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Research paper

ECBP: an energy efficient cross layer cluster based routing protocol for improved multimedia data dissemination in VANETs

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Abstract

Vehicular Ad hoc network (VANET) is an infrastructure less decentralized dynamic network, offers safety and multimedia applications. To strengthen these services, VANET demands networking of high data packets among fast moving vehicles with less link breaks. In this paper, "An Energy Efficient Cross layer Cluster Based Routing Protocol (ECBP) for Improved Multimedia Data Dissemination in VANETs" is proposed. Design of ECBP with energy efficient is achieved by considering (i) mobility metrics such as Residual distance and Relative velocity to group the vehicles into clusters reduces unnecessary flooding of control beacons (ii) Neighborhood knowledge, identifies adaptive relay vehicle reduces delay. Simulation results using Network Simulator (NS) -2.34 indicate that the proposed ECBP improves throughput of multimedia data with reduced energy consumption for different vehicle density in comparison with existing VANET cross layer based routing approach.

Keywords: *VANETS; Cross Layer; Multimedia Applications; Reliability.*

1. Introduction

VANET is an infrastructure less wireless communication network provides an intelligent transportation system services among fast moving vehicles. Such type of communication connects vehicles with internet and brings safety and comfort drive [1]. In general VANET routing protocols categorized into two types such as topology based and position based routing protocols. Topology based routing protocols are highly preferred for safety/emergency and multimedia/entertainment services over position based routing protocols because of less utilization of control packets for route discovery. Thus routing overhead, routing cost and end to end delay reduced greatly in transferring of data packets. Whereas position based routing protocols needs continuous monitoring and updating of location information about vehicles utilizes additional control packets for data transfer. If the location system fails, increases routing overhead, delay and decreases network availability due to high percentage of route error. Based on these constraints design of efficient data dissemination protocols for VANET multimedia and safety services.

However, according to previous research on VANET traditional topology based routing protocols, gravely suffer from unnecessary flooding of control beacons during high vehicle density scenarios. Further, it leads to high bandwidth consumption and collisions. In this context recently, some of the works has majorly focused on reducing broadcast storm problem in urban VANET [2-4]. On the other side due to the short communication duration and range, VANETs with topology based routing algorithms are likely to experience connectivity problems during low vehicle density and network link breaks in urban traffic scenarios. To this end, there exists routing protocols addressed disconnected network problem by route recovery mechanism based on link lifetime estimation [5].However, during route re-discovery, network suffers from packet loss, delay and further influence multimedia applications. Thus, to balance both disconnected network issue and broadcast storm problem, a cross layer cluster based routing protocol with improved reliability to satisfy multimedia applications like audio/video streaming is presented. The major contributions of the proposed ECBP are summarized as:

1) Dividing vehicles into virtual groups (clusters) based on residual distance and integrate it to existing CLARR.
2) Identifying adaptive relay vehicle called as Cluster Head (CH) and finding optimal path using relative velocities among vehicles.
3) Performance evaluation of ECBP and existing Cross Layer Design for Efficient Multimedia message Dissemination with an Adaptive relay nodes selection in VANETs (CLARR) for different vehicle density using Network Simulator (NS)-2.34.

The remainder of the paper is prearranged as follows. Section 2 illustrates related work in high mobility vehicular networks. Then the implementation of proposed framework is explained in section 3. Section 4 presents simulation environment and analysis of the proposed algorithm. Finally, concludes the paper in Section 5

2. Related work

This section presents several routing approaches to address the data dissemination issue in VANETs.

Authors in [6-9] presented topology based routing protocols for vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communication. In [10] authors presented a multicast topology based data dissemination approach by considering rapid topology changes. However it suffers from frequent link breaks as network density and speed of the vehicle increases. Towards this Marina et.al [11] designed advanced multipath routing protocol, which rediscovers the path during link breaks. But during heavy traffic scenarios re-routing mechanism leads to increased load on communication channel and thus increases delay. Furthermore, to balance above drawbacks authors in [12] presented broadcasting protocols based on neighborhood network density and radio range, which reduces redundancy in disseminating the data packets. However during high vehicle density it also facing critical Broadcast Strom problem due to extreme amount of control beacons used for route identification, which is a serious challenge for safety/multimedia services.

