STATIONARY CLUSTER BASED ROUTING PROTOCOL FOR INTER VEHICLE COMMUNICATION

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Abstract : ***Vehicular Ad-Hoc Network (VANET) is considered as special case of Mobile As-Hoc Network (MANET) with distinct characteristics. Due fast movement of vehicles, VANET routing protocols meets several challenges. Also Vehicular ad-hoc network is not stable and hence MANET routing protocols are not so effective for VANET applications. With the objective of increasing cluster stability and route stability, a cluster based routing protocol is proposed in this paper. For electing cluster heads, a new parameter called active life is used. The proposed protocol is simulated for performance evaluation.***

Index Terms - VANET, Cluster Stability, Active Life, Re-Election, Store and Forward.

I. INTRODUCTION

Vehicular Ad-Hoc Network is the network formed by vehicles without any centralized device, which can be seen as extension of MANET. VANET has self-organizing and self-managing capability similar to that of MANETs. The two key devices seen in VANETs are On-Board Devices (OBU) and Road Side Units (RSU). RSUs are present at fixed locations and OBU present in vehicles includes various wireless devices and sensors etc.

The unique features of VANET are [2]: Highly dynamic changes in topology, Network is frequently disconnected, Sufficient amount of energy and storage are available, Mobility can be predicted, Network has hard delay constraints, etc.

Dedicated Short Range Communications (DSRC) is a short to medium range communication technology. The objective of DSRC is to support both vehicle to vehicle communication and vehicle to roadside communication also called as vehicle to infrastructure communication. DSRC is targeted to afford high data transfers and low communication latency in communication zones. Federal Communications Commission (FCC) of United States has allocated 75 MHz of spectrum at 5.9 MHz band for DSRC in 1999 [1]. This spectrum is divided into 7 non-overlapping channels. These channels are used for safety and non-safety applications of VANET.

The most of the applications of VANETs fall under the following categories [3]: Safety related, driving improvement, public and comport services. Some of the safety related applications are issuing warning message and notifications when a vehicle is overtaking or about the road condition etc. These safety applications are given higher priority always. Driving improvement applications updates information about surrounding environment, thus smoothens the traffic movement. Public service application example is the use of virtual signs to reach the destination location quickly during emergency situations. Comport services allows passengers to communicate with others and also provides some entertainment services like video streaming, internet access.

In this paper a cluster based routing protocol is proposed for multiple lane two direction highway. Immobile clusters having equal size are created based on transmission range of vehicles. For each cluster, head is chose based on a new parameter called active life. Then re-election process is raised only when a particular condition is meet. Only cluster heads are made responsible for routing the packets between source and destination in our protocol.

II. RELATED WORK

Finding and maintaining a path for routing packets in any routing protocol has important role in VANETs. In paper [2], authors have classified the VANET routing protocols into five categories. They are: ad hoc, position-based, cluster based, broadcast, and geo-cast routing. Where Cluster based routing protocols divide network as zones or clusters. For communication to happen, a vehicle has to be decided as cluster head by considering some parameters; remaining vehicles are nothing but member vehicles. The clustering mainly aims at improving scalability of network as well as stability.

Various clustering algorithms and routing protocols has been proposed to support VANET applications. Some of the protocols surveyed are as follows:

In the paper [4], authors have proposed a routing strategy called as Cluster based location routing (CBLR). Here based on communication range, cluster are created. When packet has to be routed, initial step is finding location of destination vehicle which is followed by the routing process.

In [5], a routing protocol for highway has been presented with the name Cluster based directional routing protocol (CBDRP). A node which is nearest to the center of the cluster is decided as cluster head. When source sends packet to its cluster head, head vehicle will pass that to destination cluster head. Hence mobility features of vehicles are not considered. But CBDRP has good results compared to AODV protocol.

A clustering method for highway based on position of vehicle is proposed in paper [6], in which clusters are formed based on number of vehicles present and on their communication range. With the help of estimated travelling time and deviation in velocity, a priority value is calculated for vehicles, then a vehicle having greater priority becomes cluster head.

