

Cluster Head Selection Procedure using Priority based Technique in VANET

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Abstract

Objectives: To improve in the MAC protocol channel sensing mechanism for data transmission from source to destination to improve the throughput and overcome the delay of the network. **Methods:** High degree algorithm is proposed for selection of the Cluster Head under MAC protocol. We have compared the prediction-based algorithm and high degree algorithm with throughput, delay, packet loss, jitter and Packet Delivery Ratio (PDR). **Findings:** Vehicular Ad-hoc Network (VANET) is the self-organizing type of network and a subclass of Mobile Ad-hoc Network (MANET), in which vehicular nodes can move or leave the network when they want. Due to decentralized nature of VANET, security, routing and Quality of Services are major issues which arise in the network and leads to increase the delay with continuously link break in the communication of vehicular nodes. Medium Access Control (MAC), layer helps in the fast transmission of the packets from one node to another. Therefore, the technique of MAC protocol works on Time Division Multiple Access (TDMA), Request to Send (RTS) and Clear to Send (CTS) packets which will increase the routing overhead due to the extra exchange of packets in the network. So to overcome this issue, we have designed high degree algorithm and compared with prediction based algorithm using the time constraints of throughput, delay, packet loss, jitter and PDR which conclude that the high degree algorithm is better than prediction based algorithm. **Improvements:** Throughput, PDR, jitter, packet loss and delay are compared and the result shows improvement using high degree algorithm rather than prediction based algorithm.

Keywords: High Degree Algorithm, Medium Access Control (MAC) Protocol, Prediction based Algorithm, Vehicular Ad-hoc Network (VANET)

1. Introduction

VANET is a wireless network where all the vehicular nodes communicate with each other. VANET is divided into two categories, Vehicular to Vehicular (V2V) and Vehicular to Infrastructure (V2I), V2V communication takes place in between the vehicular nodes with random mobility and V2I communication is in between the vehicular node and infrastructure based Road Side Unit (RSU). RSU is a fixed communication antenna on the road side for better wireless links. Inter-vehicle communication provides driver comfort and road safety¹. VANET is self-ruling and self-organizing wireless communication network, where any node can act as a server-client. There is also a possibility that any node may join or leave the network anytime.

The architecture of VANET network is divided into three parts pure ad-hoc, pure cellular and hybrid. Routing is the main phenomenon to transfer the information from source node to the destination node. The topology of the VANET is continuously changing with the node mobility. It is more important to maintain the route of the packets from hop to hop. Therefore, to overcome the routing issues different routing protocols were proposed. They are as follows:

1.1 Topology-based Routing Protocol

The protocol uses medium information for forwarding the packets from source to destination in the network. They are further divided into two parts²:

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1.1.1 Reactive Routing Protocol

Reactive routing is used on demand basis of the nodes. It maintains only that path which is currently in use, as a result, it reduce the burden. Query packets are flooded to find the route in the network called as route discovery phase and the route phase ends when the final established route is found for the transmission of packets from source to destination. AODV, PGB, DSR and TORA are the examples of the reactive routing protocol.

1.1.2 Proactive Routing Protocol

For communication request next forwarding hop node is maintained for a communication purpose. The advantage of this type of protocol is that there is no need of route discovery phase because the destination is stored in the background but it is very slow in real time application. A table is maintained for each node. LSR and FSR are the proactive routing protocol³.

1.2 Position based Greedy V2V Protocol

The intermediate node formed in the network transfers the data to its remote node which is at the end of the network in the direction of next destination. The objective of the protocol is to transfer the information from source to destination in minimum time that's why these protocols are also named as the minimum delay routing protocol. GPCR, CAR and DIR are position based greedy V2V protocols⁴.

1.3 Broadcast Routing Protocol

Broadcast routing protocol is used in VANET to share weather, emergency, traffic and road conditions among vehicles. The main protocols under broadcast routing are BROADCAST, UMB and V-TRADE.

