# CPROB: A dynamic hybrid broadcasting protocol for Vehicular Ad hoc Networks

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***Abstract*—Vehicular Ad-hoc networks VANETs is a sub-class of Mobile Ad-hoc networks MANETs that has many promising future applications. For example, VANETs can significantly reduce car deaths. In VANETs, nodes mainly communicate by broadcasting messages to each other. Such broadcasting needs to be designed carefully to minimize both congestion and latency. However, most prior broadcasting protocols minimize either congestion or latency, but not both. In this paper, we present CPROB, a new broadcasting algorithm for VANETs that minimizes both congestion and latency. We achieve this result by setting a key parameter (namely the waiting time before retransmission) based on the characteristics of the surrounding environment. Through NS2 simulations, we show that CPROB achieves 57% less latency and comparable congestion than prior work in congested areas. In less congested areas, CPROB has a comparable performance to prior work.**

***Keywords— VANET, MANET, ITS, IVC, Broadcatsing protocols, Broadcast storm.***

## I. INTRODUCTION

The increase in the number of vehicles all around the world induced an increase in the number of vehicle accidents and fatalities with more than 1.2 million victims annually across the globe. Statistics relate that vehicle accidents are the primary cause of death for humans in both Europe and the USA [1, 2]. In Morocco for example, the vulnerable road users (pedestrians and users of two-wheelers) are the first victims of road accidents, which remain the most concerned recording 52.96% of deaths category, followed by car users who present 36.36% of all killed pedestrians [3]

The related dangers are considered to be a solemn problem that society nowadays is facing. Thus, the VANETs become the mobile Ad-hoc networks class with most challenge to have a major impact on enhancing road safety, traffic efficiency, comfort to passengers, and traffic management through a multitude of new pervasive applications developed in this context [4]. It is indeed in this light that the suggested solutions within the VANET's domain have been successfully effective in lessening the consequences and damages of an accident.

Therefore the fundamental purpose of VANETs is to ensure road safety and to diminish traffic congestions of vehicles. VANET are decentralized, distributed and self-organized with high speed mobility of vehicles causing accordingly frequent changes of topology [4].

VANETs are predicted to be the largest MANETs that have been ever implemented. The Federal Communications Commission (FCC) put up the service and license rules for dedicated short range communications (DSRC) service, specified under IEEE standard 802.11p, which operate in 5.9GHz frequency band from 5,850 to 5,925 MHz, with the allocated bandwidth of 75 MHz for the use and support of ITS services and development of pervasive private applications that could potentially improve road safety, traffic efficiency, and introduce new entertainment and business applications [5,6].

The Inter vehicular communication (IVC) includes two types of communications V2V and V2I [7,8];*V2V* in which Vehicle can communicate with other vehicles, and the *V2I* in which the communication is between vehicles and fixed equipment located along the road. These kind of communications permit to vehicles to disseminate some kind of information such as traveler related information, detect another vehicles that are in a dangerous situation, rapid stops, traffic jamming, parking, fuel station and weather information , with the main intention to warn drivers about expected risks, in order to diminish the number of accidents and save people's lives [8].

This paper presents detailed classification of broadcasting protocols. It also cover the related works in the broadcasting domain, then explain the proposed adaptive protocol and test using the network simulator NS2 , and finally conclude and give some perspectives.

## II. BACKGROUND

A poorly elaborated mechanism for disseminating messages can flood the network with redundant data and increase the number of collisions due to disputes between vehicles for accessing the medium. These problems are usually known as broadcast storm problem.

Broadcasting become the most used technique in VANET that cope with the storm problem, and because of their dynamic nature of its architecture, Vanets became a critical challenge. They can be divided into several categories: Simple flooding, probabilistic-based, counter-based, distance-based, location-based, cluster-based, traffic-based and neighbor knowledge based flooding schemes [9,10].

Simple flooding is the simplest mechanism for broadcasting, where every node in the network retransmits every received packet exactly once [11], but may lead to a serious problem,

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often known as the broadcast storm problem [9,12] that severely affect the resources consumption due to redundant message re-broadcast. So to solve this problem, the researchers present new broadcasting protocols to help to reduce the number of redundantly received packets.

