Automatika

Journal for Control, Measurement, Electronics, Computing and Communications

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/taut20

Adaptive scheduled partitioning technique for reliable emergency message broadcasting in VANET for intelligent transportation systems

M. Ramya Devi, I. Jasmine Selvakumari Jeya & S. Lokesh

To cite this article: M. Ramya Devi, I. Jasmine Selvakumari Jeya & S. Lokesh (2023) Adaptive scheduled partitioning technique for reliable emergency message broadcasting in VANET for intelligent transportation systems, Automatika, 64:2, 341-354, DOI: 10.1080/00051144.2022.2140392

To link to this article: https://doi.org/10.1080/00051144.2022.2140392

AUTOMATIKA
2023, VOL. 64, NO. 2, 341–354
https://doi.org/10.1080/00051144.2022.2140392

Taylor & Francis
Taylor & Francis Group

REGULAR PAPER

OPEN ACCESS Check for updates

Adaptive scheduled partitioning technique for reliable emergency message broadcasting in VANET for intelligent transportation systems

M. Ramya Devi [a], I. Jasmine Selvakumari Jeya [b] and S. Lokesh [c]

[a]Department of Computer Science and Engineering, Hindusthan College of Engineering and Technology, Coimbatore, TN, India;
[b]Department of Computer Science and Engineering, Hindusthan College of Engineering and Technology, Coimbatore, TN, India;
[c]Department of Computer Science and Engineering, PSG Institute of Technology and Applied Research, Coimbatore, TN, India

ABSTRACT

This paper aims to enable accurate and reliable emergency message broadcast in Vehicular Ad hoc Network (VANET). The VANET is the most common topology used in Intelligent Transportation Systems (ITS), where changes in standard topology due to the mobility of nodes create challenges in broadcasting the emergency message and efficient data delivery in both highway and urban scenarios. The main problems in urban scenarios are channel contention, message redundancy and road structure. To obtain information, broadcast protocols for VANET typically use beacon messages, which are distributed among the vehicles. When multiple vehicles transmit messages at the same time, a broadcast storm occurs and vehicles experience message delivery failure. To address this problem, Adaptive Scheduled Partitioning and Broadcasting Technique (ASPBT) for emergency message broadcast and beacon retransmissions for message reliability were proposed. This protocol dynamically modifies several partitions and beacon periodicity to reduce the number of retransmissions. Later, the partition size is determined by estimating the network transmission density of each partition schedule via the Black Widow Optimization (BWO) algorithm is proposed. The simulation is carried out with different network densities at the vehicle speed of 110 km/h, a direct path length of 12 km under a four-way direction path and performance analysis was performed.

ARTICLE HISTORY
Received 17 May 2022
Accepted 20 October 2022

KEYWORDS
Vehicular ad hoc network (VANET); broadcasting messages; beacon; black widow optimization; adaptive scheduled partitioning and broadcasting technique

1. Introduction

One of the most significant impacts of today's technological advancements is on communications, which has undergone significant change due to advancements in wireless technology that have helped reduce traffic accidents to some extent [1]. This is the context in which our work is situated. This technology, which allows vehicles to establish direct (or indirect) links among themselves so that they can be responsive to potentially critical situations such as imminent accidents or dangerous obstacles [2], will be used by investigators to solve the vehicle crash problem. VANET is referred to as "activation technology". Using such networks, vehicles can be fitted with sensors that can monitor their immediate surroundings and alert the driver if there is a risk of an accident. A vehicular ad hoc network system that improves road safety and other efficiency parameters in modern transportation systems [3]. In this technology, cars are used as nodes in a network to create a mobile network, the distance between cars is typically between 100 and 300 metres, and only those vehicles are permitted to connect. Vehicles that broadcast messages in an open-access environment raise several serious security concerns and mishandling of this information can lead to several serious issues, including traffic accidents and other traffic problems [4]. As a result, vehicle authentication is required to improve network security. During vehicle authentication, confidentiality-related data, such as user identity and location information, must be kept private. There are many kinds of authentication schemes, and each one protects the privacy of vehicle data in a different way. Two methods of comfort communication can be used with VANET: Periodic Safety Message (referred to as a beacon in the sequel) and Event-driven Message (referred to as Emergency Message). One control channel is shared by two different message types [5]. Beacon messages contain information about the sending vehicle's status. The sender's location, speed, direction and so on can be determined using status information [6]. The beacons forward or update information from the sending vehicle to the entire vehicle grant network, allowing the current network status to be known and vehicle movement to be predicted [7]. Because such messages are so important, it is critical that they reach the greatest number of vehicles with the least amount of delay. This emergency message is broadcast; all vehicles within the sender's coverage area must receive messages [8].

Data transmission reliability is critical in high-density networks. In an open-access environment,

CONTACT M. Ramya Devi ramyamurugadasan@gmail.com

This article has been corrected with minor changes. These changes do not impact the academic content of the article.

VANET tiles information related to safety, infotainment and multimedia data [9]. A malicious vehicle may disrupt a network, and malfunction during data transmission may occur, resulting in serious traffic accidents [10]. Transmission in VANET may be completely devoid of road side units (RSU), implying that direct communication between vehicles is possible. The mobility of vehicles is important in broadcasting. Each vehicle travels at its own speed [11]. A variable range of mobility guides vehicles with a lower percentage of receiving critical information. To resolve an issue, an effective retransmission strategy is required. It finds a vehicle that is missing an emergency message and requests that it be retransmitted [12]. If necessary, a message would be redirected to avoid redundancy and improve channel operation. Following the initial transmission, the entire vehicle did not receive emergency messages within the transmission range due to poor link quality and packet collision [13].

This research specifically addresses the following issues with message prioritization technique, handling network density partition size and enabling accurate & reliable emergency message broadcast mechanisms. The background and related works of these issues are discussed in the next section.

2. Background and related works

Numerous research studies with a focus on broadcasting have previously been conducted, a brief analysis of some of them is presented here. Y. Bi et al. [14] introduced Urban Multi-Hop Broadcast Protocol (UMBP) for broadcasting emergency messages in this paper. For reducing the delay in transmitting emergency messages and decrease message redundancy, UMBP has a new forwarding node selection method, which uses repetitive partitioning, mini-slot and black-burst to rapidly choose remote neighbour nodes, asynchronous successfully chose a unique forwarding node contention between them. Then two-way broadcast, multi-directional and directional broadcasts were intended in terms of the positions of senders of emergency messages. In particular, initial hop, the bidirectional or multidirectional broadcast performs the forwarding node selection method in various directions concurrently, and a unique forwarding node was effectively selected in every direction. After that, the directional broadcast was accepted in every hop of message propagation direction till the emergency message arrives at the intersection area where the multi-directional broadcast was implemented once more, at last allowing the emergency message for covering a target area with no problem. Analysis and simulation outcomes display, which UMBP considerably enhances a multi-hop broadcast performance based on one-hop delay, message propagation speed and message reception rate.

The emergency broadcast strategy was introduced by Y. Hsin et al. [15] in this manuscript, while a car accident happens; the vehicle's sensors notice a crash and directly send emergency messages for informing another nearby vehicle. Additionally, they introduce a method for removing redundant transmissions and guarantee an emergency message may be transmitted correctly. They introduce a stability function for evaluating transponder reliability. Back off the procedure of the established technique allocates adequate waiting times to dissimilar forwarders. The planned method was performed by the NS2 simulator in terms of WAVE/DSRC standards. The simulation outcomes display that the introduced protocol shows exceptional performance based on forwarding counts, packet loss rate and delay time in dissimilar environments. Additionally, its protocol preserves stability in diverse vehicle density scenarios consequently every vehicle gets emergency messages and maintains less latency for ensuring that driver consists of sufficient safety response time for improving traffic safety.

Tian et al. [16] introduced an enhanced position-based protocol for broadcasting emergency messages between large-scale vehicle networks in this manuscript. Particularly, defined using suggested protocol, messages are transmitted next to their Region of Interest (ROI), and retransmission of message is in terms of information included on a message that has arrived. Simulation outcomes show that the suggested protocol may significantly decrease needless rebroadcasts and collisions may be efficiently mitigated.

Shah et al. [17] introduced a data broadcast method that uses a time barrier mechanism for decreasing message overhead that may clutter the network in this paper. The proposed solution depends on a super-node to disseminate the message concept on time. Also, to evade unnecessary transmissions that may cause broadcast storm issues, the time barrier method was modified for dealing with the issue. So, the furthest vehicle rebroadcasts a message that may cover the most distance. So, a message may arrive at the furthest node fewer times, therefore improving coverage and reducing delay. The proposed method was compared with traditional probabilistic methods. An evaluation section displays a reduction in message overhead, transmission delay, enhanced coverage and packet delivery ratio.