1.4 Geo-Cast Routing

It is basically a location-based multicast routing. Its main aim is to deliver a packet from source to destination with all nodes in a specified geographical region⁵. Geo cast routing considered as a multicast routing under the defined region of the network. The vehicles outside the zone are considered as a rest node which is not able to participate in the transmission of information. The example of Geo cast routing protocols are IVG, DG-CASTOR and DRG⁶.

1.5 Cluster based Routing Protocol

Cluster based routing preferred in the clusters formation⁷. In a cluster, a group of nodes classified as a part of the cluster and a node is designed as a Cluster Head broadcasts the packet to the other cluster. It helps to provide good scalability in large networks but there is a chance of network delay in highly mobile nodes. COIN and LORA_CBF are Cluster based routing protocol⁸. Clustering consists of three types of nodes Cluster Head (CH), Cluster Member (CM) and Gateway Node. CH is the head node which helps in communication with the CM. The head node collects all the information from CM and transfers it to another neighbour cluster. CM is an ordinary node which only takes part in the communication. Gateway is a node which connects the two clusters in the network, a gateway node is common for the two different cluster for the transmission of information from one node to another node is shown in Figure 1.

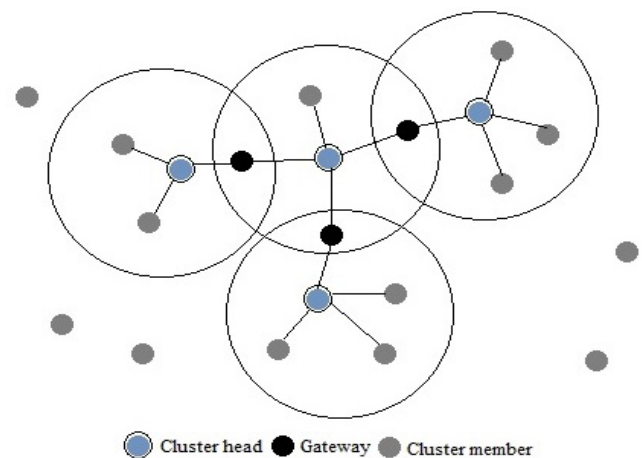


Figure 1. Clustering mechanism.

In this paper, we proposed the high degree algorithm over prediction based approach for selecting the CH under MAC protocol. Direct Sequence Distance Vector (DSDV) routing protocol is used for transmission purpose. DSDV is a table driven protocol which solves the problem of routing loop in the network. It uses the sequence number for the routing table. The sequence number is generated by the destination node in increasing order. The routing information and updates are continuously distributed in between the nodes of the network as shown in Figure 2.

Destination initiates the sequence number and periodically updates the table of routing information. Nodes can communicate with the intermediate node as '4' to

form a path between the nodes. Each node maintains the routing table which consists of the sequence number, destination address, the number of hops and next hop address. We designed a VANET lane model under traffic conditions using different mobile nodes and we have applied the prediction-based approach and high degree algorithm for the comparison of different Quality of Services (QoS).

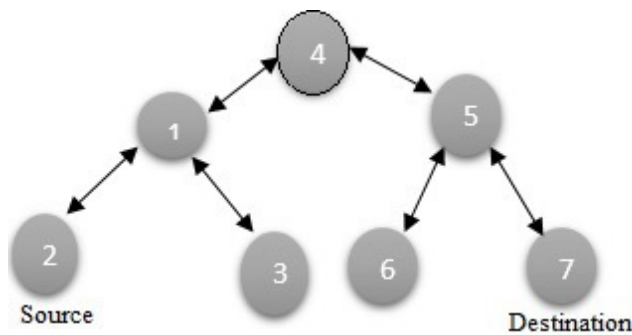


Figure 2. DSDV mechanism.

VANET is a class of MANET with unique properties of a topology change and high mobility. But still there are some disadvantages in the VANET network. Many researchers have proposed MAC protocol to improve the performance of the network. A survey of MAC protocols for VANET has been provided and classified existing MAC Protocol into three major categories of time-based, Dedicated Short Range Communication (DSRC) and antenna based⁹. VANET forms the network under the defined location based region without any fixed infrastructure and centralized access.

