Predictive Handoff Management in Vehicular Networks Using both Weight Value Based and K-Means Algorithm Based Clustering Algorithm to Meet Desired QoS

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Abstract. Vehicular Ad-hoc Networks is a interesting and key research area which have more number of issues which needs immediate attention when moving towards intelligent transportation system. In this research work, we have proposed a new mechanism of IP scheme which highly helps in handover of vehicle from one RSU to RSU. RSU is playing a key role in delivering of one vehicle from its range to other RSU. Here, how Quality of service can be handled when unexpected handover happens between RSU. So, A new mechanism to predict the vehicles which may enter into handoff process based on its mobility and GPS location. This proposed IP scheme and the predicted handoff is tested through two protocols called Weighted Clustering algorithm and also with Mutated K-Means algorithm to test the performance. The results shows better results to maintain the QoS demands of the vehicle when the handoff is predicted in prior.

1. Introduction
Another important issue that needs immediate attention to the VANET research is Handoff mechanism. The well-known characteristic of the VANET network is the mobility. Clustering of vehicles is an effective way in handling the entire network. Due to this high mobility feature of the VANET vehicles, there is high probability of vehicles to move from one cluster head to another cluster head. This will lead to more number of cluster member exchanges between cluster heads results in routing overhead. This research issue needs more concentration, because handoff in mobile ad hoc network and cellular network was managed and still managing through various possible solutions. The vehicle must be connected to the network to make sure that quality of service demanded by the user who travels in the vehicle got satisfied with that travel and also packet loss in the network should be minimum. Since, the vehicles density increases day by day which leads to increase in single road side unit. This leads to chance of failure of the entire network if the Road side unit gone down. This not only make the network to go done which also leads to packet loss to happen which in turn to make sacrifice in quality of service desired by the vehicular network. So, in this proposed work, cluster-based handoff mechanism is proposed which helps in making smooth handoff vehicles between cluster heads without scarifying the QoS.

Firstly, the clustering mechanism of handling a network is an effective in node management. Because, overhead associated with one particular node is lesser when the network is handled through clusters. Secondly, the road side unit need not to manage all the nodes on the network. There is no
mandatory that every node in the network should only be handled by the Road side unit. Cluster heads can be used for handling nodes and cluster heads can be allowed to communicate to the road side unit which reduces number of communication request that arises in the network.

The idea behind this work is focus on reducing the load of Road side unit and also in predicting the nodes that possibly involve in cluster-to-cluster movement [6,7] and capturing the packets of that particular node to avoid packet loss. Broadcasting [3] during handoff is also difficult to perform.

In this scheme, three level of hierarchy is maintained to reduce a greater number of transmissions in the networks. In first layer, the central road side unit which offers services to the vehicles when they are in travel. The second layer consists of the elected cluster heads [4, 5] which acts as a intermediate between the cluster members and the road side unit. It plays vital role in managing the networks by allocating the IP address to its members for communication. Cluster members in the lowest layer will participate in communication within the cluster. If it wants to communicate to the cluster member of other clusters, then it will approach the cluster through which the particular node can able to communicate to the other cluster members. Each vehicle is equipped with an onboard unit through which a vehicle can communicate to all other vehicles in the network. Here two major roles are played by the nodes, cluster head and cluster members.

2 Proposed Methodology

2.1 Cluster Head
Cluster Head acts as an intermediate between the cluster members and the roadside unit. Members of the cluster are allowed to communicate to the cluster head. The major functions of the cluster head include assigning IP addresses, exchanging the information that transfers between two clusters. Figure 1 describes the handoff mechanism between the cluster heads with the help of road side unit.

![Figure 1. Cluster based Handoff Mechanism](image)

2.2 Member Node
Member nodes are ordinary vehicles which exchanges information to the other members in the cluster. It also communicates to the other cluster groups with the help of cluster head. It cluster member communicates to the cluster head for getting some favor from roadside unit.

2.3 IP Assignment
Every node in the network needs to have an IP address to communicate to other nodes in the network. The IP assigning work will be taken care by the RSU with the help of well-known protocol of network layer. Every device in the network should pose an IP address [6]. In these three levels of hierarchy,
every device in the network roadside unit, cluster heads and the cluster members hold an IP address. An IP address holds 32 bit of the information. Since, more number of vehicles participating in the communication. Entire 32 bit of address is divided into three information’s. Each for representing each hierarchy, first 16 bit of address space is to uniquely identify the roadside unit from which the request is made. The request made by particular RSU will be uniquely identified by the 16 bit of information. Every cluster that belongs to the same RSU will hold a same RSU ID. Another 8 bits are allocated to uniquely identify the cluster head. Each member node that is associated to the particular cluster head holds the unique member ID which consists of rest 8 bits.

| RSU ID (16 Bits) | CH_ID (8 Bits) | CM_ID (8 Bits) |
|------------------|----------------|----------------|

**Figure 2. Proposed scheme of IP Assignment**

The above figure 2 describes the proposed scheme of IP Assignment of every vehicle in the network for communication.