Multi-hop broadcast protocols in terms of black bursts were an effective method of broadcasting Emergency Messages (EM) on VANET. Although Clear to Broadcast (CTB) collision would happen, the propagation speed would be reduced. To address this issue, Libing et al. [18] introduced a multi-hop broadcast protocol based on multi-channel and Black-burst in this paper. Vehicles through multiple antennas may transmit and detect black bursts on dissimilar channels at the same time according to multi-channel technology.

Compared to previous black burst-based techniques, Black-burst based and multi-hop broadcast (BMMB) shortens the repetitive procedure for finding an optimal segment. A relief vehicle may be quickly chosen for the optimal collision-free segment of CTB. BMMB allows alternative broadcast techniques, i.e. unidirectional and multi-directional broadcast for straight roads and intersections, correspondingly. A theoretic analysis was carried out on BMMB performance, and the simulation outcomes show that a BMMB carries out best based on average one-hop delay and propagation speed.

C. Lyu et al. [19] introduced a capable broadcast authentication method named Prediction Based Authentication (PBA) not only to defend against computational-depend DoS attacks but also to oppose packet loss caused by high mobility of vehicles in this paper. Unlike the existing authentication methods, PBA was a well-organized and lightweight method, as relied mainly on symmetric cryptography. Moreover, verification delay decreased for a few emergency applications, PBA was intended to take advantage of sending the vehicle's capability for forecasting future beacons in advance. Furthermore, for DoS attacks based on preventing memory, PBA stores abbreviated and re-encrypted Message Authentication Codes (MAC) of signatures devoid of compromising security.

Rajput et al. [20] suggested a method of authentication that preserves privacy at VANET. Its hybrid method combines the helpful aspects of pseudonym-based and group-signature-based approaches for avoiding its own disadvantages. The suggested scheme did not need a vehicle for handling a certificate revocation list, nor does it allow vehicles on any group management. A suggested scheme uses a well-organized and lightweight pseudonym, which is employed not only for message authentication but also as a hatch for giving conditional anonymity. They grant several attack scenarios, which display the resilience of the suggested method to several security and privacy threats. They also give calculation and communication overhead analysis to display the competence of the suggested method. Moreover, they run extensive simulations to grant a brief analysis of network performance. Outcomes display the feasibility of the proposed method based on end-to-end delay and package delivery ratio.

Saeed et al. [21] introduced simple models of single-lane and multi-lane road models for designing effective probabilistic flood methods of VANET in this paper. The proposed analytic framework presents a new and common tool that may cover as count of lanes, vehicle transmission range and density. They obtain dissimilarity equations whose solutions give up the probability that entire vehicles will receive an emergency alerting message as a function of retransmission probability, count of neighbours of every vehicle and broadcast distance. The models were evaluated through simulations that realistically represent traffic and network features were employed as the baseline for designing two information dissemination methods that use probabilistic floods. It was analyzed by simulations and established to obtain important performance development compared with blind flood regarding attained accessibility, end-to-end delay and count of retransmissions, comparable to performance reached with optimal flooding, not through brute force [22–24].

Background and related works indicate that when there are changes in the standard VANET topology on the node mobility poses numerous difficulties for the effective delivery of data in a moving environment. Low latency, high reliability and scalability are issues that emergency message broadcasting faces in urban and highway scenarios. The main problems in urban scenarios are channel contention, message redundancy and road structure. To obtain neighbourhood information, broadcast protocols for VANET typically use beacon messages, which are distributed among the vehicles. When multiple vehicles transmit messages at the same time, a broadcast storm occurs and the vehicles experience message delivery failure. This research specifically addresses issues with message prioritization techniques, handling network density partition size and enabling accurate and reliable emergency message broadcast mechanisms. This research proposes a message prioritization technique that can be used to prioritize emergency messages, common messages and entertainment messages. Initially, all messages are prioritized according to their requirements. Priorities are then assigned to messages based on message priority and dissemination distance to maintain message QoS. In this case, an adaptive scheduled partitioning and broadcasting technique [25] based on the distance of nearby nodes and network density is suggested for recognizing the partition that will transmit the emergency message first. In our proposed method, network density determines partition size, and the transmission plan for each partition is evaluated using the black Widow optimization algorithm [26]. The effectiveness of our investigation work is evaluated by metrics such as success rate, propagation distance, delay, number of beacons, redundancy rate, collision rate and dissemination efficiency.

The organization of this manuscript is depicted as follows. Section 3 portrays an overview of the proposed method with Adaptive Scheduled Partitioning and Broadcasting Technique, Partition Length Estimation and Black Widow Optimization. Section 4 includes the experimental outcomes and section 5 the conclusion and future works.

3. Proposed methodology

The most important improvements in the automotive car industry and among our people centre on information technology and communication. Mobile

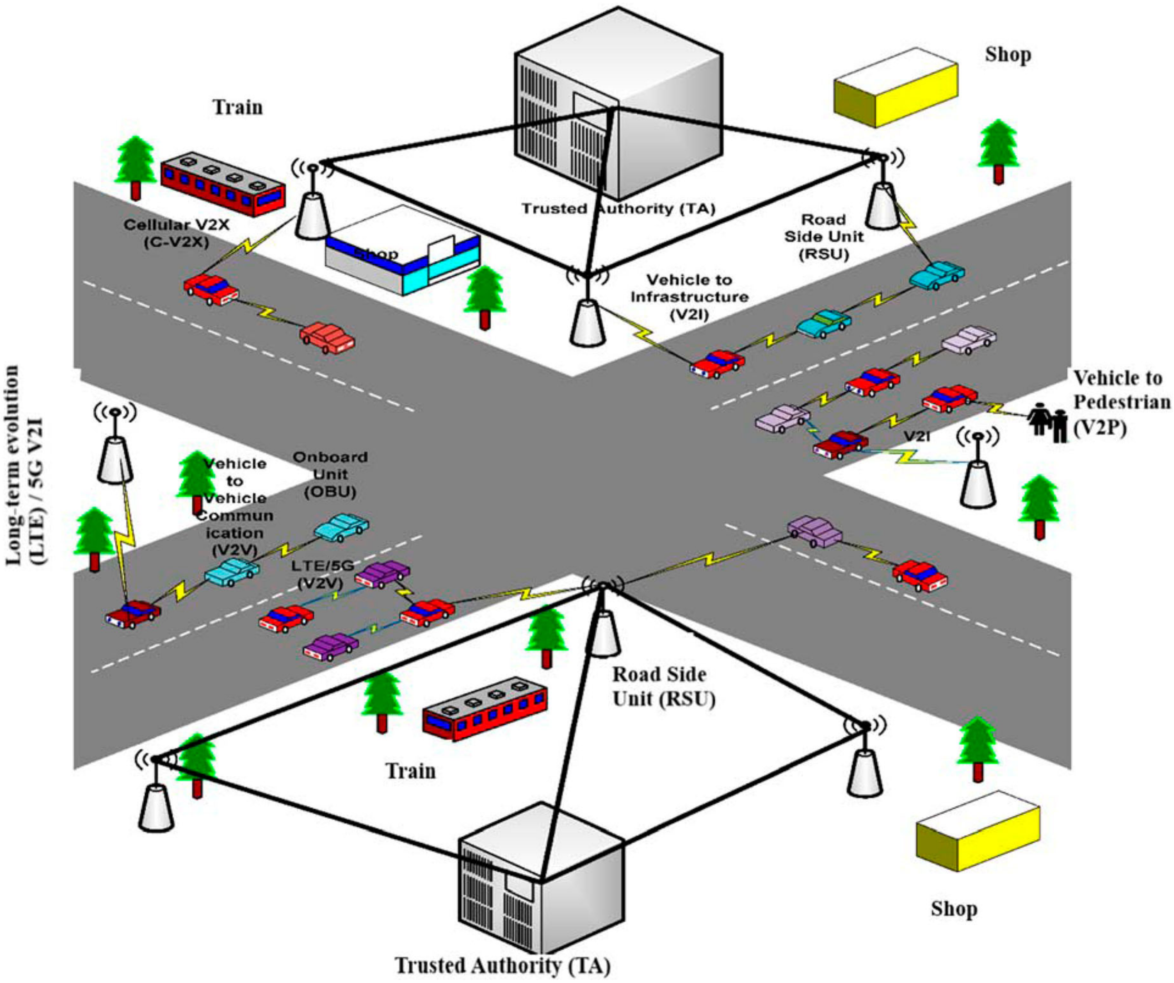

Figure 1. Message broadcast of VANET.

communication has altered our way of life over the last two decades and made data exchange possible. It is made up of the "mobile ad hoc network (MANET)" and "VANET" two different kinds of ad hoc networks in portable exchanges. The proposed method is created as VANET applications because VANET is a remote ad hoc network that is becoming more and more popular. Messages are transmitted from one vehicle to another and the emergency message is transmitted using warning messages. Utilizing the Black Widow optimization algorithm, the density and distance are optimally fixed. This method aims to send messages instantly, resolve issues that were concealed, disconnect the network during storm broadcasting and then send messages in both directional and uni-directional directions depending on the vehicle's density.