As a pre-requirement of transmission over any communication network is routing. Routing is an important factor where the nodes change network topology rapidly. The protocol must be reliable and scalable under the high traffic vehicular conditions with mobile nodes, which is the main objective of any routing protocol. In¹⁰ the greedy routing protocol is discussed over the MAC protocol for the comparison of quality. The timeline and the design factors are discussed for the development of smart Intelligent Transport System (ITS). But the problem is that the VANET protocols are not able to establish the linked protocols of MANET. To overcome the situation another position based protocol¹¹ is designed for VANET. The carry and the forward mechanism are followed by the route which is a key feature for the designing of protocols in VANET. The fragmentation problem of the

rapid change in the topology of the network will decrease the performance of the whole network. Thus, a reliable and efficient protocol is required for the transmission of data over the network. In Ad-hoc On-Demand Multipath Distance Vector Routing (AOMDV), as the number of hops are increased the data traffic also increases and creates a situation of congestion. Therefore, a new technique is proposed¹², Multipath Reliable Range Node Selection Distance Vector (MRRNSDV) routing in which the multiple hops can be selected at the same time and the data traffic is also maintained at high traffic conditions. It will reduce the number of hops and provides multiple routes from source to destination which results in the channel congestion control. RSU hardware is costly therefore, multi-hop communication is required for the communication with RSU.

The vehicles which have a large number of hops will take more time to transmit the information from source node to destination node and congestion is also more in the scenario. The Bandwidth Utilization and Fairness Enhancement (BUFE) with MAC protocol¹³ are discussed, which performs the operation over the fixed gateway mechanism through RSU. The aim of BUFE-MAC is to provide congestion less network, high performance over rapid mobility and bandwidth utilization. The overall result of the protocol shows the congestion control and improves the throughput of a network from the end-to-end node.

2. MAC Protocol in VANET

Medium Access Control (MAC) is a core of an ad-hoc network which provides communication services without any infrastructure or central access point. So there is no base station to coordinate with the access point. Since channel resources are limited, there is interference from a neighbour which shares the same channel to work in a distributed manner¹⁴. Useful MAC protocols under the high traffic conditions are discussed below:

2.1 Time Division Multiple Access (TDMA) based MAC Protocol

TDMA is a multiple communication protocol that is divided into two or more carrier waves using time. In addition to, it supports orthogonal waves for its own channel. Therefore, TDMA is more powerful than FDMA. If data rate increases, the inference of symbols also increases,

thus it requires synchronization. RR-ALOHA is one of the medium access algorithms under TDMA-MAC¹⁵.

2.2 DSRC based MAC Protocol

Dedicated Short-range Communication (DSRC) is an intelligent transport system introduced under wireless local area network. In DSRC, RSU and On Board Unit (OBU) are placed on the side of the road and in vehicles. DSRC is divided into passive DSRS and active DSRC. The protocol has been proposed to remove the disadvantages of TDMA protocol in VANET. This is an attempt to reduce the transmission delay and increase throughput to improve efficiency and driver comfort using CCH and SCH in monopolistic access or reservation-based technology of 5.95 GHz DSRC. DSRC is used to remove hidden terminal problem in a single MAC protocol and improve network throughput to improve efficiency using multiple channels. When RSU could not be used then an ad-hoc method can be used in order to resolve adjustment problem.

2.3 Directional Antenna based MAC Protocols

Y.B. Ko proposed D-MAC protocol; directional antennas are hard to manage at the implementation level and to be made more compliant¹⁶. Recently, many researchers have proposed to resolve these problems. However, the deafness problem is generated in a vehicular environment due to a rapidly changing topology. In the algorithm, if any node broadcasts to a neighbour node then, the other neighbour nodes do not try to communicate with the broadcasting node. This network solves the collision, delay, low throughput and broadcasting storm problems.

2.4 Battery-Aware TDMA Protocol

It is designed to increase the lifetime of the network. This protocol takes the following parameters into account for medium access: Electrochemical properties of battery, time-varying wireless fading channel and packet queuing characteristics¹⁷.

