Performance analysis of an improved Probability-based and Counter-based broadcast protocols for VANETs

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***Abstract*—VANETs use many wireless communication techniques to improve driver's safety and transportation efficiency. Therefore, the design of a good broadcasting protocol that performs well in all criteria in order to avoid storm problem, remains the most paramount task. The thriving chore is how to maximize reachability while minimizing saved rebroadcast and end to end delay. Most of prior work maximizes reachability or minimizes the delay, but not both. In This paper, a novel method was proposed to calculate the waiting time of the counter-based and probability-based schemes, based on the speed of the vehicle, to assess the congestion level of the network. Simulation results through ns2 using 802.11P show that the new method give better performances using different mobility scenaios (Grid and highway Map).**

***Index Terms*—VANET, Broadcasting protocol, V2V, V2I, IVC, NS2.**

I. Introduction

Vehicular ad-hoc network (VANET) is a distributed system composed of a set of vehicular nodes, which form an instant network to communicate with each other by the means of wireless links without the need of an existing deployed infrastructure, because of their self-organization. It's a key component of ITS (Intelligent Transportation Systems). VANET is a class of MANET, and so, has several different characteristics as dynamic topology due to the frequent topology changes that happen, high mobility of nodes, and frequent data exchange. It's worth of cite that VANET has no constraint of energy consumption.

Broadcasting is the suitable mode of communication for VANETs and has a primordial role in several applications in VANET, for example, if an accident occurs, a message must be sent to all vehicles in the surroundings to avoid an expected congestion or traffic jams. Each node in the network resends each received packet which leads to a serious problem, often known as the broadcast storm problem [1] . Vehicles communicate with each others via V2V (Vehicle to Vehicle) and via V2I (Vehicle to Infrastructure) which are used for communication between vehicles IVC (Inter-Vehicle Communication) [2], to evolve traffic conditions and accident preventions, which are the primordial application of VANETs. Thus, to well design a broadcasting protocol, it must meet some requirements, such as performing well in all areas which is the challenging chore (Rural, Urban, Sparse and Dense areas). The broadcasting protocol should also ensures a good reachability, which means that all vehicles in the area receive the sent message. The storm problem caused by redundant broadcasts must be tackled in the same design taking into account that emergency messages have to be sent without any latency. So, we have to consider different parameters when evaluating the performances of a broadcasting protocol under realistic conditions of roads.

This paper presents a novel method in order to cope with problems of the probability-based and counter-based schemes. The scenarios of simulation were varied for the performances analysis: Number of nodes, the speed and area size (If it is a grid or highway scenario).

This paper is structured as follows: Section II tackles the related work. Section III introduces our proposed method. Section IV presents and discusses the simulation results of the proposed methods, compared with the other schemes (Counter-based and Probability-based protocols). Section V concludes the paper.

II. Related work

An improvement of driver's safety consist of a notification of any dangerous situation to be disseminated in the network to avoid a critical situation. There are many applications in this context using data dissemination protocols to provide the state of the road and of the surrounding vehicles. Those protocols can be considered as infrastructure-less broadcasting protocols. They can perform without the need of any aid of infrastructure (Costly infrastructure) to disseminate data. The main goal of those protocols is how to inform all vehicles of the network without having the storm broadcast problem. Indeed, several broadcast schemes was proposed in this context to cope with this problem, this includes probability-based protocols, counter-based, location-based, distance-based and hybrid-based schemes [3].

