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# Directed data dissemination to optimize packet delivery rate, delay, and overhead in vehicular ad-hoc networks

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ABSTRACT

The enhancement of security inroads is an issue that has attracted the attention of many researchers and many studies have investigated this issue. One of the ways of avoiding accidents is to use health-related applications that use wireless networks to maintain communications. Vehicular ad-hoc networks (VANETs) is a domain of research in wireless networks. In this paper, the method of directed data dissemination was proposed for VANETs. The introduced method can be used by some health-related applications. This protocol can diffuse the intended data in the specified direction on the road. It can provide useful information for the vehicles, i.e. vehicles at the back of the road which are moving in a specific direction. The introduced algorithm tried to select the vehicle farthest from the source node in the data dissemination direction. In this study, an attempt was made to a base simulation of the proposed method on reality. The results of the simulation indicated that the proposed method, when compared with other methods, diffuses the data with a better packet delivery rate, lower delay and less network overload.



## 1. Introduction

Vehicular ad-hoc networks (VANETs) are regarded as systems that were produced based on collaboration among vehicles for the management and health of the transportation system. In line with this purpose, this system was based on vehicle to vehicle (V2V) communication and V2I infrastructure to detect danger and communicate information about traffic conditions. Through VANETs, probably, it is possible to maintain flexible communication among vehicles and get information about roads.

Special features and characteristics of VANETs can be utilized to develop fascinating services and applications. However, it is regarded as a challenging endeavor for researchers in this filed. Some of the applications and functions of VANETs include the followings: health-related applications (Ghandour et al., 2014), management of traffic flow (Sánchez-Medina et al., 2009), monitoring road conditions (Li et al., 2008), protecting environment (Noor et al., 2012) and entertainments in motion (Salvo et al., 2012).

In this study, the researcher focused on health-related applications among the above- mentioned applications and diffusing data such as emergency messages when required. The study was aimed at achieving the following objectives:

- Maximizing the number of vehicles receiving a data packet in the specified road, i.e. an optimal data delivery rate
- Reducing end-to-end delay
- Diminishing the overhead imposed on the network while maintaining the highest coverage for diffusing data.

An acceptable data dissemination protocol should meet the characteristics of the network within which it operates. Hence, the features and characteristics of V2V networks should be first described. It is assumed that the respective vehicles within this system should be equipped with processing and communicating tools and device, namely a GPS which enables the vehicle to locate and trace the route geographically, geographic map, sensors which detect certain events, etc. indeed, it should be highlighted that the capability of diffusing and broadcasting multi-hop data is one of the chief advantages of VANETs. Diffusing and broadcasting multi-hop data can help the development of security, urgent warning messages, exchanging queries, relaying internet data, etc. Hence, the flow of multi-hop data in VANETs can result in a wide range of applications which can significantly impact on the technology of data diffusing. The majority of routing and diffusing protocols that are designed for VANETs make use of location-based techniques. These techniques need information about the location of the node for selecting the forwarding node. Thus, for obtaining this information, the vehicle should use the tool of GPS. For detecting and identifying adjacent vehicles, vehicles exchange beacon messages periodically.

## 2. Data dissemination in VANETs

Data dissemination in VANETs can be categorized into two modes: Vehicle-to-Infrastructure (V2I) and vehicle to vehicle (V2V). In V2I, vehicles are required to use the infrastructures embedded on roadsides to diffuse data. In this mode, two types of data dissemination can occur (Villas et al., 2014). In the first type, the infrastructure can transmit data such as accidents to all the available vehicles within the radio range. In the second type, the vehicle can demand specific data such as traffic conditions from the infrastructure.

Regarding V2V mode of data dissemination, vehicles communicate with each other on an ad- hoc basis. As a case in point, in the flooding method, vehicles diffuse a message to all the adjacent vehicles. Then, upon receiving the message, the vehicles store and forward it. In general, this method is more appropriate for heterogeneous networks and applications which need less

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delay. However, it should be noted that this method produces more traffic and results in the problem of the broadcast storm.

In contrast with the above-mentioned method, in the relaying method, data are broadcast to the adjacent vehicles. Receiving the data, the adjacent vehicles store them. Then, one of the adjacent vehicles is selected based on specific conditions to broadcast data to the adjacent vehicles. This method is useful for networks with high vehicle density. However, it should be noted that for achieving high efficiency in this method, an appropriate algorithm should be designed. Finally, in an opportunistic algorithm, data are stored in each of the intermediate nodes and as they encounter a new node, they forward data to it so that it can reach the destination. This method is suitable for scenarios with irregular node density.

Algorithms mentioned above deal with certain challenges such as broadcast storm problem, network partition, and temporal network fragmentation. Some methods use the forwarding mechanism in broadcasting vehicle data. Consequently, the network will be full of redundant data. Hence, due to the difference among nodes, it will result in a collision. This problem is referred to as a broadcast storm (Tseng et al., 2002) which leads to high data traffic, high network density and high packet collision. Furthermore, more service interruptions and delays will be created in the MAC layer. This problem occurs more in data broadcasting protocols based on the flooding method.