To effectively communicate to the all the members in the cluster and also in the network, this proposed scheme needs to maintain lots of information’s.

- Medium Access control ID
- IPV4 address assigned by the RSU [8]
- Trust value of the node
- Speed of the vehicle
- Signal strength
- GPS location of the vehicle
- MAC address of the cluster head
- A special bit, to represent it as a cluster head or not
- And, cluster number

Each RSU will keep track of all cluster head and the clusters that belongs to. If there is any change in the network for example, if a cluster head moves from one cluster to another cluster and loses the position as cluster head, the same will be intimated to the RSU regarding the change in the network. The RSU will maintain the newly elected cluster head and its other details. At the same time, the cluster head also wants to maintain following information to keep track of the details of the cluster members belongs to itself.

- Medium access control ID
- IP Address assigned

Cluster head also keeps track of its cluster member’s activities inside the cluster. The member of the cluster is allowed to communicate only within the cluster. If the node wants to communicate to the other nodes in the other clusters, have to approach the cluster head to transmit the message to the respective cluster head. RSU also maintains another table which helps in knowing about the other RSU belonged clusters and cluster members. This table contains the following information’s.

- Medium Access control ID of neighbor RSU
- IP Address of Neighbor RSU

This information is getting circulated to the entire network once the entire fixed infrastructure RSU of the network is defined. This table will also get updated when it new RSU’s are included in the network. The aim of this table to get to know about the RSU’s and its information’s to the entire network.
2.4 Proposed Cluster Formation Using Weighted Clustering Algorithm
The cluster formation occurs based on the weight value calculated using the weighted clustering algorithm. The nodes with similar and closest weight values will be under one common cluster head. The cluster head will manage and control the rest of the cluster members in the cluster.

2.5 Cluster Detection
The cluster detection is done in SRB with the help of RTB and CTB messages explained in chapter 1. The source vehicle transmits the RTB packet to all its neighbours with the location information using the GPS module and the neighbours that receive the RTB packet will enter into the backoff process and waits for a time and decreases the time gradually. When the time reaches zero, each neighbour vehicle transmits a CTB packet to the source which contains a vehicle ID and its distance from the source. After the source receives the CTB packet, vehicle leaves from the contention phases and backs into the backoff process. Based on the information received from each vehicle and the angle of the direction of the message, source vehicle calculates the direction and the distance from itself to the neighbour vehicles. This helps in identifying the nearby vehicles based on the angle of the direction of the message, source vehicle calculates the direction and the distance from itself to the neighbour vehicles. This helps in identifying the nearby vehicles.

The size of the cluster purely depends on the threshold value $D_{\text{min}}$. $D_{\text{min}}$ value varies between $(0, D_{\text{max}})$. If the value of $D_{\text{min}}$ is lesser number of vehicles will be under one cluster. If the value of the $D_{\text{min}}$ is large more number of vehicles will be in under a cluster. If the value of $D_{\text{min}}$ [9] is assumed to be 0, then each vehicle will become a cluster.

To get more reliable cluster head, a new parameter is considered before doing election process. Each node has a weight value and based on the weight value and also the response received from the vehicles, the source node identifies the maximum weight value as cluster head the cluster.

To make a decision on nominating the cluster head in an organized way, the process of election is divided into four steps:

- Problem: To elect the right node as cluster head
  - Structure the decision hierarchy from top to bottom to reach the goal
  - Reach the objectives in broader perspective through the all the levels from intermediate to lower
  - Comparison matrices should be constructed for each pair

Weight value of the node is calculated according to the parameters that are listed below.

- Relative Speed of the node ($W_{g1}$)
- Distance Connectivity ($W_{g2}$)
- Reciprocal Mean of Expected Transmission count ($W_{g3}$)

$W = W_{g1} + W_{g2} + W_{g3}$

The weight value calculated using these values is used to elect the cluster head.

2.5.1 Relative speed of the vehicle
The importance of relative speed of the vehicle has to be considered to elect the cluster head due to following reasons.

- One node moves faster compared to all other nodes in the networks which cause frequent failures of connections between nodes
- If suppose the node which moves faster is nominated as cluster head, then frequent change in cluster head occurs which makes the network collapsed.