In paper [7] AODV protocol based new clustering technique has been proposed, where vehicle can be in any one of the three states i.e. states can be either cluster head, cluster member or gateway vehicles. Head is elected for virtual cells formed, based on average speed of vehicles. Hence the position of vehicles is not taken into consideration here.

A new routing technique for VANETs has been shown in paper [8], called as Backbone routing. By considering antenna height, number of vehicles on highway along with speed of vehicles, some nodes are treated as backbone nodes. The packets for destination node are carried only by elected backbone nodes, hence overhead is reduced.

In paper [9], a moving zone architecture based routing protocol is proposed called as Moving Zone Based Routing Protocol. Vehicles with same movement patterns are grouped to form moving zones. A head vehicle is selected for moving zones based on distance and average velocity of vehicle. The packet is routed by captain vehicle by using the location information of destination vehicle which is specified by the source node.

Hence care has to be taken for deciding the parameter to be used for cluster head election while proposing any cluster based routing protocol. If elected vehicle acts as head only for shorter duration, clusters formed are not stable which in turn results in instable network.

III. PROPOSED PROTOCOL

The proposed protocol for communication between vehicles present in different clusters has two methods, one a clustering algorithm and another one is routing algorithm. Here we have made some assumptions such as, the vehicles velocity is not changed in highway and vehicles speed and position is known.

3.1 Clustering Algorithm

3.1.1 Cluster Creation

A straight highway is divided as number of equal size clusters and distinct ids are assigned to clusters. The clusters formed are static and size is same as half of the transmission range of vehicles as in the fig.1. Here an assumption is made as all the vehicles on highway have same transmission range capacity. Vehicles can be decided to which cluster it belongs by their position i.e. location on highway. Vehicles are also given distinct ids.

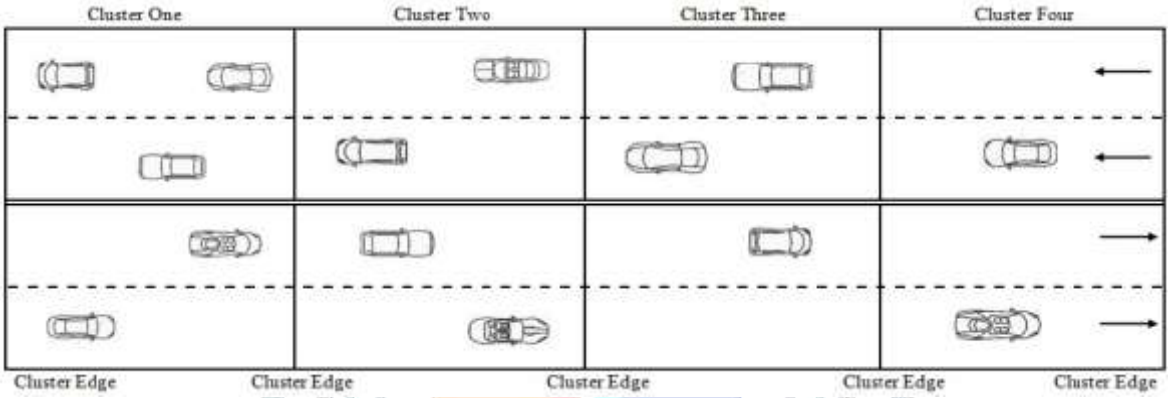

Fig.1 Cluster formation on highway

3.1.2 Cluster Head Election

When a vehicle enters a cluster, it sends information about it i.e. id, speed, location in the form of hello message. Then its state is decided as cluster member (CM) if cluster head (CH) is available. When no vehicle is present in the cluster other than the newly entered vehicle, then new vehicle itself is elected as cluster head.

