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PRIORITIZED DIRECTIONAL BROADCAST TECHNIQUE FOR MESSAGE DISSEMINATION IN VANETS

S. LAKSHMI[1], Dr. R.S.D.WAHIDA BANU[2]

[1]Senior Assistant Professor, Department of Computer Applications,

Sona College of Technology, Salem

[2]Principal, Government Engineering College, Salem

lakshmisethuramalingam@gmail.com

ABSTRACT

In Vehicular Ad Hoc Network (VANET), there is a possibility of occurrence of accidents within a cluster, when the driver does not react rapidly. To resolve this problem, in this paper, we propose a Prioritized Directional Broadcast Technique for Message Dissemination in VANET. Initially, message priority assignment technique is used in which three levels of message priorities, that is, very urgent, urgent and general messages are considered. Binary partition phase is then performed for finding the candidate relay node inside the coverage area of the source. Simulation results shows that the proposed approach provides high reliability during emergency message dissemination.

Keywords: *Vehicular Networks, Data Dissemination, Clustering.*

1. INTRODUCTION

1.1. VANET

VANET comprises vehicles that are equipped with computing, sensing, and communication capabilities. Vehicles in VANET are advanced smart vehicles used in computing and wireless communication technologies. VANET has the potential to greatly minimize the system operating costs by reducing the dependence on public infrastructures. VANET extends the coverage of costly roadside infrastructures. In VANET, the vehicles exchange the information such as detour, traffic accident, congestion information, etc., and provide the early warnings to nearby vehicles to reduce traffic jams near the affected areas. In this network, information about on-road vehicle activities is obtained accurately. Vehicular application ranges from road-safety to internet access to online vehicle entertainments [1][2][3].

1.1.1 . Factors Affecting Mobility in VANET

Route discovery, maintenance, reconstruction, consistency and caching mechanism are significantly influenced by mobility pattern of node. The factors affecting the mobility of VANET are as follows:

Block size: If the block size is big, it will cause few intersections and then, in turn, the frequency of which the vehicles stop decreases; streets layout.

Average speed: The speed of a vehicle determines how fast its position changes, which in turn determines the rate of variation in network topology. The factors affecting the average speed are limit of each road, acceleration and deceleration.

Interdependent vehicular motion: In difficult mobility models, the movement of each vehicle is influenced by the movement pattern of its surrounding vehicles.

Traffic control mechanism: The traffic control mechanism like stop signs and lights affects the mobility and results in the formation of clusters and queues.

On the contrary, clusters of vehicles can affect the network performance due to the channel contention and longer network partitions [2][3][4].

1.2. Data Dissemination in Vehicular Networks

In VANET, the working method used for processing the information is data dissemination. Several problems can arise while processing the information. In general, there are several methods

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for information delivery. Some of them are discussed below:

- *Opportunistic Data Dissemination:* Here, the information is pulled from other vehicles or the infrastructure, as a target vehicle encounters them.
- *Vehicle-assisted Data Dissemination:* A vehicle delivers information to her vehicles or the infrastructure when it encounters them. This process involves mobility and wireless transmissions in order to disseminate the information.
- *Cooperative Data Dissemination:* Before obtaining the complete content, vehicles can download partial units of content and share them. This method is particularly suitable for content dissemination where the amount of information is rather important in terms of file size. It was adopted to develop the dissemination protocol based on rate less codes [4][5][6][7].

1.3. Cluster based Vehicular Networks

A cluster is made up of a collection of nodes that are similar to one another within the same cluster and dissimilar to the nodes in other clusters. The process of grouping the nodes into clusters is called clustering. Clustering has its roots in many areas including networks, data mining, statistics, biology, and machine learning.

The nodes can be grouped into the groups based on distance. The labels are assigned to the relatively small number of groups. Clustering method is adaptable to changes and helps single out useful features that distinguish different groups. Dissimilarities are assessed based on the attribute values describing the nodes. Often, the distance measures are used.