3. Model for Selection of Cluster Head

We have designed a lane model with 35 nodes which communicate with each other under clusters. RSU helps

to increase the wireless link in between the vehicular nodes. The prediction based algorithm scenario of CH selection procedures for MAC protocol model consists of 15 vehicular nodes. These nodes form the CH using prediction based mechanism. The mechanism randomly selects CH node according to their position in the cluster. All the nodes which are present at the corners of the clusters are selected as CM and the node which is at the center are selected as the CH as shown in Figure 3. The all CM denoted with '0' and the selected CH denoted as '1'. These numbers are given to the nodes according to their position in the cluster. The problem in the prediction based algorithm is that there is more than one node which is present at the center of the cluster with priority '1'. The location-based mechanism forms the clusters and the each cluster consists of different nodes with CM and CH. Thus, it takes more time to decide the better CH because more than one node is present at the center which has a priority '1'.

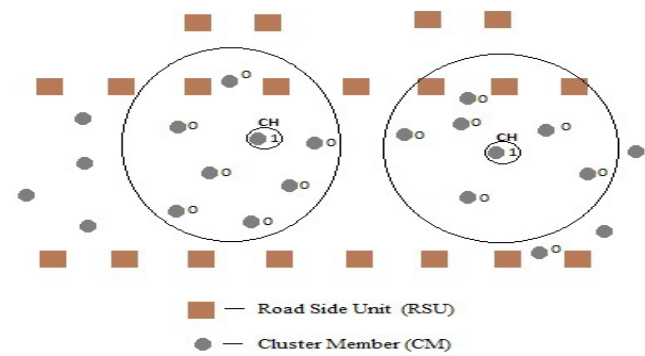


Figure 3. Model of prediction-based algorithm.

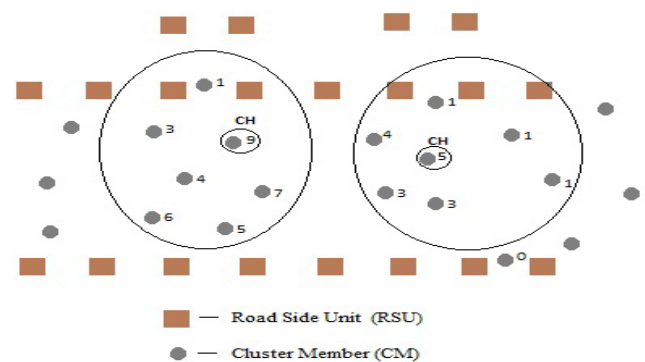


Figure 4. Model of high degree algorithm.

To reduce the delay in the CH selection procedure we have designed another similar model which decreases the time in the selection procedure and provide the channel access to minimize the channel access collision. The same

35 nodes are designed as shown in the Figure 4; in this scenario the location-based mechanism form the clusters of the vehicular node. The high degree algorithm is applied to all the nodes in the cluster, the node which has maximum neighbour nodes and less mobility will set with the highest priority number and the node which has minimum neighbour nodes and high mobility will set as the lowest priority number. The mobility is calculated using speed, distance and time of the vehicular node. The node which has the highest priority will be selected from the CH.

4. High Degree Algorithm for Cluster Head Selection

We proposed an improvement in the MAC protocol, in this work whole network is divided into clusters and in each cluster, a Cluster Head is selected which provide time slots to the vehicle to take channel access. In prediction based algorithm CH is selected using the neighbour nodes and location. During the beacon interval for selecting the coordinators, the vehicles that are close to the center are selected as coordinators, but there are more than one vehicle that is present near the center, then at the first time when a beacon with a coordinator status is received, the sender is considered as the coordinator of the segment that means node is being predicted as coordinator. But at the time of allocation of slots, vehicles transmit beacons in time slots chosen at random from an initial allocation. In addition to employing the basic procedure, it is necessary to resolve collision that happens when more than one closest vehicle selects the same random slot for beacon transmissions; their collision happens and due to this ambiguity, delay increases. The higher degree algorithm reduces Cluster Head selection time. We have simulated the results and compared the improvement in throughput, delay, jitter, packet loss and PDR using prediction based algorithm and high degree algorithm over the designed VANET model. Flow chart of the overall mechanism shows the proper procedure as shown in Figure 5.