Another issue regarding data dissemination is related to the network. In other words, the problem will occur when the number of vehicles in the respective region for broadcasting data within a group is not enough. Indeed, there is a distance between groups of cars on the road. Hence, the broadcast data cannot be transmitted from one group to the other (Villas et al., 2013). This is a problem is common in VANETs which is attributed to the inappropriate distribution of cars along the roads. Accordingly, this issue imposes serious challenges for data dissemination in VANRTs. For a better understanding of this problem which is related to a component of the vehicular network, assume a section of the road indicated by red color illustrated in Fig. 1. The time an accident occurs, the network cannot deliver the accident warning message to the cars which are in the respective area. Hence, it should be highlighted that the capability of diffusing and broadcasting a warning message towards different parts of a network with a little delay and overhead is considered to be a significant research issue that should be addressed by researchers in this field. For solving this problem, vehicles moving in different directions can be used for storing, retransmitting and delivering messages throughout different parts of the network.

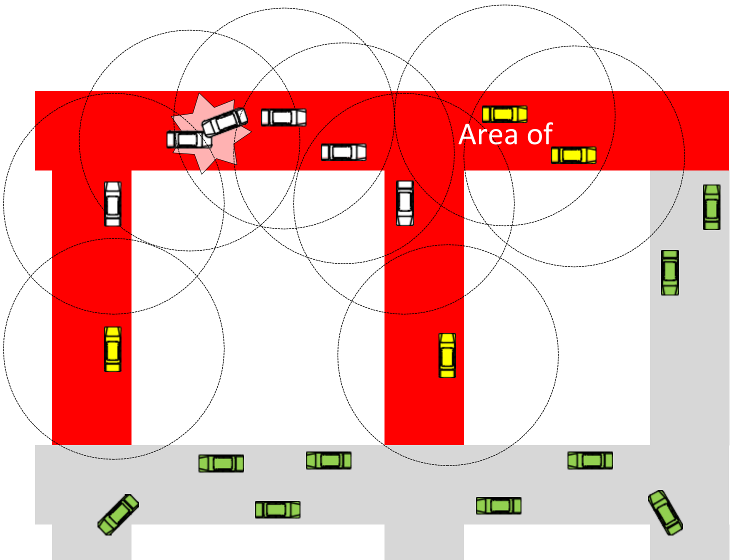


**Fig. 1.** One component of a given VANET.

In the transitory breaking of the network into parts or chunks, chunks or components are transitory and short-term. This issue is produced due to the high movements of vehicles, loss and collision of messages. Fig. 2 depicts the transitory chunking of the network. At first, Vehicle (Ve) detects and identifies the urgent incident at time t (Fig. 2a). With respect to the characteristics of the occurred event, certain data about the happened event are broadcast to the vehicles in the respective area. Hence, the message is directly transmitted to the v1 and v2 vehicles which are located within the transmission range of the Ve vehicle. However, it should be noted that this message cannot be transmitted to the V3 and V4 vehicles. The conditions might change as the vehicles move. Fig. 2b demonstrates the next moment, namely t+1. At the t+1 moment, the v2 vehicle gets out of the transmission range of the Ve vehicle and V4 gets into the transmission range of Ve. Although v3 is not within the transmission range of Ve, it can receive urgent data through v1. One possible way for sorting out this issue is to use vehicles that are not within the respective area (such as v5 and v6) but they can be used for transmitting and delivering urgent data. Nevertheless, it should be noted that identifying and keeping these substitute routes can result in the issue of a broadcasting flood.

## 3. Review of related works

In the literature on VANETs, different protocols have been designed for broadcasting messages under different traffic conditions. With regard to dense and compact conditions, certain techniques have been introduced for handling the flooding issue. Indeed, the solution to this problem is to find the minimum number of nodes that can transmit and deliver the broadcast message to the other nodes available in the network. That is, in case only the nodes within this set broadcast the message, redundancy will be minimized. Regarding mobile ad-hoc networks (MANETs), numerous solutions have been proposed for sorting out the flooding issue. However, it should be noted that the solution put forth for MANETs might not be appropriate for VANETs due to the following reasons; firstly, the movements of nodes within a VANET are based on road patterns that simplify the node which should broadcast the message. Secondly, the speed of nodes within VANETs is much higher than those in a MANET. In contrast with the state of art in MANETs, fewer techniques have been proposed for solving this issue in VANETs. Three broadcasting techniques for the network layer were introduced by Wisitpongphan et al. (2007). Among these techniques, the technique of Slotted 1-Persistence managed to achieve higher efficiency by reducing the number of redundant broadcasts as well as diminishing end-to-end delay and enhancing message delivery rate. This method is based on time; hence, it is non-probabilistic. Since the number of time slots is fixed, earlier time slots were allocated for vehicles that are farther from the source vehicle in the message direction for rebroadcasting message. Vehicles for which different time slots have been allocated will stop their transmission as they received the repeated message. In this way, the message will be diffused and all the repeated messages will be suppressed and eliminated. However, it should be noted that the Slotted 1-Persistence technique has a consistency problem (Blum and Eskandarian, 2009). This problem occurs when a one-time slot is allocated too many vehicles where they start transmitting the message at the same time. Hence, due to lots of collisions, this issue worsens the rate of message delivery.

