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NSSC: Novel Segment Based Safety Message Broadcasting in Cluster-Based Vehicular Sensor Network

IBRAHIM S. ALKHALIFA AND AHMAD S. ALMOGREN, (Senior Member, IEEE)
Department of Computer Science, College of Computer and Information Sciences, King Saud University, Riyadh 11633, Saudi Arabia
Corresponding author: Ahmad S. Almogren (ahalmogren@ksu.edu.sa)

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ABSTRACT Extensive research attention has been devoted to the Vehicular Sensor Network (VSN) owing to its great potential in environment monitoring. Still, it is difficult to diminish the broadcast storm and data collisions in vehicular senor environment. Due to improper broadcasting of safety message and transmission of packet at same time from multiple vehicles leads to collision. Our key intention is to overwhelm these shortcomings in VSN. Hence, we propose Novel Segment based Safety message broadcasting in Cluster (NSSC) based VSN. Our NSSC is mainly concentrated in three successive processes that are Cluster Formation, Collision Avoidance and Safety Message Broadcasting. Cluster formation is performed originally to sustain stable vehicular environment. Here, Variant based Clustering (VbC) Scheme is proposed to elect Cluster Head (CH) and to form clusters. CH is selected using Chaotic Crow Search (CCS) algorithm. In accord to mitigate the data collision during transmission between CH and Cluster Member, we propose Adaptive Carrier Sense Multiple Access/Collision Avoidance (Ada-CSMA/CA) protocol. Safety message broadcasting adopts Segment based Forwarder Selection (SFS) scheme which selects optimal forwarder using Fuzzy-Vikor method. In this, optimal forwarder is selected concerning to broadcast safety message which reduces the broadcast storm. In regard to validate the proposed NSSC, we have conducted simulations on Omnet++ and SUMO simulator based Veins framework. The acquired results are auspicious in terms of succeeding metrics reachability, average number of collision, duplicate data packets, latency, packet delivery ration and throughput.

INDEX TERMS Clustering, collision avoidance, safety message broadcasting, security, vehicular ad hoc network, vehicular sensor network.

I. INTRODUCTION

In Vehicular Ad-hoc NETwork (VaNET), there are certain demands on sensing and transmitting data among vehicles in order to satisfy the services like emergency broadcasting and data transmission [1], [2]. In order to satisfy this demand, VSN has been aroused which is an effective and reasonable way to sense the vehicular surroundings [3]. It is also notable VSN is progressing as a new infrastructure for sensing the definite world specifically in metropolitan regions which large amounts of vehicle furnished with the on board sensors.

Owing to number of the vehicles, velocity and frequent topology changing constraints induces the frequent disconnection of communications and transmission losses [4]. In order to enhance the communication in vehicular sensor environment, clustering is a resulting technique which divides the vehicles into set of clusters [5]. Each cluster is managed through specific vehicle named as Cluster Head (CH) which collects data from its Cluster Member (CM) [6]. CH vehicle is selected regarding to the certain criteria such as mobility, link, etc. In several works, CH is elected using optimization algorithm such as Moth Flame Optimization (MFO) algorithm [7], Hybrid Genetic algorithm Data collision avoidance is significant process while collecting data from CM [8]. Standardized Medium Access Control mechanisms are used to avoid data collisions among vehicles. [9]. Clustering plays vital role in safety message broadcasting in terms of reducing number of rebroadcasts in vehicular sensor environment [10].

Safety message broadcasting is significant in vehicular based network in order to preserve safety among vehicles in

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road areas [11]. Since, there exist several unforeseen incidents that are occurred frequently on the roads which threaten the people lives [12]. If an accident happened in the environment, a message must be transmitted to all vehicles present in the surroundings. Different broadcasting algorithms are utilized to transmit safety message to the vehicles whenever accident occurs in the vehicular sensor environment [13]. The algorithms that are used to broadcast the safety message are listed as follows: Selective Epidemic Broadcast (SEB) [14], Adaptive Emergency Broadcast [15] and Hybrid Relay Node Selection [16]. However, blind broadcasting of safety message results in broadcast storm and also induces loss in safety message [17].

