International Journal of Engineering Research in Computer Science and Engineering (IJERCSE) Vol 3, Issue 5, May 2016

Cluster Based Channel Access

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***Abstract*- vehicular ad-hoc networks include mixed traffic which needs different quality of services. Vanet applications are supported by ieee 802.11p protocol which works on the csma/ca technique. The protocol categorizes the access cate- gories into four priority levels ensuring successful transmission of higher priority packets. However, the increasing number of vehicles with its dynamic topology, probable number of collisions increases, and creating congestion at the control channel. In this paper, a cluster based channel access scheme (cbca) is proposed. Here, the communication to the control channel is done by means of the central node of the non-overlapping clusters of the zone.**

Keywords- VANET; IEEE 802.11p; Control Channel; CBCA

I. INTRODUCTION

The increase of vehicular usage in the day- to- day life has increased the number of causalities on roads. At times, a huge amount of time is wasted in traffic jams. This made the researchers think about an effective scheme to manage the vehicles on road. VANET, vehicular ad hoc network is a simple but complex solution offered by the researchers to improve the scenario on road. The vehicles on road forms an ad hoc network controlling each other by means of cooperative communication. VANET applications are supported by IEEE 802.11p standard that relies on the CSMA/CA scheme. The IEEE 802.11p along with the WAVE amendment supports a multi-channel operation for VANET. IEEE 802.11p categories the access categories inside a station into four; voice, video, beacon and background. Based on the type of access categories inside a vehicle, each vehicle can access the channel. The protocol ensures the successful transmission of higher priority packets with respect to the lower priority packets within a station. However, as the vehicular density increases, the number of packets to access the channel also increases leading to congestion at the control channel [2].

In this paper, we consider a multi-channel approach of IEEE 802.11p improved including WAVE amendment. It covers a single control channel and six service channels [1]. The bandwidth allotted for VANET is licensed under ITS band of 5.85-5.925 GHz. The control channel is used for transmitting control messages and the service channel for transmitting data. The scheme groups the vehicles into non overlapping clusters and the communication occurs through the cluster central node. The paper is organized as follows. An introduction is covered in Section I followed by related works in section II. Section III covers the system model followed by an algorithm for cluster based channel access scheme is discussed in section IV. Experimental set up of the scheme is covered in section V followed by a conclusion in section VI.

II. RELATED WORK

The related and existing work in the field include the IEEE 802.11p and IEEE 802.11e protocols, which support vehicular ad-hoc networks. The IEEE 802.11p protocol is one that utilizes a priority scheme while the IEEE 802.11e is an enhanced version of the IEEE 802.11 protocol that takes into consideration the different priority channels. Different access categories are used and each category has a Contention Window size that may be set based on its arbitrary inter frame space number. However, the IEEE 802.11p has a poor broadcasting capability as discussed in [3].

The Carrier Sense Multiple Access/Collision Avoidance algorithm [2] is one that allows a node in the network to first sense the channel after the packet has been created. If the channel is free, the carrier transmits the signal. This process is called Carrier Sense where the node senses the channel. In the other case, where the channel is not free, the carrier has to wait an amount of time called the back off period. After this back off period, the node then tries to transmit again.

The basic CSMA/CA technique is enhanced with two handshaking signals to avoid the hidden terminal problem. RTS/CTS handshake ensures successful transmission of mes- sage packets between nodes without having collision by means of hidden terminals. The node that is ready to transmit first sends out an RTS signal. The

International Journal of Engineering Research in Computer Science and Engineering
(IJERCSE) Vol 3, Issue 5, May 2016

RTS signal is responded to by a Clear-To-Send or CTS signal. On receiving the CTS signal, the nodes know that the transmission may be proceeded with. However, as the number of nodes increases, the demand for channel access also increases leading to congestion at control channel.