Steps of high degree algorithm for selection of CH:

Initialization: Input the number of vehicles in a wireless network.

Step 1: Cluster the whole vehicles in the network and initialize with the location of vehicles.

Step 2: Apply $D = \sqrt{(x - x_1)^2 + (y - y_1)^2}$

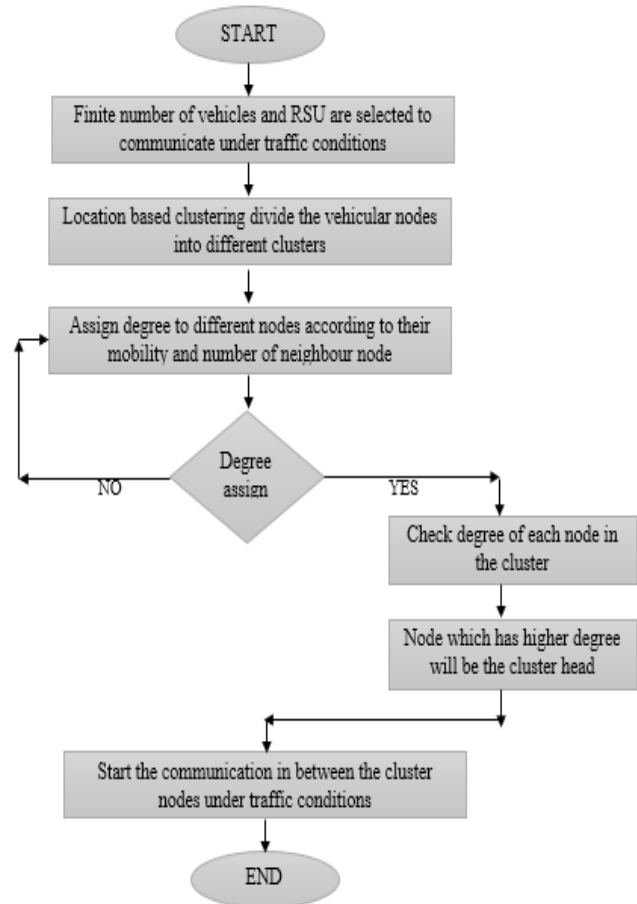


Figure 5. Flow chart of high degree algorithm for the selection of CH.

Step 3: If vehicles are at a similar distance, assign the first cluster. Otherwise, assign another cluster.

Step 4: Assign priority to each node in the cluster and identify the speed of each vehicle using formula $S = D/T$ (where, S = Speed, D = Distance and T = Time).

Step 5: Calculated speed of the vehicular nodes compared with each neighbour node.

Step 6: A node which has a minimum speed in the cluster is selected as a CH and assign the high priority number while comparing with the other neighbour nodes.

Output: Data transmission starts through the selected CH.

5. Simulation Results and Analysis

We have designed lane model for both prediction based algorithm and high degree algorithm using Network Simulator (NS) 2.35¹⁸. The parameters and the output val-

ues are used to design the whole scenario are shown in Table 1.

Table 1. Simulation parameters and output values

Sr. No.	Name	Values / Type
1.	Channel	Wireless channel
2.	Antenna	Omnidirectional
3.	MAC type	IEEE 802.11
4.	Number of mobile nodes	35
5.	Routing protocol	DSDV
6.	Area (x) and (y)	800 and 800
7.	Simulation length in seconds	7.90724854
8.	Number of generated packets	2903
9.	Number of sent packets	2546
10.	Number of dropped packets (Prediction based algorithm)	646
11.	Number of dropped packets (High degree algorithm)	542
12.	Average delay	0.00918749327
13.	Average packet size (Prediction based algorithm)	233.3742
14.	Average packet size (High degree algorithm)	235.9972

The delay is an important factor in the transmission of packets from source to destination. Delay defines the data bit transmission from initial node to the end node. The comparison between the prediction based algorithm and high degree algorithm is shown in Figure 6. At 9-second, the number of delayed packets under prediction based is 174 whereas the high degree algorithm reduced the packets from 174 to 105. Therefore, high degree algorithm performs 39.65% better as compared to the prediction based approach.

