Volume: 02, Issue: 04, Pages: 755-761 (2011)

# CBVANET: A Cluster Based Vehicular Adhoc Network Model for Simple Highway Communication

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**ABSTRACT**

**VANET is a special class of Mobile Ad hoc Network. VANET is mainly used to model communication in a Vehicular environment where the vehicles are considered as VANET nodes with wireless links. In this paper an attempt has been made to create a new cluster model for efficient communication among the VANET nodes. For this purpose, taking the Simple Highway Vehicular model concept into consideration, a clustering model has been created. The proposed mobility model is called simple highway mobility model(SHWM). This paper focuses on the development of a clustering framework for communication among the VANET nodes. The various timings required for the formation of Clusters, Cluster head election time and Cluster head switching time are computed and presented. The proposed model can be used to characterize the Cluster Based Simple Highway Mobility Model (CBSHWM).**

Keywords - **VANET, MANET, SHWM, DRSC, OBU, CBVANET and CBSHWM.**

Date of Submission: September 09, 2010 Date of Acceptance: November 11, 2010:

## 1. Introduction

In a VANET the vehicles are considered as nodes[1]. The vehicles move either with high speed or low speed. Unlike MANET there is no power constraint for nodes in a VANET and the network formation is dynamic. VANET is the important component of the intelligent Transportation system [2]. The main advantage of the VANET is to provide the safety measures to passengers and drivers [3]. The vehicles of a VANET are equipped with the DRSC (Dedicated Short Range Communication). Vehicles can move along the same road way and transmit information or receive information. Communication from the source node can either directly reach the destination or through an intermediate node which may be a router or a road side unit. The movement of the vehicles is limited by the road condition such as narrow or curved. High speed vehicles form quick dynamic network topology and it requires real time packet transfer. These characteristics of VANET play an important role in creating a vehicular ad hoc network, new protocols and architectures.

The VANET technology enables communication between vehicle to vehicle and vehicle to roadside infrastructure units [2][3]. All vehicles use a communication device known as Online Board Units (OBUs). These devices are used to communicate with the devices in other vehicles and also with roadside units. The roadside units are connected with backbone network. The moving vehicles have access to internet through the backbone network [4].

The most challenging task in a VANET is to model the communication between nodes in VANET when the vehicles are inside the city [5] [6] or outside the city. The communication between one vehicle and another (V2V) is established using roadside unit. This paper attempts to propose a new clustering model for VANET communication.

## 2. Work Related To Vanet

VANET is a new class of MANET. Most of the existing research work is done on MANET. However these works cannot be directly applicable to VANET due to the fundamental difference between VANET & MANET. Hence VANET requires new models for studying the communication behavior [7] [8]. As on date the literature available for VANET is very limited, mostly extension of MANET concepts. Another big challenge is modeling the vehicular movement in a city and downtown. Already models such as Manhattan model and Freeway model were developed by researchers to characterize the vehicular motion within a city. The real issue is to model the highway mobility outside the city. Therefore, a cluster model to characterize the VANET has been developed.

## 3. LIMITATIONS WITH EXISTING MODELS

Most of the existing VANET models[5][6][7] assume VANET model as a collection of nodes (vehicles), links and fixed units called Roadside Units(RSU). Communication at any point is done through a VANET node to another VANET node through a Fixed Roadside Unit only [9]. This scenario is valid inside a city where the vehicle moves slowly and more number of fixed base stations are available. But if the vehicle moves with high speed on a highway outside the city, where there is very little or no roadside units, it is not possible to consider the city model of VANET [10]. Hence the requirement to propose a new model for VANET on a highway. The following section discusses the details of the proposed VANET Model.

