provided by the Gravitational Search Algorithm-Particle Swarm Optimization (GSA-PSO) to a selected group of nodes as suitable member nodes. The MPR-OLSR used this technique to lessen the burden of the control topology and made more efficient usage of the network's capacity. This approach has enhanced routing performance across the board, including latency, channel utilization, packet loss, throughput, and PDR. However, effect of mobile vehicles was not considered in their study. The Cluster Head Electing in Advance Mechanism (CHEAM) was introduced for VANETs intersections in [25]. Capabilities of cluster metric were improved by considering into account the mobility and transmission power loss to assess and maintain which vehicle is apt for CH. When number of outlying cars was reduced, the connection quality improved, leading to a stable cluster having low overhead.

To choose optimal relay while keeping broadcast and collaboration phases safe, authors of [26] proposed a Generalized Optimum Relay Selection (GORS) approach. Next, they provide an incremental Adaptive Optimal Relay Selection (AORS) approach to delivering and maintaining security. Vehicles (nodes) have a unique understanding of their neighbors' whereabouts, making it difficult to quickly determine next hops for data transfers. Because of these limitations, route selection processes and mobility data are reduced, decreasing message delivery dependability.

Quality of Service Optimized Link State Routing (QoS - OLSR) was proposed to guarantee network stability throughout communication in [11]. They analyzed QoS and mobility restrictions to determine how to prevent connection failure. This method reduces network instability by cutting down on transmission overhead and lag time. However, they failed to account for the effort and complexity involved in keeping the alternative route operational. Chain-Branch-Leaf (CBL) clustering approach was developed for building a VANET's virtual backbone by the authors of [27]. The magnitude of the packet flooding was decreased by limiting the retransmission of packets in accordance with a predetermined strategy. Chain-Branch-Leaf and Multi-point relay were evaluated over a wide range of situations thanks to the realistic traffic road layouts provided by Simulation of Urban Mobility (SUMO). Without considering probable conjunctions at CH, which is related to traditional members, Chain-Branch-Leaf may function based on position and velocity data. The primary drawback of the proactive approach is the extra work required for control, which is notably noticeable in VANET contexts.

In [28], authors have been proposed a best route for cooperative multi-hop vehicular to vehicular (Coop V2V) communication. The optimum route from source vehicle to destination was determined by utilizing a close-optimal and optimal intermediate vehicle selection technique to enhance efficiency of a multi-hop cluster vehicular network. Signal-to-noise ratio (SNR) at time of transmission was taken into account by the writers of this paper to determine the best relay to use. Since nodes in vehicular network are not fixed, the best route calculated using this method may not be trustworthy.

A quality-of-service based Cluster-based Adaptive Cooperative Algorithm (CACA) is suggested by authors in [19]. This technique attempts to improve scalability of routing by selecting CHs and multipoint relays with QoS requirements and mobility constraints in mind, and it obtains tradeoff between mobility constraints and QoS by evaluating the quality of link parameter and mobility factor. The suggested method compares the signal strength and distance between any two nodes to get an overall rating for the quality of the connection between them. The quality of service is maximized while selecting relay trucks. The paper [31] addresses challenges in vehicular ad hoc networks (VANETs) by proposing a fuzzy logic-based routing method with authentication. The three-phase method includes clustering, routing, and authentication to enhance security. The paper [5] addresses challenges in vehicular ad hoc networks (VANETs) by proposing a fuzzy logic-based routing method with authentication. The three-phase method includes clustering, routing, and authentication to enhance security. Simulations using NS2 demonstrate the proposed method's superiority over AODV, R2SCDT and 3VSR in various performance metrics with a slight increase in routing overhead.

To combat the rising cost of routing in a dynamic network, many clustering methods were introduced to improve scalability of OLSR protocol's. Our proposed solution employs a clustering approach to select highest-quality multipoint relay. To further minimize overall energy usage, an optimization process is introduced during each hop to acquire the ideal number of cooperating cars. Our proposed approach is to maximize cluster heads for lower network overhead and highest PDR achievable while minimizing cluster heads to obtain lower network overhead. Each hop incorporates an optimization process, and the best possible number of cooperating cars is determined to minimize total energy use. The simulation parameters used in this paper are listed in table 1.