3.1. Adaptive scheduled partitioning and broadcasting technique

This technique divides the area in terms of vehicle density and this density is evaluated by beacon messages received from neighbouring vehicles and by transmitting the status. When a vehicle receives an emergency message, it sends a message to nearby nodes. The emergency message is transmitted based on partitions and back-end solutions; the emergency dispatcher assigns priority to each partition, and these priorities can be resolved with the help of the BWOA. It depends on vehicles' waiting times at the furthest vehicle for short waiting time. The timer is minimized on a channel when idle, and the channel is connected with the timer freezes to recombine.

Figure 1 shows the message broadcasting of VANET where the vehicles are communicated to the road side unit (RSU) using the wireless technology known as wireless access in the vehicular environment [26]. This communication will ensure the passengers' safety for the information and traffic flow and the safety of the driver. This will improve the efficiency and traffic flow in the management system. The VANET architecture has OBU (on-board unit), RSU and TA (trusted authority). The RSU is used for communication, OBU is used for collecting information such as acceleration, speed, etc. RSU is a fixed side of the road in the location to provide the connection of vehicles.

This method employs the partition network's density and distance schedules. These select the partition that will generate alert messages. The first partition chooses the contention window, A_u, at random from $A_u = [1,2,\ldots .a_u]$, where a_u represents the size of the contention window. Because it selects the list separately for each partition, the list cannot overlap. The sender area is divided into many static or dynamic partitions

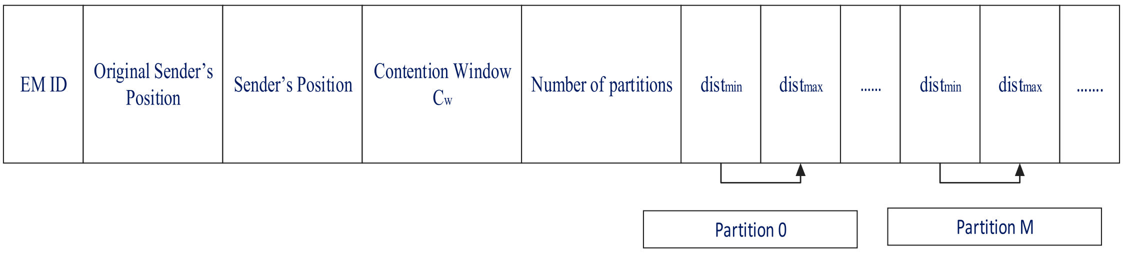

Figure 2. RTB packet format.

in this scheme. The network density will be determined by the partitions; if a static partition is chosen in this scheme, it must use static partitioning for all network densities. It will cause the partitions to become empty with low density, and the contention will slow down the process, causing message delivery to be delayed.

If the choice of choosing dynamic partition size will be changed depending upon the density of the vehicle. The partition size increases the covering of the node and the packet collision of vehicles between them. The emergency message broadcast is a vehicle-to-vehicle communication (V2V) the vehicle is considered a node that transmits the beacon's message to the vehicle's density, location and acceleration, so on. When an emergency arises such as an accident, damage and so on, the vehicle sends a critical message to the observer (i.e. the vehicle that met the incident). The critical message is sent and it is denoted as r and the time waiting is t the sender will give a busy tone if the time is extended and the tone is denoted as BT in the band. If the busy tone is given by the sender, the band will generate another message time and repeat the process. If the busy time is given by two times and it is denoted as 2D-BT.

The data packet contains some details about the ID, location and time of the sender broadcast (RTB) transmission. It sends an emergency message and the Network Assignment Vector (NAV) to prevent conflicts, and then the sender risks waiting to receive the tone from the receiver by turning off the 2D-BT.

If the vehicle area arrives RTB packet, then turns tone in the vehicle transmission and the emergency message would be waiting. A sender can find RTB from the receiver and broadcast the message as an emergency and the message contains formats header, size, position, partitions, etc. The packet is shown in Figure 2. The EM-id denotes the information id for the message broadcasting, the original sender's position is the location of the source, the sender's position denotes the vehicle location for message transmission, the congestion window is represented as A_u the use of the sender, in the fifth column the partition is given that how many numbers are used, the last distance is given as $dist_{min}$ and $dist_{max}$for the partition 0 to partition M. The partition number is denoted as $N_p$where the p is the utmost partition of the sender, its range is $0 \leq p \leq N_p - 1$.

The contention window is given as

$$A_u = \{p.a_u, p.a_{u+1}, p.a_{u+2}, \ldots ..(p+1).a_{u-1}\} \quad (1)$$

After receiving the RTB the node stays for the message and if the message arrives it checks that it comes from the partition and chooses the contention window as random to message forward. If the broadcast is finished then the sender sends the WIN packet to the id and turns off the R-BT.

The vehicle receives the WIN packet then other vehicles are in the contention phase. The acknowledgement will be sent to the sender who will turn off R-BT. The vehicle will be sender and forwards the position to utmost partition. Broadcast is successful when mobile density and mobility are in good condition. First, the sender transmits an emergency message to a nearby partition, if the high mobility vehicle is too far away, it will move rapidly to another vehicle so one vehicle will miss the chance to broadcast. The best broadcast emergency messages can be found in the message broadcast partition. It will be selected near or far position by the back widow optimization algorithm. The input of the optimization algorithm is density, mobility speed of the vehicle, etc.

3.2. *Partition length estimation*

The partition size is calculated as the partition in the vehicle that is at least scheduled in the contention window A_u in the particular period. Figure 3 shows the partition length estimation [27]; the vehicles receive the message from the sender, and the received vehicles ensure the message is not forwarded to others; the partitions from 0 to 3 are the effective portion that is divided into partitions and allocate the priorities for forwarding. Forwarding priorities will determine whether the received vehicles are farthest or nearest [28].

The vehicle contains the collision possibility and congestion between vehicles that automatically delay the transmission. At traffic conditions, the partition size is unpredicted and calculated as

$$P_{least} = P(len \leq l | len \leq R) = \int_0^1 \frac{\partial . e^{-\partial len}}{1 - e^{-\partial R}} dlen$$
$$= \frac{1 - e^{-\partial len}}{1 - e^{-\partial R}} \quad (2)$$

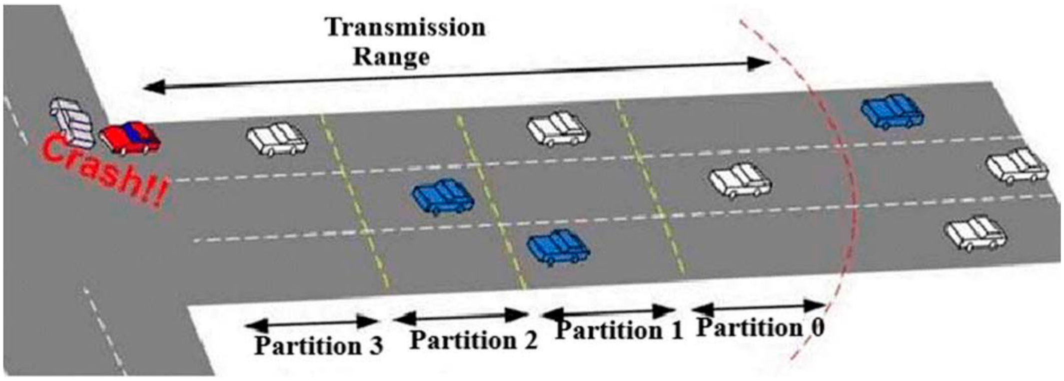

Figure 3. Partition length estimation.

