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Dynamic Clustering and Prioritization in Vehicular Ad-hoc Networks: Zone Based approach

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ABSTRACT: Vehicular Ad hoc Network (VANET) is new network type which is used for short range high speed communication among vehicles and between vehicles and road side infrastructure units. In most of the existing literature, the gateways are considered static, deployed on the road side at fixed distance from each other, depending on their transmission range, which makes the overall system costly. The proposed work is for enabling the mobile data access for vehicle anytime and anywhere. Dynamic clustering of vehicles is used to achieve this access of mobile data in vehicles. Clustering is done here based on zone based approach and by considering the dwelling time of vehicles with their velocity. Dwelling time of a vehicle is the time of that vehicle that resides in a particular range. Zone based clustering is similar to normal clustering but all of the members of this clusters can act as cluster head. The different clusters can be overlapping each other. The velocity of vehicles taken here are 40m/s, 60m/s, 80m/s and 100m/s. The velocities of vehicles in same track have same velocities for simplifying the simulation. Requirements of vehicles such as ambulance, fire service vans are crucial during emergency situations. Hence such vehicles need to be given a high priority in this network architecture. Prioritization of vehicles can be done by considering inter vehicular communication property calculating the deviation of vehicular velocities.

KEYWORDS: Prioritization, Dynamic Clustering, Dwell time, Vehicular Ad-hoc Network, Wireless Access in Vehicular Environment.

1 INTRODUCTION

It is possible giving birth to a new network type called Vehicular Ad hoc Network (VANET), along with the advances in dedicated short range communication and wireless technologies. VANETs are used for short range high speed communication among vehicles and vehicles and road side infrastructure units. Collision avoidance can be achieved by exchanging warning messages between vehicles by using vehicle to vehicle communication.

A Vehicular Ad-Hoc Network is a new technology in which the moving vehicles are turn into moving nodes in a network. When a vehicle turn out of signal range, this will drop out and another vehicle can come instead of this vehicle.

UMTS (Universal Mobile Telecommunications System) is a third generation mobile cellular system which uses wide band code division multiple access technique. It is based on GSM standard and DEVELOPED and maintained by 3GPP. It ensures the delivery of multimedia services to the users in mobile range.

Wireless Access in Vehicular Environment (WAVE) comes in the case of short duration communication in fast changing environment where the broadcasting of large amount of data is difficult. IEEE 802.11p forms the standard for WAVE which is the enhanced version of IEEE802.11a.

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1.1 REVIEW OF LITERATURE

In the existing systems, the gateways considered as static which is not suited for the dynamic nature of vehicles. The dynamic clustering of vehicles is depicted in [1]-[2]. The normal dynamic clustering methods are detailed in this papers.ZRP protocol is detailed in [3]. This is similar to normal clustering methods but all of its members can act as cluster head. The properties of zone based approach are also depicted in [4]. This approach can use both the advantage of proactive and reactive nature of vehicles. So the ZRP is best suited example of hybrid routing protocol.

For achieving high speed and short range communication the VANET is integrated with UMTS networks. The properties of UMTS (Universal Mobile Telecommunication System) and Vehicular ad hoc networks are detailed in [5], [6]-[7]-[8] and [9]. UMTS provides delivery of multimedia message to the user in mobile domain. VANET provides communication among different vehicles and communication between the vehicles and neighboring equipments.

IEEE 802.11p is best suited for the Vehicular networks because it provides better performance compared to IEEE 802.11a. The details of IEEE 802.11p are depicted in [10]-[11]. The better performance is for WAVE protocol as compared to the normal protocols. The performance evaluation is detailed in [12]. Handover of messages in dynamically arranged vehicles are greatest challenge. The method of handover technique is depicted in [13]-[14]. The Mac and PHY layer is enhanced in the case of IEEE 802.11p as compared to IEEE 802.11a. The MAC layer of IEEE 802.11a is known as simple MAC and that for IEEE 802.11p is known as enhanced MAC [15]-[16].