Authors in [4] propose a technique to avoid congestion using Volunteers Dilemma game, they modeled the problem and observed the effect of probability to volunteer in a Nash equilibrium stemmed from mixed strategies and

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the probability of volunteering in QRE equilibrium with additional parameter of aversion, and results showed that the involved concepts used in both equilibriums are goods and parameters to setting the routing probability QRE equilibrium to contribute to this probability decreases more slightly than in the Nash equilibrium. Prior work [5] presents a distributed broadcast protocol that uses local connectivity information provided via periodic hello messages. It performs well in sparse areas, where network disconnections can occur mostly. This can be done by keeping a message by the node until it will be connected to other nodes. Authors [6] suggest a spanning tree-based broadcasting protocol which resends the emergency messages to all nearby vehicles of the accidental location. This protocol reduces the redundant messages (That causes the storm problem) latency and evolve the packet delivery ratio. The source vehicle decides by executing prim's algorithm for finding the minimum cost spanning tree which vehicle is within its radio range. A Vehicle Density based forwarding was proposed for VANETs [7], it chooses adaptively the forwarder based on the node density (Gotten from the number of received hello messages in its transmission range) and with an optimal hop distance. Then they assign several waiting times to decide whether to rebroadcast or discard the message.

To minimize the broadcast storm problem, Authors in [8] propose an Optimistic Adaptive probabilistic broadcast protocol that consider the previous broadcast probability and node density (gotten from beacon messages) to calculate its own forwarding probability. So the node with high probability use shorter waiting time. A Reception Estimation Alarm Routing protocol was suggested which uses the previous probability to calculate the broadcasting probability using the theory model of wireless channels [9]. Thus, only vehicles in the propagation direction can calculate this reception probability. Then relay vehicles are those with least contention delay. In this paper, we suggest a function to set the waiting time value, then we make a comparison of the probability-based and counter-based protocols with the mean of seven thresholds using the new delay formula against a random value of the same waiting time.

III. OUR PROPOSED BROADCASTING PROTOCOL

The conventional employed technique to broadcast a packet in VANETs is flooding, in where a vehicle simply rebroadcasts each received message once, which leads to the broadcast storm problem. The underlying idea of our proposal is to change the waiting time from a random value to a value that can be obtained according to the next formula:

$$\begin{cases} 0 < \tau < 0.4(Secs) & 0 \leq speed < 30(Kmph) \\ 0.4 \leq \tau < 0.7(Secs) & 30 \leq speed < 70(Kmph) \\ 0.7 \leq \tau < 1(Secs) & speed \geq 70(Kmph) \end{cases} \quad (1)$$

Where τ is the assessment delay and it's given in seconds, while *speed* is the speed of the current vehicle and it's given in KmpH. The assessment delay increases as speed increases. It is worth of cite that if the speed is low, the node may probably be in a congested area. We assume that the other vehicles around it will have an average speed equal to it, that's why the assessment delay must be short in this case.

Algorithm 1 *Probability-based with a new delay*

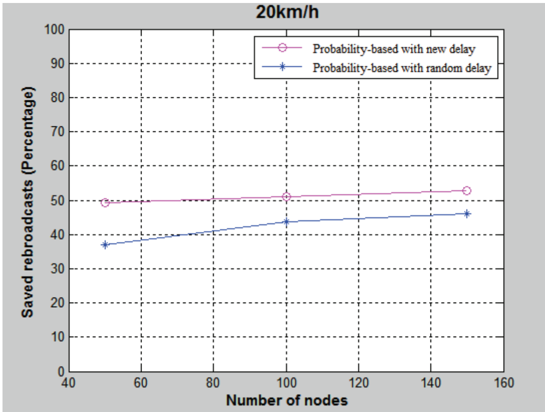
```
On hearing a broadcast message m for the first time
set a waiting time W(S)
Generate a random probability p
if p < P then
                              ▷ (P: Probability threshold-value)
    Rebroadcast the message
else
    Stop waiting
    Drop the message
end if
```