Here ∂ refers to the average density of vehicles nearby. For calculating the farthest vehicle of partition length, the vehicle exits the final of the transmission range in the sender and the size of the position l in which the virtual probability of the vehicle is P_{least} and the farthest partition is equal to R.

$$P_{least} = P(len \leq l | len \leq R) = \frac{1 - e^{-\partial len}}{1 - e^{-\partial R}} \geq P_{Thr} \quad (3)$$

P_{least} is the farthest vehicle partition with the virtual probability and the partition length is measured with the density as given as

$$\rightarrow l \geq -\frac{\ln(1 - P_{Thr}.(1 - e^{-\partial R}))}{\partial} \quad (4)$$

$$P_{Thr} = \frac{1 + \frac{e-1}{e^{-(1-e^{\partial R})}}}{2} \quad (5)$$

The partition length is applied for the partitions in equal length of extreme partition at Equation (3) and the number of partitions is as shown below:

$$M_r = \frac{E}{l} \quad (6)$$

Partition size is varied in the density and the threshold e.g. The transmission range is 360 m as a fixed value the network varies from 0 to 1 representing the minimum to maximum density. The range of the transmission is R and density is in the unit of 1 and the vehicle density of the network is 36 with thresholds from 0 to 1. The partition length is increased when the threshold increases and the value varies from 0.7 to 0.9. So the network density varied from 0 to 0.15. Partition length denotes the transmission range of the network in the high probability thresholds and the density network. The probability of the threshold in partition size has a high-density value.

Figure 4 shows the partition length l in the changes of rate value of the probability of the threshold from Equations (4) and (5) in the actual length of one variable function. The threshold value is P_Thr and density function ∂ and it ranged from 0 to 0.15, the threshold value is 0.815 to 0.84 and the length is varied from 11.29 to 156.62 m.

The proposed research work uses Black Widow Optimization despite in [26]. There are several other optimization algorithms which are suitable for this work are the Dwarf Mongoose Optimization Algorithm proposed in [29], Ebola Optimization Search Algorithm: A new nature-inspired metaheuristic algorithm implemented in [30], Reptile Search Algorithm (RSA): A nature-inspired meta-heuristic optimizer utilized in [31] and The arithmetic optimization algorithm Aquila Optimizer: A novel meta-heuristic optimization algorithm [32]. These algorithms suggested in [29–32] may be utilized for future investigation with the combination of various methods proposed in [33–35].

3.3. Black widow optimization

The black widow optimization is used as the black widow spider inspiration in the Meta heuristic function in the species of optimal solutions. Meta heuristics has a better heuristics function and the implementation is popular in the potential of the solutions.

3.3.1. Initialization

To solve an optimization issue, the variables' value of the issue should form a suitable structure of solution for the current problem. In GA and PSO terminologies, this structure is known as "Chromosome" and "Particle position", correspondingly, other than the BWO algorithm it is named "widow". At BWO, a potential solution for every issue is assumed from the black widow spider. The probable solution for the issue has been to deal with the black widow spider and it exhibits the issues of the variable values. The basic block of black widow optimization is shown in Figure 5.

In the optimization problem, the dimensional value is M_{var} and the array of the widow is $1*$ Mvar for the problem solution. The array is defined as

$$widow = [x_1, x_2, \ldots\ldots x_{Mvar}[]] \quad (7)$$

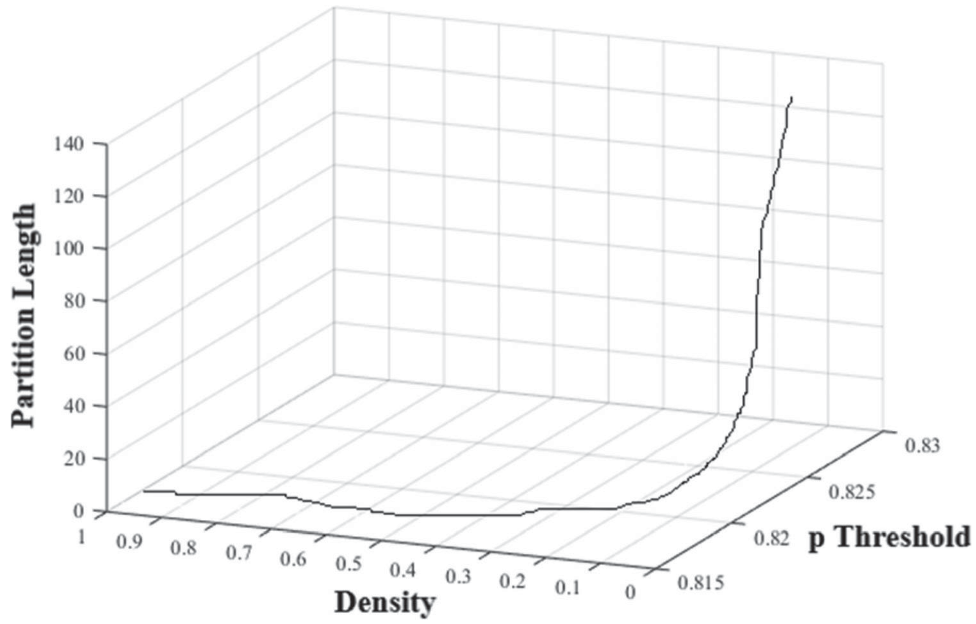

Figure 4. Partition length versus network density.

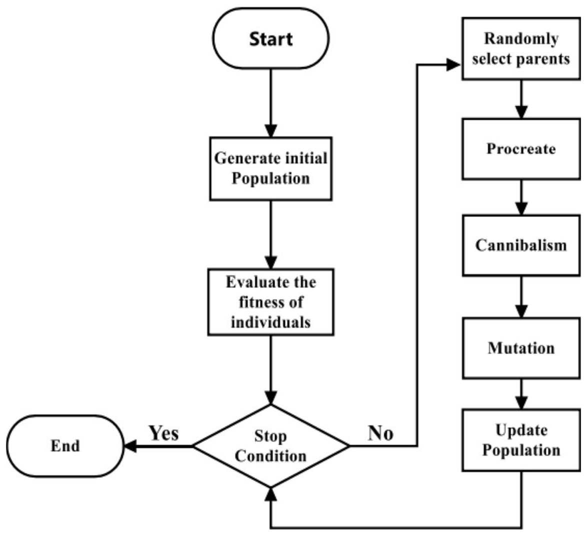

Figure 5. The basic block of black widow optimization.

Each variable are $(x_1, x_{2,} \ldots \ldots x_{Mvar}())$ floating number, fitness widow is determined using fitness function f in widow $(x_1, x_{2,} \ldots \ldots x_{Mvar}())$ so,

$$Fitness = f(widow) \tag{8}$$

The widow refers to the propagation of every node at partition over the message receiving and M_{var} is represented as the total number of partitions used for the space, $(x_1, x_{2,} \ldots \ldots x_{Mvar}())$is used for the partition number for which the vehicles transmit the messages.

The optimization algorithm starts with the candidate widow matrix size $M_{pop} * M_{var}$ generated by the spider's first population. The parents are chosen randomly for implementing the procreating through mating; the male black widow is eating through the female.

3.3.2. Procreate

As pairs are autonomous for everyone, it begins to mate for reproducing the novel generation, in parallel, and nature, every pair mate on their web, individually from others. In the real world, about 1000 eggs are created at every mating, other than eventually few spider babies survive, which is stronger. This algorithm is reproducing the array with alpha which is created with the widow array of random numbers containing the offspring producing the equation that x_1 and x_2 denote parents and the offspring refers to y_1 and y_2.

$$\begin{aligned} y_1 &= \alpha \times x_1 + (1 - \alpha) \times x_2 \\ y_2 &= \alpha \times x_2 + (1 - \alpha) \times x_1 \end{aligned} \tag{9}$$

The process is repeated for the $M_{var}/2$ times, in randomly chosen numbers, the children and parents are added to the array by the fitness value based on cannibalism rating for the best individuals that are newly generated in the population.

3.3.3. Cannibalism

It has three types of cannibalism. The initial one implies sexual cannibalism in that a black widow eats her husband during or after mating. With this algorithm, it would identify women and men via its fitness values. Another type is sibling cannibalism whether strong spiders eat their weaker siblings. This algorithm establishes a cannibalism rating based on the count of survivors, which is solved. They utilize the fitness value for evaluating spider hatchlings, whether it is strong or weak.