To choose a cluster head, all the vehicles in the cluster will calculate a value called as Active Life (AL). Active life value is dependent on speed of the vehicle and remaining distance to directional cluster edge from current location as in the equation 1. Vehicle with maximum active life is nominated as cluster head. Active life value for a vehicle is calculated when it enters to a new cluster.

$$AL(n) = Dte(n) / V(n) \quad (1)$$

Where,
AL (n) - Active Life value of vehicle n
Dte (n) - vehicle n's distance to directional cluster edge from present position
V (n) - velocity of vehicle n

3.1.3 Cluster Head Reelection

A new cluster head is elected only when present head vehicle reaches a predefined directional handover point i.e. a fixed distance from cluster edge is considered as handover point as shown in fig.2. For this reason, a threshold is calculated for cluster head vehicle using handover time. Handover time is the time necessary for electing a cluster head and to give all the responsibility to that vehicle.

$$T(CH) = V(CH) * HT \quad (2)$$

Where,
T (CH) - threshold value of a cluster head
V (CH) - velocity of cluster head
HT - handover time in sec,

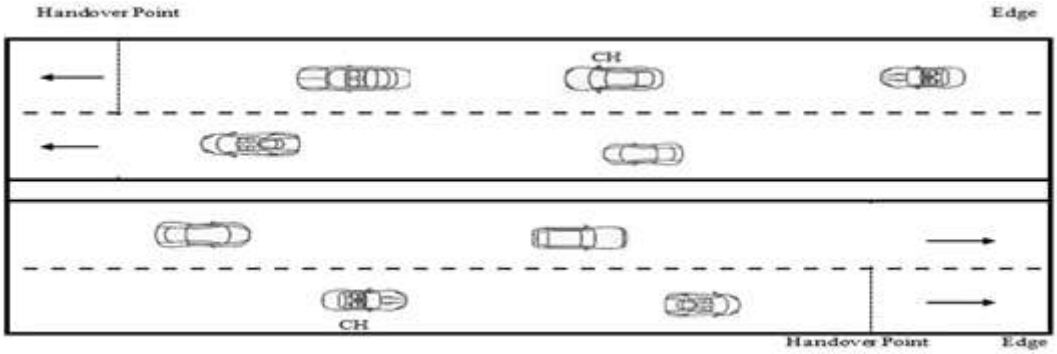

Fig.2 fixing handover point

In fig.2 we can see how handover point is set in the same moving direction of head vehicle. Fig.3 shows the flowchart of clustering algorithm of proposed protocol.