Algorithm 2 *Counter-based with a new delay*

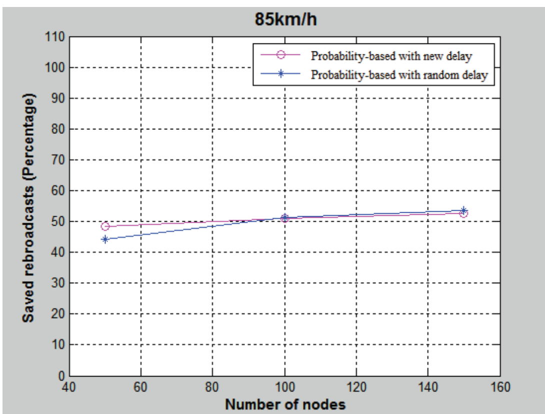
```
On hearing a broadcast message m for the first time
initialize the counter c = 1;
set a waiting time W(S);
For each new message, Increment c , c=c+1;
if c < C then
                              ▷ (C: Counter threshold-value)
    Rebroadcast the message
else
    Stop waiting
    Drop the message
end if
```

It's worth mentioning that all of this will help us to set the delay depending on the node's speed in each area. In the reminder, we test the probability-based and counter-based protocols with different fixed thresholds (But we will consider the mean value) for different scenarios, trying to mitigate the broadcast storm problem. The decision of whether to rebroadcast or not is made based on the waiting time and a probability or counter threshold. This solution will solve the problem of the generation of the waiting time in sparse and dense areas.

So, for algorithm 1 when a node receives a message for the first time, a waiting time is launched (calculated according the previous formula (1)). When it expires, a random probability p is generated between 0 and 1, if p is less than a threshold value P, the message is rebroadcasted. Otherwise, the packet is discarded. Furthermore, for algorithm 2 when a node receives a message for the first time, a counter c is initialized and increment each time we receive the same message, then a waiting time is calculated and lanched. When it expires, if c is grather than a threshold value C, the message is discarded. Otherwise, the packet is rebroadcasted.



(a)



(b)

Fig. 1: SRB of probability-based schemes vs. node density : (a) low speed (20km/h) ,(b) high speed(85km/h)

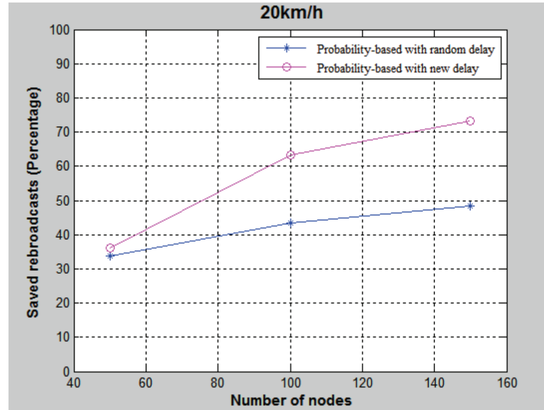
IV. SIMULATION ENVIRONMENT AND PERFORMANCE EVALUATIONS

This section contains details of performance metrics, simulation environment, simulation results and their discussions.

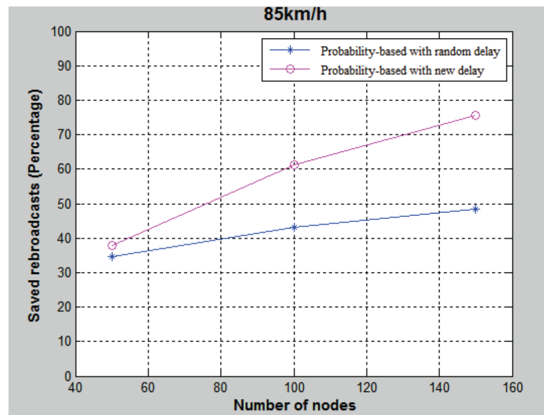
A. *Evaluation metrics*

The simulation evaluation is carried out through three metrics that have to be kept under consideration during the broadcasting mechanism [3] [1]:

- **Reachability**: Which is the amount of nodes that received the packet over the total number of the nodes in the network.
- **End to end delay**: is the difference between the time when the packet is sent and the time it's successfully received by the receiver.
- **Saved Rebroadcast**: This is the percentage of nodes that have received but not rebroadcast the message. Thus, SRB is defined as ((r –t)/r)*100, where r and t are the number of nodes that received the broadcast message and the number of nodes that transmitted the message respectively.