3.3.4. Mutation

At this stage, arbitrarily choose the Mute pop number of individuals as the population. Each of the selected

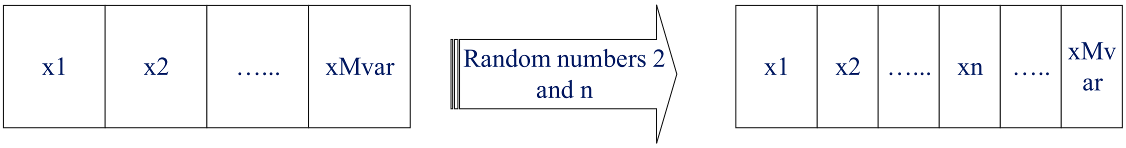

Figure 6. Mutation.

solutions replaces approximately two components in an array, as shown in Figure 6. The mutation value indicates that the message is broadcasted to vehicles without delay and retransmission is neglected.

The mutation is used for the population of chromosome values in the BWO; the mutation is employed to send a value of emergency broadcast to the vehicles. The mutation and diversity in the sample population used to bypass the local minima by blocking the number of chromosomes to stop the optimization of the global optimal value will prevent the chromosome from stopping the optimization.

3.3.5. Convergence

As with another evolutionary algorithm, the three stopping conditions may be assumed: (A) a predefined number of iterations. (B) The observation is that there is no modification in the fitness value of better widow used for various repetitions. (C) Achieve a certain level of accuracy. In the following section, BWO would be used for a few benchmark optimization issues.

3.4. Parameter setting

In the BWO algorithm, it consists of a few parameters that are necessary to obtain better outcomes. Such parameters contain the procreation rate (PP), cannibalism rate (CR) and mutation rate (PM). Parameters must be adjusted suitably to enhance the success of the algorithm in ruling superior solutions: best adjustment of parameters, greater opportunity to exit any local optimization and greater capability for exploring the search space globally.

The pop solution from the pseudo-code is the best message broadcast to vehicles and the number of beacons that parents and children pass chromosomes is transmitted. The best solution is the vehicles that are transmitted the best message.

Step 1 Initialization

The initial population of black widows is chosen as D-dimensions

Step 2 Procreating and Cannibalism

for i = 1 to *PP* do

Select two solutions from pop 1 as randomly

Step 3 mutation

Select the mutated value for the best solution of chromosome in the randomly selected solution

Step 4 updating

The best solution is updated in the pop which is the sum of two pop solutions.

4. Result and discussion

This section covers simulation settings and parameters, performance metrics and comparison and performance analysis by the existing techniques. The

The pseudo-code of the black widow optimization

Input: Iteration, procreating, cannibalism, mutation.
Output: optimal solution for the objective function

```
// Initialization
The initial population of black widow spiders
    Each pop is a D-dimensional array for the chromosomes in the dimensional problem
// Loop until terminal condition
The procreating rate calculates the reproduction of the spiders as PP;
Based on the solution the best pp select in pop and save as pop 1;
// Procreating and Cannibalism
    for i = 1 to PP do
    Select randomly two solutions from pop1;
    Using Equation (9) the children's solutions are generated;
Further the father solutions will destroy;
The cannibalism rate will neglect the children's solution for getting the new solution;
Save the remaining solution into the pop 2;
End for
// Mutation
The mutation rate calculates the mutation of children's solutions as PM
for i = 1 to ττ do
Select the solution from pop 1;
Mutate the chromosome value randomly in the solution and generate a new solution;
Save the new solution into pop 3;
End for
// Updating
    Update the solution pop = pop 2+pop 3;
Returning the best solution;
Return the best solution from the pop;
```

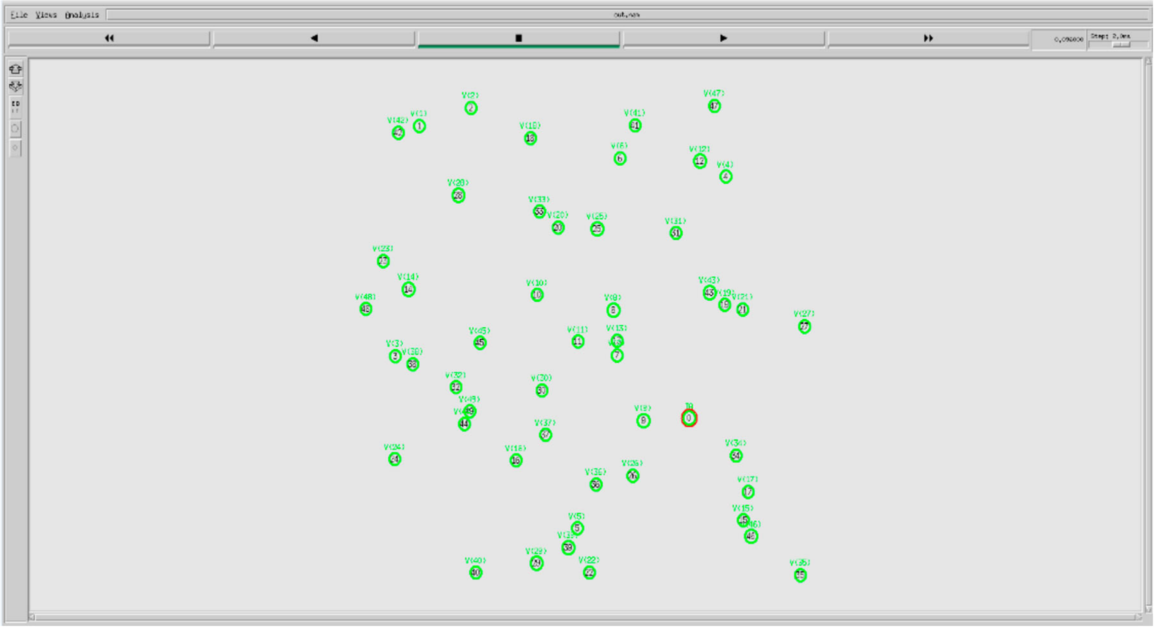

Figure 7. Network deployment.

Table 1. Simulation set-up.

Parameter	Value
MAC layer	802.11 *p*
Transmission range	200 m
Transmission power	0.98mW
Bit rate	18Mbps
Beacon size	32Mbps
Propagation model	Two-way interference
Number of repetitions	33
Time slot	16µs
RTB max. slot	100 bytes
Procreate rate	0.56
Cannibalism rate	0.41
Mutation rate	0.33

proposed research was implemented using the network simulator, NS2 [27] and the simulation setup is shown in Table 1. The vehicle speed is 110 km/h, the length is 12 km for the direct path and the four-way direction path is selected. The network density is designed as 500, 800, 1000 and 5000 vehicles per hour. In the simulation, the analog model with bidirectional interference is chosen and nodes are arbitrarily selected. An investigation is experimented with for urban and highway roads and emergency awareness is propagated with vehicles on high roads, as shown in Figure 7, as Network deployment, the vehicle movement in different directions is shown in Figure 8, and the communication channel between nodes is shown in Figure 9. For the dimension of 50 and population of 300, the experimental algorithms are examined. The best and maximum iteration number for both experiments is 2000. The results from more than 30 consecutive runs have been recorded.

4.1. Performance analysis

The performance analysis can be used for delay, efficiency, redundancy rate and collision. The performance evaluation is compared with the existing methods as Y. Bi [14], Y. Chou [15], U. Rajput [20] and T. Saeed [21]. The performances metrics are used in the evaluation.