Table 1. Simulation Parameters

Notation	Parameter	Quantity
	Area of the Network	1400m x 1200m
P	Transmit Power	1mW
$V_s(s)$	set of nodes in transmission coverage area of vehicle v_s.	
h_{v_s,v_d}	Rayleigh fading channel coefficient	
$\Pr\left(LQ_{v_s}\right)$	probability that number of vehicles having Link quality LQ_{v_s,v_k} greater than threshold	
BW	Band Width	22MHz
M_l	Link Margin	40dB
N_0	Noise power spectral density	-171dBm/Hz
N_f	Noise figure	10dB
P_{Tx}	Transmission circuit power consumption	97.8mW
G_{Tx}, G_{Rx}	Transmitter and receiver gain	5dB
P_{Rx}	Receiver circuit power consumption	119.8mW
	Combining Strategy	MRC
V_r	Vehicle speed	2.70 – 30.0m/s
	Transmission range	250.0m
P_e	Target BER	10^{-3}
	MAC protocol	IEEE 802.11

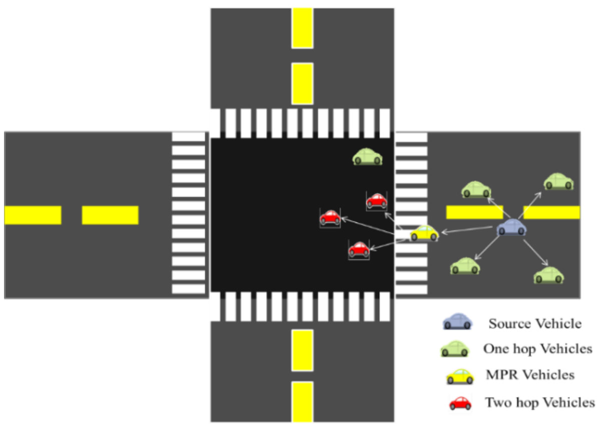

Figure. 1 Cooperative Vehicular Networks

3. System model

The Fig 1, presents a system model with cooperative NOMA in vehicular networks. The selected CH acts as a relay node to enhance the data transfer between the source and destination vehicles with Decode and Forward (DF) relaying protocol and successive interference cancellation (SIC). We presume source vehicle as v_s, $v_1, v_1, \ldots \ldots . v_K$ depicts K intermediate vehicles, and destination v_d. Each node sends and receives data simultaneously in full-duplex mode to avoid spectral efficiency loss. Channel estimation is presumed to be out of this purview and channel is assumed be accurately known. Furthermore, for $k = 1,2, \ldots \ldots, K$ we assumed a channel existed between each transmitter node $p \epsilon \{v_s, v_k\}$ and reception node $q \epsilon \{v_k, v_d\}$. Let $V_s(s)$ is the set of nodes in transmission coverage area of vehicle v_s.

According to system design, NOMA is evaluated with DF relaying protocol in two-ways. It is affected that S, r, and D utilizes same transmit power (P). Received signal at Candidate Relay (CR) set nodes to destination from source vehicle is depicted as [4]:

$$y_{v_d,v_s} = \sqrt{P} h_{v_s,v_d} \bar{x} + \eta_{v_d} \tag{1}$$

$$y_{v_k} = \sqrt{P} h_{v_s,v_k} \overline{x_1} + \sqrt{P} h_{v_s,v_k} \overline{x_2} + \eta_{v_k} \tag{2}$$

In cooperative phase, relay node broadcasts signal $\bar{x}$ with transmission power P, signals received at v_d can expressed as

$$y_{v_d,v_k} = \sqrt{P} h_{v_k,v_d} \bar{x} + \eta'_{v_d} \tag{3}$$

At destination node, MRC (Maximum Ratio Combining) strategy is utilized to integrate encoded information from different paths to attain information with lower error probability.

4. Reliable cluster based cooperative routing (RCCR) algorithm

The RCCR method for vehicular networks is discussed in present section. By taking capacity, connection quality, distance, and mobility parameters into account, this routing technique increases Optimized Link State Routing (OLSR) scalability.

