

Achieving Broadcasting Efficiency in V2X Networks with a Distance-based Protocol

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Abstract—Vehicular wireless networks are prospective tools which contribute to safer and more efficient roads. Therefore, they require the design and development of new communication protocols that should constitute the building blocks of future vehicular communication architecture. Many works have been carried out in this wide research area. In this paper, we propose a reliable distance-based broadcast protocol to deliver safety information to nodes located in a geographical area when an emergency event occurs. Simulation results show that the proposed protocol achieves its design goal of delivering information in a rapid and efficient manner. Furthermore, we conclude that our proposal performs better in terms of information reception delay as well as redundancy factor as compared to a scheme inspired from previous proposed schemes.

Index Terms—Wireless Vehicular Networks, Safety Applications, Distance-based Broadcast, Realistic Simulation.

I. INTRODUCTION

The original motivation behind vehicular communication has been safety on the road, many lives were lost due to car crashes. According to World Health Organizations (WHO), road accidents annually cause approximately 1.2 million deaths worldwide. If preventive measures are not taken road death is likely to become the third cause of death in 2020 from ninth place in 1990 [1]. The premise that wireless vehicular communications can alleviate this severe problem and enhance road safety efficiency has led governments and private entities to support several national and international projects around the globe. These projects investigate, on the one hand, the performance of mobile communication technologies in vehicular environment, and in particular, of IEEE 802.11-based technologies referred to as 5.9 GHz DSRC (Direct Short Range Communications). Thus, the Federal Communications Commission [2] allocated a 75MHz spectrum from 5.850 to 5.925GHz referred to as 5.9GHz DSRC to be used for Vehicle to Vehicle communications (V2V) and Vehicle to Infrastructure communications (V2I) in the United States. In order to make the system more attractive for deployment, commercial applications can use the spectrum with certain restrictions as well. In Europe, Intelligent Transportation Systems (ITS) applications may be deployed and developed with a frequency designation of 30 MHz for road safety applications in the band 5875-5905, 5855-5875 MHz for non safety applications and the band 5905-5925 MHz to be considered for future ITS extension.

Also, in Japan, the bands 5835-5840 and 5845-5850 MHz were allocated for up link and 5790-5795 and 5800-5805 for down link for the Association of Radio Industries and Businesses standard (ARIB STD-T55). On the other hand, many efforts have been conducted resulting in different communication and routing proposals since vehicular networks require the design and development of new communication protocols that should constitute the building blocks of future vehicular communication architecture.

In this paper, we are mainly interested in broadcast communications for safety applications which assist drivers to reduce accidents and fatalities on the road. We propose a new multi-hop and distance-based dissemination scheme overcoming the challenges of wireless vehicular networks. Basically, it is designed to be triggered when an emergency event is detected, and its main goal is to deliver reliably to the vehicles, within a geographical area, the information required to avoid such situations. The main feature of the proposed protocol is that it gives more opportunity of relaying message to nodes which has more additional coverage. This paper is structured as follows. In Section II, we discuss related works. Section III introduces the proposed broadcast protocol. Afterwards, a simulation study is performed, in Section IV, that evaluates the performance of our designed broadcast protocol. Finally, Section V reports the conclusions that can be drawn and provides directions for further research.

II. RELATED WORKS

Basically, broadcasting approaches can be classified into three categories: the blind flooding, the congestion aware broadcast and the reliability aware broadcast. Flooding is the classical broadcast mechanism, where every node in the network, after receiving the broadcast message, retransmits it to its neighbors. This technique is very easy and simple to implement and has an excellent message delivery rate even with a high mobility of nodes. However, it may lead to a very serious problem, often well-known as the broadcast storm problem [3]. Hence, many mechanisms have been proposed to alleviate broadcast storm problem while preserving the high probability of reception that flooding mechanism ensures. There are approaches which have been focused on reducing channel congestion (congestion-aware broadcast schemes) by

