Cluster Based Energy-Efficient Routing Protocol for VANET to Improve the Network Performance

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Abstract

Vehicular Ad Hoc Networks (VANETs) is a special case of mobile ad hoc networks, which allows its users with high mobility. The network used to spread the informationamong vehicles to facilitate roadside navigation, traffic monitoring, and vehicular safety.Clustering in VANET solves the issue of scalability and makes the network increasingly vigorous. The paper designs an energy efficient clustering mechanism to achieve effective way of resource utilization. Optimized energy processing ability of node is used for cluster formation. The proposed mechanism is validated with NS2, and performance is compared with existing residual energy based clustering in an identical environment. Results indicates that the proposed mechanism outperforms in terms of energy consumption, packet delivery, and delay.

Keywords:- VANETs, cluster, performance, and energy.

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1. Introduction

Vehicular Ad Hoc Networks is a special instance of mobile ad hoc networks, which allows its users to move with high mobility [4]. The network used to spread the information among vehicles to facilitate roadside navigation, traffic monitoring, and vehicular safety. IoV (Internet of vehicles) is an enhancement of traditional VANETs with respect to infrastructure, scalability, and applicability [2]. IoVprovides promising solutions to extend the VANETs to further level. This extension leads to various communications between human, vehicles, and road side units at road level. The major advantage of IoV is to provide easy and fast way of internet access. The vehicles in network share the information like its location, time, and direction, apart from this network also provide the information like parking details, availability of infrastructure, and sophisticated applications.

The architecture of IoV consists of two main parts such as access network and backbone network,shown in figure 1. The access network consists of two things such as road side unit, and on board unit. The vehicles are equipped with on board unit for communication. The board unit consist of four components such as GPS, vehicle-to-X (X may be a vehicle, human, and internet) module, dataacquisition module, and input-output module. On the other hand road side unit is a computing module that is equipped at road side for enabling communication between vehicles. Backbone network primarily consist of three modules internet, transportation control center, and cloud center [2].

Clustering in VANET solves the problem of scalability topreventpricey long-distance communication and enhance the availability of network resources by offering service locally [1]. Clustering is considered avitalprocedure in VANET toachieve the effective way of resources availability. The clustering in the procedure of executing the network into set of small groups of nodes known as cluster members, and headed by one of the node, known as cluster head. In literaturevarious clustering methods have been developed to manage and construct the cluster in VANET. Majority of these are designed for single hop communication such as direct communication between cluster head to cluster member. These approaches can cover the small region, and there is huge probability of overlapping, as clustering is formed by single hop communication. Work [2] concluded that the single hop communication based clustering mechanism is not advisable for VANET, as network is highly mobile and unpredictable topological nature. Thus multi hop communication based clustering approaches have been proposed in literature to overcome the problems caused by single hop communication clustering approaches such as network coverage, and stability [5-7]. Further multi hop clustering includes the phenomena of mobility and distance to pick the cluster head. These mechanisms further included the selection of secondary cluster head selection, in case of primary cluster head absence or failure. Recently, Ren et al. [8] designed the cluster formation based on the mobility, and direction of vehicles and estimated link lifetime. Work [2] reviewed the Ren et al. designed approach and concluded that it is having control packet overhead, and poor performance. Further, work [9] designed a way of clustering in VANET based on the affinity propagation, but work [2] reviewed it and concluded that the affinity propagation forms the loops in network that causes the delay in communication. Work [5]designed a way to selecting the cluster head based on the relative mobility of vehicles, but work reviewed it and concluded that the it is having the control packet overhead and reduction in energy efficiency. Distributed multi hop clustering is proposed in work [7], where cluster head is nominated based on the characteristics of neighbor node, but work reviewed it and concluded that the selection of cluster is based on the various metrics which I terns leads to overhead of control packets and degrades the network performance. In literature [9], mobility based cluster formation mechanisms have been designed for VANET,these methods suffer from the control packets overhead, and collision of packets.