Clustering is used to identify dense and sparse regions in node space. Cluster analysis has been widely used in numerous applications including wireless networks, market research, pattern recognition, data analysis, and image processing. Clustering may help in the identification of nodes of similar attribute values and groups of nodes according to location, distance, speed, direction of motion and link stability. In networking, the efforts have focused on finding methods for efficient and effective cluster analysis in large group of nodes [6][7].

1.3.1 . Hierarchical Clustering Method

Hierarchical method creates a hierarchical decomposition of the given set of nodes. This method collects the nodes to form a group of clusters. This methods can be further classified into two types, namely agglomerative and divisive hierarchical clustering.

1.3.2. Agglomerative Hierarchical Clustering

Agglomerative Hierarchical clustering operates on bottom up strategy. It starts by placing each node in its own cluster and merges these atomic clusters into larger and larger cluster, until all of the nodes are in a single cluster or until certain termination conditions are satisfied.

1.3.3 .Divisive Hierarchical Clustering

Divisive Hierarchical clustering operates on top-down strategy. It is the reverse operation of agglomerative hierarchical clustering by starting with all nodes in one cluster. It subdivides the cluster into smaller and smaller pieces, until each node forms a cluster on its own or until it satisfies certain termination conditions [7][8][9][10].

1.4.Accident prevention in Cluster based Vehicular Networks

One of the most important advantages of vehicular network is safety. If there is a chance for accident, the message will be sent to the all the nodes in that networks so that they will be in safe mode. The accident prevention is vital in high way scenario as there is a huge chance of accidents. When the drive does not give replay to the message and one vehicular is very close to another, then the alert message will be sent to all other nodes with a high priority. The message sent to the all other nodes in the vehicular network and all the nodes will alter. To maintain the quality of the messages, the priorities to the messages are used [12][14].

In the proposed extension, we propose a Directional Broadcast and message priority assignment in a cluster based reliable forwarding mechanism for Data dissemination in vehicular networks.

2. LITERATURE REVIEW

Sara Mehar *et al.*, [11] have proposed dissemination protocol called Dissemination protocol for Heterogeneous cooperative Vehicular Networks (DHVN). DHVN considers roads topology, network connectivity and possible partitioning in case of low traffic density, and heterogeneous communication capabilities of the

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vehicles. DHVN considers the non-homogeneous topology and connectivity characterizing urban vehicular environment. It considers the non-homogeneity of the vehicles in terms of communication capabilities.

Jagruti Sahoo *et al*., [12] have proposed an IEEE-802.11-based multihop broadcast protocol to address the issue of emergency message dissemination in VANETs. The protocol adopts a binary partition-based approach to repetitively divide the area inside the transmission range to obtain the furthest possible segment. The forwarding duty is delegated to a vehicle chosen in that segment. Aside from accomplishing directional broadcast for highway scenario, the protocol exhibits good adaptation to complex road structures. The broadcast delay must be reduced for time-critical safety applications. The contention delay remains almost constant, irrespective of vehicle density. Mathematical analysis is performed to assess the effectiveness of the protocol.

Tarik Taleb *et al*., [13] have proposed a cluster based organization of the target vehicles. The cluster is based upon several criteria, which define the movement of the vehicles, namely, the directional bearing and relative velocity of each vehicle, and the inter vehicular distance. Risk-aware Medium-Access Control (MAC) protocol is designed to increase the responsiveness of Cooperative Collision Avoidance (CCA) scheme. According to the order of each vehicle in its corresponding cluster, an emergency level is associated with the vehicle that signifies the risk of encountering a potential emergency scenario. To swiftly circulate the emergency notifications to collocated vehicles to mitigate the risk of chain collisions, the medium-access delay of each vehicle is set as a function of its emergency level.