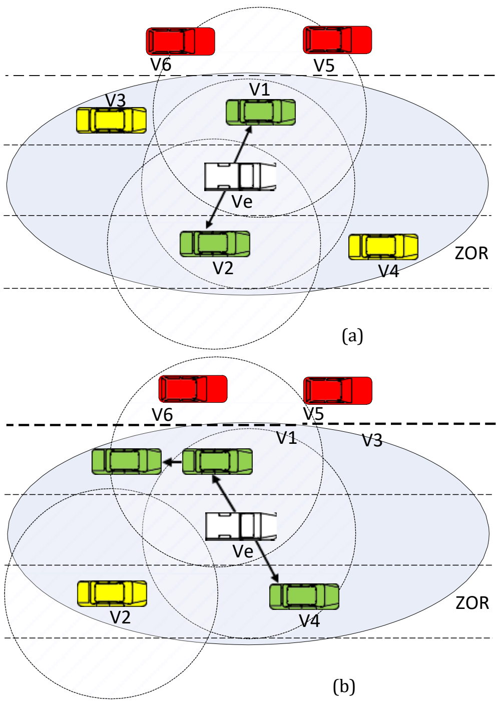


**Fig. 2.** Transitory breaking of the network into chunks.

Research studies have been conducted on vehicles moving in the opposite direction which can be used to aid message broadcasting in heterogeneous networks (Nadeem et al., 2006; Little TD and Agarwal, 2005; Yu and Heijenk, 2008). Three scenarios were taken into consideration by Nadeem et al. (2006). The vehicle moves in the same direction, the opposite direction of the message production creation or both of them. The results of the simulation carried out by Little TD and Agarwal (2005) indicated that using vehicles that are moving in the opposite direction of the message can enhance the efficiency of message broadcasting in different scenarios. The message dissemination protocol introduced by Yu and Heijenk (2008) allows for the directed dissemination of messages from the source. This protocol needs cluster creation and cluster amendment mechanism and distinguishes inter-cluster communication from intra-cluster movement. Persistent and sustainable Geocast discussed by Yu and Heijenk (2008) broadcasts crash or congestion data to all the vehicles passing through the warning area at the time span the event occurs.

Epidemic routing makes use of flooding method for broadcasting data in the network (Vahdat and Becker, 2010). In this method, as the nodes identify a new neighbor, they get to communicate data with them. To the best of the researchers' knowledge, only the following three methods have made use of store- carry-forward mechanism for broadcasting data in VANETs: distributed vehicular broadcast (DV-CAST) (Tonguz et al., 2010), the acknowledged parameterless broadcast in static to highly mobile (ack- PBSM) (Ros et al., 2009) and directed data dissemination for vehicular areas (Schwartz et al., 2011).

Tonguz et al. (2010) introduced a protocol for broadcasting in VANETs. The purpose of DV- CAST protocol was adjusting itself with different traffic conditions i.e. light traffic, intermediate traffic and dense traffic. Also, this protocol was intended to produce little overhead when the traffic is heavy. Furthermore, it was designed to handle connection gaps in the case of light and low-density traffic. DV-CAST depends upon the periodical exchange of hello messages among all vehicles which maintain communication. IF the vehicles are not perfectly consistent with one another, particularly in dense and dynamic networks, the hello message will result in the increase of collision and argument. Consequently, it will lead to a waste of bandwidth. All the vehicles which are located within the vehicle range function as supporting vehicles at the end of the cluster. Accordingly, they can lead to the enhancement of consistency and consolidation. Furthermore, based on the arguments given by Ros et al. (2009), the DV-CAST protocol has lower reliability.

Ack-PBSM protocol makes use of connected dominating sets (CDS) for broadcasting (Ros et al., 2009). Like DV-CAST, ack-PBSM depends on the periodical exchange of hello messages for collecting one-ho data. The acknowledgment data in this message were used to enhance the message delivery rate and reduce redundancy. This protocol was designed to operate in both scenarios of civil roads and highways.

A directed data dissemination protocol was introduced by Schwartz et al. (2011) which necessitates the periodical exchange of messages. It also uses a technique for preventing the issue of broadcast flooding and reducing the number of broadcasts. Furthermore, this protocol does not depend on a vehicle while bridging radio gaps. In this protocol, each vehicle needs to know whether it is located along the movement direction of the message or not. All the vehicles located within the radio range of the ending vehicle function as support vehicles.

In the present study, it has been argued that the majority of vehicular scenarios based on directed broadcasting are appropriate and rational. As a case in point, if a collision occurs on one direction of a two-way highway, this information is transmitted only to the vehicles which are moving in the same direction but they have not reached that spot yet. Indeed, this information is related to them. However, this information is not related to the vehicles which have passed that place or moving in the opposite direction.