III. SYSTEM MODEL

The traffic is unidirectional and that all the cars on the network always have, at any given time, at least one packet ready for transmission. The road is divided into different

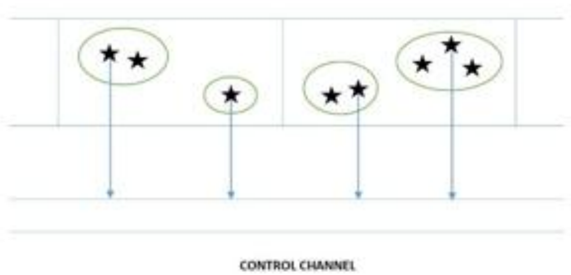

Fig. 1. Road Scenario

Fig. 2. Road Division

Zones and each zone contains same number of non-overlapping clusters. The proposed system requires all cars in the network to be fitted with an electronic On-Board Unit (OBU), which will be able to broadcast information using an antenna. The memory stores a table for mapping the details of the nodes in the cluster. The table contains information such as the neighboring vehicle's OBUs MAC ID as well as the distance between them. If the distance between them is below a value, then the cars are part of the same cluster. The vehicles in the network then chose a leader for the cluster. This leader is the vehicle in the cluster that is equidistant from all other vehicles in the cluster. Now the setup is such that all the vehicles in the network are part of some cluster and each cluster has its own head who is the only figure authorized to access the control channel. This helps reduce the congestion on the control channel as opposed to the conventional scheme where, in the worst case scenario, all the cars on the network want to access the control channel.

The mathematical setup for each vehicle involves calculation of the range of each onboard unit. We assume a circular range. Assuming a car at position (x,y), we can write the range of its onboard unit, given by the equation.

x21+ y21 = r2 (1)

We have used (x,y) to represent the vehicle's spatial position and 'r denotes radius of each onboard unit.

To determine if a car is in another cars range where one cars position is (x1, y1) and the other is (x2,y2), we may check if, the condition in equation is satisfied.

(x2 □ x1)2 + (y2 □ y1)2 < r2 (2)

The algorithm above gives an account of the centroid of each cluster being calculated. First, we sum up all the x co- ordinates of all nodes in the cluster and perform the same operation for the y co-ordinates and find the average value. The node closest in position to this average is set as the cluster head and the node closest to it is assigned as the sub cluster head. The purpose of the sub cluster head is to cater the the needs of the other nodes when one node is in communication with the cluster head at any time.

IV. ALGORITHM

while *true* **do**
  Vehicle X transmits packet containing MAC ID and MSGTYPE as REQ;
  Begin timer;
  if *!replies* **then**
    Try again after a Backoff Time;
  end
  Neighbors receive broadcast packet;
  if *message content is REQ* **then**
    Reply with their own MAC ID and MSGTYPE as CLR;
  end
  Vehicle X receives packet;
  if *MSGTYPE == CLR* **then**
    Note receivedtime;
    Save MAC ID in a table in controller's memory;
    Save half the receivedtime to find distance;
  end
  Calculate distance from neighbor;
  Save neighbor's MAC ID in table;
end

Algorithm 1: Cluster Formation

```
Assign xtemp= 0 and ytemp=0;
Assign centroidnode as node 0;
while all nodes not picked do
    Pick a node;
    if !picked then
        Add x-cordinate to xtemp;
        Add y-cordinate to ytemp;
        Increment counter;
        Set picked flag for node; ;
    else
        continue;
    end
end
Set X = x/numofnodes;
Set Y = y/numofnodes;
while all nodes not picked do
    Pick a node;
    if !picked then
        if
        mod(dist(picked_node,(x,y))¡dist(centroid_node,(x,y)))
        then
            centroidnode = pickednode;
            Set picked for pickednode;
        end
    else
        continue;
    end
end
```

Algorithm 2: Cluster Centroid Calculation

```
Prepare Packet;
Set destination = Address of foreign cluster sub head;
Check if ControlChannelBusy;
while ControlChannelBusy do
    Initialize Backoff timer;
    Begin timer;
    if timer == 0 then
        Sense ControlChannel;
        if ControlChannelFree then
            break;
        else
            Set ControlChannelBusy = true;
        end
    else
        Decrement timer;
    end
end
if !ControlChannelBusy then
    Sub Head access control channel;
    Send packet;
    Prepare next packet;
end
```

Algorithm 3: Inter-Cluster Communication

```
Prepare Packet;
Set destination = Address of same cluster's Sub head;
Check if ChannelBusy;
while ChannelBusy do
    Initialize Backoff timer;
    Begin Timer;
    if time == 0 then
        Sense Channel;
        if ChannelFree then
            break;
        else
            Set ChannelBusy = true;
        end
    else
        Decrement timer;
    end
    if !ChannelBusy then
        Send Packet;
        Prepare next packet;
    end
end
```

Algorithm 4: Intra-Cluster Communication

V. EXPERIMENTAL SETUP

The images below show a simulation of the clustering as mentioned in this paper. The circle represents the range of the On-Board Unit (OBU) of the red node. The green nodes are all in the range of the red node, which is the cluster head, and the yellow node is the sub head of the cluster.

