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Optimization of Cluster Head Election in VANET

G. Deepa[1], Balambigai Subramanian[2], Janarthanan.P.P[3], Kousalya.J[4], Medhini.K[5], Nandhini.R[6]
[1, 2, 3]Associate Professor, [4, 5, 6]Bachelor of Engineering,
Department of Electronics and Communication Engineering, Kongu Engineering College, Perundurai, India
[1]g.deepa@kongu.ac.in, [2]sbalambigai@gmail.com, [3]ppjanarthanan.ece@kongu.ac.in,
[4]kousalyajayakodi@gmail.com, [5]medhinik2105@gmail.com, [6]rasunandhini32345@gmail.com

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Abstract
In order to make Vehicular Ad hoc Networks (VANET) topology less dynamic, clustering is used in VANET. Clustering is the process of grouping the vehicles which are based upon some parameters like density of vehicles, speed and the location of the vehicles. Mobile Ad hoc Networks (MANET) led to the evolution of the clustering algorithms of VANET. Yet, they are represented by their high mobility range. By electing the most appropriate cluster head, the cluster structure is made stable. Vector - based cluster head election algorithm is the existing work where only the position of the vehicle is considered for electing the Cluster Head (CH) i.e.; the cluster head should always lie at the center. A Weight-based cluster head election algorithm is proposed in order to optimize the frequent cluster head change in VANET environment considering a highway scenario with the intend of improving the stability of the network.Weight includes both position of the vehicle and the vehicle moving with constant moving velocity are considered for cluster head election. This is done by taking the mean difference between two longest end nodes in a network with constantly moving velocity; therefore, it will communicate with the entire vehicle with minimum delay to create relatively stable cluster structure.Simulation was done to evaluate the method and compare it with the existing vector-based cluster head election algorithm. The simulation results show that the proposed work provides more stable cluster head in highway environment.

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1. INTRODUCTION

The communication between the vehicles, is given by means of VANET using Dedicated Short- Range Communication (DSRC). DSRC is known as IEEE 802.11a, which is the modification for low overhead operation to 802.11p. Vehicles can directly communicate between themselves either by vehicle-to-vehicle communication (V2V) or with road which is called as Road Side Unit (RSU) thus forming the vehicle-to-infrastructure communication (V2I). VANET helps the vehicles in sharing information, such as safety-related messages to prevent accidents, post-accident investigation or traffic jams in roads and non-safety information like traveler related. This information is used to intimate the drivers about expected problems to decrease the number of accidents. An OBU is a device which is mounted on-board in a vehicle to exchange the information between the RSUs or with other OBUs. The OBU is connected to an RSU or to the other OBUs via a wireless link which is responsible for the communications between them.

OBU is also responsible for the access of Wireless radio, data security, stable message transfer, ad-hoc routing and topographical routing, network congestion control and IP mobility.

The RSU is a device fixed along the roadside or in sPublic places which is equipped with a network device so that it can serve the purpose of communicating within the network. Figure 1 shows the architecture of VANET.

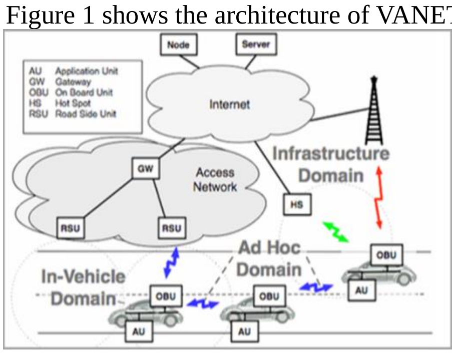

Figure 1: VANET architecture

1.1 Applications of VANET

Safety applications: VANET applications use wireless communication between vehicles or between vehicles and infrastructure to improve road safety by avoiding accidents. The intention behind this application is to save people's lives and to provide a pleasant journey. The basic idea behind VANET is to build efficient and secure communication.