For handling the issue of broadcast flooding and ascertaining that a message is delivered, contention-based forwarding (CBF) is one of the introduced methods for broadcasting in MANETs. Indeed, it is a geocast mechanism that makes a balance between reliable data transmission and delay. In the CBF-based method, each vehicle receiving a broadcast message sets a wait time. Wait time is conversely related to the distance between the sender and the receiver. The receiver transmits the message when the wait time expires. Moreover, in case the receiver gets a similar message from another sender, it will stop the forward operation. Consequently, the farthest vehicle within the transmission range can rebroadcast the message. Through repeating broadcast, messages will be broadcast to all the vehicles located within the destination area.

One more protocol based on a discussion that has been proposed for VANETs is TOPOCBF (Rondinone and Gozalvez, 2013). This protocol measures its route based on multi-hop connection and selects it by means of the DiRCoD technique (Rondinone and Gozálvez, 2010).

## 4. Directed data dissemination in VANETs

The purpose of this study was to propose a data dissemination protocol which would be appropriate for some health-related applications and meet the special needs of these protocols such as high packet delivery rate, little overhead, and delay. Also, an attempt was made in this study to solve the broadcast flooding and enhance the capability of a broadcasting message along with the components and chunks of the network.

In some applications, a vehicle might want to transmit data to all the vehicles in the back of the road, i.e. vehicles that have not arrived at a certain position of the road. For instance, the main reason for the chain accidents on a highway is that one accident happens after another and continuous so on. If the vehicles in the back are informed of the accident immediately after the accident, the chain accidents will be prevented. Moreover, in some cases, a vehicle might inform the vehicles ahead of an event, namely vehicles which have passed a specific position. For example, rescue vehicles such as ambulances should request the cars ahead to open the way for them so that they can reach their destination as fast as possible. Also, sometimes, a vehicle might transmit data to all the available vehicles on the road. In this study, the researcher made an attempt to design a data dissemination protocol that would take all the different modes into consideration.

### 4.1. Assumptions

The objective of this study was to diffuse and broadcast data on civil and intercity roads. It was assumed that the maximum speed of the vehicles moving on the road was 120 km/h. Also, it was assumed that all the vehicles were equipped with GPS and a digital map which can determine their locations at any given moment. Furthermore, in the digital map, all the roads were numbered according to the position and the movement direction of the vehicles. All the roads and streets had a unique identity. In this study, it was assumed that all the vehicles are equipped with a radio which functions according to the IEEE 802.11p standard. Moreover, all the vehicles have processing tools which can process given data at any moment.

## 5. The performance of the proposed protocol

The rationale behind the proposed vehicle was to eliminate the issue of broadcast flooding and select a vehicle among neighboring vehicles, i.e. vehicle which is within the radio range of the message forwarding node. The efficiency of forwarding a message is measured in terms of minimum delay and high coverage. For selecting the node to forward messages, neighboring nodes should cooperate with each other.

The performance of the protocol proposed in this paper can be classified into three main parts: at first, the vehicle transmits a message to all the available vehicles within its own range (neighboring nodes). Then, the vehicles receiving a message compete with each other for forwarding a message. In this stage, each node decides how much it is ready and appropriate for a forwarding message. Finally, the vehicle winning the competition stops the forwarding operation of other vehicles and introduces itself as the next message forwarding vehicle. In the following section, a detailed account of the performance and operation of the proposed vehicle on diffusing and broadcasting data in VANETs is given. Then, the method of how the vehicles compete with each other using the timer is described.

### 5.1. Timer-based competition

Selecting one node within a set of nodes is considered as one of the widespread problems in major sections of computer networks. In local wired or wireless networks such as IEEE 802.11, this issue is referred to as medium access control and different algorithms have been proposed for it. The followings are some of the methods which are commonly used:

- Frequency division multiple access (FDMA)
- Time-division multiple access (TDMA)
- Code division multiple access (CDMA)
- Space division multiple access (SDMA)

The method used in this study for selecting the node was based on the concept of time (time- based competition). The time-based competition operates in this way that it sets each timer node with a random value. The first node whose timer expires is announced as the responsible node and the timers of other nodes are canceled and responsibility will be taken from them.

A significant problem that might occur when this algorithm is used is that more than one node might react to it even though a good suppression algorithm is used. This situation might happen when the expiration time of more than one node is the same. Hence, the selection range of the expiration time should increase as the number of nodes participating in a competition increase. AS a result, the probability of having more than one node with the same expiration time decreases. Nonnenmacher and Biersack (1999) found that the exponential distribution of the random timer can reduce the number of simultaneous responses more significantly than a timer with a uniform distribution. The algorithm proposed in this paper used a timer-based mechanism for selecting the next message forwarding node. In this algorithm, all the nodes receiving message check whether they are located on the route for transmitting a message on the respective road or not. In case the answer is positive, they consider their distance from the transmitter. Ultimately, the algorithm will set a timer for starting the competition. The value of the timer is a function of its distance from the transmitting node. The node starting the transmission earlier will be selected for the next stage.