### 3.1 Proposed Simple Highway Mobility Model (SHWM)

In our Model a Simple Highway is taken for characterizing the VANET. On a highway vehicles can move freely on either direction. Each vehicle can have a limited radio range. Vehicle within a radio coverage range can communicate directly as against the communication through a fixed roadside unit in the existing model. In this model a very few Fixed roadside units are assumed. Figure (1) illustrates the scenario of a Simple Highway Mobility Model. Our proposed system takes care of two scenarios

i. Vehicle moves inside the city [5]
ii. Vehicle moves outside the city

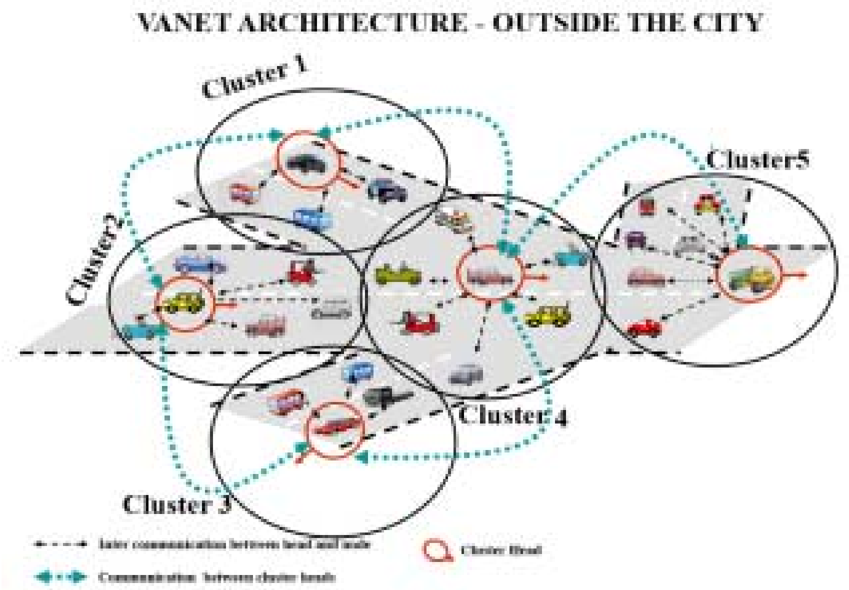


Figure1. Architecture of the VANET

### 3.2 Cluster Based Simple Highway Mobility Model (CBSHWM)

In this architecture the VANET area has been split up into a number of clusters using the proposed cluster formation algorithm. Each cluster has a cluster head. The cluster head may be either RSU or any one of the vehicles with good database storage and access capabilities [11] [12]. This cluster head is selected by the new cluster head algorithm given in this paper.

Each cluster head has all the service descriptions that are available in the network. All the cluster heads in the VANET are regularly updated if a new service enters in the network. All the cluster heads are synchronized in a specific time interval. The cluster heads are synchronized to ensure that the cluster heads have latest service description. Nodes of the clusters are managed by service requests and service updates.

### 3.3 Cluster Creation

A group of VANET nodes within a radio range can form a cluster area. Cluster concept has successfully been applied in MANET for a better delivery ratio and to reduce broadcast storms. In a Cluster environment, the Cluster Head gathers data from any node of that cluster and sends them to another cluster head[13][14]. Cluster-based solutions provide less propagation delay and high delivery ratio[15]. Clustering can simplify such essential functions as routing, bandwidth allocation, and channel access. Several heuristic clustering techniques have been proposed to choose cluster heads in MANET.

Cluster heads may frequently change their relative position on highways, and then, the size and stability of clusters change unpredictably if lowest ID and node-weight heuristics are used. On the other hand, vehicles on (one way) highways have almost the same direction within a certain area. Therefore, their geographical location and speed information are helpful when they are evenly divided into non overlapping clusters along highways [16]. Better performance could be achieved if the geographic positions of the network nodes are known. Cluster-based solutions may be a viable approach in supporting efficient multi-hop message propagation among vehicles [17].

The Cluster creation in the proposed model is different from the existing model. In MANET clusters are created dynamically but in the VANET the cluster area remains same and predefined [18]. The size of the cluster changes only during unavoidable situations like sudden increase in the number of vehicles moving in a particular road due to traffic changes. In our system the cluster remains in the same frequency. Unlike MANET, the VANET nodes move on predefined paths mostly in roads only. So the cluster areas are created as fixed ones. But, the cluster creation process involves a series of steps to ensure that the node created cluster is efficient and it gives better efficiency in service discovery[19][20]. While creating cluster, it should be ensured that the cluster head of any cluster is not frequently crossing the cluster boundary. If the vehicle moves out frequently then the Cluster head election algorithm frequently elects new cluster head. This algorithm follows two strategies while creating a cluster area.