4.1 Cluster formation and cluster head selection

To reduce number of multipoint relays and quantity of control messages, the shortest route technique of OLSR routing protocols utilized in [20], [17], and [15] was created. Since these algorithms don't take into account other routes that have similar hop path length and connection reachability, they don't always provide the optimal alternative. In many cases, such paths may provide advantages as to total delay, packet delivery ratio, and network load. Choosing as many one-hop neighbors as feasible is a means to this end, with the optimal route being a top priority.

Each source node routinely sends out a beacon signal and control messages to ensure that no transmissions are duplicated within the same zone. To maintain routes that have few neighbor cars that may forward, a routing database is regularly updated. When a vehicle gets a beacon message from its own one hop neighbor's cars, it evaluates the message's quality by considering factors such as connection speed, distance, and bandwidth. By considering bandwidth parameter, we can guarantee dependability; by considering the connection factor, we can guarantee a wider coverage area; and by considering the speed and distance, we can guarantee route stability. Let v_s be a network source node and v_k be a two hop vehicle. Metrics are allocated to link between $(v_s; v_k)$: dis_{v_s,v_k} is distance between v_s and v_k, and WF_{v_s,v_k} is cooperative weighting factor of both v_s and v_k. Capacity present between v_s and v_k is represented by C_{v_s,v_k}. The quality of link for v_s is $LQ(v_s)$, and representation to source vehicle neighbors is $N(v_s)$.

WF_{v_s,v_k} is proportional to inverse of mobility factor and distance. Proportionality constant is ratio between CR of v_k to total CR. WF_{v_s,v_k} can provided as represented in equation below:

$$WF_{v_s,v_k} = \left(\frac{CR_{v_k}}{CR_v + CR_{v_k}}\right) \times \left(\frac{dis_{v,v_k}}{MF}\right) \tag{4}$$

The source node will calculate WF_{v_s,v_k} utilizing periodic beacon signals and distance between two vehicles as represented by Eqn. (5) given by [29].

$$dis_{v_s,v_k} = \lambda \left(\frac{\phi}{4\pi} - \frac{B}{2}\right) \tag{5}$$

Where, λ is carrier wavelength. ϕ is overall phase attained from signals which are communicated with B is an integer and fixed carrier frequency.

Algorithm 1 Reliable Cluster Based Cooperative Routing

Input: A new flow request from source vehicle to destination

Output: Multi hop Cooperative routing path from source vehicle to destination

1: **While** $v_s \notin V_s(v)$ **do**
2: Find $V_s(s)$
3: Source vehicle v_s calculates the LQ_{v_s} of all the vehicles in $V_s(s)$
4: Forms the cluster based on LQ_{v_s}
5: selects the vehicle v_k with high LQ_{v_s} as CR
6: k^{th}hop CR vehicle will act as source vehicle for $(k+1)^{th}$ hop
7: **end**

The proposed effort makes use of CR cars to rebroadcast information, and these CR vehicles are ideally suited to slow-moving automobiles. Average mobility factor value as a function of vehicle (v) speed is shown in Equation (6). In this equation, calculating the next hop takes priority.

$$MF_{v_s,v_k} = \frac{V_r - V_{min}}{V_{max} - V_{min}} \tag{6}$$

where V_r represents speed of receiver vehicle. V_{max} and V_{min} are maximum and minimum speed of vehicle, respectively.

The product of weighting factor $\left(WF_{v_s,v_k}\right)$ and capacity is utilized to compute route quality. Because, in case of a increased mobility factor, MF_{v_s,v_k} will be less and resulting in a lower value of LQ_{v_s,v_k}, as depicted in Equation (7). If denominator value MF_{v_s,v_k} is small, the WF_{v_s,v_k} taken by Equation 1 is high, resulting in a higher LQ_{v_s,v_k}.

$$LQ_{v_s,v_k} = C_{v_s,v_k} \times WF_{v_s,v_k} \tag{7}$$

Generally, selection of new MPR method increases vehicle nodes (v_k) with a higher number of MPR linkages to get an multi point relay of v. As a result, LQ_{v_s,v_k} selects vehicle v_k with larger MPR linkages while keeping number of MPR in v_s less.