(a)



(b)

Fig. 2: SRB of counter-based schemes vs. node density : (a) low speed (20km/h) ,(b) high speed(85km/h)

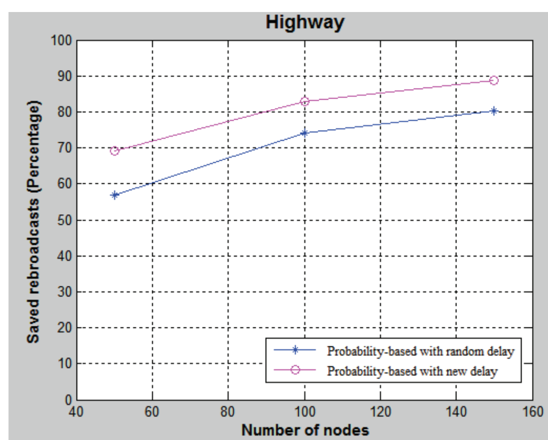


Fig. 3: SRB of counter-based schemes vs. node density in a Highway with high speed (120km/h)

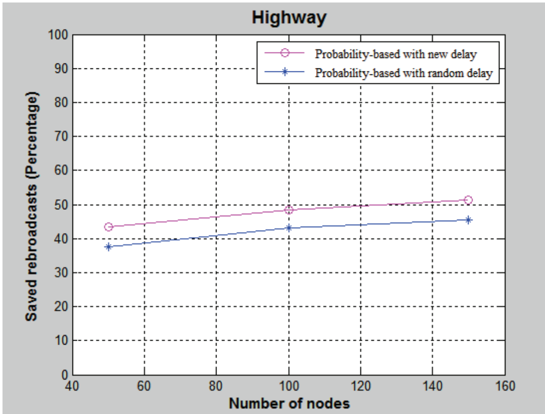


Fig. 4: SRB of probability-based schemes vs. node density in a Highway with high speed (120km/h)

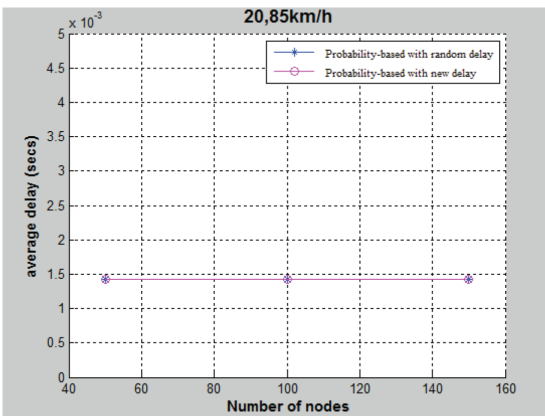


Fig. 5: Average delay of probability-based and counter-based schemes vs. node density in a Highway and grid map

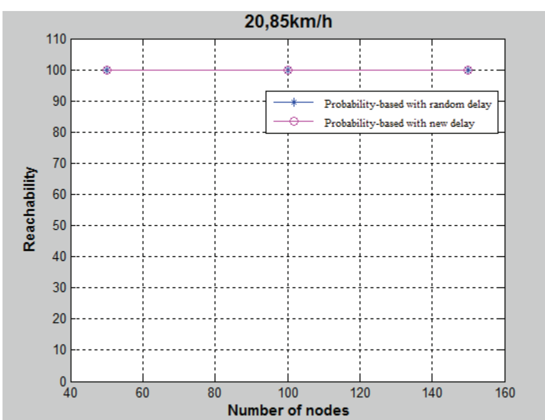


Fig. 6: Reachability of probability-based and counter-based schemes vs. node density in a Highway and grid map