The clustering is the process of partitioning the VANETs into virtual groups based on different metrics (relative velocity, distance coverage and position etc), thus reduces the number of control messages for routing, as clusters includes Cluster Head (CH). The elected CHs manage the cluster members with in and capable of communicating other cluster heads or members. Hence, stability of the CHs is essential for the network performance. Clustering has been mainly employed in VANETs for safety and successful data dissemination and routing [6] [7]. In literature reported several clustering algorithms. Authors in [8] presented, Highest Connectivity Clustering (HCC) algorithm, consider the vehicle connectivity for cluster formation. But HCC suffers from Cluster instability because each Cluster Member (CM) in a cluster forced to alter its cluster head as and when it finds a new cluster head with a better connectivity and further leads to degraded network performance. Authors in [9] presented Lowest Relative Mobility (LRM) routing protocol, includes a relative mobility of the vehicle for cluster formation. The limitation of the algorithm is that it takes single parameter of a vehicle into account to form clusters.

Authors in [10], presents Weighted Clustering Algorithm (WCA). This employs collective weight metric, such as combination of radio transmission power, mobility, and battery power of moving nodes. Thus the weighted sum of three indices helps in identifying the cluster head provided with the minimum weighted sum of the three indices. One disadvantage of WCA is that it is designed for low vehicle speeds thus not adoptable directly in highway scenarios. For high speed data dissemination in VANETs, deployed several bio inspired algorithms to optimize multiple criteria.

Towards this authors in [11] have proposed a bio-inspired protocol for VANETs called Multicast routing protocol through Ant Colony Optimization (MAV-AODV). MAV-AODV is an improvement to AODV [12] routing protocol for improving multicast routing for VANETs. MAV-AODV firstly builds stable multicast routes based on mobility information. [13] M. Gunes et.al presented another algorithm based on Ant-Colony routing offer several routes for networking of data packets and cannot react directly to changes in topology and unable to detect routes during low vehicle density. To address the limitation authors in [14] proposed an improved WCA, based on change of transmission range dynamically according to network density. Thus connectivity between vehicles improved irrespective of vehicle density. Recently, to improve the network performance, integrated cross layer design with cooperative routing known as CLCR protocol, is presented in [15]. This enables mobile nodes to exchange information among different layers. Thus reduces retransmission of control packets with slightly increased delay during exchange of information. To this end, authors in [16] have presented a novel cross layer approach known as CLARR, designed based on link life time estimation for infotainment solutions such as safety and multimedia services with reduced routing overhead, error rate and delay. Towards this for improved connectivity during low vehicle density, in this paper by exploiting the features of cross layer design and concept of clustering, we present ECBP for efficient multimedia data dissemination in VANETs.

3. Proposed work

In this section, our proposed approach ECBP Protocol for VANETs is demonstrated. To this end, design of ECBP is achieved by considering mobility metrics such as (i) Residual distance to group the vehicles into clusters and (ii) Relative velocity to identify adaptive relay vehicle for packet routing with Neighbor Set Ratio (NSR) [17] mechanism to improves stability.

3.1. Cluster formation and cluster head selection

Vehicles which are entering into the network are formed into virtual groups based on mobility metrics such as relative velocity and residual distances between them. At the beginning the source vehicle floods RREQ packets to all its neighbors within the radio coverage same as AODV. To find the relative velocity of any vehicle it is recommended to insert a new field format known as <Send Time> in RREQ packet. Upon reception of RREQ by immediate neighbor, calculates delay time Td as shown in (1). If delay time exceeds transmission range (RT) of source vehicle, indicates distance of separation between the vehicles is high.’

$$Td = Tr - Ts \qquad (1)$$

Then the relative velocity of the vehicle can be obtained using the expression $R_D = V_R .\ T_d$. Where RD represents relative distance between source and immediate neighboring vehicles and is assumed all the time as $R_D < 2R_T$ for successful packet routing. Thus the vehicles with same relative velocities are grouped into clusters.

Pseudo Code 1: Cluster Head selection

1) Set the number of vehicles ‘S’ in the network;
2) Procedure 1: Cluster Head formation;
3) Initialize RREQ packet by source vehicle;
4) Transmit RREQ to immediate neighbor ;
5) Calculate Delay Time (T_d) using (1);
6) Then calculate relative velocity $V_{R;}$
7) Group the vehicles with same $V_{R;}$
8) Choose relay node with minimum V_R;
9) End procedure 1;