To address the above problem, work [2] designed efficient hierarchical clustering approach for forming cluster in multi hop VANET to utilize resources effectively and to extend the network lifetime. The work does not consider the problem of the cluster head resources for communication. Thus the cluster head becomes the bottleneck and could not support for communication. The node in the communication path behave like bottleneck, if it faces the extra overload greater than its handling ability. It is happen in network due to either insufficient energy or buffer overflow. It is a single plug of through which traffic flows more that it’s handling ability. In VANET, it is due to constrained energy. In order overcome the problem, the paper design a cluster head selection based on the optimized energy, and processing ability of the node. The designed mechanism validated with the help of NS-2 [10-11], and the results computed in terms of remaining energy, packet delivery, and delay.

The reminder of paper is structured as follows; next section designed the cluster head selection based on the optimized energy, and processing ability of the node, further section validate the designed mechanismin terms of different measures, and the work ends with conclusion and future scope.

2. Cluster formation in VANETs based on optimized energy, and processing ability of the node

The prosed mechanism considered the VANETs environment which consist of vehicles, road side unit, on board unit, internet, cloud center and transportation control center. The vehicles are equipped with GPS and act as a communication devices, work considered it as a mobile nodes. The vehicles are also equipped with on board unit to enable the communication between vehicles and with road side units. Road side unit is a static communication point build at road sides to enable V2I communication. The transportation control center unit acts interface between internet and access network (AN). The cloud center is a virtual server to save and distribute resources to carry out the formation of cluster. There is direct communication between vehicles to vehicles, if they are in the communication rage of each other. There is the communication between vehicles to road side units and vice versa, with single or multi hop compunction manner based on the location of road side units and vehicle. Finally, there is a V2I communication, it is a between vehicles to internet through road side units and transportation control center.

The work proposed a novel optimized energy, and processing ability of the node mechanism for V2I communication to enhance the performance of network. The proposed work considers that the vehicle are connected with internet through road side units and get the information of neighbor vehicles. The proposed work compute the optimized energy, and processing ability of the node decide the cluster head. The proposed work consists of four steps such as registration, gathering neighbor node information, and clustering formation and cluster head election, and maintenance. The work is an extension of the existing work i.e., residual energy based clustering [3] in terms of cluster head selection, rest of the things such as gathering neighbor node information, maintenance, and registration is as identical as existing EHCP.

2.1. CH selection

VANETs consists of N number of vehicles in a communication region of m*n km^2. All the vehicles have the same communication rage let r km. Each node information regarding location and time can be determined by GPS by and same can be shared to neighbor vehicle. All the vehicles consist of the buffer capacity of L kbs as well as energy of E joules to process the information through them. The cluster head selection is based on the optimized energy, and processing ability of the node to avoid the vehicle to becomes an intermediate bottleneck node for multi hop communication. The nodes which is having E joules of energy need to process the maximum number of packets let ‘Pi’ packets through it, where i=,2,3….n, where each packet is having the size of l kbs and consume the e_l energy of the node for process through it. Let consider the packet P_i that need to be process through the any node having E joules of energy, the consumption of energy is calculated by equation (1);

$$E(P_i) = E_r + E_t + E_p \quad (1)$$

Then the remaining energy of the node is computed as follows;

$$E_{rem} = E - E(P_i) \quad (2)$$

To compute optimized energy, and processing ability of the node let N with its energy E joules, and its remaining energy after one packet process is about E_{rem} joules, is followed by below considerations;

1. Data packets must be communicated through node must node be greater than to combined energy consumption at most E joules.
2. Need to process as much as possible packets through the node in an available energy E joules.
3. Complete communication must happen partial transmission is not applicable.

Paper computed the remaining energy after processing the one packet through the node in the multi hop communication model by equation (1), and (2). To compute the optimized energy, and processing ability of the node, the paper uses the knapsack algorithm with n-Topples of positive values as

- The packets that needs to process through the node are Pi', where i=,2,3….n
- Each packet consumes the $E(P_i)$ joules of energy to process through the node, and after processing the one packet the remaining energy of the node is E_{rem} and can be computed by equations (1), and (2).