B. Simulation parameters

The network simulator ns2 [10] is used to conduct simulations with different speeds (20, 85km/h) and node densities (50, 100 and 150 nodes) that are randomly distributed in the area, and setting the transmission range to 250m. Thus, we used the default propagation model of ns2, and a bite rate of 10Mbps. A map of 800*800m is used in this simulation with a block size of 200*200m and a highway of 6000 m. In these scenarios, each node uses IEEE 802.11P MAC protocol for the transmission of messages. Therefore a time simulation is set to 1000s for the grid map and 3600s for the highway.We repeated the simulation 20 times and took into consideration the mean value for each 20 outputs. Table 1 summarizes the used simulation parameters.

Simulation Parameter	Value
Simulator used	800 m x 800m Grid, 6000m Highway
Transmission range	250 m
Speed of Nodes (km/h)	20, 85 for Grid; 120 for Highway
Bandwidth	10 Mbps
Simulated of nodes	50, 100, 150
Packet size(bytes)	1000
Simulation time(Secs)	1000-Grid Map; 3600-highway
Trials	20

TABLE I: ***Simulation Parameters***

C. Simulation results

Through all simulations, the main goal is to improve saved rebroadcast, reduce latency and increase the saved rebroadcast ratio, which leads to an important mitigation of the storm problem, and then, reducing the packet collisions in the network. Afterward, we present a comparison of counter-based and probability-based schemes(Considering the mean of different thresholds) using a random assessment delay against calculated waiting time. We evaluate the impact of the nodes'density, speed and mobility scenario on the performance of the protocols.

The simulation was repeated twenty times and we choosed several thresholds, but we have considered the mean output value. Figure 1 and figure 2 depict the results of the comparison of the probability-based and counter-based schemes respectively using a random delay against a new delay for different number of nodes and different nodes speeds (20 and 85km/h) in term of Saved rebroadcast ratio (SRB). The SRB increases as node density increases for the two speeds 20 and 85km/h and for all scenarios.SRB is low for lower number of vehicles and increases as the number of vehicles increases. The results show that the modification of the waiting time give better performances than the use of a random waiting time, which exhibit lower SRB. For a network of 50 nodes in figure 1 and for both speeds, the proposed method is 1.25 better than the probability-based schemes that use a random assessment delay. For a node density of 150 nodes, it is 1.66 better than the counter-based protocols. These results justify the effectiveness of the use of local information as the speed of the vehicles.

Figure 3 and figure 4 show also that SRB increases too as the nodes' density increases, and the proposed method outperforms the probability-based schemes by 1.27 for 50 nodes and the counter-based schemes by 1.18 for 50 nodes too.

Figure 5 presents the average delay of the probability-based and counter-based schemes, we can remark that it stays contant equals to 0.001425 seconds, it reprents the time between the node sends the message to another node in it is range, we remark that it is very small and near to 0.001 secondes because we use 802.11P that uses a dedicated channel to send data. And because we use one hop communication, that is why it stays as a constant for all the transmissions from a node to all other nodes in it's range, and for all node densities and speeds.

Figure 6 presents a comparison of Counter-based and probability-based algorithms with random delay against new delay for all network densities and sizes and all speeds. 802.11P offers a good reachability for all schemes. As a recapitulation we can say that the proposed method outperforms the other schemes in term of SRB, but the reachability and average delay stay constant for all scenarios.

V. Conclusion

In this paper we tried to change the definition of the waiting time for both counter and probability based protocols. The main aim of the proposed method is to get better performances for all requirements in all scenarios and for all densities. Doing so, it lets us meet our goals, such as having a good reachability as well as a high saved rebroadcast and lower latency. Carried out experiments show that the proposed method helps to improve the performances better than the classical counter-based and probability-based schemes especially in terms of saved rebroadcasts. We plan in the future to realize extensive experiments while increasing area size and use a real map.

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