Chakkaphong Suthaputchakun *et al*., [14] have proposed Broadcast based routing protocol along with priority and position enhancement. This protocol provides fully distributed routing protocol, different Quality of Services (QoS) for different types of messages, maximum message dissemination distance per hop. Priority based Routing Protocol (PRP) is evaluated using simulation software called OMNeT++. The performance parameters include average MAC delay, percentage of message reception and collision, as well as average message dissemination distance per hop.

Carolina Garcia-Costa *et al*., [16] have proposed a stochastic model for the number of accidents in a platoon of vehicles equipped with a warning collision notification system. This is able to inform all the vehicles about an emergency event. The model enables the computation of the average number of collisions that occur in the platoon, the probabilities of the different ways in which the collisions may take place and other statistics of interest. Although an exponential distribution has been used for the traffic density, it is also valid for different probability distributions for the traffic densities as well as for other significant parameters of the model. Moreover, the actual communication system employed is independent of the model since it is abstracted by a message delay variable, which allows it to be used to evaluate different communication technologies.

Mohammad Nekoui *et al*., [17] have developed a model to characterize the delay requirements needed to prevent such collisions. They address the analytical design of a communications system that seeks to provide timely safety information for drivers who are unaware of an imminent collision. They initially developed a model to determine the delay requirements of the safety message delivery system for arbitrary speed, inter-vehicle spacing, and driver and vehicle characteristics. They then addressed the packet success probability under interference, path loss and fading.

Vicente Milanés *et al*., [18] have proposed propose a Vehicle to Vehicle (V2V) communication system based on broadcasting positioning information over WiFi. Vehicle to vehicle communications are needed to ensure that the other intentions of cars are available. They describe the development of a controller to perform an emergency stop via an electro-hydraulic braking system employed on dry asphalt. An original V2V communication scheme based on WiFi cards is used for broadcasting positioning information to other vehicles. The reliability of the scheme has been theoretically analyzed to estimate its performance when the number of vehicles involved is much higher.

In [15], a cluster based reliable forwarding mechanism is proposed for data dissemination in vehicular networks. In this technique, the multilane two-way highway is divided into clusters based on the deployment of road-side units. Within the clusters, the node with the highest transmission quality is selected as the cluster head based on the transmission quality. The cluster head uses the backfire algorithm for data transmission that minimizes the redundancy in the network.

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But there is a chance of accident within a cluster, if the driver does not react quickly. No action is taken to maintain the QoS of the messages.

In the proposed extension, we propose a Directional Broadcast and message priority assignment in a cluster based reliable forwarding mechanism for Data dissemination in vehicular networks.

3. OVERVIEW

In this paper, the Directional Broadcast and message priority assignment is proposed to prevent from the accidents. Initially, message priority assignment is used. After that, the priorities to the message are assigned depending upon the message's urgency and dissemination distance to maintain the QoS of messages. In message priority, the three levels of priorities are very urgent, urgent and general messages. If a very urgent message is received, then the directional broadcast will be used. If a very important message is received, it indicates that the message is in emergency message transmission. Binary partition phase is used to find the candidate relay node inside the coverage area of the source.

3.1. Message Priority Assignment

In the message priority assignment [14], the priority to the messages is assigned. Message Priority Assignment is mainly useful in the accidental emergencies. The message, which has high priority will take the first priority among the all messages and that will forward it to the all the nodes in the range.

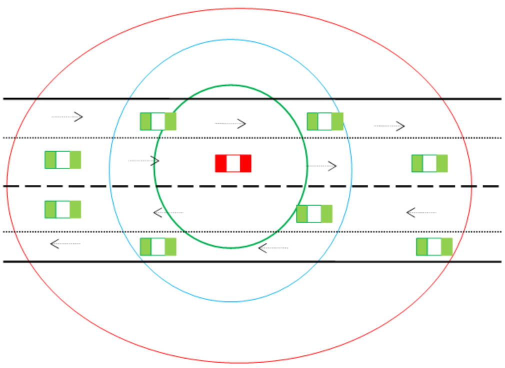

Fig 1: Example for Range Division in VANET

Fig 1 contains totally three ranges that is sector division. The ranges are divided into the three sectors. It will be useful in message dissemination. The range increases automatically, when the message dissemination decreases.