Data dissemination in vehicular ad hoc networks is explained in [17]. Dissemination of data in dynamic vehicular environment is briefly explained in the paper. RSU based frame work dissemination is explained. Prioritization of data access is also an important factor in the vehicular ad hoc networks. The reliable reception of important message is also a challenge in the network. Priority access can be possible EDCA mechanism [18]. Mobility impact on IEEE 802.11p MAC performance is in [19]. A detailed explanation of deviation of vehicles and the level of priority is explained.

2 METHODOLOGY

The topology of the proposed work is depicted in fig.1. The scenario considers two different Lanes over a particular road (e.g, highway), with each Lane for each direction. Communication of vehicles are possible with the road side base stations. These road side equipments are considered to be static and they are deployed in fixed distances. The performance of the network is evaluated in terms of Throughput, Packet Delivery Ratio (PDR), and Delay parameters.

The performance evaluation is done for communication among different Lanes and between Lanes and the comparison of parameters throughput, PDR and Delay is performed in the communication among Lane1, Lane2, from Lane1 to Lane2 and from Lane 2 to Lane 1. Overall performance also evaluated.

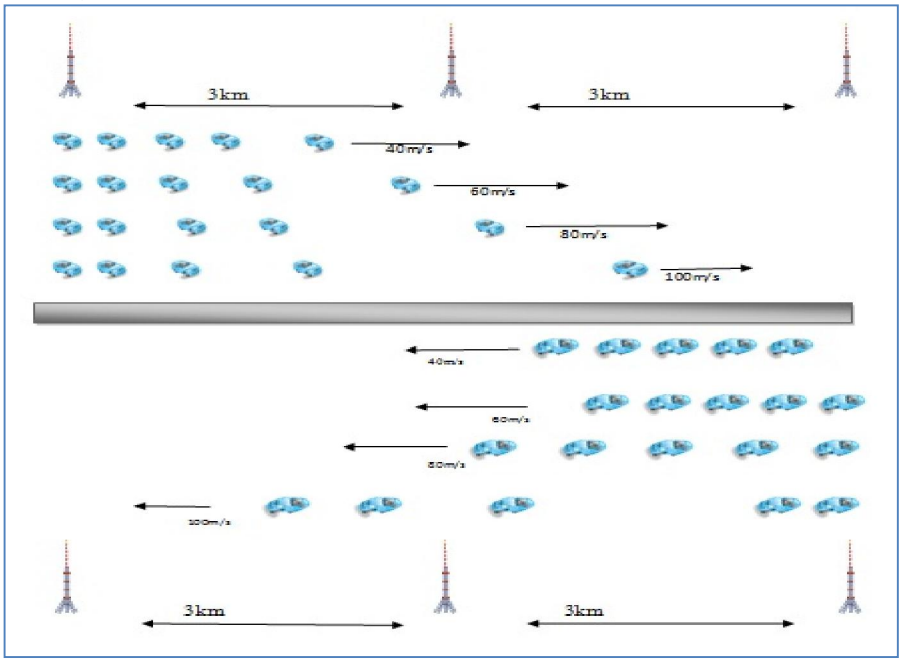

Fig. 1. Proposed Model for Vehicular Network

2.1 CLUSTERING- ZONE BASED APPROACH

Clustering is the grouping of vehicles based on similar characteristics. Zone based clustering is similar to normal clustering with the exception that every node act as a cluster head and a member of other clusters. The protocol used here is Zone Routing Protocol (ZRP). In this, zone is formed by a number of ad hoc nodes within one, two or more hops away from central nodes. In ZRP, Proactive approach is used. Route updates are performed in nodes. So each node has a route to all other nodes within the zone.

In this work zone based clustering is done with slowest vehicle among the vehicles which are in range as the cluster head. Here BSTs are deployed in fixed distances from each other. So we can calculate the location of vehicles from the dwelling time and velocity of the vehicle as shown in the table 1.