Redundancy rate: The replicated messages are used in the transmission ratio between the messages. This method has achieved minimal overhead/redundancy

$$RR = \frac{\text{number of duplicate messages}}{\text{number of source messages}} \tag{10}$$

Collision rate: The collision rate is also called packet loss, which is the performance data of the MAC layer of the collision in the proportion of transmission/transmitted packets. The ratio of data loss is minimal in the effective protocol.

$$CR = \frac{\text{number of collision packets}}{\text{number of send packets}} \tag{11}$$

Delay: Time is measured as end-to-end propagation time or delay; the time required for the transmission of sending nodes to the receivers is evaluated. For emergency messages broadcast, the delay will be low

$$PT = \text{received message time} - \text{initial time} \tag{12}$$

Dissemination efficiency: The extreme of the data may be broadcasted via a network in a unit of time, and then the efficiency value increases in message distribution in the farthest neighbour as quicker with the large success rate and redundancy.

$$DE = \frac{\text{propagation distance} * \text{success rate}}{PT * RR} \tag{13}$$

Success rate: The ratio of the delivery message with the successful delivery of the message with the number of vehicles that have a highly reliable technique has the

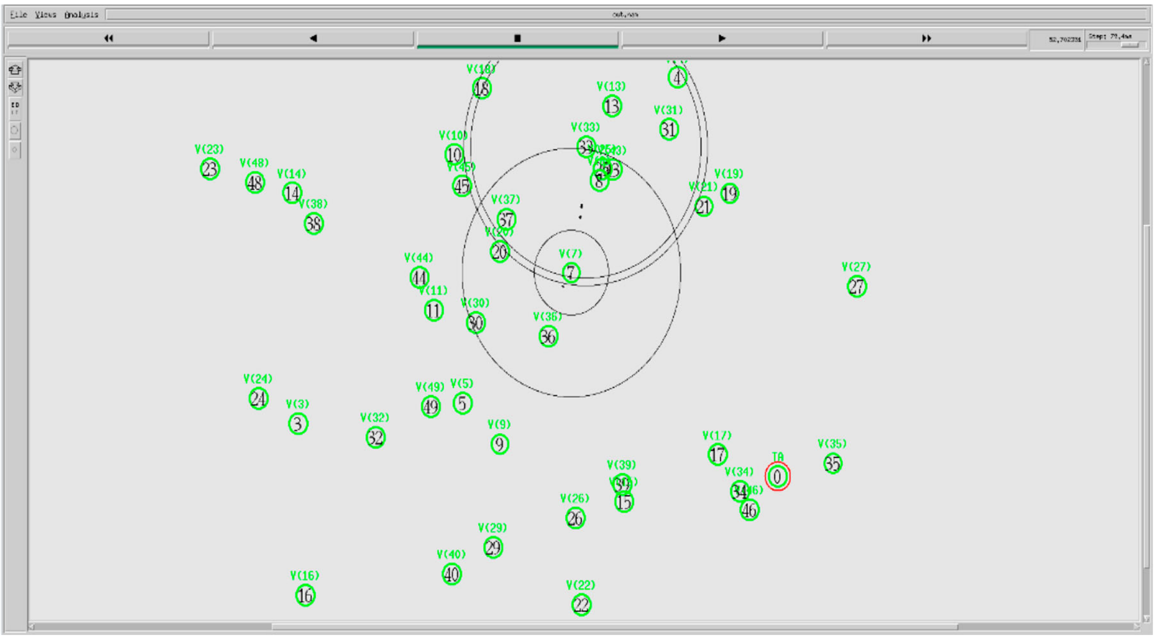

Figure 8. Vehicle movement in different directions.

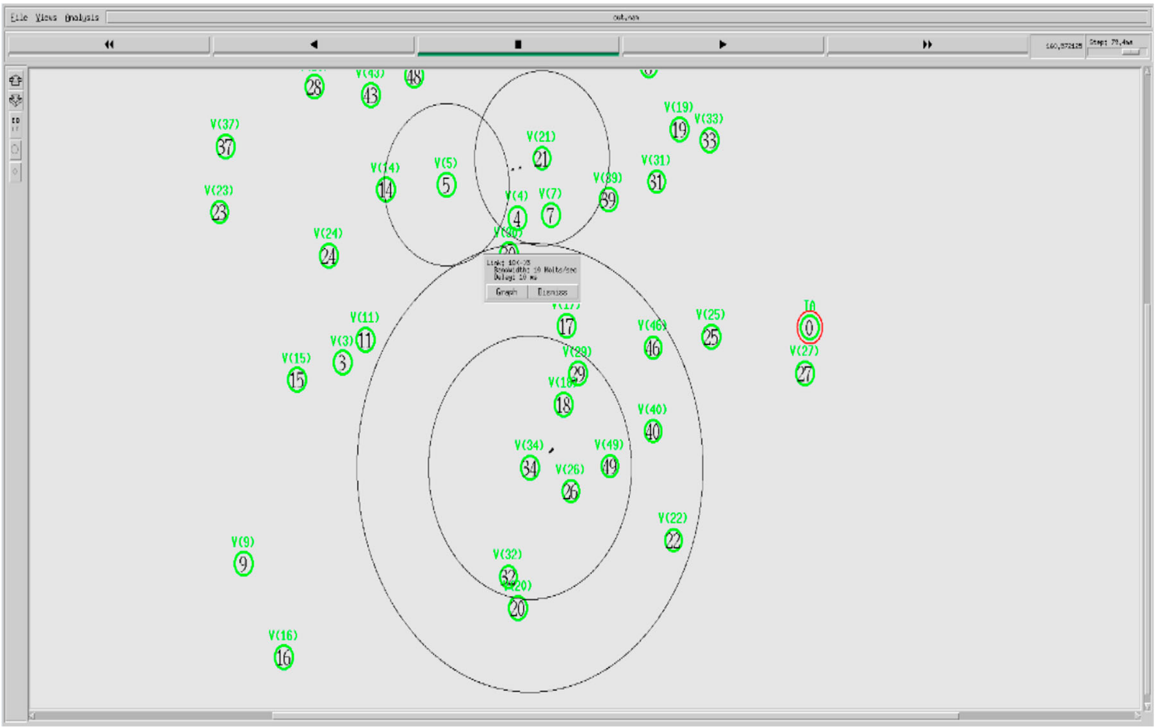

Figure 9. The communication channel between nodes.

highest ratio of 100%.

$$SR = \frac{\text{number of vehicles received messgae}}{\text{number of vehicles network}} \quad (14)$$

The total number of beacons: Beacons are generated with messages transmitted over the network density, the amounts of beacons reduce the dense efficiency.

$$TB = \frac{\text{number of beacons}}{\text{number of send packets}} \quad (15)$$

Figure 10 shows the analysis success rate of different protocols in various traffic flows. The experiment analysis shows that the proposed technique gets better results than the existing methods such as Y: Bi 28% lower than the proposed, Y. Hsin 30% lower than the proposed, U. Rajput 40% lower than the proposed, T. Saeed 50% lower than the proposed method. Our proposed results are better achieved using separate message dissemination in the undelivered message in problem time rise in the network partitioning and coverage is maximized for applications with sparse and dense network.

The minimum number of nodes for vehicle flow reaches a reasonable success rate. The rate is better

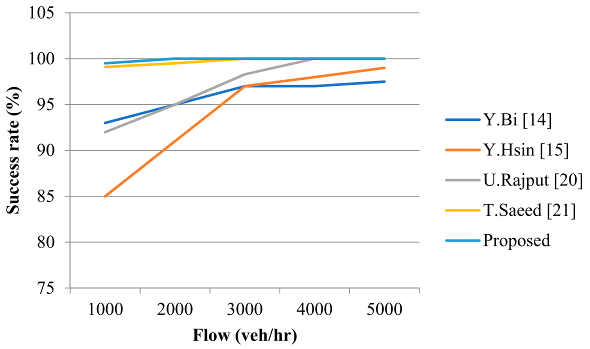

Figure 10. Success rate.

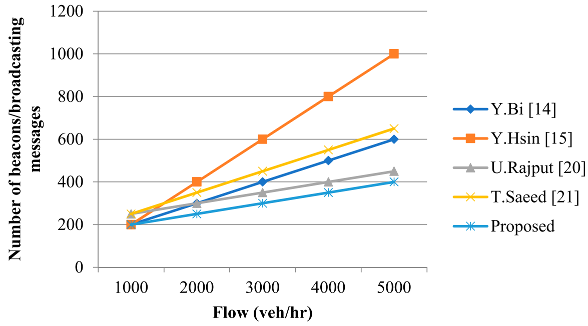

Figure 12. The number of beacons.

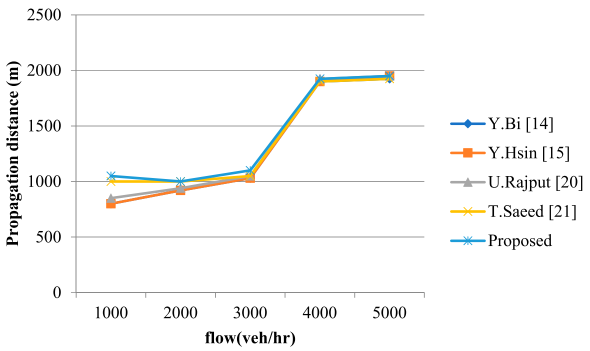

Figure 11. Propagation distance.