The message priority depends on the message's urgency and dissemination distance. In message priority, there are three levels of priorities, namely, Very urgent, Urgent and General messages.

If the message is very important, the highest priority will be assigned to that message. The Rebroadcast value (R) is used here to count the number of message broadcast. If the value of R increases, then the priority will be decreased.

To assign the priority to a message, Priority Metric (PM) is estimated. PM decide whether the message is very urgent, urgent or general message. PM is given by,

$$PM = K * \left(\frac{1}{e^{0.05 * d}} \right) \quad (1)$$

where K is the priority coefficient that represents the how quickly the message priority dropped

d is the dissemination distance i.e. the distance between the event and receivers location. The value of d is estimated as per the previous paper [15]. When the value of d increases, PM will be reduced.

Let us assume that the priority coefficients of very urgent, urgent and general messages are 10, 5 and 2, respectively. After calculating the priority metric, the message priority is assigned as per the Table-1.

Table 1: Message Priority Assignment Table

Message priority	Priority Metric
1	PM >=5
2	5>PM>=2.5
3	PM<2.5

If the PM is less than 2.5, then it will be considered as general message. If the PM is between 5 and 2.5, then it will be assigned as urgent messages and if the PM is greater than or equal to 5, then it will be considered as very urgent messages.

The messages will send to all the neighbors in the three sectors. When the message is repetitively rebroadcasted far away from a vehicle location, the priority will drop. This is because the message becomes no longer urgent.

If the message priority is very high, then the rebroadcast value is used to count the number of times the message was broadcasted. When the rebroadcast value increases, the priority value

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decreases. The algorithm for Message Priority Assignment is given in Algorithm-1.

1. Start
2. Define the K, d, R;
3. Calculate the PM using the equation (1);
4. Assign the message priority using the message priority assignment table
5. If (message priority = very urgent)
6. {
7. Increase the Rebroadcast value and performs the directional broadcast (given in section 3.2);
8. Decrease the priority;
9. }
10. End

Algorithm-1 Message Priority Assignment

3.2 . Binary Partition Phase

On detecting a very urgent message, a node starts emergency message transmission by using directional broadcast. Binary Partition phase [12] is a method with fixed number of iterations. Due to the limited number of iterations, this method achieves significant improvement in terms of broadcast latency. The main objective of the Binary partition phase is to find the candidate relay node inside the coverage area of the source. A node in that segment is chosen at random as the forwarding node.

In binary partition, the selected-burst emission is used for one time slot duration. Selected-burst is used to select the potential segment and eliminate the non-potential segment from further consideration.

Relay node within cluster is selected using Binary partition phase to choose the candidate relay node. In the message dissemination, the two control packets RTB/CTB are used to provide reliability during emergency message dissemination.

3.2.1 . Relay Node Selection Procedure

The source node initiates the selection procedure of relay node by broadcasting the RTB packet to its neighbors. The header packet of RTB contains the geographical position of the source, geographical position of the current sender, message propagation direction, a timestamp, and a flag. Flags are to decide whether it is directional broadcast and intersection broadcast. If the flag is set to 0, then it will be directional broadcast. If the flag is 1, then it will be intersection broadcast.

The neighboring node receives the RTB packets and extracts the information such as source position, message propagation direction, and timestamp. The procedure first employs a binary partition algorithm accompanied by selected-burst transmissions to find the furthest segment. Then, it carries out contention among the nodes located in the resultant furthest segment to select the relay node among them.

All the participants start black-burst transmissions at the specified time instant in the beginning of the procedure. The advantages of using this method is as follows:

1. Source will aware of the presence/absence of the participants by sensing their black bursts. Based on the information, the source makes a decision whether to continue or restart the procedure.
2. The selected-burst event ensures that no transmission in the neighborhood will interfere with the subsequent transmissions to occur as part of the ongoing broadcast procedure.