limiting the number of re-broadcasts or adjusting the nodes transmission power while other focused on improving the reliability of message delivery (reliability-aware broadcast schemes). In this paper, we are interested basically in the congestion-aware broadcast techniques and especially in relay selection schemes. Several protocols have been proposed in prior research addressing congestion problem in order to enhance message dissemination and to improve flooding-based approaches. Most of them focused on how to select the relay node that will be responsible for forwarding safety messages. These proposals can be categorized into four classes: distance-based [4, 5, 6, 7, 8, 9, 10], channel-aware [17], benefit-based [15, 16] and cluster-based [12, 13, 14] schemes. The distance-based broadcast schemes are based, fundamentally, on a contention mechanism where the waiting time is inversely proportional to the distance from the sender. The main advantage of this scheme is to decrease the number of retransmissions which results in improving the bandwidth consumption. Moreover, the broadcast procedure is controlled by limiting the number of hops [4] or by defining the geographic area or/and the direction of propagation where the safety information must be delivered [5, 6, 7]. Some optimization techniques are proposed in [8, 9, 10] and by Kim *et al.* in [11]. Another work that seems to us of a considerable importance has been proposed for ad hoc networks by Kim *et al.* in [18] which is based on a contention-based scheme. The waiting time of each node is inversely proportional to the distance from the sender, on the one hand. On the other hand, it depends on the *distance threshold* that they define as a parameter for the algorithm and it corresponds basically to a given distance from the sender. We will further discuss this algorithm later.

Durreesi *et al.* in [12], Bononi *et al.* in [13] and Chen *et al.* in [14] proposed three different cluster-based algorithms. The main idea of the cluster-based scheme is to organize vehicles on the road into groups. For each group, a node, which will be responsible for relaying the emergency message to all the group members, is elected. The advantage of this scheme is reducing the number of broadcasting nodes which results in attenuating redundancy. However, the difficulty in updating and maintaining the formed groups remains a major problem that must be considered.

The benefit-based approach is studied by Eichler *et al.* in [15, 16]. Each node computes the benefit provided by each packet to all the adjacent nodes which depends on various parameters such as the distance to information source, the information type and quality, vehicle speed and message specific characteristics like message age. Obviously, the packet providing the highest benefit to all neighbors has the highest priority to be forwarded. Furthermore, a contention scheme is introduced and which depends on the estimated benefit of the message to broadcast.

In [17], the author proposes a channel-aware scheme. The proposed protocol's main contribution is to select the propagation relay according to the estimated receipt probability. Obviously, a node is selected as a relay if its neighbors have the highest receipt probability. Every node can calculate the

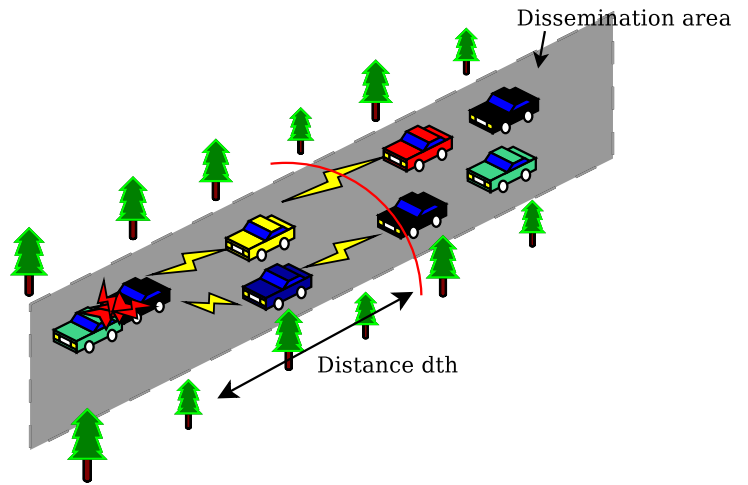


Fig. 1. Illustration of an example of a road situation where a vehicle in a dangerous situation issues emergency messages

estimated receipt probability for its neighbors based on their position and their environment exchanged via beaconing. In this paper, we have been interested essentially in distance-based approaches, we are not considering other methods in relay selection.

III. PROPOSED BROADCAST SCHEME

A. Problem statement

When a vehicle detects a hazard, as depicted in Figure 1, the information related to the urgent event must be disseminated to all vehicles located in the danger area (dissemination area) by the mean of V2V communications. In order to prevent any other dangerous situation from happening, emergency information must be delivered in brief delay and with high reliability. Communication protocols designed for safety applications in vehicular environment must fulfill these requirements.