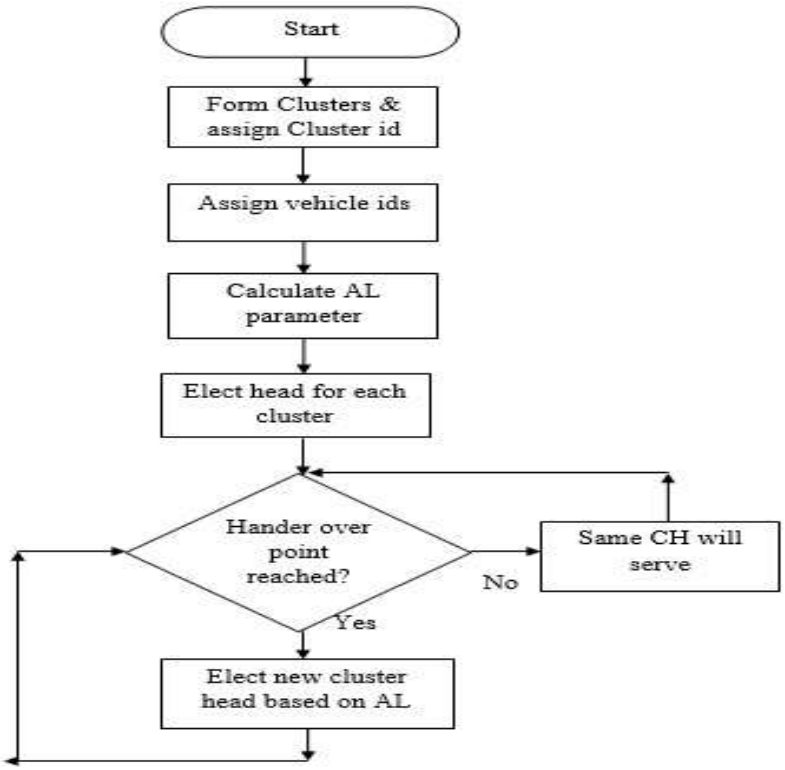

Fig.3 clustering algorithm

3.2 Routing Algorithm

In order to route a packet head vehicle maintains a routing table. This table contains information of vehicle id, head id, active life and location. Here we have assumed that all cluster head vehicles provide the copy of their routing table to other head vehicle present in highway.

When a source vehicle want to route a packet, it sends the packet to head vehicle present in the same cluster. Head vehicle now checks for head present in the cluster of destination vehicle and adjacent cluster heads towards the destination. Then routes the packet to adjacent head vehicle present on the way to destination. This step is repeated till the destination cluster head is reached. Then that vehicle has to route the packet to the destination node.

But there is a possibility that, the adjacent cluster head towards destination may not be present. Hence as a recovery process, the packet is stored by source head vehicle and it will be routed when adjacent head vehicle is available i.e. store and forward technique is followed. The flowchart of routing algorithm is shown in fig.4. Therefore at any time, stable routes can be created.

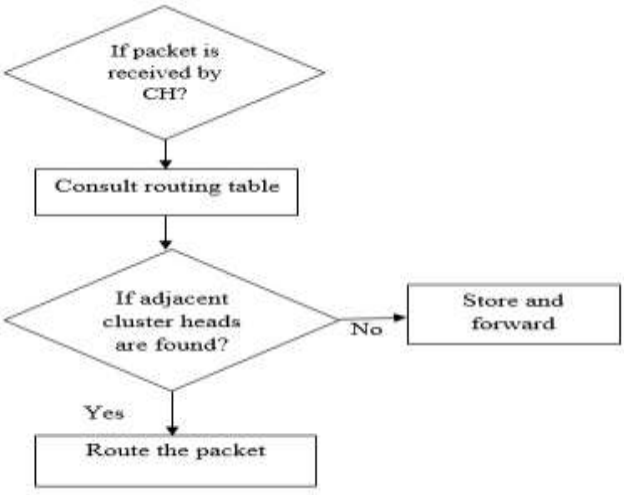

Fig.4 routing algorithm

VI. SIMULATION RESULTS AND ANALYSIS

The proposed protocol is simulated using MATLAB version R2013a. Simulation is done till nodes are present on highway. By varying the velocity of vehicles two metrics are calculated for analyzing the cluster stability. They are average cluster head duration and average number of re-elections. To compare the cluster stability of our proposed protocol, a clustering algorithm is also simulated where average velocity metric is used for electing head vehicle for the same network created. Simulation parameters are shown in table 1.

Table 1 Simulation parameters

Parameters	Values
Highway Area	1000m*40m
Radio Range	500m
Size Of Cluster	250m
Network Size	60 nodes
Velocity Range	30kmph to 80kmph

4.1 Average Cluster Head Duration

The cluster head duration is the time up to which an elected vehicle maintains its state as cluster head. Maximum cluster head duration is wished for any cluster based protocol. After measuring total cluster head duration average value of the same is calculated by simulating three scenarios with 60 vehicles and it is plotted in fig.5.