If the nodes are moving slowly and the node density is high then the algorithm creates a medium size cluster. When the node density is high, traffic is heavy, road condition is poor and vehicular movement is slow, cluster area is chosen to be small. If the cluster size is small then there is a possibility for the node to reach its cluster boundary very quickly. If the cluster size is small then the efficiency of the network is low. When the density of the vehicles is less naturally the speed of the vehicle will be high. Then the algorithm creates a large size cluster. When the vehicles movement is slow in the cluster area then the cluster head switching may not occur frequently. Care should be taken to keep the cluster as medium size for efficient management. It ensures that the cluster head switching may not occur frequently.

Algorithm1: Cluster Creation

```
 [Xi, Yi] = Get _Pos ( n);
Track the positions of nodes in cluster areas
[Ai,Bi]=Subset(Xi,Yi);
for(k=0;k<count(Ai);k++)
{
Find Movement Speed(N[k])
}
if(average movement of all node speed is slow)
{
Take the cluster size as smaller
}
else
Take the cluster as some larger
end if

function Get_Pos(int n)
for(i=0;i<n;i++)
{
Xi,Yi=FindGps_xy(i)
}
return X,Y
```

In this algorithm n is the total number of nodes, i is the ith node that is varying from 0 to n-1. If n = 3 then the values become $x_0y_0$, $x_1y_1$, $x_2y_2$. This algorithm tracks the position of the node in the cluster areas. [Ai Bi] is the subset of (Xi Yi) that contains the X, Y position of the node of a particular cluster area.

This algorithm finds the movement speed of N[K] that belongs to AiBi . If the average speed of the vehicle is low then this algorithm takes a small cluster size. Otherwise it takes a large cluster size. The function used in this algorithm returns X, Y position of each individual node.

### 3.4 Cluster Head Election

Initially this algorithm makes a search for the available nodes in the cluster. The cluster contains two types of nodes.

i. Vehicle nodes
ii. Roadside unit

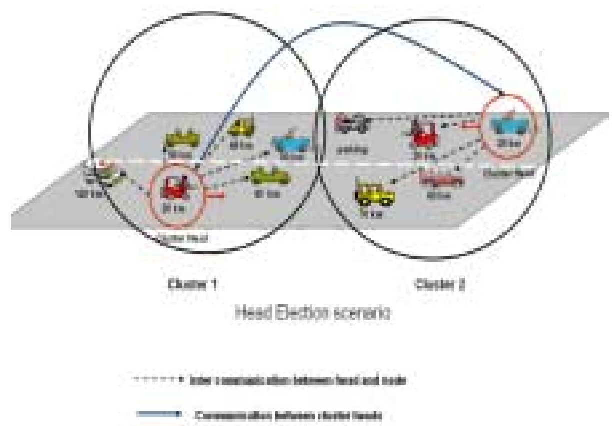


Figure 2: Head Election Process

If the algorithm finds any roadside unit, it immediately elects that one as the cluster head, because normally the roadside units have greater processing power. Moreover they are fixed and unmoving. Hence it is not necessary to change the cluster head. Thus it provides a more reliable service than other mobile nodes. If the cluster is not having a Road side unit then the algorithm finds a cluster head using the following steps:

Counts the available nodes in the cluster
Finds the position of the node at Time Tx using GPS
Finds the position of nodes at time Tx+10 using GPS
Finds the velocity of the node using the two positions at time Tx and Tx + 10
Take the node as cluster head which has less velocity.

This algorithm measures the distance between the node in position1 at time Tx and the same node in position2 at a time Tx+10. It finds out the distance between all the nodes at time Tx and Tx+10. It compares the distance of each nodes and chooses a particular node as the cluster head whose distance is very small due to low node velocity. It elects slow speed vehicle as cluster head because this node ensures that it will remain in its own cluster coverage area for a maximum period of time than the high speed vehicles.