To achieve the objective, work needs to determine the energy consumption by packets processing through the node in joules E Є $\{P_1, P_2 \ldots P_n\}$ to

Maximize $\sum P_i$ where I Є E Subject to $\sum E(P_i) \leq E_{rem}$

To compute the optimized energy, and processing ability of the node with available energy capacity 'E' joules, and energy consumption after one packet is about $E(P_i)$, and remaining energy about Erem, the procedure is to try all the possibilities of subsets of E to build the two dimensional array as follows

J[0…..n,0….Erem]∀1≤Pi ≤n&0≤E(Pi) ≤Erem

Such that J[I, Erem] is going to determine the optimized energy, and processing ability of the node with data packets which consume the $E(P_i)$ energy to process.

The entries of the array J[I, Erem] gives the optimized energy, and processing ability of the node. However work avoids the following considerations;

The J [n,Erem] array entries will consist of highest flow of process from given intermediate node, array entries must avoid the following conditions;

1. J[0,Erem]=0∀0≤ E (P_i) ≤Erempacket does not processed

2. J[i, Erem] = - ∞∀ E (P_i) < 0, not acceptable

Optimization explanationis as follows

$$J[I, Erem] = \max (J[I-1, \boldsymbol{E}(\boldsymbol{P_i})], J_i + J[i-1, \boldsymbol{E}(\boldsymbol{P_i}) - \boldsymbol{E}(\boldsymbol{P_{i+1}})]$$

$$\forall\ 1 \leq I \leq n \text{and}\ \ 0 \leq \boldsymbol{E}(\boldsymbol{P_i}) \leq E_{rem}$$

To calculate the optimized energy, and processing ability of the node, Knapsackattaches an auxiliary Boolean array Keep [I , $\boldsymbol{E}(\boldsymbol{P_i})$] which become one whenever no ready to process the P_i' the packet in J[I,$\boldsymbol{E}(\boldsymbol{P_i})$]otherwise it indicates zero.

The algorithm to compute the optimized energy, and processing ability of the nodeis given below

Algorithm

1. Knapsack(l,$\boldsymbol{E}(\boldsymbol{P_i})$,n,$E_{rem}$){
2. for($\boldsymbol{E}(\boldsymbol{P_i})$=0to$E_{rem}$) J[0, $\boldsymbol{E}(\boldsymbol{P_i})$]=0;
3. for(l=1ton)
4. for($\boldsymbol{E}(\boldsymbol{P_i})$=0to$E_{rem}$)
5. If(($\boldsymbol{E}(\boldsymbol{P_i})$≤$E_{rem}$)and(l[i]+J[i-1,$E_{rem}$- $\boldsymbol{E}(\boldsymbol{P_i})$]> J[i-1,$\boldsymbol{E}(\boldsymbol{P_i})$])){
6. J[i,E_d (P_i)]=l[i]+J[i-1, E_{rem}-$\boldsymbol{E}(\boldsymbol{P_i})$];
7. Keep[i,$\boldsymbol{E}(\boldsymbol{P_i})$]=1; }
8. else J[i,$\boldsymbol{E}(\boldsymbol{P_i})$]=J[i-1,$\boldsymbol{E}(\boldsymbol{P_i})$];
9. Keep[i,$\boldsymbol{E}(\boldsymbol{P_i})$]=0; }
10. S=E_{rem};
11. for(I=ndownto1)
12. If(keep[i,S]==1){
13. Outputi;
14. S=S-$\boldsymbol{E}(\boldsymbol{P_i})$;
15. ReturnL[n,E_{rem}];

Algorithm1. Algorithm to calculate the optimized energy, and processing ability of the node

3. Performance Analysis

Proposed mechanism of optimized energy, and processing ability of the node for cluster head selection has been evaluated with the help of NS-2with extension of VanetMobiSim. The simulation environment consists of one-directional road with 5 km of length with 3 lanes, the simulation parameters re shown in table 1. The number of vehicle considered are 100, and the area of simulation is about 1000m *1000 m. The mobility of vehicles are set with 10-40 m/s. the performance results are compared with the existing approach EHCP.The performance evaluation parameters are lifetime, packet delivery, and delay.