In counter-based schemes, messages are rebroadcasted only when the number of copies of the message received at a node is less than a threshold value, i.e. It works as follows: when receiving a packet, the node initiates a counter and a timer. The counter is increased by one for each received redundant packet. When the timer terminates, if the counter is larger than a threshold value, the node will not rebroadcast the packet; otherwise, the node will broadcast it. Counter-based broadcasting was proposed in [9,13,14] as a mechanism to reduce redundant rebroadcast messages and solve the problems appeared in flooding. The location-based scheme, exploit the geographical location of the node to calculate the additional coverage area of the sender. Sender determines the location of the mobile nodes to broadcast. Every node in a network should be equipped with a GPS receiver which is the main drawback [15]. In distance-based scheme messages are rebroadcasted according to the decision made between the relative distance of mobile node and the previous sender, only the neighbor far away from the current node rebroadcasts the message i.e. a distance threshold value is defined. Upon reception of a previously unseen message, a Random Delay Time (RDT), a random value chosen between 0 and Tmax seconds, is initiated and redundant messages are cached. When the RDT is expired, all source node locations are examined to see if the node is closer than a threshold distance value. If true, the node does not rebroadcast [15]. In cluster-based scheme, the network is divided into number of clusters; each cluster has a single cluster head and several gateways. Each cluster head have only the possibility to rebroadcast within its cluster and the gateways can communicate with external clusters, so they can transmit the broadcast message externally [9,15, 16,17]. Hybrid schemes [18,19] combine between the advantages of probabilistic and counter-based schemes to achieve the performance improvement.

Among the broadcasting techniques described above, the simplest one is flooding, which also generates the highest number of redundant rebroadcasts. The probabilistic approaches reduce the number of rebroadcasts at the expense of reachability. Counter-based approaches have better throughput and reachability, but suffering from relatively longer delay. Area-based algorithms require support from GPS or other location devices, and the neighbor-knowledge-based algorithms require the exchange of neighborhood information among hosts.

## III. Related work

A dynamic probabilistic broadcast scheme was presented in [20] which combine the probabilistic and counter-based approaches. They have implemented the algorithm using AODV protocol. Another probabilistic scheme [21] was defined as a combination of the advantages of probability-based and distance-based schemes.

Authors in [12,22] has described an adaptive counter- based scheme in which each node dynamically fix its threshold value in terms of its number of neighbors. Even so, nodes need to obtain local information through periodical hello messages to decide to rebroadcast.

Another counter-based scheme has been proposed in [19] which combine the advantages of probability-based and counter-based algorithms using a rebroadcast probability value of around 0.65, each node rebroadcasts the packet according to this probability with counter threshold to enhance saved-rebroadcast, end-to-end delay and reachability. However, in [18], they used rebroadcast probability value around 0.5 and achieve better performance than other schemes.

An adaptive counter-based scheme was described in [12] in which each node dynamically captures its threshold value C based on its number of neighbors by changing the fixed threshold C into a function C (n). In this approach each node needs to estimate the current value of n where n is the number of neighbors of a node [9]. The method used to get information about neighbors of any node is by exchanging 'Hello' packets between neighbors to construct a neighbor list at the nodes. A high number of neighbors implies that the node in a dense area but the low number of neighbors implies that the node in a sparse area.

Mobility aware Velocity based Broadcasting Scheme [23] eliminates many redundant broadcasts by choosing the nodes with low mobility to discover a more stable path. Thus avoiding the frequent link breakages associated with using unstable paths that contain high mobile nodes. New Velocity Aware Probabilistic Route Discovery Scheme [24] considers the velocity vector probabilistic route discover in MANETs. The study proposed a high broadcast probability for RNs, while a low value is assigned for U-RNs. Thus it implicitly helps in establishing the most stable routes and excluding most unstable routes. Also the have improved it adding dynamic counter and timer concepts to the mobility aware probabilistic scheme.