Algorithm 2: Number of Cluster nodes in a cluster area

```
Note the border of the cluster
Procedure : Compute Node Count()
              XiYi = fin Pos (n);
            For(i=0;i<count(Xi);i++)
              {
                If ((Xi,Yi) within the cluster border)
                {
                  Select that as cluster Node
                }
              }
```

Algorithm 3: Cluster head Election

```
Procedure
 Node _Count = Available nodes in the Cluster
 For i=0 to Node _Count
   Ti(x)=X position of Node i at time T
   Ti(y) = Y position of Node i at Time T
   U=T+10;
   Ui(x)= X position of Node i at time U
   Ui(y)= Y Position of Node i at time U
   DIFFi(x)=Find the difference between the X position of  node i
between
   the time T and U
   DIFFi(y)=Find the difference between the Y position of node i
between
    the time  T and U
       Find the direction of  Node movement
         If  (Slow moving node is in left end
              than all  other nodes  in  the cluster
               and  nodes are moving slowly towards  the
            right direction)
        then         {
                        Select that as Cluster Head
                     }
         If  (Slow moving node is in right end of the cluster
              than all  other nodes  in  the cluster
               and  nodes are moving slowly towards  the left
             direction)
        then        {
                      Select that as Cluster Head
                    }
       Select the best Cluster Head among these Cluster heads
End Procedure
```

## 3.5 Cluster Head Switching Algorithm

If the speed of the cluster head increases then there may be a possibility that the cluster head may reach the cluster boundary or exit from the current cluster. So the system has to elect a new node from the current cluster as cluster head. If the speed of a cluster head increases then the system has to perform the following steps:

i. Run the cluster head election algorithm excluding the current cluster head.
ii. Elect new cluster head
iii. Transfer information from old cluster head to new cluster head.
iv. Broadcast new cluster head ID to all the nodes in the cluster.

The speed of the current cluster head is a critical parameter. It is always expected to be within a threshold value. If a cluster head speed exceeds the threshold value then the cluster head switching algorithm 4 is activated. Before this cluster head crosses the boundary of the current cluster area, this algorithm releases this cluster head from the current cluster and reelects a new cluster head.

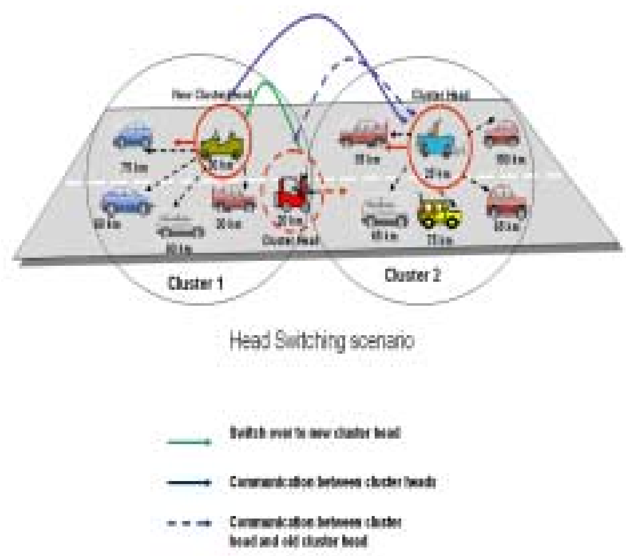


Figure 3: Head switching process

Algorithm 4: Cluster Head Switching

```
function  Track_Cluster()
    while(true)
        {
            X,Y=Get_Pos(Clusterhead);
            if(speed(X)>Xthreshold  and  speed(Y)> Ythreshold)
                {
                    Finds the new node which has less mobility;
                }
           if(Current cluster head  is near to cluster boundary)
                {
                    Run the cluster head election algorithm;
                    Copy data from old cluster head to new cluster
                    head;
                    Broadcasts changes   to all other cluster heads;
                    //Cluster  head  updates its status and also updates
                   their local
                      cluster  members//
                }
               endif
            endif
        }
```