Table-1: Simulation Parameters

Network, Parameters	Values
Compunction range	100-300m
No. of Road side units	3
Simulation, Time	1500 s
Mobility	10-40 m/s
Mobility Network layer Communication.	Random RCRP Two-Ray-Ground
Queue	Drop-Tail
Energy	100j
Simulation area	1000m x 1000m
Traffic	CBR

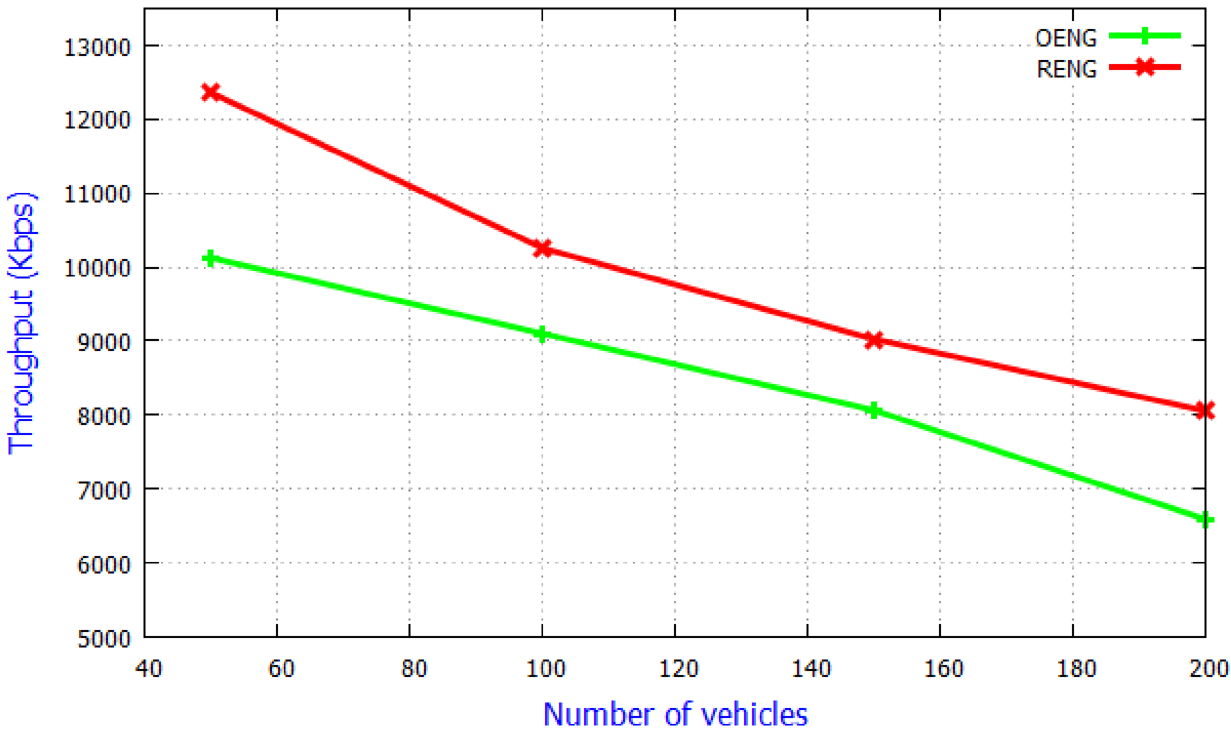

Figure 1:- Performance analysis a **Throughput with optimized cluster forming and Residual energy based cluster forming**