This context creates more overhead on the network so to avoid such scenarios, it is necessary to nominate a vehicle who is driving slow and stable so that cluster head could stay with a relatively long time with its neighbour nodes. A new metric has to be introduced to calculate the relative stability of the node. It depends on the variation of the neighbourhood. It is defined as stability of the one hop
neighbours. Absolute stability cannot be used because it depends on the road. Since VANET involves frequent topology change, relative stability suits well for transmission of data.

Relative speed of the vehicle = \( \text{Sum of (Relative speed of neighbouring node)} \times \frac{1}{\text{Number of neighbours}} \)

If the number of neighbours is zero, Node itself is chosen as a cluster head.

2.5.2 Distance Connectivity
The second parameter is number of neighbouring nodes and its distance from them, which is referred as neighbour distance based connectivity. Lower the value of neighbour distance connectivity (NDC) shows node stay longer with its neighbours.

\[ \text{Neighbour distance connectivity} = \frac{\text{Distance between node and its neighbour}}{\text{Number of neighbour nodes}} \]

The higher the value of NDC means node is in important position, node with higher connectivity degree has the higher possibility of selecting as cluster head. This improves cluster stability and reduces node breakage.

2.5.3 Transmission Count Expected
Expected transmission count predicts the number of transmissions of a packet over a link. This is used to optimize the overhead and to reduce end to end delay. The mean of reciprocal the expected transmission count is the improved version of expected transmission count which considers characteristics such as speed, changing topology and so on. The new version focuses on the transmission capability whereas the Expected transmission count concentrating on link or a path.

2.6 Cluster Formation
When the source node receives the information on vehicle ID and weight value, then it sets the backoff time according to that, the node will check whether it receives the message from another node. It receives message from any of the cluster head, the node will become the member of CH. When the node doesn’t receive any information from any cluster head, the nodes become act as new cluster head. When node receives more than two messages from different CH then Link Life Time is set for the node to nominate the cluster head. If the node receives message from multiple CHs, then two choices exist If messages are received in short span of time, then cluster head with larger LLT \([10]\) value will be nominated as cluster head and set its state value into direct gateway for two adjacent clusters. Suppose if it is already a member of a cluster head and it receives message from another cluster head about change of location then it changes the state from member to gateway. Suppose if it is already in one cluster and receives the message from a non-cluster head from another cluster it changes its state to indirect gateway. It LLT value is less than threshold minimum LLT, the node will not member of any cluster.

2.7 Cluster Maintenance
Maintenance of cluster represents the re-election process of cluster head. It two cluster heads meet, if CH1 finds that it has larger weight value, it sends a merge message to CH2. Now cluster head 2 sends a re-clustering message to its members. Members of CH2 which are in the communication range of CH1 will change the ID to CH1. The nodes which are outside the CH1 range elect a new cluster head among themselves. CH2 change the state to member.

2.8 Handoff Process in weighted clustering algorithm \([2]\)
After successful completion of cluster formation, the cluster head keeps track of the cluster members. Handoff is a process that will happen frequently when a cluster member moves between two clusters.
Figure 3 shows the cluster members that are predicted to participate in handoff between cluster heads based on the location.

This cluster change should be notified to the cluster head and the same should be updated in the RSU who is taking care of one or more cluster head by sending a leave message with its ID. On reception of the message from a cluster member to the cluster head, the head will update the table that contains the information of cluster members. It removes the member information from its table. Figure 4 cluster member intimates the cluster head about the leave of cluster.

Figure 4. Handoff Initiation by cluster member

Figure 5 describes the confirmation message from the cluster head to the road side unit.

Figure 5. Cluster member leave message confirmation to RSU

Figure 6 describes about the arrival of the new cluster member into new cluster head after the completion of the handoff process.
Figure 6: New cluster member arrival

Figure 7. Adding of new cluster member confirmation message

Figure 7 describes about the confirmation message sent from the new cluster head to the RSU. This prediction of the handoff process is done through various parameters. First, the relative speed of the vehicle compared to the other nodes in the cluster. Second, GPS location of the particular vehicle. Every node in the cluster should exchange the information frequently to all other nodes regularly. This is to keep track of the vehicles movement. While exchanging information, it includes its vehicle ID, GPS location with it. When a cluster head receives that information, it will identify the farthest node from the position of the cluster head. If the node is close to the boundary of the cluster head, it checks the speed of the vehicle, if the vehicle travels with higher than the cluster head’s speed, then the cluster head predicts that the node will participate in handoff process. Figure 5.8 shows the possibility of the movement of cluster head.
If a cluster head is likely to move from one cluster to the another cluster, it is the responsibility of the cluster head to nominate a new cluster head based on weighted clustering algorithm and also considering the $D_{\text{min}}$ distance. So, before leaving a cluster, cluster head need to nominate a cluster head and the same has to be intimated to the cluster members and also to the RSU about the change in cluster head.