Comfort/entertainment applications: This category of applications is also referred to as non-safety applications, and aim to improve drivers and passengers comfort levels (make the journey more pleasant) and enhance traffic efficiency. They can provide drivers or passengers with weather and traffic information and detail the location of the nearest restaurant, petrol station or hotel and their prices. Passengers can play online games, access the internet and send or receive instant messages while the vehicle is connected to the infrastructure network.

1.2 Clustering

The network is divided into smaller groups of mobile vehicles interfaced with network devices. Figure 2 shows the architecture of a cluster. Clustering is used in VANET environment. It is the process of grouping nodes (mobile devices, sensors, vehicles etc.) thus forming a sub-network on the road based on some predefined metrics, like density of vehicles, velocity, direction and geographical locations. Clusters are used in various applications like accident or congestion detection, information distribution and entertainment purposes. Clustering is one of the most important tasks of VANET in optimizing communication. It makes the network more robust.

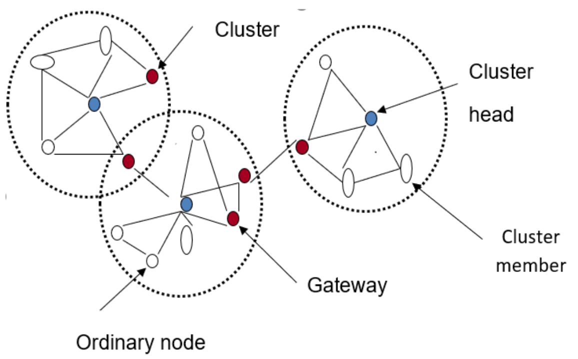

Figure 2: Architecture of a cluster

2. EXISTING METHOD

Assumptions made for clustering of nodes are

(1) Both LTE and 802.11p interfaces are present in almost all vehicles.

(2) All vehicles are provided with Global Positioning System (GPS) devices. Hence, they have accurate geographic locations.

(3) Every vehicle knows their location, rate of speed and distance between the nodes.

Based on the assumptions, vector-based cluster head election is structured. In this scheme the cluster head node always lies at the center of the cluster equally covering all the vehicles in a network. During the first stage of cluster formation, vehicles send a set of messages to all neighbouring vehicles within the cluster. Vehicles within the transmission range are considered to be stable neighbours. To form a cluster group on a highway, vehicles moving in the same direction will only be considered. The set of messages of a vehicle contains the current position, current speed, direction (considering a highway scenario all vehicles moving in the same direction). After receiving the set of messages, the system analyses vehicle's position information and detects the centers of the vehicle. If a vehicle k, is in cluster i, distance between vehicle k and the remaining N vehicle in the same cluster is given by

$$\mathrm{Dk} = \sum_{n=1}^{n} \sqrt{(\mathrm{xk} - \mathrm{xn})2} + (\mathrm{yk} - \mathrm{yn})2 \tag{1}$$

The difference between k and other N vehicles' speed within the same cluster is

$$Vk = \sum_{n=1}^{N} |\mathrm{Vk} - \mathrm{Vn}| \tag{2}$$

The number of neighbours of node *i* at a given time t within a cluster is generally calculated as:

$$\mathrm{Ni(t)} = \sum_{j=1}^{n} \mathrm{dist(i,j,t)} < Txrange \tag{3}$$

The position coordinates gives the vehicles node position *np* which is represented bys:

$np = (x_1, y_1)$ (4)

where *x* and *y* represents the position coordinates of the vehicles.

2.1 Cluster Head Election

Mean distance=longest distance between two nodes/ 2 (5)

The vehicle which lies nearer to this mean distance value having the high probability to become a cluster head. In addition to this, high mobility of vehicles leads to frequent cluster head changes due to reducing in lifetime of a vehicle in a network. Figure 3 shows the CH election. In order to reduce the frequent cluster head changes less dynamic, vehicle with constant moving velocity is preferred.