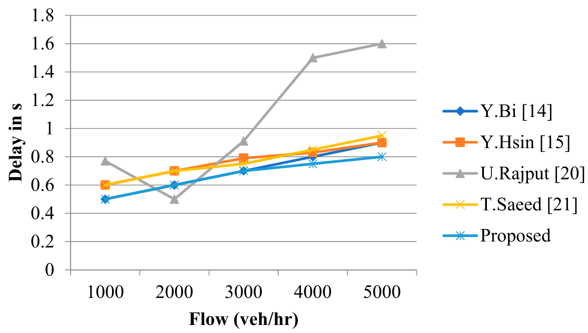

Figure 13. Delay.

for the proposed method while flowing at the slightest change in performance in the transmission of vehicles. The success rate is not continuously increased, which makes a slight difference. The performance of the success rate on each flow occurs at the vehicle's rate of message broadcast in the delivered number of packets that the emergency message transmitted.

Figure 11 shows the propagation distance being analyzed for vehicle flow. Our proposed method gets better results than other existing techniques as it consists of a message monitoring scheme with sparse and dense network density. When the vehicles flow higher the distance also gets higher than with other methods. The proposed method gets higher than Y: Bi 18%, Y. Hsin 25%, U. Rajput 27%, T. Saeed 30%.

For the propagation distance, the presence of a road side unit during the vehicle's flow in the message transmission of informed vehicles will consist of the message of subsequent vehicles that must be transmitted in long-distance vehicles. The length of the long-distance vehicle is represented in the position variable, which sends an emergency message after measuring the distance of vehicles that have high density in the first sender vehicles. As the flow of the vehicles increases, the propagation distance also increases according to the vehicle's distance.

The proposed method uses fewer f-beacons than other existing methods. Because congestion controls the network density. It is noted that the BWO technique will reduce the beacon level at the network. This technique regulates the line among beacon retransmission over the node density in a broadcast storm.

In Figure 12 the number of beacons decreases as the vehicle flow increases. The beacon is very small on the message broadcast and the payload size will be compared with the data messages that use beacon information for routing decisions. The beacon is used in the information for decision-making. A large number of broadcasting data packets will cause bandwidth losses. The beacon information is independent of the routing algorithm that reduces the number of data packets broadcast in the vehicle's use of the route discovery of the destination vehicle.

Figure 13 displays the proposed method end-to-end delay between all methods that gets better results because the delay is low when the number of vehicles is increased on road for message transmission. Our proposed method shows better results for reliable message delivery and the information received by the receiver.

The deviation of simulation and analytical may be observed in the graph by receiving the processing of packets in message broadcast of processing time the vehicles flow increases the delay gets low to our proposed method because the density and distance are fixed optimally by optimization method. The end delay is obtained towards the upper bound of probability distribution in the density distribution of the delay of the VANET.

Figure 14 shows the redundancy rate of traffic vehicle flow. Our proposed method has a suppression mechanism to rebroadcast the message. All our proposed

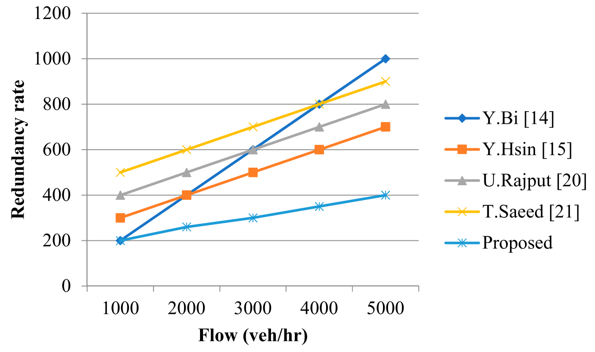

Figure 14. Redundancy rate.

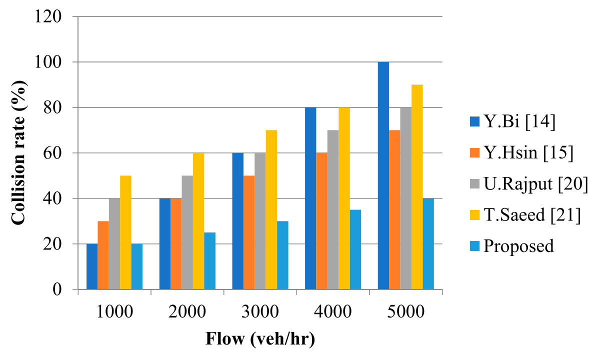

Figure 15. Collision rate.

method gets better results, Y: Bi [14] 97% higher than the proposed, Y. Hsin 45% higher, U. Rajput 75% higher and T. Saeed 80% higher than the proposed method.

The redundancy rate is a consistent error in the mechanism that requires the synchronization between the sender and the receiver vehicle in the communication for information broadcast in the entropy for retrieving the vehicle's information, while the broadcast of the message corresponds to the redundant data in the source information. Entropy, which increases the packets in the number of beacons of packet loss in the partition encoded in the original network code, is the same size as in the broadcast transmission in the information of the segments in the code encoded in packets of the same size.

Figure 15 describes the collision rate with the various traffic of vehicles and our method gets the better value. The collision rate is the same as the redundancy rate, which is the protocol with the maximum number of collisions when it doesn't broadcast the message and it gets a storm problem while broadcasting. Our proposed gets better results, Y: Bi 95% higher than the proposed, and Y. Hsin 80% higher U. Rajput 75% higher; T. Saeed 85% higher than the proposed method.

The vehicles are informed of the collision rate during the transmission and the forwarded message will send an emergency message already passed by the road side unit. The collision rate is encountered in the area of vehicles in the equipped OBU with information around the road side unit. The collision is a common problem

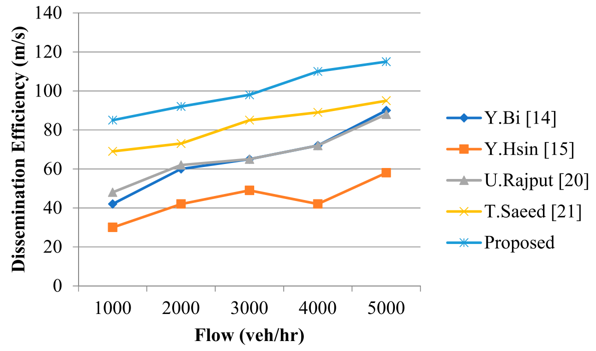

Figure 16. Dissemination efficiency.

whenmessage broadcasting occurs, but the use of optimization and partition length in our proposed method reduces conflict in our method. The location of the vehicles to transmit the message is clearly searched along the length of the partition and the message is in the communications of the flow beacons of the vehicles.

The efficiency is shown in Figure 16. The proposed method to calculate the efficiency of the method with 4 other methods gets better results. The efficiency is calculated with the message of overhead, reliability and reachability. The slot time is selected for transmission as the vehicle increases, so efficiency gets the better value. The efficiency of our method is 98% better when compared to that of other methods.

A VANET with infrastructure requires a useful network for vehicle communication. The network that determines efficiency in terms of the flow of vehicles for vehicle density efficiency is measured under redundancy rate, collision, success and delay with the propagation density with the existing method. The proposed result gets 98%, while other methods get less than our method.

5. Conclusion and future works

In this paper, we have experimented with adaptive scheduled partitioning and broadcasting techniques with black widow optimization to enable an accurate and reliable emergency message broadcast mechanism in VANET. The adaptive scheduled partitioning scheme divides the area based on vehicle density, which was evaluated using beacon messages from neighbouring vehicles. Vehicles send emergency messages to nearby nodes when they receive them and reduce the message retransmission message delay and control the beacon congestion for reducing the storm problem during the broadcast. In the species of optimal solutions, the black widow optimization was proposed as the black widow spider inspiration in the Meta heuristic function. Meta heuristics has superior heuristics function and is widely used in the potential of solutions. The performance has been analyzed with other existing broadcast schemes of

VANET and gets better experimental results by determining the success rate, propagation distance, delay, number of beacons, redundancy rate, collision rate and dissemination efficiency.