If the value of the timer is selected randomly, the problem which will result from it is that all the nodes, i.e. both the node closer to the message transmitter and node farther from the transmitter will have an equal chance for being selected as the next message forwarding node. Nevertheless, it should be noted that our objective was to select a node that would be farther from the transmitter in the message direction. For solving this problem, the researcher considered the distance of the node from the message transmitter as one another factor for determining wait time. That is to say, wait time is conversely related to the distance of the message received from the transmitter. In other words, it can be argued that the receiver which is farther from the message transmitter has more chance for being selected as the next message forwarding node. In such a condition, the number of hops for diffusing message will decrease.

In this study, the researcher layered the radio transmission range of vehicles. Then, the layer in which the receiving node is located will be identified. Each layer has its own wait time and the vehicles located within the same layer will have different random wait times. This is done so that the probability of simultaneous transmission for the vehicles having the same distance from the transmitter (within the same layer) is highly reduced. L stands for the length of each layer which is obtained through equation ($L=R_{radio}/c$), where R radio denotes nominal radio transmission range and c refers to the number of layers. The value of c is regarded as one of the factors of the proposed protocol. The value of wait time (t) can be measured through the Eq. 1.

$$t = \left(\left\lfloor \frac{Dist(p,z)}{L} + rand(0,1) \right\rfloor\right) \times \frac{T}{c}, \quad T = T - t \tag{1}$$

where p denotes the position and location of the receiving node, z refers to the position and location of the transmitter, $Dist(p, z)$ stands for the Euclidean distance between p and Z. The function r $rand(0,1)$ produces a random number between zero and one and T refers to the highest value of delay for forwarding a message. By doing so, we can ascertain that the node with the most progress will be selected as the next node. Hence, the time of executing the timer depends only on the transmitter's distance which is the same for all the nodes located within the same loop around the destination.

For a better understanding of why we used a random number, assume that the best node has the p1 progress value and at least the node has the p progress value so that $t(p) - t(P_1) < \delta$, where $\delta$ stands for the lowest time span required for suppressing and the repeated packet will be produced while forwarding data. Moreover, as depicted in Fig. 3, all the nodes with the p progress value will be located within the interference range; hence, they cannot be suppressed.

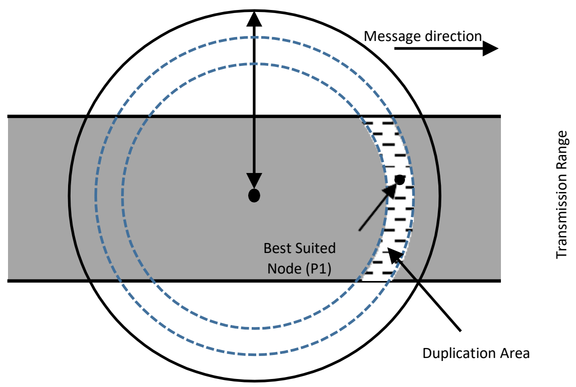


**Fig. 3.** Duplication area.

The repeated packet is one of the cases which was integrated into the MAC layer. In the majority of MAC layer methods such as IEEE802.11, the packets are serialized to avoid repeated packets. In wireless networks based on CSMA/CA, sterilization is not done only in the area of nodes that are located within one another's transmission range. Rather, serialization is usually done based on interference range which is approximately twice as much as the transmission range. Hence, as a result of transmission, all the neighboring nodes of the forwarding node will be serialized. Thus, the distance of two neighboring nodes will exceed the doubled value of the transmission range. If the packets can be removed from the queue of the MAC layer interface, obligatory serialization can be done for eliminating the traces of the repeated packet which was produced with the $\delta$ delay. Firstly, one node will set to forward the packet. As the rest of the nodes hear about the repeated packet in their queue which was forwarded by the others, they will drop it.

## 5.2. Suppression

At first, all the neighboring nodes of the forwarding node adjust their own competition timer based on their distance from the forwarding node. Then, the timer will expire and a suppression algorithm will be required; this algorithm will be used to remove the timers of the other nodes for preventing the repeated packet. In the proposed method, suppression operates in the following way: if the timer of a node expires, the node assumes that it is the next forwarding message; hence, it begins to broadcast messages. In case a node receives this packet while it still has an expired timer that is working for that packet, the timer will be canceled and the node will not forward the message.

Depending on where the first next-hop is located, the rest of the nodes may be outside of its transmission range. Hence, suppression will not be conducted. In the worst case, as shown in Fig. 4, three copies of the packet might be forwarded. In case there are more nodes within the source transmission range, the probability for the presence of one or more repeated packets will increase.

It should be noted that the repeated packet discussed here is different from the repeated packet which was described in the previous section.