2.2 Routing Protocol

Nodes (vehicles) have high mobility and moves with high speed in VANET.AODV is considered as a reactive routing protocol for wireless and mobile ad hoc networks which operates on single hop pattern. The AODV protocol routes between nodes only if requested by source nodes and does not create any extra traffic for communication along links. The routes are maintained as long as they are required by

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the sources. The node that initiated the request uses the best route containing the least number of hops through other nodes. If a link fails, the routing error is passed back to the transmitting node and the process is repeated.

2.3 Simulation

Weight includes the measured mean distance and vehicle with constant moving velocity. For every 0.1 seconds, the weight can be calculated and it is updated periodically. After 1 second, the vehicles having highest weight value with compete to become a cluster head and become a cluster head. After 1 second, again the weight for each vehicle is calculated and updated and again the vehicle with highest weight is elected as a cluster head. The simulation time is 20 seconds.

2.4 Algorithm

Initialization: Input the number of vehicles in a wireless network.
Step 1: Cluster the whole vehicles in the network.
Step 2: Calculate the distance from ones vehicle to all the vehicles within a network.
Step 3: Longest distance between two vehicle is taken and divide the distance by 2, mean distance is obtained.
Step 4: Based on the calculated mean distance, the Cluster members (CM) compete to become a CH.
Step 5: The vehicle with suitable distance is elected as CH.

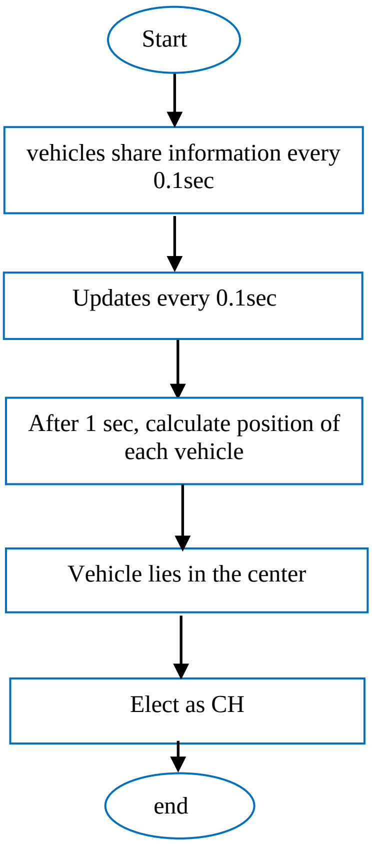

Figure 3: Vector based CH election

3. PROPOSED METHOD

In this paper, a weight- based cluster head election algorithm is proposed. The existing algorithms so far shows only the vehicles with identical speed range to form cluster groups. It is considered that an identifier known as node id will be given to each vehicle that joins the network. It is assigned based on the arrival of the vehicle to the network Considering 3 lane in a network of a specific distance. A group of vehicles moving with different velocity randomly moving in all the lane. Each vehicle is assigned with individual node ID. Vehicle lies in the center which covers the entire vehicle acts as a CLUSTER HEAD(CH) respective of distance. The elected cluster head is assigned with CLUSTER ID.

3.1 Average CH Lifetime

The time between the node acts as Cluster Head (CH) and when it leaves the cluster is called the CH lifetime (i.e., being a Cluster Member or leaving the network). When a CH leaves the cluster, a new CH is elected, or the cluster is split up. The average life time of the CH increases, stability of a cluster also increases.

3.2 Average Cluster Member (CM) Lifetime

How long a Cluster Member is in the same cluster is known as CM lifetime. Average CM lifetime is calculated by taking average of length of all vehicles. Evaluating the stability of cluster is another important metric.

3.3 Algorithm

Input: Vehicles in a cluster
Output: CH for the corresponding cluster
1. Set Wmin = +α;
2. for each vehicle k do
3. calculate the weight W ;
4. if Wmax<Wmin then
5. count ++;
6. if count >= 3
7. elect CH;
8. end
9. end
10. return 0;
Initialization: Input the number of vehicles in a wireless network.
Step 1: Cluster the whole vehicles in the network.
Step 2: Calculate the distance from one vehicle to all the vehicle in a network.
Step 3: Longest distance between two vehicle is taken and divide the distance by 2, mean distance is obtained.
Step 4: Consider the calculated distance as the weight 1.
Step5: Calculate the moving velocity for all the vehicle.
Step 6: Identify the vehicle which is moving with constant velocity in a network and consider it as weight 2.
Step 7: Calculate the computed weight by adding weight1 and weight 2.
Step 8: Vehicle which maintain the highest computed

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weight value for more than 3 iteration will be declared as a cluster head.