The elected relay node sends a Clear-to-Broadcast (CTB) packet to the source node. CTB packet contains the node ID of the RTB sender. On receiving the CTB packet, the source node broadcast the emergency message to all its hops in the network.

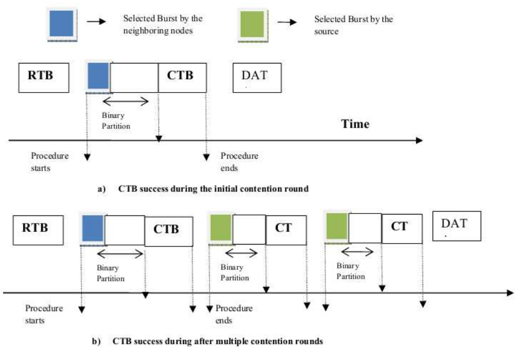

Fig 2: Broadcast procedure

3.2.2 . Binary Partition

To perform the binary partition, first the given segment is divided into two sub-segments of equal width. The coverage area is estimated by the following equation.

$$CA = \frac{R}{2^N} \qquad (2)$$

where R is the radius of the coverage area of the source., N is the number of the partitions.

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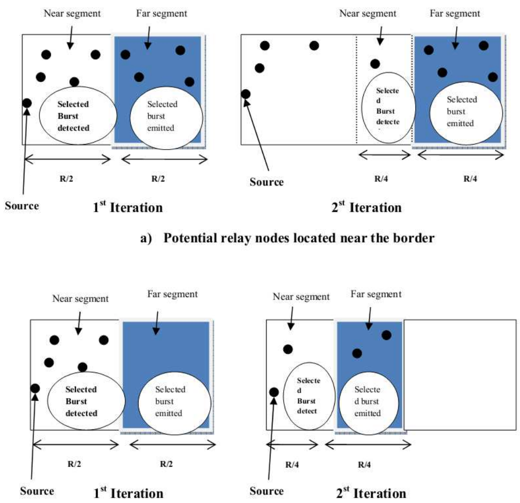
One of the two sub-segment that is closer to the source is selected and given as input to the next partition. For each iteration, the segment will be deleted and moved to the next segment in each sub segment.

We will divide the coverage area into two equal segments and those are named as near segment and far segment. The segment, which is near to the source, is termed as near segment and the other segment is far segment. The reason behind the segmentation of coverage is to locate the furthest possible segment with respect to the distance from the source.

After segmentation, the process is initiated to check for candidate relay node up to the one time slot. When the one time slot over, the node starts the next iteration. In the next iteration, the node will take the far segment as the potential input. If the node detects the candidate relay node, it exits the iteration and remaining segment is eliminated.

Start
1. Define the N
2. Choose the relay node
3. Calculate the coverage area (using the equation (2))
4. Divide into the sub segment
5. While (upto one time slot)
6. {
7. Node searches for candidate relay node
8. If (node finds the candidate relay node)
9. {
10. Exit the iteration
11. Remaining segments are deleted
12. }
13. Else
14. {
15. Go to next iteration and far segment is taken as a potential input
16. }
17. }
18. End

Algorithm 2: For Binary partition phase



b) Potential relay nodes located near the Source

Fig 3: Operation of the binary partition algorithm (N = 2)

In fig 3, the binary partition algorithm is explained with an example. Consider the value of N be 2. It means the coverage area is partitioned into the two parts, that is, near segment and far segment. First, it will check in potential relay nodes located near the source and in that it will locate nearer to the source. If it does not find the burst, then it will again divide the segment into the two segments and repeat the procedure. Then the relay nodes are located near to the source.

In this approach, there is no chance of accident if the driver is not responding. High reliability will be provided during emergency message dissemination.