B. Assumptions

Basically, we assume a scenario where all nodes are equipped with a positioning system, such as GPS (Global Positioning System) in order to obtain their accurate positions in real time. Furthermore, we assume that vehicles exchange two types of messages: periodic messages or beacons and emergency messages. The first type of messages is transmitted in single hop mode. They contain information about the state of vehicles (geographic position, speed, direction, etc.). The main goal of beaconing is to improve driver awareness of the surrounding environment. For instance, in case of close distances to the sender, the information provided by the exchange of beacons can help to prevent unforeseeable emergency situations. The second type of messages is triggered when a hazard is detected. Hence, the information transmitted is considered of primary importance for the whole dissemination area and they should be delivered in brief delays. The originating node, according to the corresponding safety application, specifies the dissemination area. Moreover,

we assume that the exchange of beacons and emergency messages is done through the control channel (CCH) as suggested by the ETSI/ITS architecture [19].

C. Design goals

One of our major goals that is considered in this paper is to design a broadcast communication system which supports and improves road safety and traffic efficiency. This protocol should aim to fulfill safety applications requirements. So, in case of such application, the information must be delivered reliably to the whole dissemination area as quickly as possible. Moreover, the proposed protocol should consider the problem of choosing the strategy responsible to disseminate emergency messages. In order to improve the communication level delivery ratio and control the packet overhead, only a given number of vehicles must rebroadcast the emergency information. The scheme used to select the next forwarder should ensure reliability in message reception for all vehicles in the dissemination area and has to be robust against the uncertainties caused by node mobility, packet collisions and radio propagation phenomena.

D. Proposed protocol

The main purpose of our dissemination strategy is to select the appropriate nodes to forward the message in the direction of dissemination in order to cover the entire dissemination area and to efficiently provide the required reliability and satisfy the delay constraints. A distance-based strategy may show a satisfactory performance of a forwarding scheme since its ability to reduce congestion and increase reliability in message forwarding. According to this approach, which is based on the use of the geographical positions of the nodes combined with a contention-based approach, an emergency message is transmitted in a broadcast fashion and all vehicles receiving it are potential forwarders. In order to decide which node actually forwards the emergency message, a contention period started at each node receiving this message. The length of the contention period is different at each node and depends, on the one hand, on the progressed distance in the direction of dissemination with respect to the actual sender and, on the other hand, on the distance threshold parameter [18], described later. We assume that the dissemination area is partitioned in two adjacent and non-overlapping basic areas, as depicted in Figure 1. The former considered as the closest zone from the area of the emergency event (e.g. accident), it is defined by the distance threshold d_{th} from the source node (triggering the dissemination of the emergency message). The latter is the remainder of the forwarding area.

It is worth mentioning that our proposal depends basically on one parameter which is d_{th} . We intend to determine the appropriate value for this parameter in order to achieve the maximum performance of our protocol. For a further description of our proposed approach, a pseudo code of the protocol is presented in Algorithm 1. We define the main variables and functions used in the following:

- mylocationTable: Structure that maintains the location related information of the neighboring nodes and the node itself. Entries in the location table for neighbors are added and updated in case any type of messages are received. However, information of itself is updated locally by a positioning system such as GPS.
- senderPosition: Position of the node that sent the emergency message.
- myPosition: Own node's position.
- senderId: Identifier of the sender node.
- TransmitMessage: Procedure that transmit the emergency message to the network.
- contending: Boolean variable that is true when a node is in the contention period, and false otherwise.
- senderForwardArea: Dissemination area of the node that sent the emergency message.
- detectHazard: True if a hazard is detected by a vehicle. For instance, accidents or obstacles.
- NotRecMessage: True if the emergency is not received during the waiting time.
- Tmax : Maximum time that a node can contend.
- Time: Waiting time waited by each node.