Authors in [25,26] proposed two different neighbor-knowledge-based approaches. These approaches require mobile hosts to periodically exchange HELLO messages between neighbors. One such method, flooding with self-pruning, constructs a 1-hop neighbor list at each host from the HELLO messages. The neighbor list at the current host is added to every broadcast packet. When the packets reach the neighbors of the current host, each neighbor compares its neighbor list with the list recorded in the packets. It rebroadcasts the packets if not all of its own neighbors are included in the list recorded in the packets. Another approach of scalable broadcast algorithm (SBA) embeds neighbor list in HELLO messages from which it constructs a 2-hop neighbor list at each host. Neighbor-knowledge-based approaches make rebroadcast decisions based on the precise neighborhood information. Therefore, the number of rebroadcasts may be near optimal. However, the HELLO messages themselves consume channel bandwidth, thus affecting the overall performance.

A dynamic distance had proposed in [27]a threshold value and examining its effectiveness under different levels of density, trying to focus on the effect of the dynamic distance threshold value on the performance of distance-based scheme. The simulation results show that the proposed protocol outperform simple flooding and fixed distance in terms of reducing

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overhead, end-to-end delay, Normalized Routing Load, and increasing the packet delivery ratio.

Authors in [28] have suggested a distance-based multi-hop broadcast scheme for inter-vehicle communication, applying the Manhattan map model and its traffic movement pattern into the simulation to evaluate it. As a result, the proposed scheme guarantees rapid broadcast and reliable probability of successful transmission.

A distance-based broadcast protocol [29] called Efficient Directional Broadcast (EDB) for VANET using directional antennas. For this protocol only the node situated at a great distance will forward the packet in the opposite direction, which will help disseminating the packets to the vehicles on other road segments of different directions. Then they have evaluate it using a real mobility model generated by live GPS data of taxis in the city of Shanghai .As a result they found that this proposed protocol EDB was very suitable and effective for VANETs. More sophisticated solutions include probabilistic (gossip-based) [30,31], counter-based [31], distance-based [30,31], location-based [30,31], and neighbor-knowledge based approaches [30].

## IV. PROPOSED ALGORITHM

We will use basically 3 parameters that will be computed depending to local informations, which are the distance between the sender and the receiver nodes, the probability value and the generated time [37]. Firstly, on receiving a message for the first time , we will consider the relation of the energy consumption elaborated on [32] using the energy model consumption sending and receiving one byte of data from node I to node j over a distance d (meters), and we consider that the energy consumption costs:

$$e_{ij}^{s} = c_1 + c_2 d_{ij}^2 \quad (1)$$

$$e_{ji}^{r} = c_1 \quad (2)$$

Then we consider $d_{ij}$ as the distance between two nodes, so by knowing the energy consumed when sending data from node I to node j, we can easily deduce the distance between the two nodes using the equation (3):

$$d_{ij} = \sqrt{\left|\frac{e_{ij}^{s} - c_1}{c_2}\right|} \quad (3)$$

Secondly, there are also many deterministic approaches which have been studied. In [31] introduced a counter-based approach. They have predefined a threshold C which is the key parameter in this approach. They showed that many rebroadcasts could be saved when choosing C equal to 3 or 4. In their follow-on work [12], they showed that if choosing C > 6, few rebroadcasts can be saved in sparser networks. We use this result to set the threshold in our approach.

The major problem of the probabilistic approaches is how to set the rebroadcast probability. Current approaches assume a fixed probability. It is demonstrated [31] that the optimal rebroadcast probability is around 0.65. Intuitively, this value is not likely to be globally optimal. For example, in a denser area, each mobile host has more neighbors that will produce redundancy. To reduce such redundancy, the rebroadcast probability in these areas should be lower. On the contrary, the probability should be set higher in sparser areas so the broadcast packet can reach all hosts in the VANET.

On hearing the message for the first time a counter C is initialized to 1 and count the number of times of receiving the same message. When the generated time expires we will have 3 suggestions for the value of the probability to send depending on the number of counter C; if C=1, P=1, then if 1< C ≤6 , P=f(C)=$\frac{2}{C^2}$ (when the number of messages increase, the probability of sending decrease and vice versa ), and finally if C >6, P=0 then automatically discard the message .