When the nodes move from one zone to other it informs the following node and the cluster head of the future zone. The handoff is done when the node move from one node to another. Clustering is done based on the direction and the transmission range.

2.2 BASED ON TRANSMISSION RANGE

The transmission range of the vehicles can be calculated from the velocity of the vehicle and the Dwelling time. The relationship between velocity and dwelling time is shown in Table 1. The base stations are situated at fixed distance from each other. So it is assumed that the transmission region changes after each of their dwelling times. When the vehicle changes from one transmission range to other it will inform the previous zone head node.

Table 1. Relation between velocity and dwelling time

Velocity (m/s)	Dwelling time
40	75.27
60	50.26
80	37.39
100	30.06

2.3 BASED ON DIRECTION

The road is divided into two lanes which are towards different direction. This is considered for this type of clustering. The direction of vehicles whether it is towards or away from base stations also considered.

2.4 PRIORITIZATION

In this proposed architecture inter-vehicular communication is also possible. By using this property vehicles can be prioritize according to their needs. Certain vehicles such as ambulance, fire service vans need to be given a high priority in the envisioned network architecture, as their requirements are crucial during emergency situations. Higher priority vehicles cannot be act as cluster heads. These vehicles continuously deliver messages to the vehicles which are going in front of them. When those vehicles are received this messages they will change their path for the higher priority vehicles and clear the route for them.

A MAC scheme is proposed for the prioritization of vehicles. The concept used here is that, the deviation of the node speed from the average speed of the neighbors is proportional to the level of channel access priority. We can relate the channel access time to the node velocity is to adjust the contention window size to provide service priority. For a transmitting node, i, with a velocity, V_i, the deviation from the average speed V_{avg} is given in equation (1)

$$d = |V_i - V_{avg}| \quad (1)$$

Where, V is the average speed of the (M - 1) one-hop neighbors in the cluster. For simplicity in implementation, vehicles are categorized into different classes based on their speed deviations from the average speed [44].

3 RESULTS AND DISCUSSIONS

The proposed clustering based Vehicular Ad Hoc Network is implemented in network Simulator tool 2. IEEE 802.11p is used as the protocol here. The simulation parameter is given in table 2. The performance of the network is evaluated in terms of Packet Delivery Ratio, Throughput, and number of packets Dropped, End- End Delay which is defined as follows.

- Throughput is the average rate of successfully transmitted data packets over the communication network.
- Packet Delivery Ratio (PDR) is defined as the ratio of the total number of successfully transmitted data packets to the total number of data packets sent from the source to the destination.
- Dropped Packets ratio is the ratio of difference between total number of packets sent from source to destination and the total number of successfully transmitted data packets to the total number of packets delivered.
- End to End Delay refers to the time taken for a packet to be transmitted across a network from source to destination.

Performance of the network based on the above parameters are evaluated under IEEE 802.11a and IEEE 802.11p. We can understand that the performance under IEEE 802.11p is better compared to IEEE 802.11a. The comparison of performance under these two situations are given in the table 3. There is 2.2% improvement in the case of IEEE 802.11p when Packet Delivery Ratio comparison is done. When we done the analysis of network with the parameter Throughput we can see that there is 22.26 % of improvement When we use IEEE802.11 p. From these analysis we can understand that IEEE 802.11p is more suitable for VANET.

Table 2. Simulation Parameters

PARAMETER	VALUE
Area	10000 x 1200 (m^2)
Channel	Channel/Wireless Channel
Propagation model	Propagation/Nakagami
Network Interface	Phy/WirelessPhyExt
Interface Que Type	Queue/DropTail/PriQueue
Interface Queue length	20 packets
Total number of VANET vehicles	20
Routing protocol	AODV
Peak mobility speed	100m/s
Transport layer protocol	TCP/Newreno
MAC Interface	Mac/802.11Ext
Antenna Type	Antenna/OmniAntenna
Application	FTP

After the performance evaluation dynamic clustering of vehicles are done by using zone based approach. Zone based approach is done by considering the dwelling time of vehicles. In this method all the cluster members can act as the cluster head. So as the number of clusters increases the avrage throughput also increases as in Fig 2.