Our ways picks source vehicle's CR set based on LQ_{v,v_k} parameter; algorithm selects vehicles in v_k with highest LQ_{v,v_k} without repetition. Other vehicles in CR set helps source vehicle to forward information towards *MPR vehicle* which are known as *Candidate Relay* vehicle.

5. Analysis of energy consumption and optimization

An energy consumption design for a single hop of a cooperative Multi Input Single Output (MISO) transmission technique is described. Using this method, we were able to determine the optimal number of collaborative nodes. Data will be communicated in two parts, broadcast phase and cooperative phase, in each hop once route information between the source and destination vehicles has been obtained.

5.1 Broadcast phase

Initially, data is distributed to all n nodes in cluster, where n can be computed by

$$n = \frac{\pi r^2 V}{A} \Pr\left(LQ_{v_s}\right) \tag{8}$$

Where $\Pr\left(LQ_{v_s}\right)$ is probability that number of vehicles having Link quality LQ_{v_s,v_k} greater than threshold and A is taken as road area.

For M-QAM modulation, utilization of average energy may be shown as [30]:

$$E_{ph1} = \frac{\chi}{\eta} \frac{(4\pi)^l M_l N_f}{G_{Tx} G_{Rx} \lambda^2} \bar{E}_{avg,ph1} r^2 + \frac{(P_{Tx} + P_{Rx})}{b.BW} \tag{9}$$

Where $\chi = 3\frac{2^{b/2}-1}{2^{b/2}+1}$, b is bitrate, BW is Bandwidth, G_{Rx} and G_{Tx} are receiver and transmitter gains respectively, M_l is link margin, carrier wavelength is represented by λ, l path loss exponent, N_f Noise figure, P_{Tx}, P_{Rx} are transmitter and receiver circuit power respectively, $\bar{E}_{avg,ph1}$ is average received energy per bit.

5.2 Cooperative phase

In this phase, candidate relay receives the data from n nodes i.e., $n-1$ intermediate vehicles and source vehicle. Energy consumption on an average in cooperative phase can be computed by

$$E_{ph2} = \frac{\chi}{\eta} \frac{(4\pi)^l M_l N_f}{G_{Tx} G_{Rx} \lambda^2} \bar{E}_{avg,ph2} d_{max}^2 + \frac{(nP_{Tx} + P_{Rx})}{b.BW} \tag{10}$$

Upper bound of $\bar{E}_{avg,ph2}$ can be computed by applying Chernoff bound (11), represented as:

$$\bar{E}_{avg,ph2} \le \frac{2(2^b - 1)N_0 n}{3b} \left(\frac{4}{bP_e}\right)^{1/n} \tag{11}$$

Therefore analytical expression for energy consumption per bit for a hop is

$$E_{hop} = Q_0 n \left[Q_e \frac{A}{\pi \mathrm{VPr}(LQ_{v_s})} + (Q_e)^{1/n} d_{max}^2\right] + (Q_p)(n+1) \tag{12}$$

Where $Q_0 = \frac{\chi}{\eta}\frac{(4\pi)^l M_l N_f}{G_{Tx}G_{Rx}\lambda^2}\frac{2(2^b-1)N_0}{3b}$, $Q_e = \frac{4}{bP_e}$ and $Q_p = \frac{(P_{Tx}+P_{Rx})}{b.BW}$. According to developed algorithm, CH should be in transmission coverage region of source vehicle. Hence distance among two CHs $d_{max} \leq r$, so average number of nodes $n \leq \frac{\pi d_{max}^2 V}{A}\Pr\left(LQ_{v_s}\right)$ is presented. When $d_{max}^2 \geq \frac{An}{\pi V \Pr\left(LQ_{v_s}\right)}$ we can compute optimal n for optimization problem given in equation (13), otherwise $n = 1$.

$$\min_n E_{hop} s.t. 2 \leq n \leq \frac{\pi d_{max}^2 V}{A}\Pr\left(LQ_{v_s}\right) \quad (13)$$