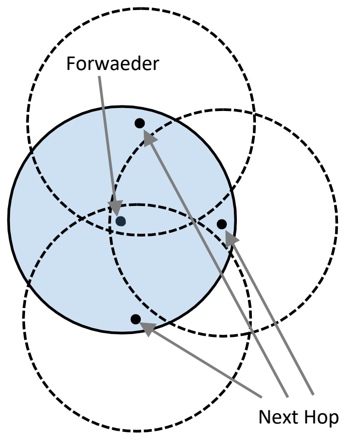


**Fig. 4.** Repeated packet.

One of the suppression algorithms introduced by Füßler et al. (2003) is an area-based suppression algorithm. This method artificially reduces the selection area of the next node; this reduced area is referred to as the suppression area. The main method for selecting the suppression area is that all the nodes inside that area should be within the radio range of one another. One technique is the Reuleaux triangle (Gleiftner and Zeitler, 2000) which better covers the area and has a better forwarding process. Considering the Reuleaux triangle as the suppression area, the suppression algorithm will operate as mentioned below:

- The forwarding node will broadcast the packet.
- The nodes located within the Reuleaux triangle will only participate in the competition process.
- The node whose timer finishes earlier than the other nodes will be regarded as the next hop and it will broadcast the message.

The rest of the nodes will be suppressed. The repeated packet might be produced due to the required time for suppression.

The method used in this study for suppression is the active selection method. This type of suppression uses a technique that is similar to that of the MAC method which was introduced by Karn (1990). IEEE 802.11 was also used in this study. In this method, RTS (Request to send) and CTS (clear to send) packets were used.

This method operates in the following way: at first, the forwarding node is known as RTF (request to forwarding) transmits packets instead of direct broadcasting. RTF packet includes the position and location of the forwarding node, the identity of the respective road and the direction of the data flow. Each of the neighboring nodes uses the RTF (request to forwarding) information packet to check whether they are located in the same direction in which packet is forwarded on the road; if it is so, the timer sets the response based on the main suppression algorithm. In case the timer is finished, the control packet, known as CTF (clear to forwarding), will be transmitted to the forwarding node. The CTF Packet includes the position of the transmitting node. If a node receives the CTF of a packet, it will remove its timer and will be suppressed. The forwarding node might receive several CTF control packets. Then, the forwarding will select one node with the highest progress from among the ones which have transmitted their CTF packets. Next, it will transmit it through unicasting.

One of the advantages of the active method used in this study is that it uses control packets to avoid the problem of the covert terminal. Although several nodes might transmit the CTF packet, an active method prevents all the different modes of the repeated packet. The forwarding node operates as the central power and decides that which node should be selected as the next hop. This task leads to an extra overhead in the form of RTF/CTF control packets.

## 6. Evaluating the efficiency of the proposed method

In this section, the efficiency of the proposed method, i.e. Directed Data Dissemination (DDD) is examined and it is compared with similar other methods. Firstly, the optimization and improvement achieved by means of DDD are compared with those of three well-known methods. The first method was the simple flooding method in which both of the receiving vehicles rebroadcast the message. The second method was the distance-based method in which the farthest receiver is selected as the next message forwarding vehicle. The third method referred to as the link-based method, in which only the vehicle with the highest connection quality is selected as the next message forwarding vehicle regardless of its distance from the message transmitter. In this method, the connection quality of a node is evaluated by the probability of successful transmission. In turn, the value of this probability is measured based on the density of vehicles. That is, the vehicle having the highest number of neighbors will have the least chance for being selected as the next message forwarding vehicle and vice versa. In the simulations carried out in this study, two scenarios of two different road schemes were tested. The maps of the tested roads were extracted by Open Street Map. One included 6 km$^2$ of highways in the city of Dar es Salaam which is illustrated in Fig. 5a. The other one included 2 km$^2$ of the road networks in Manhattan which is depicted in Fig. 5b.

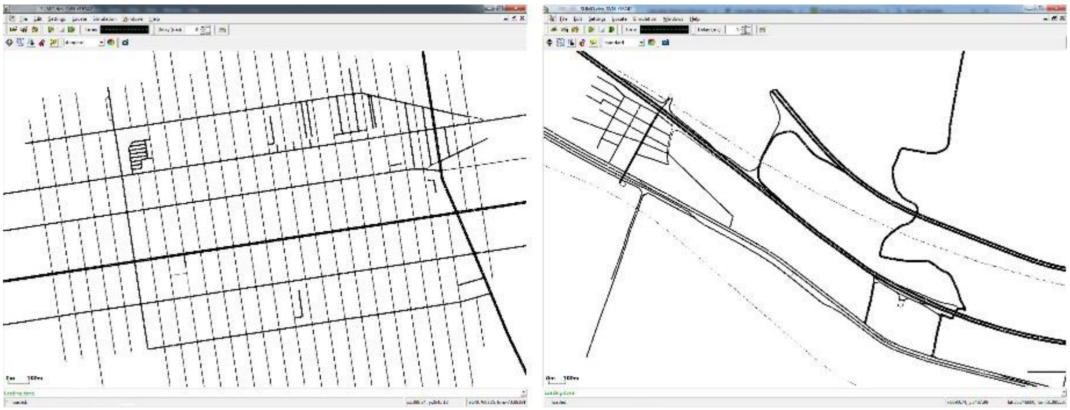

**Fig. 5.** A section of the map of (a) Dar es Salaam, highways of Dar es Salaam (b) Manhattan, New York which has been converted into SUMO format.