The focus of future research will be on addressing the storage overhead in the VANET system. Extend this scheme to handle autonomous vehicle-based traffic management that does not require infrastructure such as roadside units and transportation management centres. This scheme can be used on roads with no roadside units, and the congestion technique is also included for future work. The security issues in privacy and safety-related applications will be done with the new optimization algorithm and considers cryptographic algorithms. The simulation will also be improved through practical research in the future.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

M. Ramya Devi http://orcid.org/0000-0002-6155-0474
I. Jasmine Selvakumari Jeya http://orcid.org/0000-0003-0842-373X
S. Lokesh http://orcid.org/0000-0003-2067-6756

References

[1] Mathew D, Roy HA. A survey on different privacy-preserving authentication schemes in VANET. IOP Conf Ser: Mater Sci Eng. 2018;386. doi:10.1088/1757-899X/396/1/012033.
[2] Ramakrishnan B, Selvi M, Bhagavath Nishanth R, et al. An emergency message broadcasting technique using transmission power based clustering algorithm for vehicular Ad Hoc network. Wirel Pers Commun. 2017;94(4):3197–3216. doi:10.1007/S11277-016-3772-0.
[3] Mahipal SB, Kakria A. Article: efficient broadcasting protocol for vehicular Ad-hoc network. Int J Comput Appl. July 2012;49(23):38–41. doi:10.5120/7946-1288.
[4] Chen Y, Shih Y, Shih K. An emergency message dissemination protocol using N-way search with power control for VANETs. 2015 IEEE International Conference on Communications (ICC), 2015, pp. 3653–3658. doi:10.1109/ICC.2015.7248892.
[5] Kang M, Virdaus IK, Shin S, et al. Limited area broadcast for warning message delivery over vehicular ad-hoc networks. J Wireless Com Network 2016. 2016;159. doi:10.1186/s13638-016-0658-5.
[6] Li X, Hu B, Chen H, et al. A distance-aware safety-related message broadcasting algorithm for vehicular networks. Int J Distrib Sens Netw. 2014;10(2):1–11. Article No. 139857. doi:10.1155/2014/139857
[7] Samara G, Alhmiedat T. Intelligent emergency message broadcasting in VANETusing PSO. World Comput Sci Inf Technol J (WCSIT). 2014;4(7):90–100. ISSN: 2221–0741. doi:10.48550/arXiv.1406.7399
[8] Slavik M, Mahgoub I. Spatial distribution and channel quality adaptive protocolfor multihop wireless broadcast routing in VANET. IEEE Trans Mob Comput. 2013;12(4):722–734. doi:10.1109/TMC.2012.42.
[9] Torrent-Moreno M, Jiang D, Hartenstein H. Broadcast reception rates andeffects of priority access in 802.11-based vehicular ad-hoc networks. In: Proceedingsof the 1st ACM International Workshop on Vehicular Ad Hoc Networks, Philadelphia, pp. 10–18. ACM, 2004. doi:10.1145/1023875.1023878.
[10] Mishra R, Singh A, Kumar R. VANET security: issues, challenges and solutions. in process of International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT), pp. 1050–1055, Chennai, 2016. doi:10.1109/ICEEOT.2016.7754846.
[11] Takahashi M, Anang Y, Watanabe Y. A proposal of fault tree analysis for embedded control software. Information. 2020;11(9):402. doi:10.3390/info11090402.
[12] Ali QI. Event driven duty cycling: an efficient power management scheme for a solar-energy harvested road side unit. IET Electr Syst Transp. 2016;6(3):222–235. doi:10.1049/iet-est.2015.0036.
[13] Madasamy B, Balasubramanian P. Geographical angular zonebased optimal resource allocation and efficient routing protocols for vehicular ad hoc networks. IET Intel Transport Syst. 2018;12(3):242–250. doi:10.1049/iet-its.2017.0003.
[14] Bi Y, Shan H, Shen XS, et al. A multi-hop broadcast protocol for emergency message dissemination in urban vehicular ad hoc networks. IEEE Trans Intell Transp Syst. 2015;17(3):736–750.
[15] Hsin Y, Chu T, Kuo S, et al. An adaptive emergency broadcast strategy for vehicular Ad Hoc networks. IEEE Sensors J. 2018;18(12):4814–4821. doi:10.1109/JSEN.2017.2757698.
[16] Tian D, Liu C, Duan X, et al. A distributed position-based protocol for emergency messages broadcasting in vehicular Ad Hoc networks. IEEE Internet Things J. 2018;5(2):1218–1227. doi:10.1109/JIOT.2018.2791627.
[17] Shah SS, Malik AW, Rahman AU, et al. Time barrier-based emergency message dissemination in vehicular Ad-hoc networks. IEEE Access. 2019;7:16494–16503. doi:10.1109/ACCESS.2019.2895114.
[18] Wu L, Nie L, Fan J, et al. An efficient multi-hop broadcast protocol for emergency messages dissemination in VANET s. Chin J Electron. 2017;26:614–623. doi:10.1049/cje.2017.03.001.
[19] Lyu C, Gu D, Zeng Y, et al. PBA: prediction-based authentication for vehicle-to-vehicle communications. IEEE Trans Dependable Secure Comput. 2016;13(1):71–83. doi:10.1109/TDSC.2015.2399297.
[20] Rajput U, Abbas F, Eun H, et al. A hybrid approach for efficient privacy-preserving authentication in VANET. IEEE Access. 2017;5:12014–12030. doi:10.1109/ACCESS.2017.2717999.
[21] Saeed T, Mylonas Y, Pitsillides A, et al. Modeling probabilistic flooding in VANETs for optimal rebroadcast probabilities. IEEE Trans Intell Transp Syst. 2019;20(2):556–570. doi:10.1109/TITS.2018.2828413.
[22] Ali S, Nand P, Tiwari S. Secure message broadcasting in VANET over Wormhole attack by using cryptographic technique. 2017 International Conference on Computing, Communication and Automation (ICCCA), 2017, pp. 520–523. doi:10.1109/CCAA.2017.8229856.
[23] Sahoo J, Wu EH-K, Sahu PK, et al. Binary-partition-assisted MAC-layer broadcast for emergency message dissemination in VANETs. IEEE Trans Intell Transp Syst. 2011;12(3):757–770. doi: 10.1109/TITS.2011.2159003.
[24] Javed MA, Ngo DT, Khan JY. A multi-hop broadcast protocol design for emergency warning notification

in highway VANETs. J Wireless Com Network 2014. 2014;179. doi:10.1186/1687-1499-2014-179.
[25] Li GS, Wang WL, Yao XW. An adaptive and opportunistic broadcast protocol for vehicular ad hoc networks. Int J Autom Comput. 2012;9:378–387. doi:10.1007/s11633-012-0658-9.
[26] Hayyolalam V, Kazem AAP. Black Widow Optimization algorithm: a novel meta-heuristic approach for solving engineering optimization problems. Eng Appl Artif Intell. 2020;87:103249. doi:10.1016/j.engappai.2019.103249.
[27] Rayeni MS, Hafid A, Sahu PK. Dynamic spatial partition density-based emergency message dissemination in VANETs. Veh Commun. 2015;2(4):208–222. doi:10.1016/j.vehcom.2015.07.002.
[28] Sheikh MS, Liang J, Wang W. A survey of security services, attacks, and applications for vehicular Ad Hoc networks (VANETs). Sensors. 2019;19:3589. doi:10.3390/s19163589.
[29] Agushaka JO, Ezugwu AE, Abualigah L. Dwarf Mongoose Optimization algorithm. Comput Methods Appl Mech Eng. 2022;391:114570. doi:10.1016/j.cma.2022.114570.
[30] Oyelade ON, Ezugwu AE-S, Mohamed TIA, et al. Ebola optimization search algorithm: a new nature-inspired metaheuristic optimization algorithm. IEEE Access. 2022;10:16150–16177. doi:10.1109/ACCESS.2022.3147821.
[31] Abualigah L, Elaziz MA, Sumari P, et al. Reptile Search Algorithm (RSA): a nature-inspired meta-heuristic optimizer. Expert Syst Appl. 2022;191:116158. doi:10.1016/j.eswa.2021.116158.
[32] Abualigah L, Yousri D, Elaziz MA, et al. Aquila optimizer: a novel meta-heuristic optimization algorithm. Comput Ind Eng. 2021;157:107250. doi:10.1016/j.cie.2021.107250.
[33] Selvi M, Ramakrishnan B. Lion optimization algorithm (LOA)-based reliable emergency message broadcasting system in VANET. Soft comput. 2020;24:10415–10432. doi:10.1007/s00500-019-04545-8.
[34] Joseph FJJ. Time series forecast of Covid 19 pandemic using auto recurrent linear regression. J Eng Res. Online First Articles, 2022. doi:10.36909/jer.15425.
[35] Selvi M, Ramakrishnan B. Prioritized and secured data dissemination technique in VANET based on optimal blowfish algorithm and signcryption method. Int J Comput Netw Appl (IJCNA). 2015;2(4):165–172. https://www.ijcna.org/Manuscripts/Volume-2/Issue-4/Vol-2-issue-4-M-02.pdf.