As illustrated in Algorithm 1, when a node detects an emergency event, it generates a message (lines 2 and 3) containing information such as limits of the dissemination area, the position and speed of the originator. Upon receiving a broadcast message, nodes update their location table (line 6) then determine the area they belong to by comparing the geographical coordinates of the transmitter node (embedded in the broadcast packet header) with their own (lines 8 and 9) and enter the re-broadcast phase (line 10). Obviously, the node's distance from the source, or eventually, the forwarder node can be lower or upper than d_{th} . According to the calculated distance (line 21), a node executes the contention scheme represented by the procedure ContentionPhase() (line 20) and detailed below. At each slot time, the waiting time is decremented by one (line 37). Forwarder nodes that count-down until zero, rebroadcast the message by writing their own coordinates in the packet header in addition to the source's information (lines 38 and 39). Any time a node receives a valid copy of the emergency broadcast message it checks whether the transmitter follows the receiver along the message propagation direction and whether the message has been received before. In this case, the node aborts the rebroadcast procedure. Otherwise, the procedure is restarted by adjusting the area estimation according to the coordinates carried by the overheard packet.

The contention scheme adopted from [18] is described in the following:

As we mentioned before, the main idea of the proposed scheme is to select nodes having more additional coverage as relays. A node receiving the emergency message computes its distance from the source. It schedules, then, a rebroadcast timer with waiting time. The waiting time, as expressed by 3, is inversely proportional to this calculated distance. The upper

Algorithm 1 pseudo-code of the proposed communication protocol

```

1: Procedure: EmergencyMsgTx ()
2: if (detectHazard) then
3:   TransmitMessage ()
4: end if
5: Procedure: ReceiveMessage ()
6: UpdateLocTable (senderPosition)
7: if (NotReceivedBefore) then
8:   if (inPropagationDirection (myPostion, senderPosition))
     then
9:     if (myPosition in senderForwardArea) then
10:      ContentionPhase ()
11:     else
12:       abort
13:     end if
14:   else
15:     abort
16:   end if
17: else
18:   abort
19: end if
20: Procedure: ContentionPhase ()
21: DistFromForw  $\leftarrow$  calculateDistance ( myPostion, sender-
    Position )
22: if (DistFromForw >  $d_{th}$ ) then
23:    $T_{upper} \leftarrow T_{max} \times (1 - (\text{DistFromForw} / \text{Range}))$ 
24: else if (DistFromForw  $\leq d_{th}$ ) then
25:    $T_{upper} \leftarrow T_{max}$ 
26: end if
27: if (DistFromForw >  $d_{th}$ ) then
28:    $T_{lower} \leftarrow 0$ 
29: else if (DistFromForw  $\leq d_{th}$ ) then
30:    $T_{lower} \leftarrow T_{max} \times (1 - (d_{th} / \text{Range}))$ 
31: end if
32: Time  $\leftarrow$  random ( $T_{upper}$  ,  $T_{lower}$ )
33: contending  $\leftarrow$  true
34: Contend (Time)
35: Procedure: Contend (Time)
36: while (Time > 0) do
37:   Time  $\leftarrow$  Time - slotTime
38:   if (Time = 0 AND NotRecMessage) then
39:     TransmitMessage()
40:   end if
41: end while
42: Procedure: UpdateLocTable (senderPosition)
43: if (existInTable (senderId)) then
44:   UpdatePos (senderPosition)
45: else
46:   AddPos (senderPosition)
47: end if

```

bound of waiting time T_{upper} and the lower bound of waiting time T_{lower} defined as shown in 1 and 2 respectively.

$$T_{upper} = \begin{cases} T_{max} \times (1 - \frac{d}{r}) & \text{where } d > d_{th} \\ T_{max} & \text{where } d \leq d_{th} \end{cases} \quad (1)$$

$$T_{lower} = \begin{cases} 0 & \text{where } d > d_{th} \\ T_{max} \times (1 - \frac{d_{th}}{r}) & \text{where } d \leq d_{th} \end{cases} \quad (2)$$

$$waitingtime_t = random(T_{lower}, T_{upper}) \quad (3)$$

Where r indicates the transmission range, T_{max} is the maximum waiting time, d_{th} is the distance threshold and d is the distance from the sender. As shown in (3), a node has more chance to relay packet when his distance from the forwarder is important.

IV. PERFORMANCE EVALUATION

In this section, we evaluate the performance of our proposed communication protocol. Moreover, we intend to compare our protocol to a simple distance-based broadcast protocol that does not make a differentiation in the calculation of waiting time. In the following, we introduce a set of performance metrics suitable to evaluate the performance of both communication protocols, a detailed description of the SDP scheme is also provided, we present then the simulation setup, and finally the results of our experiments.