### 6.1. Simulation settings

In the simulations conducted in this study, the NS-3 simulator was used to simulate and implement the proposed protocol (DDD) with IEEE 802.11. In this study, an attempt was made to select a more realistic model that would really reflect the communications among the vehicles. Due to shadowing and fading effects in urban areas, radio communications are not practical and simple for modeling.

Since buildings in urban areas are regarded as a barrier for direct diffusing and broadcasting of waves, urban scenarios are different from those of the battlefield. For a better simulation of the proposed method and more real dissemination of data, we cannot ignore the buildings. The corner is considered to be a precise technique for predicting the dissemination and broadcast of ad-hoc networks in urban scenarios it is cost-effective. In this study, an optimized version of Mukunthan et al. (2012) which considers multipath fading as well as shadowing produced by buildings was used. Indeed, the Enhanced Corner was extracted from the simulator OMNet++.Then, it was adapted with the NS-3 simulator used in the present study.

The movement and dynamicity of the vehicles is another significant feature which plays a key role in the overall performance of each protocol or the operation of a VANET. In this study, the SUMO traffic simulator was used to produce traffic requests in the real road network which was extracted from the Open Street Map. Also, HINTS was used in this study. In fact, HINTS is a platform that allows SUMO and NS-3 to be implemented simultaneously and exchange data related to the movement of vehicles. A complete list of the simulation parameters used in the study is given in Table 1. In our simulation, for DDD, the value of c, which was described in section 5.1, was 83.

### 6.2. Packet delivery rate (PDR)

For investigating and acknowledging the efficiency of the proposed DDD method, the researcher used a number of parameters. These parameters were also used for comparing the proposed method with three other protocols described above, namely flooding method, distance-based method and link-based method. The evaluation parameters included the following: (1) packet delivery rate (PDR), (2) delay, (3) communication overhead. The simulation was conducted for 1200 times under different vehicle densities which ranged from 75 vehicles to 375 vehicles within each square kilometer. As depicted in Fig. 6, PDR is measured by obtaining the proportion between the number of transmitted packets and the number of received packets.

**Table 1**
Simulation parameters.

| | | |
|---|---|---|
| Physical layer | Frequency band | 5.9 GHz |
| | Bandwith | 10 Mhz |
| | Transmission range | 260 m |
| | Transmission power | 50 mW |
| Link layer | Bit rate | 6 Mbits/s |
| | CW | [15, 1023] |
| | Time slot | 13 µs |
| Scenario | Roadmaps | Manhattan grid, Dar es Salaam |
| | Roadmap size | 2000 m×2000 m |

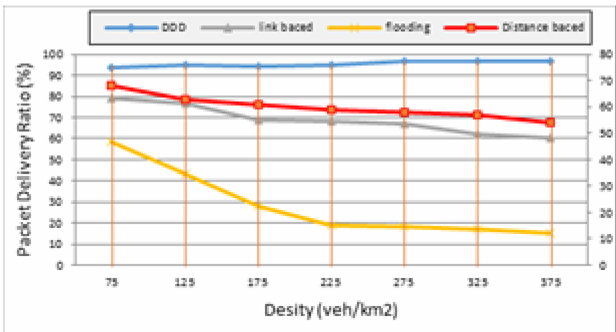


**Fig. 6.** Packet delivery rate (PDR).

In case a packet is delivered to one or more than one neighboring vehicle, other than the transmitting vehicle, it is assumed that the packet is delivered. On the other hand, if none of the neighboring nodes receives an urgent message, it is assumed that the packet has been lost. It can be maintained that, at the density of 75 vehicles in each km$^2$, 96% of the transmissions carried out by the proposed method were successful. However, comparatively, the values obtained for the link-based, distance-based and flooding methods were 80%, 70% and 60%. Indeed, according to the simulation results, it was found the link-based method was slightly better than the distance-based method. Furthermore, it was observed that PDR decreases as the density of vehicles increases in the three above-mentioned methods. Nevertheless, it was not the case with the proposed method. That is to say, the value for PDR in the proposed method was fixed within the range from 96% to 98%. At the density of 225 vehicles, PDR for the flooding method was fixed and invariable due to the high number of unsuccessful transmissions. Indeed, at very high densities of vehicles, the number of collisions increases exponentially.