3.3 . Total Work Flow

In this paper, the priority is assigned to each message using the message priority assignment. This is done according to the message urgency and dissemination distance. By this way, the messages are classified as very urgent, urgent and general messages. If it is very urgent message, then the highest priority will be assigned to that message and the directional broadcast is used. In the directional broadcast, the relay node is selected. After that, the coverage area is calculated. Binary partition is finally performed for data dissemination.

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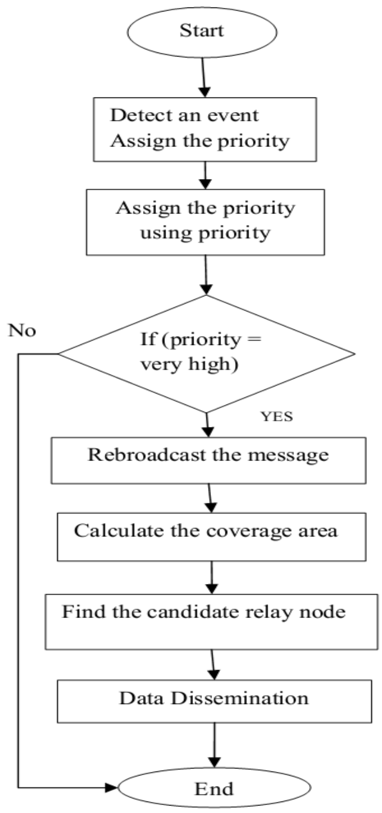

Fig 4: Flow chat for total work flow

3.4. Example for Total Process

In the above diagram, consider the vehicle S. We assume that vehicle S got accident. We will detect the event and assign the priority. Here, the situation is accident, so it is very urgent message. This is the highest message priority.

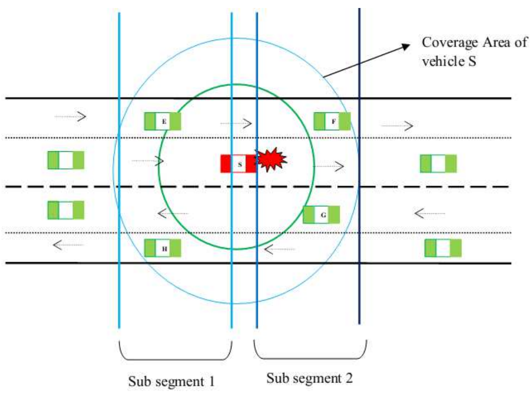

Fig 5: Example for Total Process

The vehicle S broadcast a RTB packet to candidate relay node. We will select the relay node within the cluster. The candidate relay node is selected using the Binary partition phase. The selected relay node sends a CTB packet to the source node. The vehicle S sends the RTB packet to the vehicles like E, F, G and H. Those vehicles are relay nodes and we have to select the best candidate relay node among the inside the coverage area. We will select the best candidate relay node among inside the coverage area of the source using the binary partition.

The vehicle S will calculate the coverage area and divide the coverage area into sub segments. In the above diagram, first segment contain vehicles E and H. The second segment contains vehicles F and G. The source will check for candidate node in each sub segment for one time line. When the time line over, it will goes for another segment. It will select the F is best candidate relay node because it is more nearer and it is in the same way of the source.

4. SIMULATION RESULTS

4.1. Simulation Parameters

The proposed Prioritized Directional Broadcast Technique (PDBT) for Message Dissemination in VANETs is simulated using NS-2 [19]. In this simulation, the channel capacity of mobile hosts is set to the value of 5 Mbps.

In the simulation, the number of nodes is 78. The mobile nodes move in a 2500 meter x 700 meter square region for 50 seconds simulation time. In our simulation, the data transmission rate is varied from 250kbps to 1000kbps.

The simulation settings and parameters are summarized in table 2.

Table 2: Simulation Parameters

No. of Nodes	78
Area	2500 X 700
MAC	802.11
Simulation Time	50 sec
Traffic Source	CBR
Rate	250 to 1000Kbps
Packet Size	512 bytes
Routing Protocol	AFM
Antenna Type	Omni Antenna
Mac	802.11

4.2. Performance Parameters

We compare the PDBT with the Priority based Routing Protocol (PBRP) [14]. We evaluate performance of PDBT mainly according to the following parameters.