A. Performance metrics

We should define first suitable performance metrics in order to study, in-depth, the issues associated with vehicular dissemination protocols. In general, the following metrics are adequate to evaluate the effect of these kind of protocols:

- Since it is crucial that all vehicles in the danger area receive the emergency information with high reliability, we intend to measure the success percentage. We consider this metric as one of the most relevant metrics to be used in case of safety applications. It represents the ratio of the cars that receive the broadcast message to the total number of cars in the simulation. This metric is calculated as follows:
If an emergency message is received correctly and for the first time by a given node, the number of emergency message's receivers is incremented by one. At the end of the simulation, we calculate the ratio between the obtained number of receivers and the total number of vehicles in the simulation.
- Average information reception delay is the second relevant metric. it has been measured regarding the distance from the node originator of the emergency message. This metric can be considered as an important metric to analyze the performance of safety related communication protocols because when an accident occurs the quicker that other drivers receive the emergency message, the greater the chance they will be able to avoid an accident. The Information reception delay is defined as the interval

from the time a safety application generates an emergency message to the time this message is received by the corresponding application at another vehicle located at a specific distance from the originator.

- Redundancy factor is defined as the ratio between the number of retransmitting nodes and the total number of nodes. In order to measure this metric, a number of experiments has been performed with varying traffic density.

B. Simple Distance-based Protocol

The primary objective behind these simulation experiments is to assess the performance of our proposal and to compare its performance to the performance of other existing protocols. Inspired by [6, 7, 8], we have compared our scheme with a similar one that does not make use of the d_{th} to calculate the waiting time for each node. We name this scheme Simple Distance-based Protocol (SDP). In this approach, when an emergency message is received, SDP verify if it has been received before and if the receiver is in the forwarding area. Basically, it is a contention-based scheme in which each vehicle can be assigned a delay time Delay (t) before it rebroadcasts the emergency message. This delay is inversely proportional to the distance from the forwarder node and is described through the formula 4.

$$Delay(t) = T_{max} \times (1 - (\frac{D_s}{R})) \quad (4)$$

Where R is the forwarder's transmission range, D_s the distance between the forwarder and the receiver and T_{max} is the maximum waiting time. According to this formula, a rebroadcasting vehicle that covers larger area retransmits the emergency message earlier than other nodes that cover smaller area. Hence, when a node receives an emergency message from a forwarder node, it calculates its Delay(t). During this delay time, if it receives the same emergency message, it aborts the retransmission.

C. Simulation setup

Using our designed simulation platform based on the integration of ns-3 [20] and SUMO [21], we have conducted a set of experiments in order to analyze our proposed distance-based communication protocol and to identify the optimal d_{th} for each traffic density. Moreover, we intend to compare the proposal with SDP and to determine how well it performs under various conditions.

The most obvious first step is to specify a vehicular traffic scenario and a network simulation scenario to run our simulations. Using SUMO, we have designed a traffic scenario composed, basically, of a simple one way road consisting of three separated lanes with length of 10km. Each vehicle is assigned a maximum speed of 42 m/s (151 km/h).

On the other hand, we used, in our network scenario, a constant transmission power of 20dbm (corresponding to a transmission range around 200m) and the log distance propagation loss model as a loss model. The MAC layer scheme

follows the IEEE802.11a MAC specification. Furthermore, we use the broadcast mode with no ACK/RTS/CTS mechanisms for all message transmissions. The emergency message length is set to 150 Bytes. For beacons, we take 2 beacons per second as a reasonable rate and a transmission power of 20 dbm in order to prevent collisions with emergency messages. We choose one of the lower available 802.11a rates, 6Mbps for both types of packets, since it is more robust against interferences minimizing the effect of hidden terminals. The number of vehicles in ns-3 and SUMO must be equal, we have varied this number from 50 nodes to 500 to investigate the effect of node density. Additionally, for each traffic density, we have varied the value of d_{th} . Therefore, nine different scenarios were generated for each traffic density. Each successive scenario increased the d_{th} from 50 to 200. In case of information reception delay measurement, we define four different scenarios; each one corresponds to a given number of cars (50, 200, 400 and 500 cars). For each scenario, the simulation time is set to 60 seconds. We performed simulation 10 times under the same configuration. We simulate a hazard by using the command *SetMaximumSpeed* of our simulation platform's interface. So, we set the maximum speed of a given vehicle in the simulation to zero in order to stop it during traffic simulation runtime. After being stopped, the reference node generates an emergency message that has to be delivered within the relevant area of dissemination. In our case, we set the dissemination area to 6 km. Moreover, we set the maximum waiting time to 10 ms since the safety nature of our proposed broadcast protocol. A summary of the configuration parameters of our simulations can be found in Table I.