Pseudo Code 2: Link lifetime estimation for packet routing

1) Procedure 2: Packet Routing
2) Insert Send time and NSR path into RREQ;
3) Transmit RREQ to immediate neighbor
4) Calculate Delay Time (T_d)
5) Update Delay Time (T_d) in RREQ
6) If Delay Time ($T_{d)}$ > $2R_{T;}$
7) Drop RREQ packet;
8) else
9) check for destination;
10) if immediate neighbor is destination ;
11) Wait for small time to receive all RREQ packets ;
12) Choose reverse path with minimum delay time ;
13) Then acknowledge with RREP;
14) Else repeat line 11;
15) End;
16) End

3.2. Link lifetime estimation for packet forwarding

Once the clusters are formed, cluster member with less number of neighboring vehicles is selected as cluster head based NSR mechanism presented in earlier work. NSR path is also added along with send time filed format to RREQ packet to know each and every cluster member information within the cluster. This mechanism reduces the broadcast storm problem and thus delay comes down greatly. Except for the destination vehicle, upon receiving RREQ packet by an intermediate vehicle, it primarily finds the value of NSR pathway and added relative distance to RREQ. If the intended relative distance is less than twice of the radio range of transmitting vehicle, then adaptive vehicle routes the RREQ packet to next heir vehicle, else packet will be dropped. When RREQ packet reaches the destination, the destination vehicle waits for a short time to let all the RREQ packets arrives and combines all the delay times then selects longest life time among the available paths and acknowledges a RREP through chosen path to source vehicle. This results into reduced link failures and improved link reliability. Overall the energy consumption comes down greatly by clustering mechanism with selection of high reliable paths for packet routing.

4. Simulation results and discussion

In this section, we present performance evaluation of proposed ECBP in different simulation scenarios like End-to-End (E2E) Delay, Energy consumption, Throughput and Number of Beacon messages for different vehicle density. Then compared with existing CLARR using Network Simulator-2.34 (ns-2). The simulation is carried over a network topology 1000 X 1000 m for different vehicle density varying from 20 to 100 with average velocity of 60 kmph. The remaining simulation parameters with typical values are shown in Table 1.

Table 1: Typical Simulation Parameters

Parameter	Typical Value
Network Topology	1000m X 1000 m
Data rate	6Mbps
Vehicle average velocity	60Kmph
Simulation Execution Time(sec)	300s
Min Number of vehicles	20Vehicles
Maximum Number of vehicles	100Vehicles
Traffic Source	CBR
Propagation Model	Two-Ray Ground
MAC Protocol	802.11p
Communication Range(m)	300m

Fig. 1 shows the time taken for networking of data packet to reach the destination for different vehicle density with an average velocity of 60 Kmph.

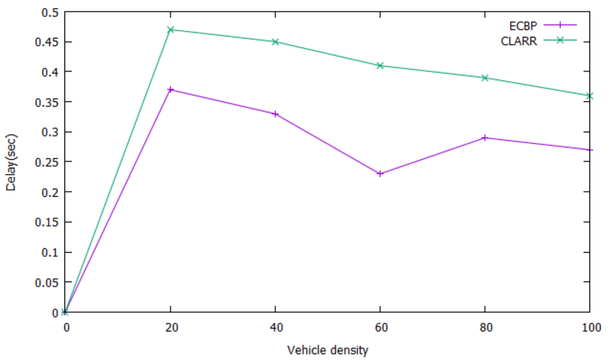

Fig. 1: Delay (Sec) for Variable Vehicle Density.

It is observed that during low vehicle density up to 20 vehicles, delay increases both in proposed and existing approaches. This is due to less number of vehicles to connect destination. But our approach works efficient and decreases delay proportionally over existing CLARR as number of vehicles increases. The improved delay performance in ECBP is because of implementation of clustering mechanism with selection of adaptive relay vehicle with high reliability. Further, delay is reduced by 35% using ECBP.
From the figure 2, it is evident that the throughput is improved in proposed ECBP over existing CLARR during high and low vehicle densities. It is also indicate that the throughput in both ECBP and CLARR is less for light traffic (for 20 vehicles), this is due to less number of cooperative relay vehicles leads to intermittent connections among vehicles. Further as number of vehicles increases from 20 to 100 in a given topology the total number of data packets received at the destination increases linearly. This is due to selection of shortest and highly stable links among Cluster Head and Cluster Members using mobility metrics. On the whole the throughput is increased by 45% using our ECBP when compared to existing CLARR.