To get critical/minimum value of E_{hop}, differentiate the equation above w.r.t. n and equate to zero.

$$\left[\frac{Q_p}{Q_0} + \frac{AQ_e}{\pi \mathrm{VPr}(LQ_{v_s})}\right]n = d_{max}^2 (Q_e)^{1/n}(\log(Q_e) - n) \quad (14)$$

Since parameters in above equation (14) are all positive, n should be less than $\log(Q_e)$. Let $Q_{min} = \min\left(\log(Q_p), \frac{\pi d_{max}^2 V}{A}\Pr\left(LQ_{v_s}\right)\right)$ and n' be proper solution of (14). Approximate optimal number of intermediate vehicles can be computed as

$$n_0 = \begin{cases} \lceil n' \rceil & 2 \leq n' \leq Q_{min} \\ \lfloor n' \rfloor & n' \geq Q_{min} \\ 2 & n' < 2 \end{cases} \quad (15)$$

6. Simulation results

In this part, we show that our suggested technique is feasible by contrasting the results of our experiments with those of other methods. Table 1 displays the input values for the suggested algorithm's simulation. In the simulation, sixty automobiles are dispersed at random and traveling at a constant speed of fifteen meters per second in all directions. In order for cars to communicate with one another, a traffic generator creates data packets of 512 bytes at a constant bit rate.

6.1 Impact of traffic density

We vary number of cars in the network from 30 to 120 to examine the effects of traffic density on network performance. As number of nodes expands, so does the pool of cars available for use in cooperative relay operations.

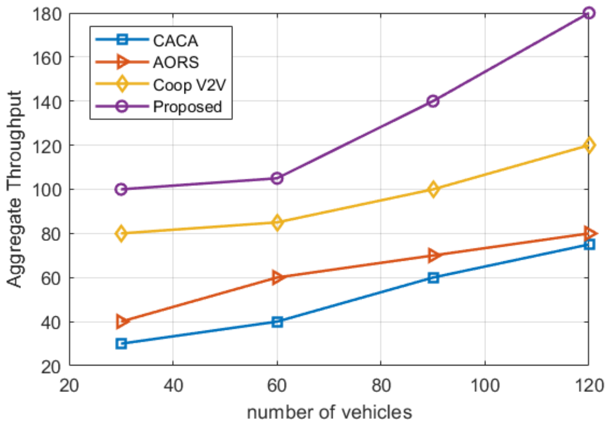

Figure. 2 Number of vehicles Vs Network throughput

Figure 2 shows how this boosts overall network performance for all routing protocols.

When compared to other routing methods, our method achieves the highest aggregate throughput as the number of cars grows. Our method can produce a significant cooperative benefit even with a huge number of vehicles because of the carefully crafted algorithms we use for route selection and relay selection. In comparison to CACA [19], AORS [26], and Coop V2V [28], our method increases network performance by 240%, 225%, and 150% at traffic density 120.

6.2 Impact of communication range

By changing communication distance from 250m to 450m and making the other assumptions in table 1, we can see how that parameter affects the overall network throughput.

Figure 3 shows that when transmission range of a node rises, aggregate network throughput first improves but then drops until it reaches a high value, where it then stabilizes.

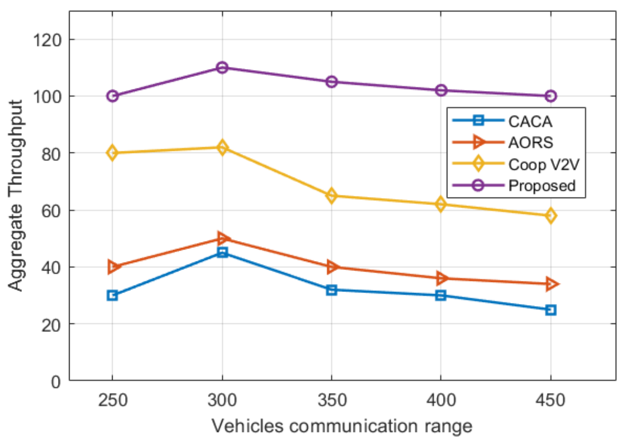

Figure. 3 Communication range Vs Network throughput

Table 2. Number of Vehicles Vs Network throughput

Number of Vehicles	Aggregate Throughput			
	CACA [19]	AORS [26]	Coop V2V [28]	RCCR (proposed)
30	30.2	40.6	80.6	100.6
60	40.1	60.2	85.4	105.4
90	60.5	70.7	100.9	140.9
120	75.6	80.7	120.6	180.5