Figure 8. Cluster Head leaves a cluster

Figure 9 shows the nomination of new cluster head when the cluster head moves out. The node that has moved from cluster 1 to cluster 2 have a weight value based on the weight calculation algorithm. If the weight value of the newly arrived node has more value than the already existing cluster head node, then newly arrived node will be elected as a new cluster head. If the value of the newly arrived node is lesser than the current cluster head, then cluster head retains its position and the newly added node will only become a cluster member.

Figure 9. Nominated cluster of cluster 1 and old cluster head joins cluster 2

2.9 Predicting the handoff:
The prediction of the some of the nodes that are likely to participate in handoff process is done based on two information’s relative speed of the particular vehicle and its GPS location. For example, if a cluster consider a scenario where a cluster member due to his mobility the nodes involve in handoff. It leaves a cluster and enters into another cluster. This scenario is explained in the following Figure 10.
2.10 Advantages of Predicting the Handoff

Major advantage of predicting the node to leave a cluster is purely depends on the quality of service demanded by the node. If the node that demands a quality of service and it is offered by the cluster head, later it leaves the cluster and enters into another cluster. This unexpected entry of one node into another cluster will take some time in offering the quality of service demanded by that particular node. So, predicting the handoff will help in this scenario. For example, if a node is likely to participate in handoff, then the quality of demands of that particular node is transferred in prior to the next RSU who is supposed to receive it in future. The cluster head will predict the handoff in earlier with the help of relative speed of the vehicle and the GPS location of the node. After the prediction, the cluster head will intimate about the handoff to the RSU and RSU will intimate about the handoff process that is going to happen soon to the next RSU. This highly helps in handling the sudden demands of the quality of service of the newly arriving node.

3.1 Handoff Using K-Means clustering algorithm [1]

Figure 11 shows the selection of centroid node in the available nodes. Calculate the distance between the nodes and the centroid, the nodes that are closest to the centroid belongs to the cluster. In K-Means algorithm, the Assuming k=4, assuming random centroids initially.
Compute new centroids:

Figure 12: New Centroids Selection using K-Means Algorithm

Calculate the distance between the nodes and the centroid, the nodes that are closest to the centroid belongs to the cluster. Figure 12 shows the calculation of new centroids due to movement of cluster head.

Nodes may participate in handoff

Figure 13. Prediction of Vehicles from one cluster to another cluster

This nodes movement is intimated to the cluster head and also the RSU. The cluster head also intimates about this to the next cluster head about the arrival of a new node. Figure 13 shows the predicted nodes that are likely to involve in handoff and also shares the information of that particular node to the next cluster head. When every node leaves a cluster and enters into a cluster, the calculation of new centroids is performed to decide the new cluster head which gives us dynamic clustering.

4.1 Experimental Results

Table 4.1 Simulation Parameters

| Parameters         | Value(s)                                                                 |
|--------------------|--------------------------------------------------------------------------|
| Simulator          | ns-2 version (2.33)                                                     |
| Network area       | 1000 x 1000 meter                                                       |
| Maximum speed      | 70 and 30 km/ hour                                                       |
| Transmission       | 250 and 150 meters                                                      |
| Simulation time    | 900 sec                                                                  |
| Number of trials   | 30                                                                       |
| MAC layer          | IEEE 802.11b                                                             |
| Channel            | 11Mb/sec                                                                 |
Figure 14 shows the signalling overhead impact has a high impact on weighted clustering algorithm than the proposed K-Means algorithm.

![Figure 14. Signaling Overhead vs Network Density](image1)

Figure 15 shows the packet loss increases with increase in number of nodes in both the proposed algorithms. But, packet loss has high impact on weighted clustering algorithm than K-Means.

![Figure 15. Packet Loss Vs Network Density](image2)
Figure 16. Handoff Latency Vs Network Density

Figure 16 shows the handoff latency of both the algorithms. The results show that latency is less in K-Means than in weighted clustering algorithm.

5. Conclusion

The proposed research has been tested with algorithms weighted clustering and Mutated K-Means algorithm in the highway scenario. Results obtained shows the better performance in maintaining of QoS desired for the each node in the simulation. During the handover process, Slight delay was observed which is due to the initial transfer of messages between the cluster heads and the cluster members. But this process doesn’t affect the QoS of the cluster member which involves in movement from one cluster head to another. This scenario can also be tested for the urban scenario with high traffic density where more number of transmissions use to happen. There results may be different which is left for future work.

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