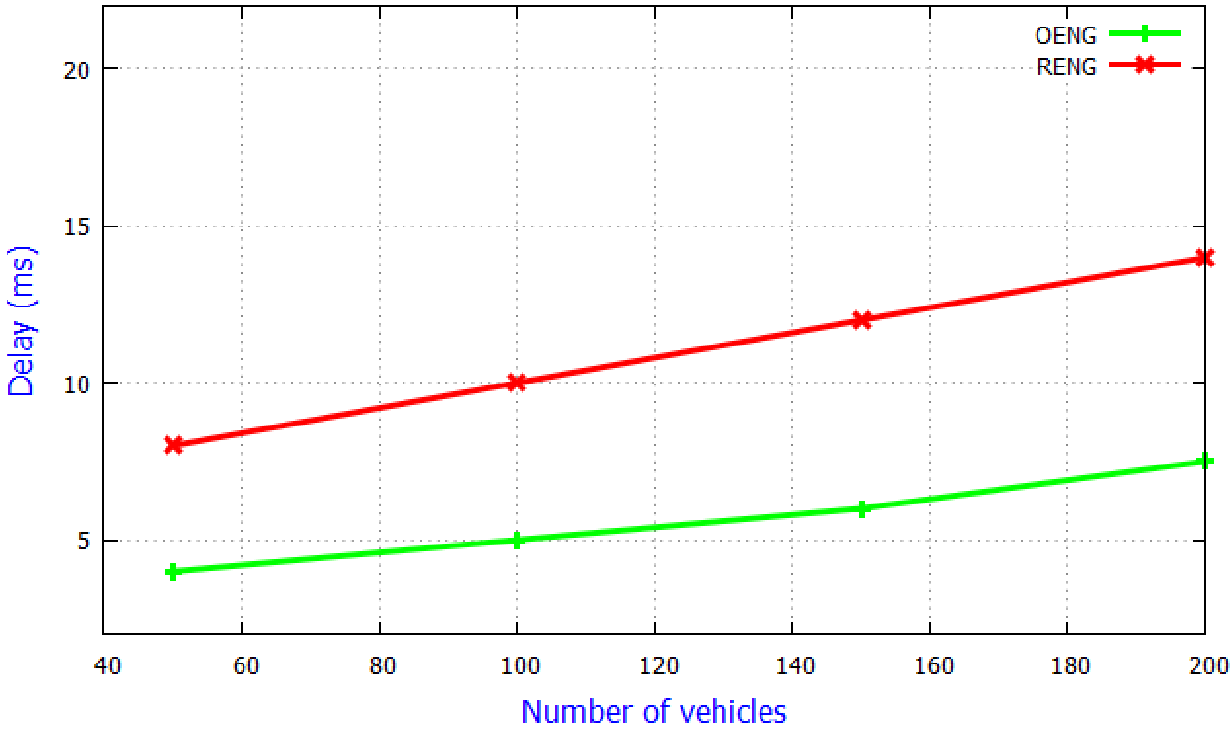

Figure 2:- Performance analysis a **delay with optimized cluster forming and Residual energy based cluster forming**