3.4 NS-3 Simulator

The software used for this work is network simulator-3 (NS-3). The simulation tool is an open source tool which is being actively developed. It is aimed at research of network and provides support for simulation of routing, multicast protocol and IP protocols, such as UDP, TCP, RTP over wired and wireless networks. Table 1 shows the various parameters used in simulation.

3.5 Simulation

Considering ten vehicles moving with different velocity in different time duration in a 4 lane. For every 0.1 seconds, each vehicle will communicate with each other vehicle. Within 1 second, status of each vehicle is shared among themselves. After 1 second, CLUSTER HEAD is elected based on distance.

Table 1: Simulation Parameters

Parameters	Values
No. of vehicles	30
Simulator	NS 3.30.1
Simulation area	1000 m
Simulation time	20 sec
Speed of each vehicle	40–100 kmph
MAC type	802.11 p
Routing protocol	AODV
No. of lanes	4

4. RESULTS & DISCUSSION

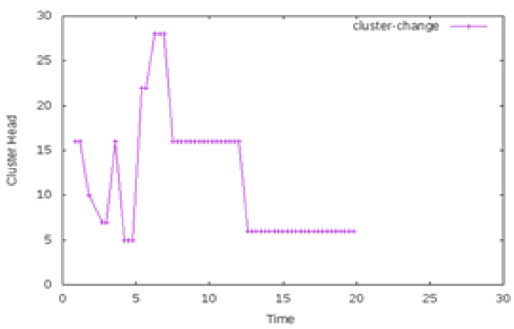

Figure 4: Cluster head election

From this Figure 4, that the nodes are being selected frequently which leads to instability and low maintenance of cluster. There will be delay in the transmitting the data and loss of data while communication. The lifetime of each cluster head is very small. In order to overcome this, an optimization method is proposed which increases the cluster head stability.

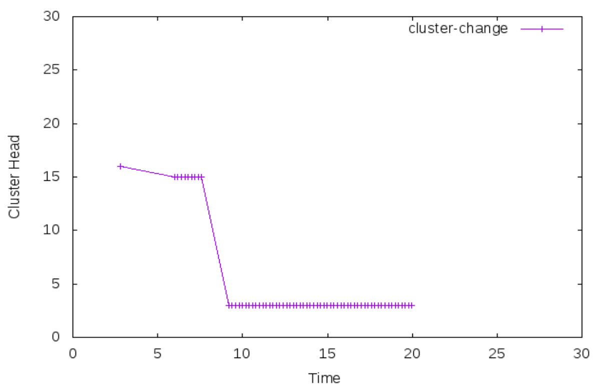

Figure 5: optimized view of cluster head selection

From the Figure 5, it is clear that the cluster head being frequently changed is optimized in such a way that the cluster head is chosen very rarely. Thus it improves the cluster stability.

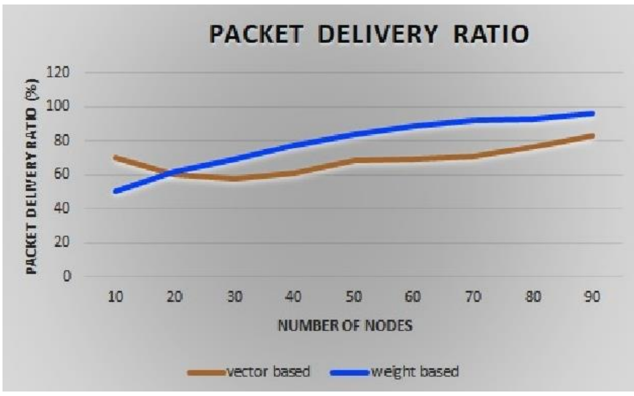

Figure 6: Packet Delivery Ratio

A higher packet delivery ratio is achieved in figure 6. Thus, loss of data is reduced in this method.