Packet loss occurs when the data packets are lost in between the network because of the congestion in the network. It is also defined as the ratio of the received packet by the sent packets in the whole network. The comparison between prediction based algorithm and high degree algorithm is shown in Figure 7. At 9-second, the number

of packet loss under prediction-based approach is 73 and the high degree algorithm reduces that packet loss from 73 to 52. Therefore, the packet loss under the high degree algorithm performs 29.16% better than the prediction based algorithm.

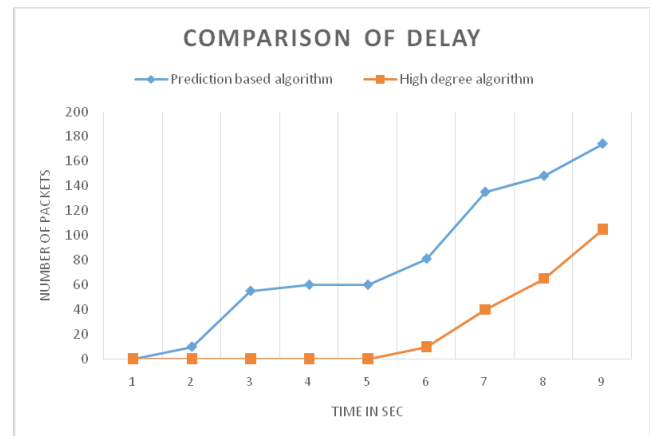


Figure 6. Comparison of delay.

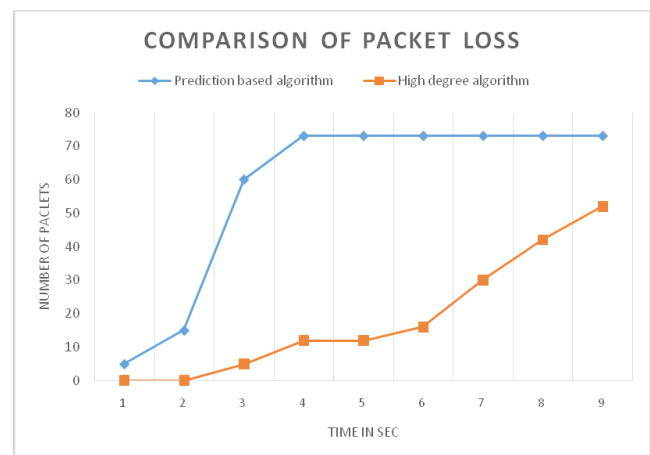


Figure 7. Comparison of packet loss.

Throughput is one of the important factors in the transmission of the packets from source to destination. It defines the number of successfully received packet by the destination over the whole network. It is also given as the ratio of the received packet by the sent packet. The comparison of throughput of both the algorithm is shown in Figure 8. At 9-second, the number of packets received by the prediction-based algorithm is 70 but under high degree algorithm, it reaches from 70 to 110 packets which indicate that the high degree algorithm performs 36.36% better than the prediction based algorithm.

Jitter is termed as delay in the variation of packets from source to destination. The destination node is responsible

for jitter factor, the cause of the variation in the received packets are queuing size, congestion in the network and low connection setup. The comparison of algorithms is shown in Figure 9. At 9-second, the number of received packets variation under prediction based algorithm is 35 but high degree algorithm reduces the variation in the packet from 35 to 20. Therefore, high degree algorithm performs 42.85% better than prediction based algorithm.