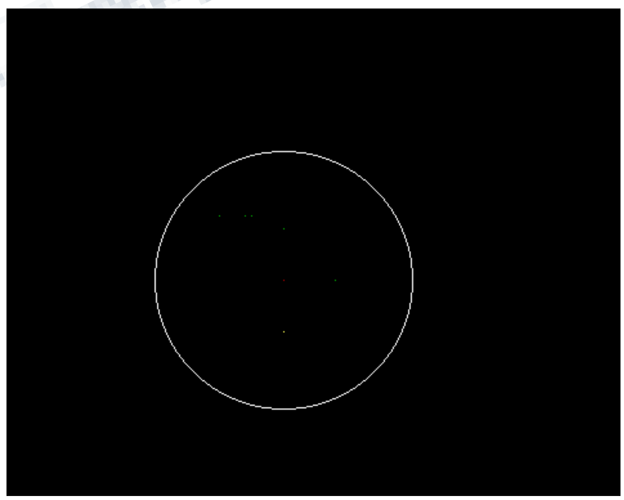

Fig. 3. Cluster Formation

The channel access is shown below where the leader of cluster accesses the control channel. This step is important as it is here that we reduce the congestion in the control channel that would usually be caused by the combined accessing of the control channel by all the other nodes in the network or most of them simultaneously.

The inter node communication, that occurs between the leader nodes of each cluster is depicted below. The intra node communication occurs where we have the communication within a node. For this type of communication, the leader of the node delegates responsibility to a sub head of the same cluster (depicted here as a yellow node), when it is busy.

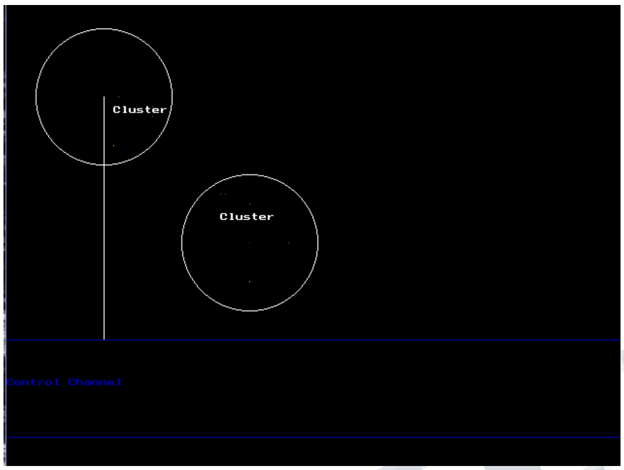

Fig. 4. Channel Access

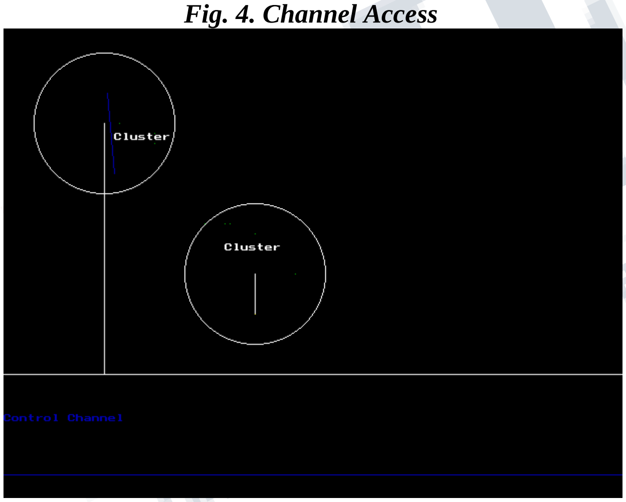

Fig. 5. Communication

VI. CONCLUSION

The ideas presented in this paper helps to provide a feasible solution to the problem of Control Channel Congestion due to multiple accesses by various nodes in the network simultaneously.

The clustering algorithm provided in this paper aims at reducing this issue by permitting only designated nodes to communicate over the channel. The future developments to the paper and its future scope could include the integration of the protocol into designing hardware and onboard units that could be used in effective regulation of cars on the VANET.

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