And finally, to calculate the generated time; we will use the equation 4

$$\tau = \frac{1}{V} \quad (4)$$

Where x is a generated number between 0 and 1, and V is the speed in m/s of the vehicle gotten for local informations of the node (if the speed is low it means that the vehicle is in dense or congested area, so it must generate a short time to decide to rebroadcast or not, and vice versa), that help us to set every time the generated time in function of the speed in each area .When the number of messages increase, the generated time decrease and vice versa.

In the fig.1 we propose an approach which attempt to combine the advantages of probabilistic and the counter based approaches to yield good requirements in terms of higher throughput, better reachability, and lower latency. The proposed scheme allows nodes to select an appropriate action (rebroadcast or discard) depending of the number of C, and calculated probability.

When the counter is equal to 1, the probability of broadcasting will be equal to 1, then the value of the probability decreases dramatically as C increases [P=f(C)], which means: The more copies a node receives, higher is the chance of its neighbors having already received the same message, and the more likely is a rebroadcast redundant. The low copies a node receives, lower is the chance of its neighbors having already received the same packet, that there are a sub-optimal number of rebroadcasts, and therefore, the message must be sent to other nodes to cover a large area and achieve better reachability.

For the proposed approach, before transmitting a rebroadcast, the mobile node initiates a generating time in terms of the speed of the vehicle obtained through local information , then a vehicle that has low speed will have a shortest generated time (the node is in a dense area). Then a counter is initiated at 1, count the number of received copies of the same packet, and increment this C for each same broadcast packet. When the time expires, the node will rebroadcast the packet with probability only if the counter does not exceed a threshold value C fixed at

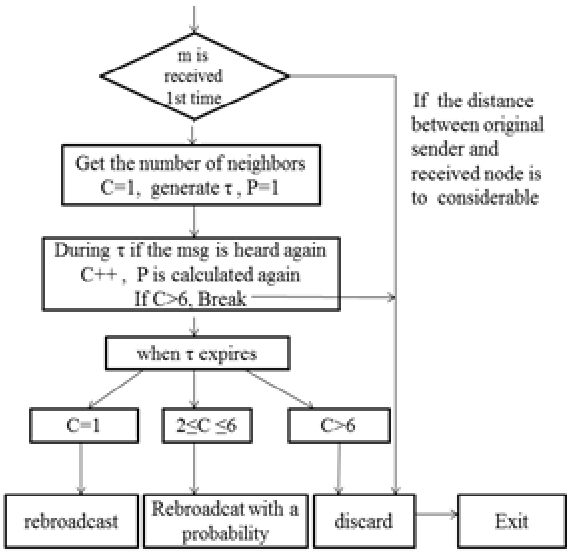


Fig.1: The flow chart of the proposed algorithm

6. Otherwise, if the counter exceeds 6 times, the probability will be equal to 0 and the rebroadcast is dropped. So each individual node can dynamically, decide on rebroadcasting, based on the number of received messages.

## V. SIMULATION RESULTS AND ANALYSIS

This section present the various performed experiments to evaluate the performances of the proposed scheme against different other broadcasting protocols using the network simulator, NS2 (Network Simulator NS2.35) [33].

### a. Mobility scenarios and traffic parameters

In this study, a realistic mobility scenario is used to conduct the simulations. This scenario is generated by Mobility model generator for Vehicular networks (MOVE) [34] and an open source micro-traffic simulator (SUMO) [35]. The scenario generated using these tools is a grid topology of 800*800 $m^2$ with a block size of 200m*200m as depicted in Fig. 2.