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Control overhead: The control overhead is defined as the total number of routing control packets normalized by the total number of received data packets.

Average end-to-end delay: The end-to-end-delay is averaged over all surviving data packets from the sources to the destinations.

Average Packet Delivery Ratio: It is the ratio of the number of packets received successfully and the total number of packets transmitted.

Throughput: It is the number of packets received by the receiver per total simulation time.

The simulation results are presented in the next section.

4.3. Simulation Results
A. Varying the Message Sending Rate

The message sending rate is varied from 250Kb to 1000kb with node speed 5m/s.

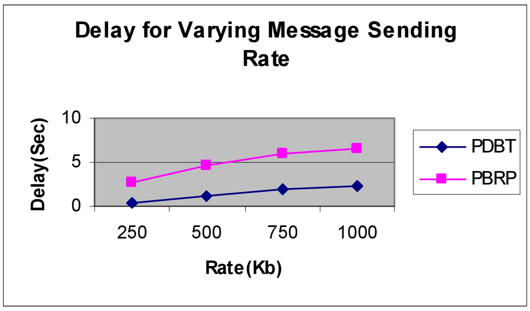

Fig 6: Rate Vs Delay

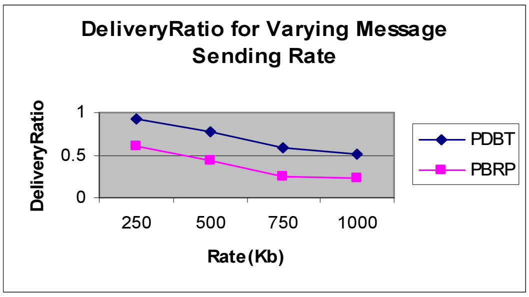

Fig 7: Rate Vs Delivery Ratio

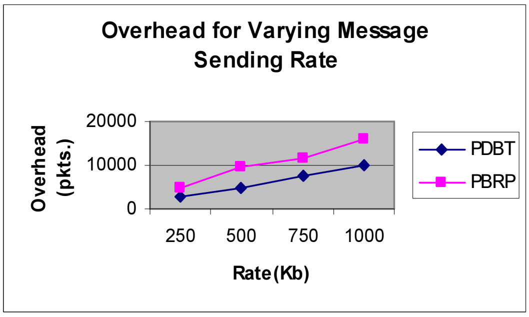

Fig 8: Rate Vs Overhead

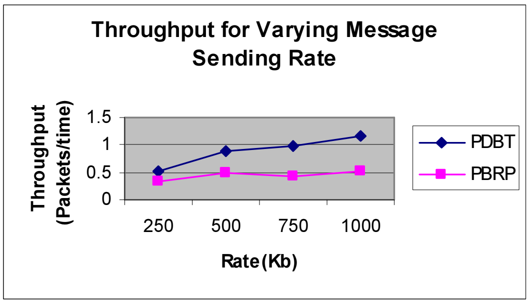

Fig 9: Rate Vs Throughput

Fig 6 shows the results of delay for both PDBT and PBRP when the rate is increased. Increase in transmission rate results in more congestion and collision leading to increase in delay, as depicted from the figure. However, we can see that delay of PDBT is 72% less than PBRP.

Fig 7 shows the packet delivery ratio of both the protocols, when the rate is increased. When the rate is increased, it results in queue overflow and hence packet loss. So the delivery ratio is decreasing, as depicted from the figure. From the figure, it can be seen that the delivery ratio of PDBT is 48% greater than PBRP.

Fig 8 presents the overhead occurred for both the protocols, when the rate is increased. Increase in transmission rate, results in more message exchanges, leading to increase in overhead. But overhead of PDBT is 41% less than PBRP.