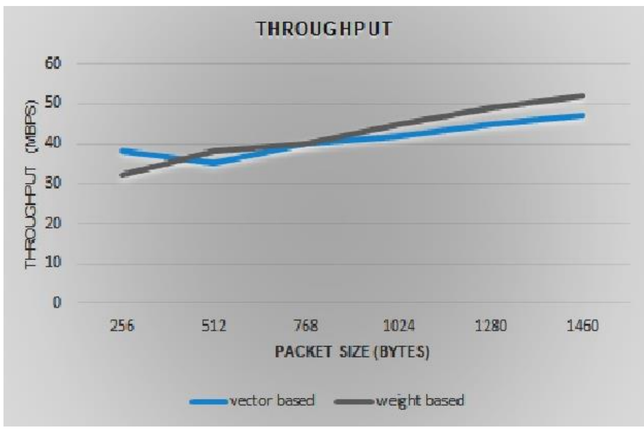

Figure 7: Throughput

From the above figure 6 & figure 7, the packet delivery ratio and throughput for weight-based cluster head election is higher than the vector-based cluster head election. This is due to the frequent cluster head change. As the cluster head changes frequently, there is some packet loss every time the cluster head changes. This leads to poor packet delivery ratio. The same condition affects the throughput also. In order to overcome this drawback, optimization of cluster head is required which is implemented by using weight-based cluster head election.

5. CONCLUSION & FUTURE WORK

In this work, Weight-based cluster head election of VANET is discussed to make the clusters in VANET as much stable as possible. Stability is achieved by electing a CH whose lifetime is higher and moving with constant velocity when compared to the existing vector-based algorithm. This is achieved by optimizing the cluster head election in which a highway scenario is considered. CH is elected by the clustering algorithm based on the mobility information of each vehicle throughout the network. Hence, this work represents the review of weight- based cluster head election to optimize the cluster head. Optimization also leads to the increased efficiency of packet delivery ratio and throughput. In future, secondary cluster head as a backup to primary cluster head can be formed, thereby increasing the lifetime of the cluster head in the cluster which is critical for most applications and protocol designs in VANET.

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AUTHORS PROFILE

Dr.G.Deepa obtained her DIPLOMA in the field of Electrical and Electronics Engineering with Honors, B.E. degree in ECE from Anna University with distinction, M.E. (Communication and Networking) from Anna University, Chennai. She has around 08 publications in reputed national and international journals/conferences. She is currently working as an Assistant Professor in the Department of ECE in Kongu Engineering College. Her research interest include Cognitive Radio, AdHoc Networks, Antenna Design and Internet of Things.

Dr.S.Balambigai received her B.E. degree in ECE from Bharathiar University with distinction, M.E. (Applied Electronics) and Ph.Dfrom Anna University, Chennai. She has around 35 publications in reputed national and international and National journals/conferences. She is currently working as an Associate Professor in the Department of ECE in Kongu Engineering College. Developments in biomedical engineering and computer networks keeps her fascinated to carry on further research in these domains.

Er.V.Govindarajan obtained his B.E. degree in Electronics and Control Engineering from Sathyabama University. He is working as an Assistant Engineer in TANGEDCO. His research interest include Cognitive Radio and Smart Grid.

P.P.Janarthanan is currently working as an Assistant Professor in Department of Electronics and Communication Engineering, Kongu Engineering College, Tamilnadu, India. He completed his Master Degree in Embedded Systems at Anna University, Chennai in 2017 and Undergraduate in Electronics and Communication Engineering at Anna University, Chennai in 2015. He published 05 peer review International journals and 02 papers in IEEE International conference. He is currently doing research in the area of medical signal processing. His area of interest includes Embedded Systems, Medical Electronics and Signal Processing.