Speed variations with the throughput also analyzed and it is plotted as in Fig 3. The throughput is changes with the vehicular speed.

Prioritization of vehicles is done by using the proposed MAC scheme. This is done by calculating the deviations of velocities and this deviation of velocity is proportional to the channel access priority. As the deviation is high the priority level is high and low priority level is for the lower deviation vehicles. The velocity of vehicles in same track is taken as same for simplifying the simulation. The performance analysis is done in this case by using the parameters throughput and packet delivery ratio. Both the packet delivery ratio and the throughput increase when the velocity of vehicle increases and it is given in Fig 4 and Fig 5.

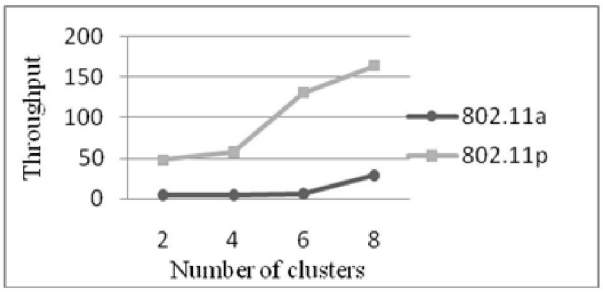

Fig. 2. Number of clusters v/s throughput

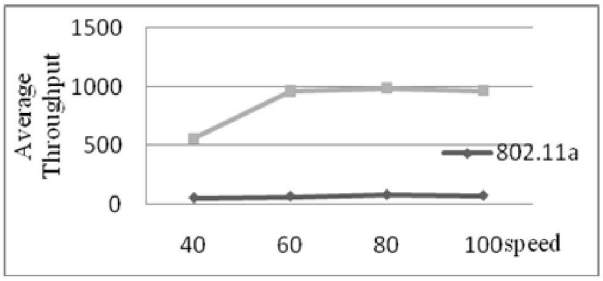

Fig. 3. Speed variation v/s Throughput

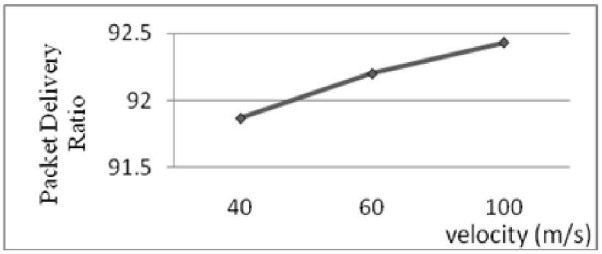

Fig. 4. Velocity v/s Packet delivery ratio

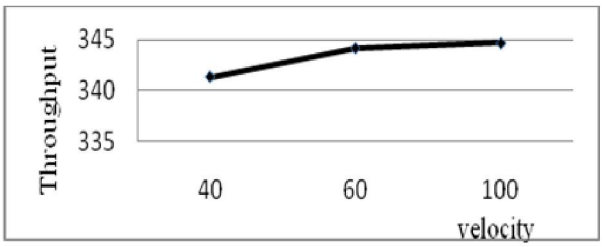

Fig. 5. Velocity v/s Throughput

4 CONCLUSION

In vehicular ad hoc network dynamic clustering is an important challenge because in some previous works gateways in this type of networks are considered static which is not suitable for dynamic nature of such networks. Dynamic clustering can easily did by using zone based approach. This is similar to normal clustering but all of the members can act as cluster head and clusters can overlap each other. This is done by considering the dwelling time of vehicles. In the prioritization scheme a new MAC scheme is developed in which deviation of vehicles are considered. Dwelling time is inversely proportional to the deviation of vehicles. When the deviation increases the level of channel access priority also increases. When the prioritization is introduced there is 0.2% increment in Packet Delivery Ratio is occurred. The deviation of vehicular velocity is used to calculate the level of priority. As the deviation increases the level of priority also increases.

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