## 4. EXPERIMENTAL ANALYSIS

The simple highway mobility model of VANET proposed in this paper has been simulated using NS2.34 version on linuxredhat9 system. The following are the critical parameters for the test bed. VANET size is assumed as 1500 * 1500 meters of highway with bidirectional movement of vehicles. Number of nodes varies between 25 and 50. Number of clusters varied between 2 and 20 in steps of 2. Speeds of the VANET nodes are assumed to be constant between 5m/s and 25 m/s in discrete steps. For this proposed model, cluster creation time, cluster head election time and cluster head switching time was estimated and its performance was compared with the two existing models namely Manhattan mobility model and freeway mobility model. To ensure reliability, for each category of time, the average 50 samples has been included.

## 5. RESULT AND DISCUSSION

5.1 Cluster Creation Time (CCT) of the proposed SHWM model

The cluster creation time of the proposed SHWM model is presented for various cluster sizes. The performance of SHWM in terms of Cluster Creation Time is shown in Figure4. When the number of clusters is low SHWM model provides low cluster creation time, and with the increase of the clusters, the cluster creation time proportionally increases. When the size of the clusters varies from 25 to 150 nodes , no major variation is noted in cluster creation time.

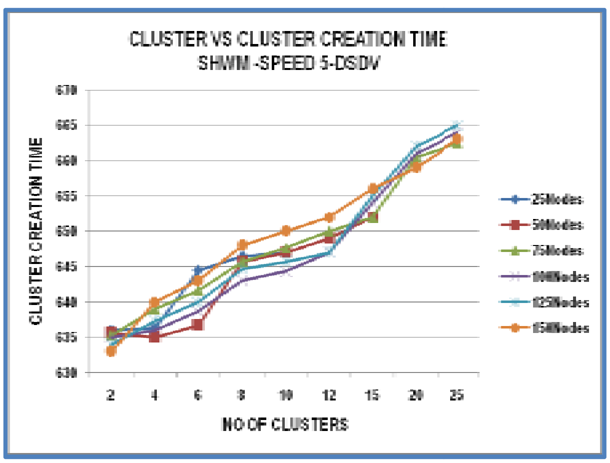


Figure4: Clusters VS cluster creation time

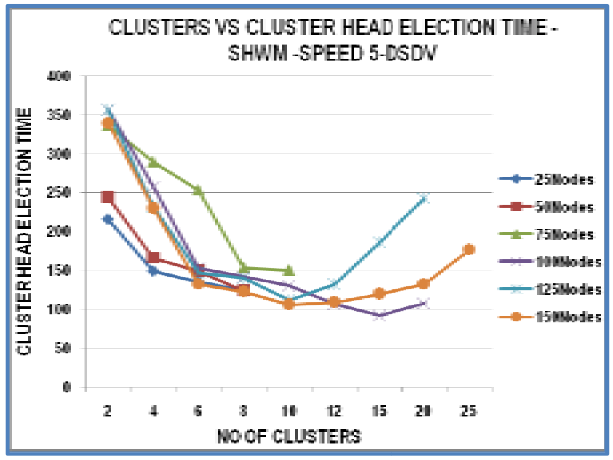


Figure5: Clusters VS Cluster head election time

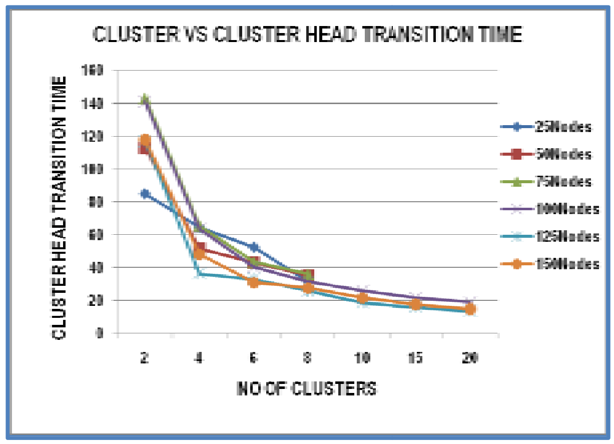


Figure6: Cluster VS Cluster transition time

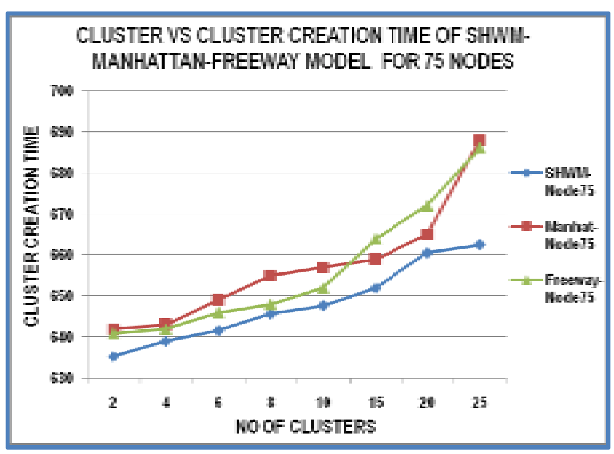


Figure7: Cluster VS Cluster creation time of SHWM-MANHATTAN-FREEWAY model

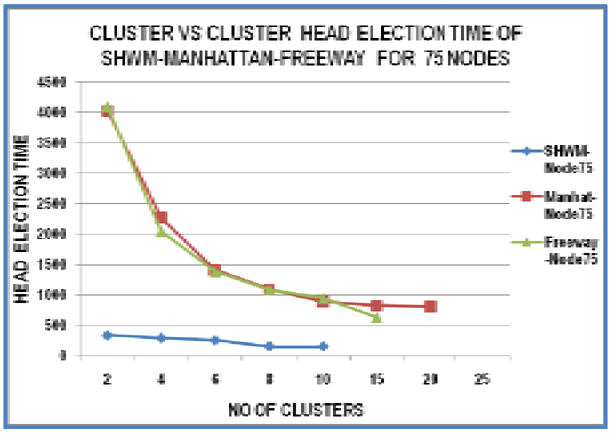


Figure8: Cluster VS Head election time of SHWM-MANHATTAN-FREEWAY model

5.2 Cluster Head Election Time(CHET) of the proposed SHWM model

The Cluster Head Election Time is estimated for different cluster sizes by varying the number of cluster as shown in Figure5. It is noticed that when the number of clusters is low it yields a high head election time irrespective of the number of nodes. It is also observed that if the optimal number of cluster is between 8 and 12, it yields a low head election time.