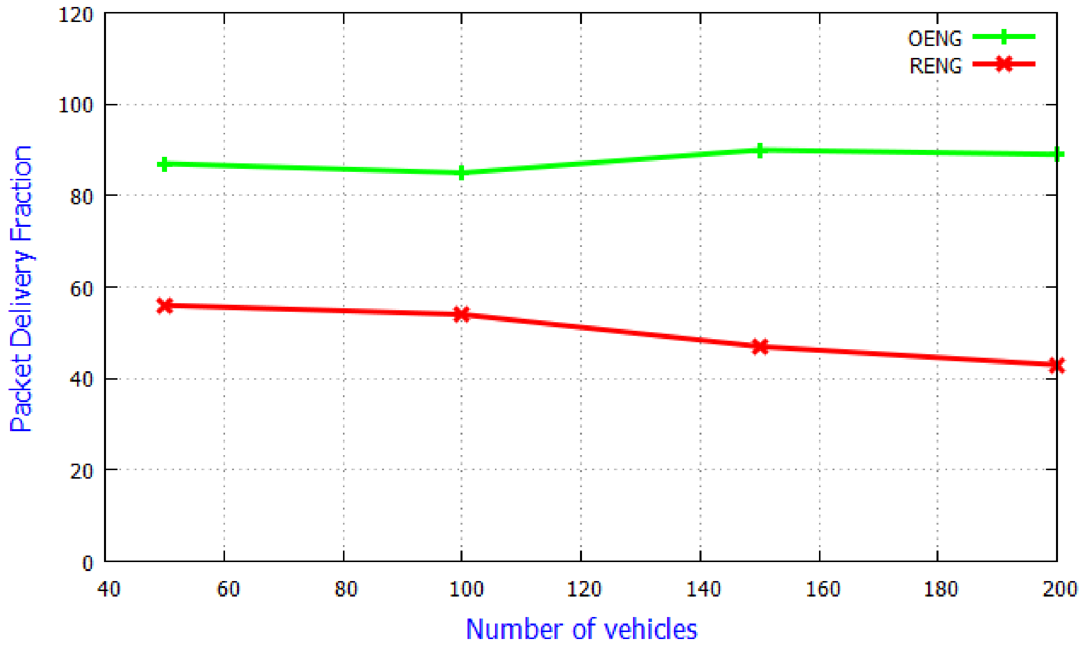

Figure 3:- Performance analysis a **packet delivery fraction with optimized cluster forming and Residual energy based cluster forming**

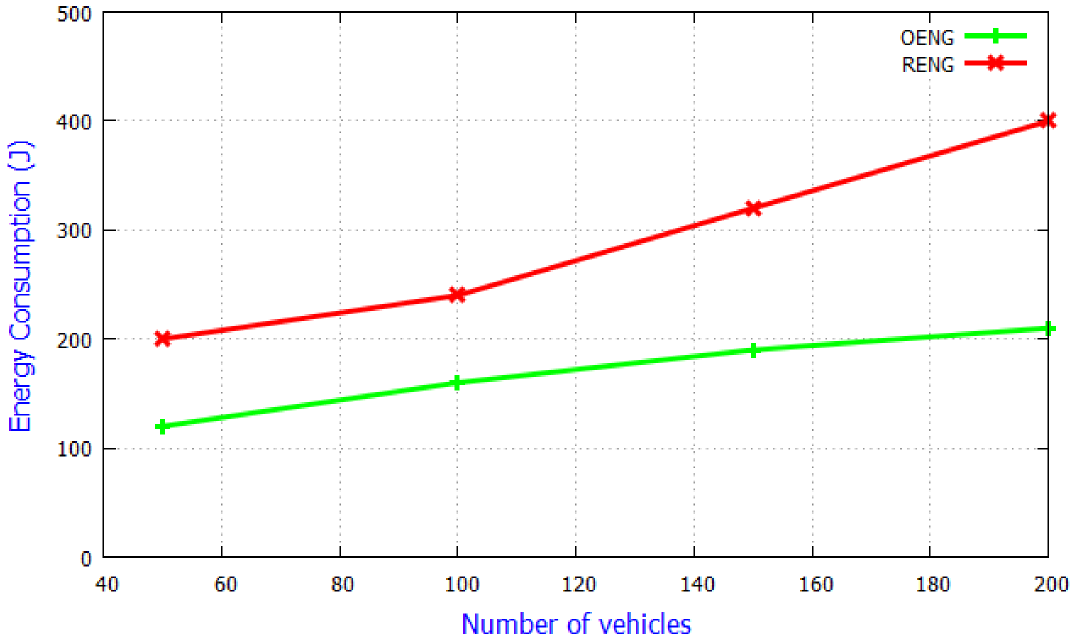

Figure 4:- Performance analysis a **Energy consumption with optimized cluster forming and Residual energy based cluster forming**

Figures 1 to 4 describes the performances evaluation results of existing Residual energy based cluster forming and optimized cluster forming in terms of throughput, delay, PDF, and energy consumption. The results are clearly indicating that the enhanced performance with proposed cluster mechanism. Just considering the node residual status in not sufficient to enhance the network performance in VANET, but need to consider the its residual status regarding packet processing ability.

4. Conclusion

Vehicular Ad Hoc Networks (VANETs) is a special case of mobile ad hoc networks, which allows its users with high mobility. The network used to spread the information among vehicles to facilitate roadside navigation, traffic monitoring, and vehicular safety. Clustering in VANET solves the issue of scalability and makes the network increasingly vigorous. The paper designed an energy efficient clustering mechanism to achieve effective way of resource utilization. Optimized energy processing ability of node is used for cluster formation. The proposed mechanism is validated with NS2, and performance is compared with existing residual energy based clustering in an identical environment. Results indicated that the proposed mechanism outperforms in terms of energy consumption, packet delivery, and delay.

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