Fig 9 shows the throughput per time for both the protocols, when the rate is increased. From the figure, we can see that throughput of PDBT is 48% higher than PBRP technique.

B. Varying the Node Speed

The mobile node speed is varied from 5 to 25m/s with message sending rate 250Kb.

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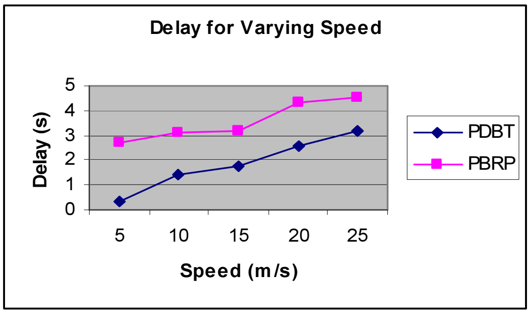

Fig 10: Speed Vs Delay

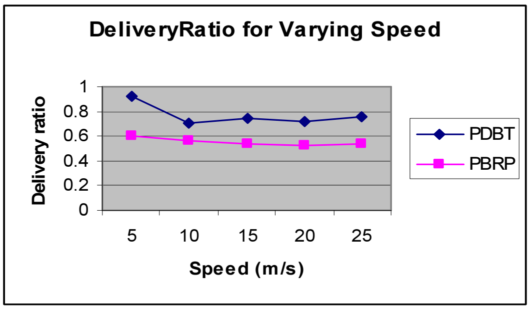

Fig 11: Speed Vs Delivery Ratio

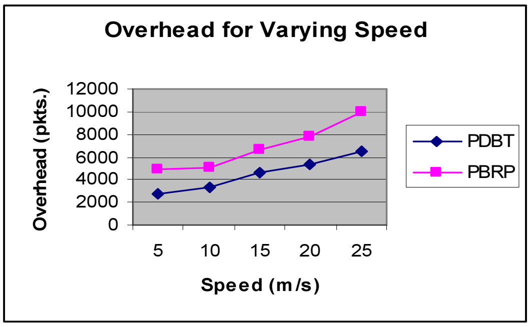

Fig 12: Speed Vs Overhead

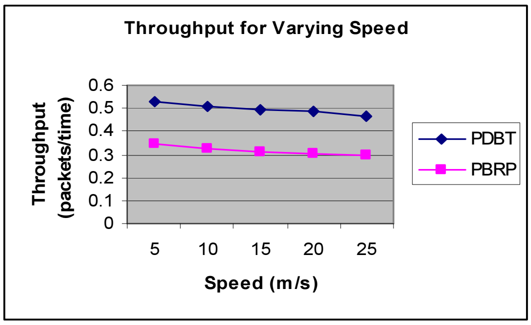

Fig 13: Speed Vs Throughput

Increasing the vehicle speed will in turn increase network disconnections and partitioning. Hence the delay and overhead will be high because of the repair and retransmission operations. Again the throughput and delivery ratio will be slightly degraded. Fig 10 to 13 depicts the effect of varying node speed in terms of delay, delivery ratio, overhead and throughput, respectively.

From these figures, we can observe that PDBT outperforms PBRP by 51%, 27% , 35% and 34% in terms of delay, delivery ratio, overhead and throughput.

5. CONCLUSION

In this paper, we have proposed a Directional Broadcast and message priority assignment in a cluster based reliable forwarding mechanism for Data dissemination in vehicular networks. The priorities are assigned to the packets using the message priority assignment. Here, the three levels of priorities used are very urgent, urgent and general messages. The main objective of the Binary partition phase is finding the candidate relay node inside the coverage area of the source. The main advantage of this method is that there is no chance of accident if the driver is not responding also. This method provides high reliability during emergency message dissemination. Simulation results show that the proposed technique reduces the delay and overhead involved in message dissemination while increasing the throughput. This approach does not provide solution for urgent and general messages. Hence, we plan to extend our proposed work for urgent and general message.

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