5.3 Cluster Head Transition Time (CHTT) of the proposed SHWM model

Figure6 presents the Cluster Head Transition Time for various cluster sizes by varying the number of clusters. It is observed that the number of clusters 8 and above shows better transition delay characteristic. The performance of Transition time is graphically illustrated in this Graph.

## 6. Comparative Analysis

The performance of the proposed SHWM is compared with MANHATTAN and FREEWAY VANET mobility models in terms of Cluster Creation Time and Cluster Head Election time. The MANHATTAN model was proposed for the movement of vehicle in Urban area where the streets are in an organized manner. The nodes in this model moves horizontal or vertical direction. The FREEWAY model describes the motion behavior of mobile nodes on a freeway. It can be used in exchanging traffic status or tracking a vehicles on a freeway. Figure7 and Figure8 presents the comparative time characteristics of the proposed SHWM model with respect to other models. The proposed SHWM model outperforms the existing schemes in terms of the creation time and switching time. In all these cases the number of cluster between 8 and 12 gives optimal time features.

## 7. Conclusion

VANET attracts most of the researchers recently. Many VANET based service applications are expected to appear in the near future. Efficient modeling of VANET is a challenging problem due to its variation from MANET. In this paper we have proposed a new clustering model for VANET node communication. The simulation result shows that the proposed model has outperformed the existing VANET models in terms of Cluster creation, Head creation and Head switching time on a Highway vehicular environment. Each VANET simulation has been done for 50 times. 50 random values are obtained for each nodes and clusters and the average value is presented. The future work would focus on finding efficient Routing scheme for SHMM.

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