Parameter	value
Propagation loss model	Logarithmic distance propagation loss model
Propagation delay model	Constant speed propagation model
Packets Tx power	20 dbm (range of 200m)
Vehicles number	from 50 to 900 Vehicles
Data rate	6 Mbps
Packet size	150 Bytes
Beacons' generation rate	2 Beacons/s
Beacon's size	84 Bytes
Simulation Time	60s

TABLE I
CONFIGURATION PARAMETERS

D. Simulation Results

In this section, we analyze the results obtained from simulations. On the one hand, we intend to determine the optimal d_{th} for different scenarios increasing the number of cars in the simulation. We start by measuring the success percentage as function of d_{th} . We study, then, the average information reception delay to identify the d_{th} that provides a high success percentage and a low delay for each given traffic density. On the other hand, we aim to compare the performance of our proposed scheme to the performance of SDP.

1) *Success Percentage*: An aspect that is worth investigation is the behavior of our proposal when varying the

distance threshold parameter. Figure 2 shows the obtained simulation results in terms of Success percentage in various traffic density scenarios. From the first sight, we can deduce that success percentage varies unpredictably regarding d_{th} . We can notice, from the first curve related to the sparse network (50 nodes), that the highest value of Success percentage, which corresponds to 1, is obtained for d_{th} 60m, 70m, 80m and 150m. However, we can observe that out of these values the Success percentage presents lower values reaching 0.62 in case of 100m. So, the potential optimal values of d_{th} in case of sparse traffic scenario, are: 60m, 70m, 80m and 150m. In case of 200 nodes, 70m and 80m achieve the highest value of success percentage. Similarly, in case of 400 nodes and 500 nodes, 70m and 80m outperform other d_{th} . We conclude that when the network becomes more and more dense, the success percentage decreases. For a number of cars upper than 200, the optimal success percentage falls from 1 but it does not decrease under 0.6 for 500 vehicles.

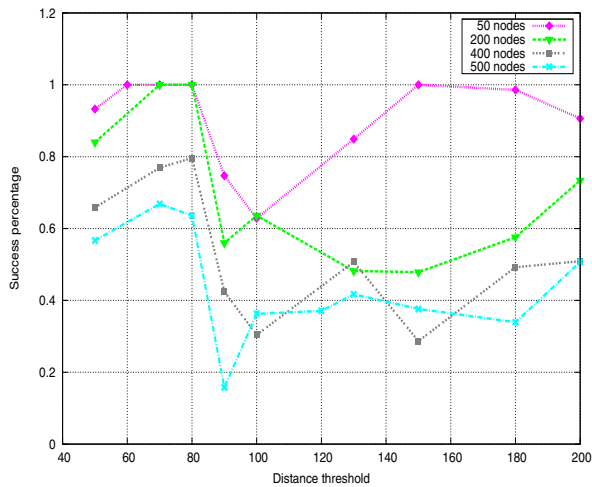


Fig. 2. Success percentage vs. distance threshold

2) *Average Information reception delay*: In this section, we present experimental data intended to show the performance of the proposed protocol in terms of average information reception delay regarding the distance from the originator node, on the one hand, and varying the d_{th} on the other hand. By this study, we aim to identify the optimal d_{th} values ensuring the highest success percentage and the lowest delays. Furthermore, we demonstrate how our proposed approach outperforms SDP not only for low but also for high density network.

a) *Low density scenario (50 nodes)*: Figure 3 plots the average delay with respect to the distance from the originator. For close distance from the source (lower than 100m), both protocols have an inconsiderable value lower than 0.2 ms. This can be explained by the fact that every node within this area can receive the broadcast message from the originator node directly. However, our proposal achieves the lowest delay for further distances in case of 60m, 70m and 80m of d_{th} . The average information reception delay doesn't exceed 36 ms

for a distance of 900m in case of the proposed algorithm. However, it is about 80 ms in case of SDP. This is due to our dissemination strategy and its reliability to provide the lowest delay to reach all neighbors. But in case of 150m, our protocol performs as well as SDP. This leads as to exclude the possibility that 150m could be the optimum d_{th} value for a network density of 50 nodes. Since the nature of safety applications requiring that all cars in the danger zone receive the emergency information as soon as possible, we opt for 60m because it ensures the lowest delay for vehicles situated in a distance lower or equal to 400m from the source, i.e. vehicles in the most dangerous situation.