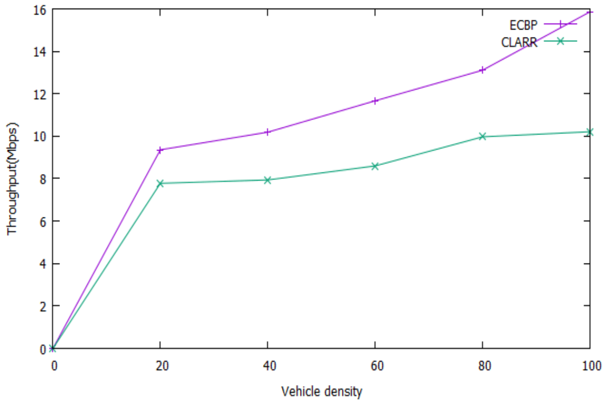

Fig. 2: Throughput (Mbps) For Variable Vehicle Density.

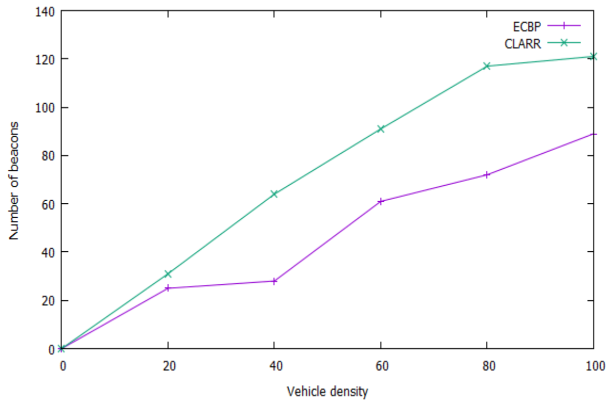

Fig. 3: Number of Beacons for Variable Vehicle Density.

Figure 3 indicate number of control a beacon used for identifying destination and is obvious that any routing protocol use of control beacons increases as vehicle density increases. But in comparison the existing CLARR makes use of more number of beacon messages over ECBP during high vehicle densities. This is due to unnecessary broadcast of control beacon messages in route discovery and loss of beacons during path breaks due to lack of stable paths. Where in ECBP because of integration of neighbor set ratio for selecting optimal path and identifying stable path using mobility metric leads to less link breaks.

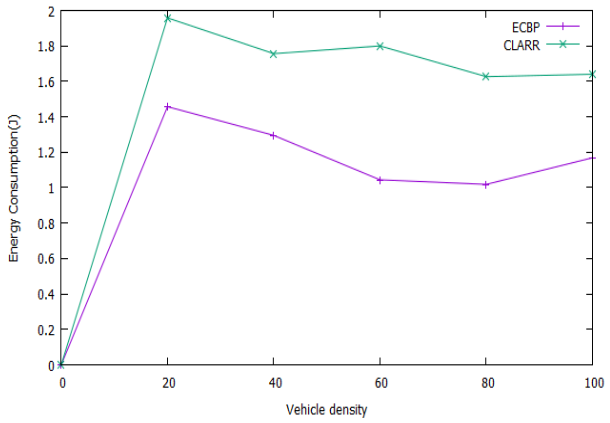

Fig. 4: Energy Consumption for Variable Vehicle Density.

From the figures 4, it is observed that the performance metric such as Energy consumption is improved in our proposed approach as number of vehicles increases from 20 to 100. It is also observed that the energy consumption is high during low vehicle density in both ECBP and CLARR. This is due to high route error rate leads increased route re-discovery and thus consumes most of the vehicle battery energy. Whereas vehicle density varies from 20 to 100, energy consumption is better in proposed ECBP due to implementation of clustering mechanism and reliable path selection leads to less route errors. Thus the battery power is consumed less and utilized for efficient data transfer between sources to destination. Over all energy consumption is reduced to 33% in proposed ECBP over existing CLARR.

5. Conclusion

In this paper, A Cross layer Cluster Based Routing (ECBP) Protocol for efficient multimedia data dissemination in VANETs is proposed. In our approach, at the beginning based on residual distance vehicles are arranged into clusters and using relative velocity metric, an efficient relay vehicle is elected as cluster head in each cluster. Later based on neighborhood knowledge and stability factor calculations between cluster members and cluster head, shortest reliable path is selected to destination for high data transfer ratio. Wide Simulation results using NS-2 demonstrate that our proposed protocol performance is better in terms of delay, throughput, and energy consumption. Additionally it is observed that over all energy consumption is reduced to 33% in proposed ECBP over existing CLARR by reducing unnecessary broadcasting of control messages. Furthermore, as part of future work we plan to investigate the performance of reliability and energy consumption for high vehicle density.

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