Table 3. Communication range Vs Network throughput

Communication Range	Aggregate Throughput			
	CACA [19]	AORS [26]	Coop V2V [28]	RCCR (proposed)
250	30.5	40.1	80.4	100.9
300	45.4	50.7	82.8	110.8
350	32.7	40.9	65.6	105.3
400	30.8	36.6	62,4	102.4
450	25.3	34.4	58.3	100.7

One explanation is that more network connections and hence a greater range of communication provide more route alternatives for more capable cooperative cars and MPR (CH) vehicles. Improved network connectivity and the identification of an optimal transmission channel are two additional benefits of the first rise in transmission range. However, this increases interference, which degrades routing efficiency. Therefore, it is harmful to use excessive transition power. The interference range must be reduced if the communication range for additional relays is to be increased.

Since all 60 nodes are randomly positioned inside constrained area of 1420m*1200m, it is assumed that they are all within transmission range and within interference range of other nodes when transmission range is higher than 400m. Therefore, all routing methods maintain the same level of performance even when the transmission range is raised from 400 to 450. Figures 2 and 3 show effect of node density on average throughput, while Tables 2 and 3 detail how far vehicles may communicate with one another.

The network's throughput is measured by testing different values of SNR in addition to effects of node count and communication distance. The simulation result of throughput in relation to SNR is shown in Fig. 4. Compared to CACA [19], AORS [26], and Coop V2V [28], simulation results show that the suggested approach provides superior performance. Because our method better utilizes cooperative vehicles resources in each hop, considerable cooperative gain may be attained even when total number of cars is very small.