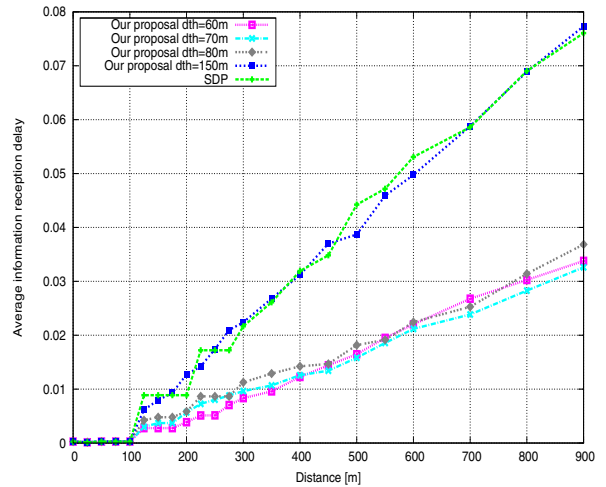


Fig. 3. Average Information reception delay vs. distance from the source node in case of low density scenario

b) *Impact of increasing the number of nodes*: In the following, we examine the effect of increasing the number of nodes on the average information reception delay. We consider several scenarios composed of 200, 400 and 500 nodes.

- 200 nodes

Figure 4 depicts the average delay with respect to the distance from the transmitter. We consider in this figure only d_{th} 70m and 80m since they achieved the highest success percentage in Section IV-D1. By the increase in the number of nodes, we notice that the delays increase too for both protocols, from 36ms to 40ms in case of the proposed protocol and from 80ms to 91ms in case of SDP. We choose 70m as the optimum d_{th} because it provides the lowest delay especially for closer distances (equal or less than 600m).

- 400 nodes

Figure 5 describes the average delay as function of distance from transmitter for a scenario composed of 400 vehicles. Using the proposed protocol we show that it is possible to reach all nodes in a wide area in a very short time (about less than 43ms). Nevertheless, in case of SDP, the information reception delay is about 92ms for a distance of 1 km. Moreover, we deduce that increasing the number of nodes leads to an increase of the information reception delay

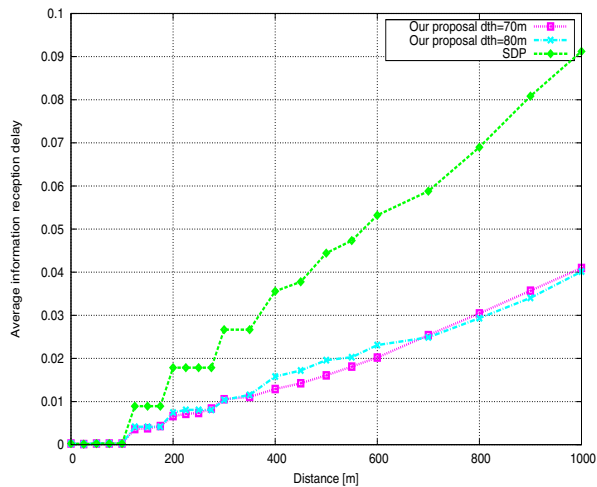


Fig. 4. Average Information reception delay vs. distance from the source node in case of 200 nodes in simulation