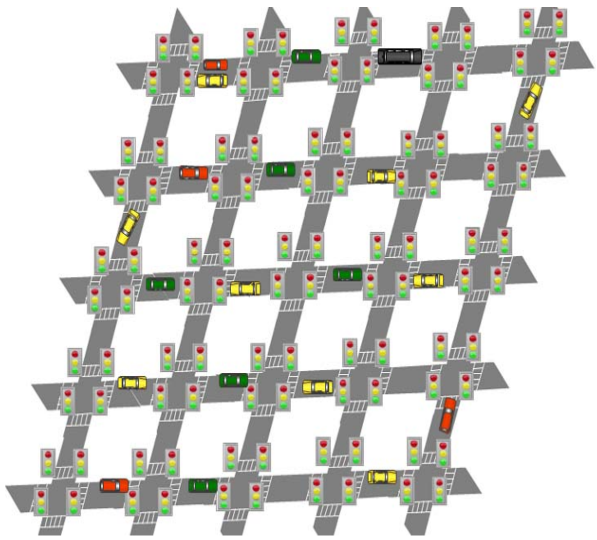

Fig.2: Mobility scenario

Table 1: Simulation parameters

| Simulation Parameter | Value |
|---|---|
| Simulator used | Ns-2 (version 2.35) |
| Network range | 800 m2 |
| Transmission range | 223 m |
| Number of nodes | 50, 100, 150 |
| Nodes speed(km/h) | 20, 60, 85 |
| Bandwidth | 2 Mbps |
| Message size(bytes) | 1000 |
| Simulation time(s) | 1000 |

The speed of vehicles is fixed to 20, 60, and 85km/h and the number of vehicles is fixed to 50,100, and 150, respectively. This scenario is randomly generated .Vehicles move along the grid of horizontal and vertical streets on the map. Each line representing a single-lane road and vehicular movement occurs on the directions shown by arrows. At a crossover, vehicles choose to turn left or right with equal probability, 0.5. At an intersection of a horizontal and a vertical street, each vehicle chooses to keep moving in the same direction withprobability1/2 and to turn left or right with probability 1/4.

A simulation time of 1000s is used, which is long enough to evaluate the broadcasting protocols by varying nodes speed and densities. Each node uses IEEE802.11p MAC protocol, operating at 2 Mbps, to send and receive messages. We used two-ray ground model for radio propagation (Network SimulatorNS2.35) and the transmission range is 223m. The simulation parameters are described in Table 1.

### b. Simulation results

The performance of the proposed scheme are measured and compared with statistical-based schemes mainly, Counter-based, Probabilistic-based, and HCAB algorithm (which observes the TTL of the retransmissions) under different node speeds and densities.

Different threshold values for these schemes are used as follows: for Counter-based scheme, the counter threshold is set to 3 and 6, and for Probabilistic-based scheme, the probability threshold is set to 50% and 75%.

The most important in a broadcasting protocol is how to enhance the efficiency of transmitting a message from a source node to other destinations nodes situated in his range [36], for example an emergency information can be relayed from a vehicle to all other vehicles in the same area without encumbering the network and in a good delay, so as to inform other drivers of the emergency case [4].

A good broadcast protocol permit the transmission of an advising message about traffic events to all other drivers of the networks while minimizing the number of redundant messages and keeping tradeoff between lower latency and good reachability [36].

The following performance metrics have been used to evaluate each scheme:

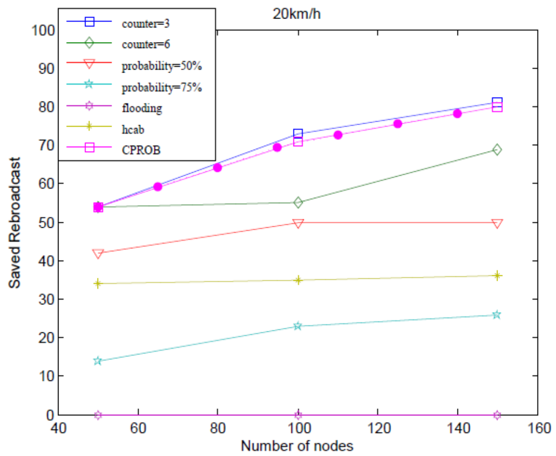


Fig.3.a: Saved rebroadcast vs. number of vehicles for 20 km/h.