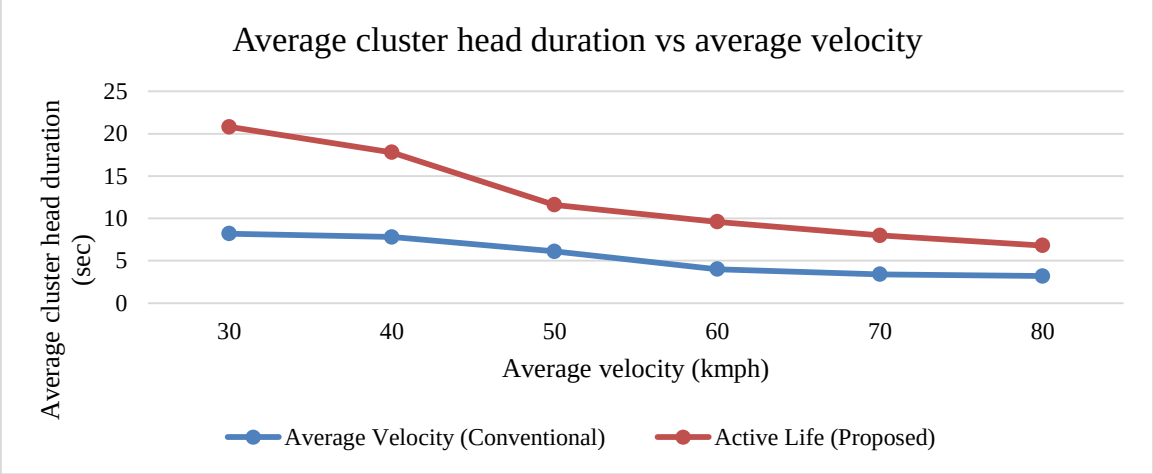

Fig.5 comparison of average cluster head duration

4.2 Average Number of Head Re-elections

The number of re-elections is the count of number of vehicles that have changed their state as cluster member state from cluster head state. Lesser number of re-elections are wished for any cluster based protocol. Then average number of cluster heads re-elected is calculated for three scenarios and plotted in fig.6 below.

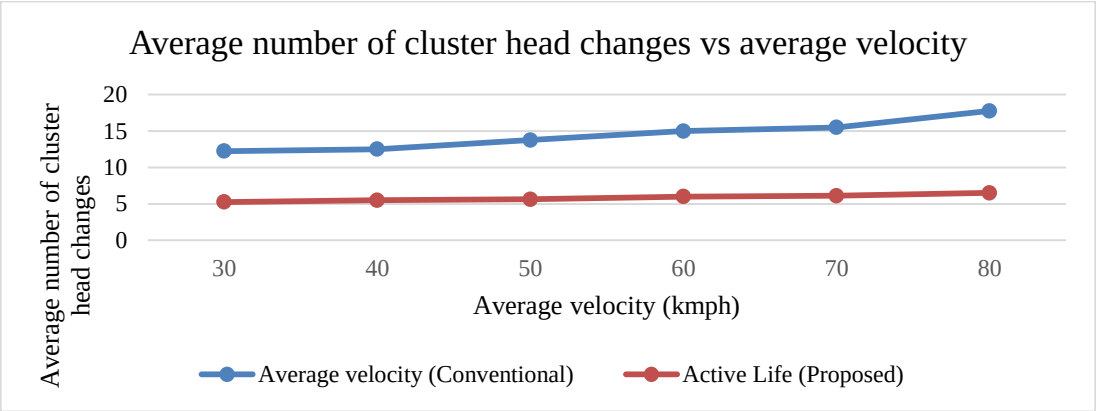

Fig.6 Comparison of Average number of cluster head re-elections

From fig.5 and fig.6 for our proposed protocol, lesser number of re-elections are needed and elected vehicle remains as head for longer duration. The reason behind this is, an elected head vehicle remains as head till handover point is reached. This results in improved cluster stability.

V. CONCLUSION

Due to advance in many communication techniques, VANET applications has received great attention. In this paper, we have proposed a cluster based routing protocol for vehicle communication in bi-direction highway. Because of new way of electing cluster head i.e. based on active life, lesser number of heads are re-elected and the elected head vehicles will present in that state for longer duration. Hence cluster stability is increased and stable routes are found from source to destination.

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