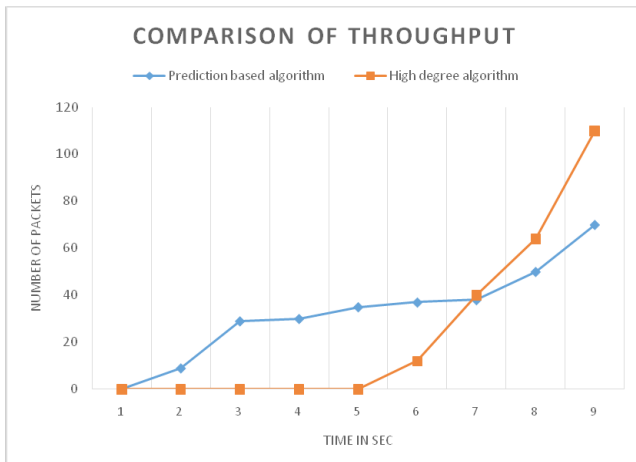


Figure 8. Comparison of throughput.

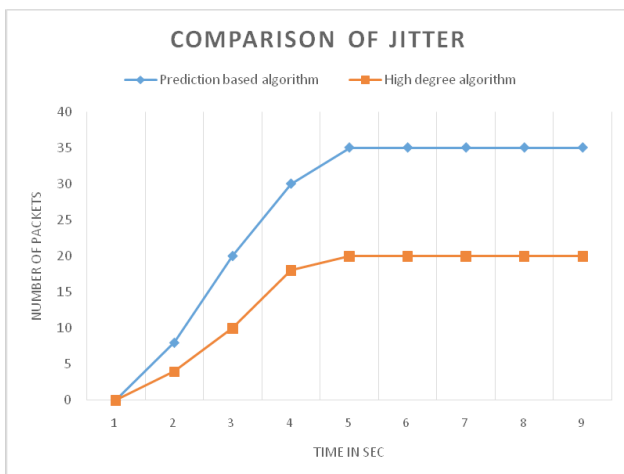


Figure 9. Comparison of jitter.

Packet Delivery Ratio (PDR) is also one the major factor to understand the performance of the network. PDR is a ratio of received data packets by the transmitted data packets. It clarifies the level of received data packets at the destination node. The comparison between prediction based algorithm and high degree algorithm is shown in Figure 10. At 9-second, received packet PDR is 30 under prediction based algorithm and under high degree algo-

rithm, PDR is increased from 30 to 34. Therefore, high degree algorithm performs 11.76% better than prediction based algorithm. The overall results of throughput, delay, jitter, PDR and packet loss shows that the high degree algorithm performs better than the prediction based approach for the selection of CH under MAC.

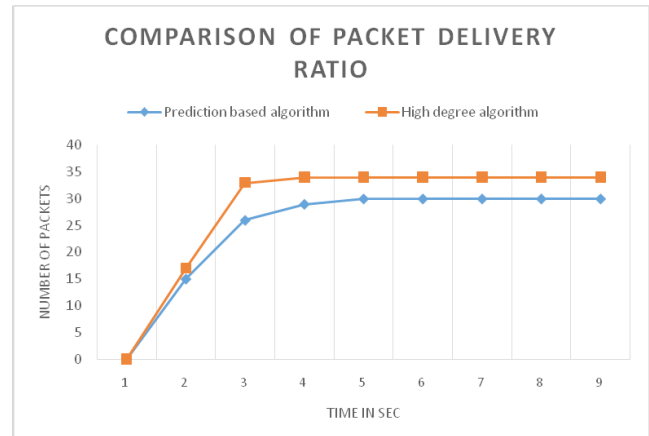


Figure 10. Comparison of PDR.

6. Conclusion

High degree algorithm is better than the prediction based algorithm for the selection of Cluster Head under MAC protocol. To start communication, source node needs to take channel access and the MAC protocol helps in the selection of channel access using TDMA, RTS and CTS packets. It is more important to provide the channels to the vehicular nodes under MAC protocol with minimum congestion links, to transfer the priority information from source to destination. The proposed algorithm has high packet overhead in the network which creates a problem of congestion. In future, improvement will be proposed in existing MAC protocol, which synchronizes the clocks and reduces packet overhead in the network.

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