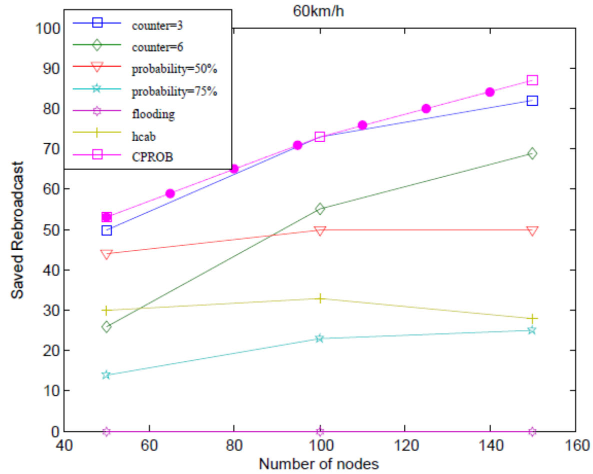


Fig.3.b: Saved rebroadcast vs. number of vehicles for 60 km/h.

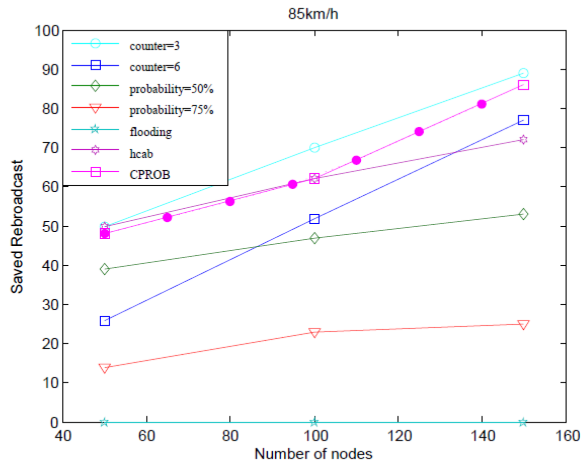


Fig.3.c: Saved rebroadcast vs. number of vehicles for 85 km/h.

Figure 3: Saved rebroadcast vs. number of vehicles for different speeds (20 km/h, 60 km/h, 85 km/h).

Saved Rebroadcast (SRB): is the parameter that minimize the congestion by maximize it; It's the ratio between the numbers of hosts receiving a message and the number of hosts actually rebroadcasting the message.

Latency: the interval from the time the broadcast was initiated to the time the last host finished its rebroadcasting.

We performed twenty simulation trials for each scenario and calculated the average number of SRB obtained with each protocol. It is worth noting that reducing the number of rebroadcasts and lowering latency is our primary concern in the context of VANETs. Furthermore, the importance of safety related information to a vehicle increases when the distance decreases between the vehicle and the place where safety data was generated, and vice versa. Receiving such message when approaching this place can help drivers to decide next actions such as decreasing/ increasing speed, finding an efficient route, and avoiding traffic jam, etc. Drivers far away from this place may not be interested since no actions are need from them to avoid such a dangerous situation.

Figure 3 plots the SRB comparison of the CPROB scheme with the other broadcasting schemes as a function of network road density within the range from 50 to 150 nodes where node speed is fixed to 20, 60 and 85 km/h, respectively. We can observe that SRB increases proportionally with the increase in the number of nodes for the all schemes. The results show that in a dense network the counter and probabilistic-based schemes exhibit lower SRB in comparison with the CPROB scheme. Under different nodes densities and speeds, the CPROB scheme has significant SRB as compared to most of the other broadcasting schemes.

These results justify the effectiveness of the proposed scheme, i.e., without using any fixed threshold, over counter-and Probabilistic-based schemes.

The figure shows that the counter based with the threshold of 3 outperform our scheme in term of SRB for both 20 and 85km/h but the CPROB scheme is better in the scenario of 60 km/h. But the CPROB is far better than the others schemes.

Figure 4 shows the broadcast latency with respect to different densities and node speeds; low, medium, and high vehicles speed. When the number of vehicles increases, the retransmission of messages increases, and hence, resulting in decreasing latency. CPROB scheme is a more efficient since it increases the number of SRB in comparison of most of other protocols with different threshold, so the network becomes less congested. This, therefore, results in lower end to end message delays. We can see that counter-and Probabilistic-based schemes have higher latency values due to higher redundant rebroadcasts if we compare it with the CPROB scheme.