### 6.3. Delay

In general, end-to-end delay, measured in ms, refers to the amount of time needed for transmitting a packet from the source and going through the network so that it is delivered to the ultimate receiver. In the proposed DDD method, there is no pre-specified destination; rather, we tried to transmit and deliver urgent messages to all the available vehicles on the road in a particular direction of the road. Accordingly, in this study, the delay was operationalized as the average time distance during which a packet is transmitted and delivered to all the available vehicles in a specific direction of the road. That is, the delay was measured as the total delays in all the vehicles receiving the message divided by the number of receptions. Fig. 7 depicts the results of the average delays of the total delays in the simulation. Although the distance-based method was designed to optimize packet progress towards the destination, the method proposed in this study also had acceptable performance. At the density of 75 vehicles, the proposed method had a 2 ms time difference while the density of vehicles was 375, it became 12 ms. The value of this parameter for the flooding method at the density of 225 vehicles was reduced to one km$^2$ and it was fixed; it is attributed to the reason mentioned earlier in section 6.2. Hence, the packets go through little distance from the source towards the destination which is attributed to the high rate of packet loss. On the other hand, a link-based method has the worst performance in this regarded when it is compared with the distance-based method and the proposed method. The poor performance of the link-based method is mainly due to the higher number of intermediate vehicles for the packets which increase the number of hops.

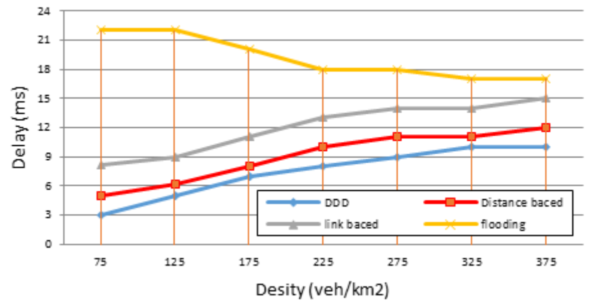


**Fig. 7.** End-to-end delay in the proposed and three comparative methods.

### 6.4. Overhead

Overhead refers to the degree of data measured in terms of the byte which is added to the network for an end-to-end delay. The rationale behind using this criterion is to measure the degree of produced information by an urgent method which has been broadcast in the network. The value is obtained by measuring the average overhead throughout the whole simulation. Fig. 8 shows the values of the average overheads for the proposed method and the three other methods which were simulated in the study. As depicted in this figure, the proposed method (DDD) and the distance-based methods approximately produced the same overheads for the range of vehicle densities from 75 to 275 vehicles in each km$^2$. The overhead difference between the two methods significantly increases when the vehicle density exceeds 275. In other words, it should be noted that the value of overhead for the proposed method remains approximately constant when the vehicle density goes beyond 275. Indeed, the invariability of overhead for the proposed method beyond the above-mentioned vehicle density is due to the fact that beyond a particular density in the proposed method, many retransmissions for sending a message to all the vehicles are not needed. That is, in each retransmission, data is delivered to so many vehicles. The link-based method produces more overhead than the distance-based method does. However, it should be pointed out that as the vehicle density decreases, the overhead difference between them decreases and it becomes less significant. In fact, packets in the majority of productive intermediate vehicles do not need hop. Hence, the number of messages in the network will increase.

In this study, an attempt was made to enhance the accuracy and precision of the transmissions so as to reduce overhead. Regarding the simple flooding method, due to the high number of collisions at the high vehicle densities, the overhead remains constant and invariable beyond the density of 125 vehicles in each km$^2$. In other words, from the density of 125 vehicles and beyond it, channel density reaches the full capacity. Consequently, each urgent message transmission collides with the transmissions of the neighboring vehicles.

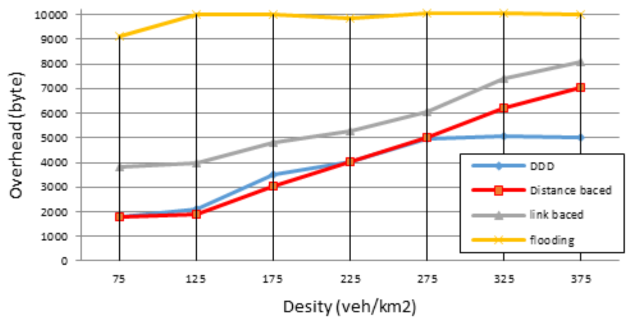


**Fig. 8.** Overhead in the proposed and three comparative methods.

## 7. Conclusion

In this paper, Directed Data Dissemination (DDD) was proposed. It was a protocol for diffusing directed data which was used for broadcasting data on a two-way road to diffuse data to the vehicles which at the behind or ahead. In this study, the widespread problems relating to the design of these protocols were investigated and discussed, i.e. broadcast flooding, components and parts of networks and transitory breaking of the network into pieces. Hence, the researcher tried to take these issues into consideration in the proposed method. In this protocol, we discussed the next forwarding vehicle or node; the objective was to select the farthest vehicle from the transmitting node at the message directly on the road so as to reduce the number of dissemination hops. Furthermore, a suppression algorithm adapted from MACA was used in the present study to prevent rebroadcasting.

In designing the proposed protocol, the researcher considered the parameters of PDR (packet delivery rate), delay and overhead into consideration. I the conducted simulations, the proposed method was implemented, analyzed and compared with three other methods, namely, flooding method, distance-based method, and link-based method. The results of the simulation indicated that the proposed protocol was better than the three other methods in terms of the three parameters of PDR, delay and overhead.

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