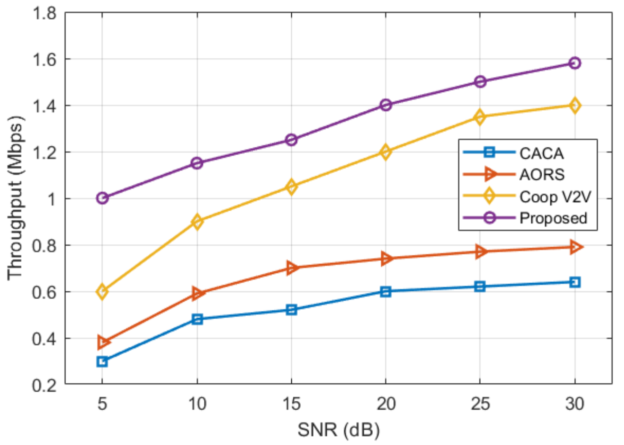

Figure. 4 Throughput Vs SNR

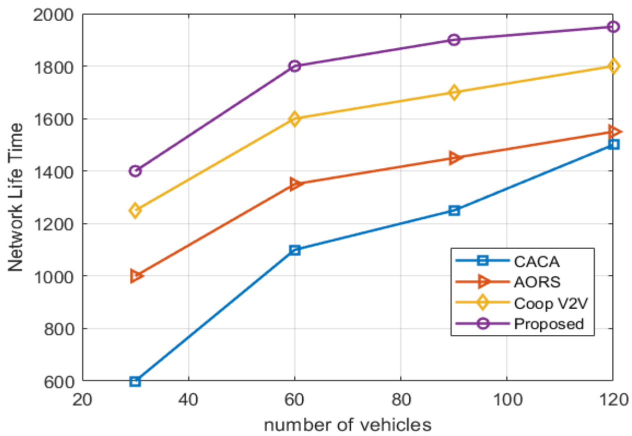

Figure. 5 Number of vehicles Vs Network life time

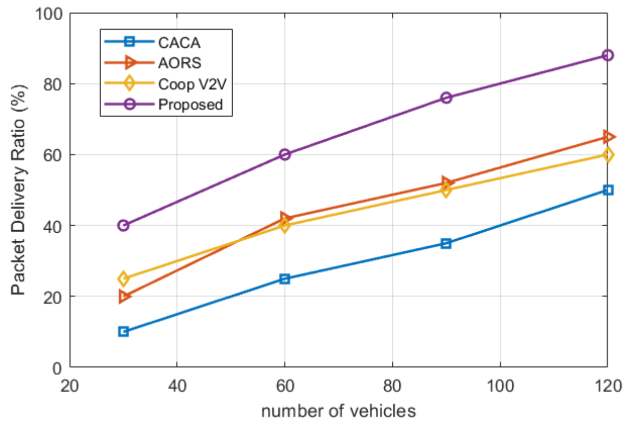

Figure. 6 PDR Vs Number of Vehicles

The lifespan of the network is shown in relation to total number of cars in Fig 5. Network's lifespan is increased since the energy needed to power a single vehicle is less when more nodes are deployed in a given area. Figure 5 represents that proposed RCCR has the longest network lifespan compared to CACA [19], the AORS [26], and the Coop V2V [28].

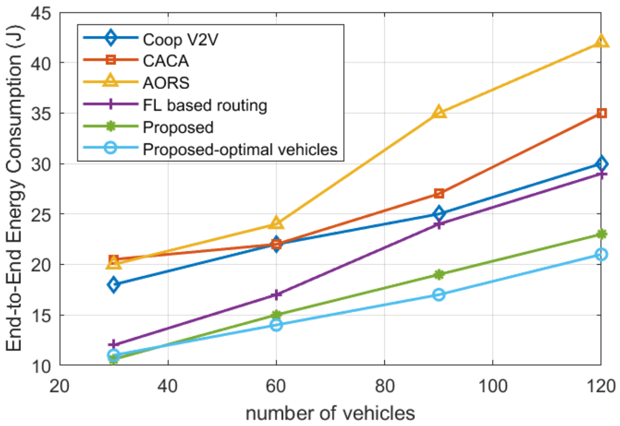

Figure. 7 Number of vehicles Vs End-to-End Energy Consumption

6.3 Packet delivery ratio (PDR)

Fig 6 represents that suggested approach (RCCR) has a better PDR based on link quality measure than the conventional CACA [19], AORS [26], and Coop V2V [28] protocols. Our method used weighted link characteristics to choose a group of multipoint relays with low collision probability, low mobility, and a wide bandwidth route, as opposed to clustering in cooperative approaches. Because of this, the vehicle at the head of the cluster in terms of its communication area and cooperating vehicles is chosen as the best vehicle. To enhance network performance and connectivity, especially in higher density circumstances, MPRs are used as a link quality parameter to link CHs together.

Fig 7 show the total energy consumption of different routing schemes (CACA [19], AORS [26], and Coop V2V [28] and FL Based routing [5]) for varying numbers of cars. As we determine optimum number of cooperative nodes in each hop, route's energy usage will go down. Our method needs fewer hops at greater node densities than AORS routing strategies do at the same vehicle density (120), and it reduces energy usage by 48.8% compared to other methods.

7. Conclusion

This work introduced a powerful technique called Reliable Cluster based Cooperative Routing (RCCR). In order to increase scalability of routing based on link quality measure utilized to pick cluster head and cooperative cars, and to address a trade-off between mobility limitations and requirements of QoS, a new method has been devised. Cluster heads and cooperative vehicles are chosen with communication reliability in mind using parameters like mobility factor and distance. With goal of decreasing total energy consumption, an ideal number of cooperating vehicles is attained via the use of optimization techniques introduced at each hop. Proposed approach improves network throughput by 225% network lifetime by 40%, energy efficiency by 48.8% compared to the AORS approach.

Conflicts of Interest

The authors declare no conflict of interest.

Author Contributions

The paper conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing-original draft preparation, have been done by 1st and 5th authors. The project administration and data curation have been done by 2nd 3rd and 4th authors.

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