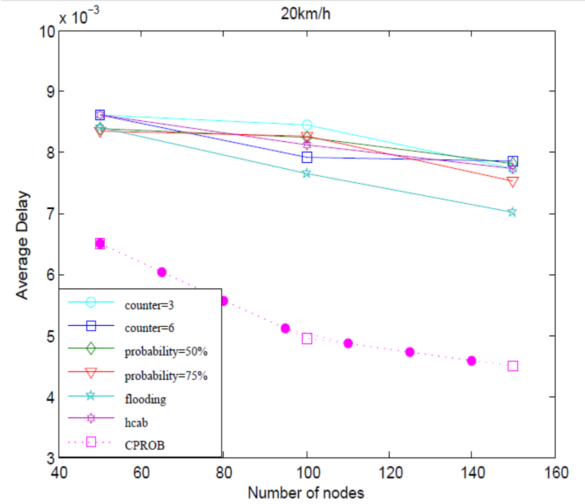


Fig.4.a: Average Delay vs. number of vehicles for 20 km/h.

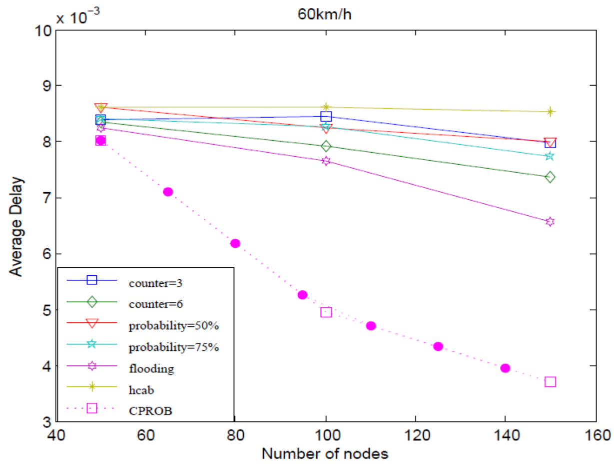


Fig.4.b: Average Delay vs. number of vehicles for 60 km/h.

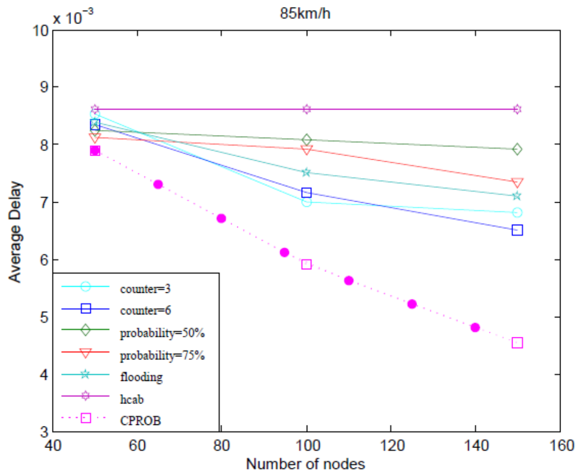


Fig.4.c: Average Delay vs. number of vehicles for 85 km/h.

Figure 4: Average Delay vs. number of vehicles for different speeds (20 km/h, 60 km/h, 85 km/h)

We would like to express our gratitude to Ghita Mezzour for useful feedback and interesting discussions.

## VI. Conclusion

We have presented an overview of different broadcasting protocols. Then we proposed a new protocol called CPROB. Through the simulation performed using NS2, we can conclude that our approach has significant achievement in utilizing network resources. The approach proposed minimizes considerable amount of duplicate packets which eventually saves the network from the congestion problem. We also minimized the end to end delay, which is one of the vital properties for VANET. We expect to test other parameters, and prepare a mathematical model for our scheme .The simulation experiments show that the proposed algorithm outperforms considerably the counter-based, flooding, and other broadcasting schemes in terms of reducing the end to end delay for different speeds and densities.

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We would like to express our gratitude to Dr. Ghita Mezzour for useful feedback and interesting discussions.

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