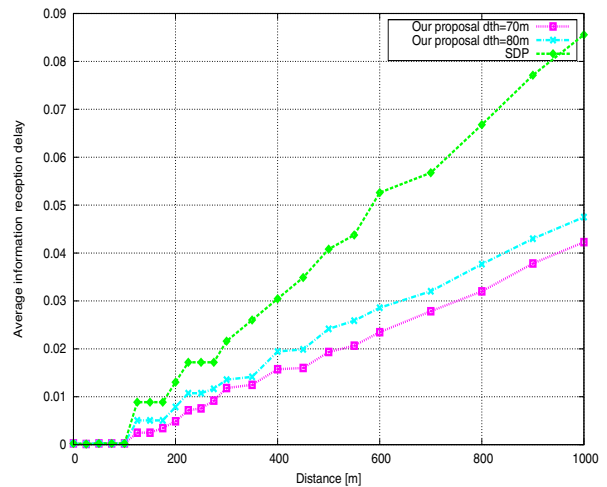


Fig. 6. Average information reception delay vs. distance from the source node in case of 500 nodes in simulation

especially for farther distance. It is observed that d_{th} 70m outperforms 80m. So, we choose this value as the optimal d_{th} in case of the scenario composed of 400 cars.

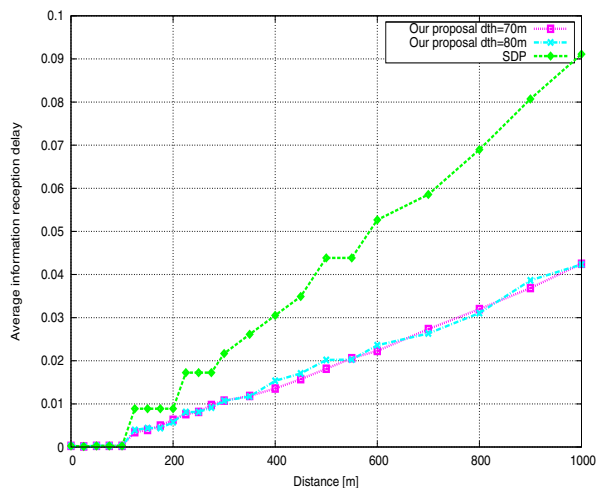


Fig. 5. Average Information reception delay vs. distance from the source node in case of 400 nodes in simulation

- 500 nodes

Figure 6 shows the average information reception delay in high density traffic (500 nodes) regarding the distance from the originator node. We can observe that our proposal outperforms SDP, one more time, in terms of delay. Obviously, the optimal d_{th} that will be selected is 70m since it has the lowest delays. We conclude that the transition from a sparse network to a dense one produce a slight increase in the d_{th} . Nevertheless, this increase is not alarming and it becomes almost constant for a certain number of nodes in simulation. It goes from 60m in case of low density network (50 nodes) to 70m for high density network (upper than 200 nodes).

3) *Redundancy factor*: Table II illustrates Redundancy factor for the proposed scheme and SDP in case of high and

low density traffic. We can deduce that our proposal performs better than SDP in case of high density scenarios. Only 113 vehicles rebroadcast the emergency message over 900 vehicles resulting in a redundancy factor of 0.12. However, in case of SDP the Redundancy factor reaches 0.31. When the traffic simulation size is small, then network may sometimes disconnect which results in higher redundancy factor than when network size gets large.

	SDP	Our proposal
Redundancy factor (100 nodes)	0.2	0.22
Redundancy factor (700 nodes)	0.18	0.12
Redundancy factor (900 nodes)	0.31	0.12

TABLE II
REDUNDANCY FACTOR FOR LOW AND HIGH TRAFFIC DENSITY

V. CONCLUSION

In this paper, we have proposed a new distance-based broadcast protocol to deliver emergency information to nodes at a specific area when an emergency event occurs. Our protocol is mainly based on a contention scheme and depends basically on one parameter. The obtained simulation results reveal that our proposal achieves its design goal of delivering information within a geographical area in a rapid and efficient manner as compared to SDP scheme. Our proposal performs better in terms of information reception delay and redundancy factor. Moreover, we conclude that the distance threshold increases slightly with the augmentation of network density. In our experiments, we have only explored the effects of a few parameters such as distance and number of nodes on the network performance. We plan to use more evaluation parameters to better assess our proposed broadcast protocol. Further study should be devoted to investigate the optimal distance threshold for our scheme. We propose, moreover, to adjust the distance threshold according to the network density. We plan to determine the network density using the

periodic information exchanged between vehicles by the mean of beacons. Besides, we aim to control the transmission power of emergency messages and beacons in order to leave more bandwidth to the emergency messages and to give better performance for the whole communication system.

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