From the above discussed studies, it is noticed that still vehicular environment faces many issues that are summarized as follows:

- Frequent topology changes induce instability in clustering which tends to concurrent cluster formation.
- Data collisions occurred during transmission due to multiple vehicles sending their data in same period of time.
- Broadcast storm is high in safety message broadcasting due to pursuing of blind procedure.

A. RESEARCH PURPOSE

VANET has arisen as an auspicious technology given effective vehicular protection, traffic organization, infotainment and position based services [18], [19]. In present days, vehicles have been required a lot of information about roads surrounding them for their safety and convenience [20], [21]. The safety driving in vehicular environment is ensured by the leveraging the incorporation of infrastructure nodes i.e RSU and other nodes including IoT nodes and smart phones [22], [23]. Under this situation, VSN is introduced for supporting communications between roadside sensor nodes and vehicles present on the roads. The safety driving of VSN incorporate media access control (MAC) protocols, data forwarding schemes, and routing protocols for unicast, multicast, and broadcast, transport layer protocols, and security services [24]-[-26]. The MAC protocol plays crucial part to increase the efficiency of any device by utilizing the power consumption [27]. Moreover, VSN comprises of two different sensor nodes, some are deployed in road sides and others are embedded on the vehicles. It creates an end to end reliable network for transmitting sensor data congregated from a vehicular environment. A plenty of research applications are emerged in VSN such as emergency warning and road monitoring. VSN comprises of two specific types that are Intra Vehicle VSN and Inter Vehicle VSN.

- Intra Vehicle VSN- It is introduced for the determinations of monitoring, control and communication between components and subsystems exist inside a vehicle.
- Inter Vehicle VSN- It is introduced for vehicle to communication with neighbor vehicle in order to transmit safety related information.

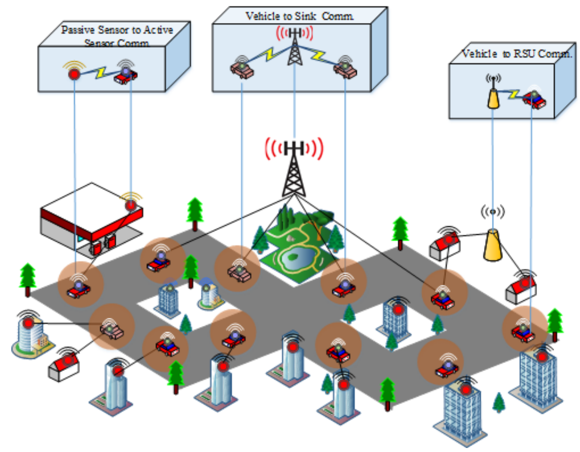

FIGURE 1. Architecture for vehicular sensor network.

Intra VSN is limited in space whereas inter vehicle VSN able to communicate with multiple vehicles through Dedicated Short Rang Communication (DSRC) communication.

Figure 1 shows the VSN architecture with vehicles (Active Sensor) and Road Side Sensor (RSS) (Passive Sensor) nodes [28]. However, most of the research studies concentrated only on the data gathering and fusion based routing in VSN [29], [30]. Yet, there is in need of clustering and collision avoidance since vehicles having high mobility behavior thus leads to frequent communication losses and collisions due to frequent data transmissions. In addition to it, broadcasting safety message and detecting event in vehicular sensor environment is also significant processes to preserve safety of the vehicular users. Therefore, in this work we have concentrated on the clustering, collision avoidance and safety message broadcasting in VSN. To the best our knowledge, we are first in integrating aforesaid processes in VSN that enhances the performance of the network.

B. RESEARCH CONTRIBUTION

This section deals with contribution of proposed NSSC system. The contributions are summarized as follows:

- In accord to construct stable network, we rely on establishing stable clusters in the VSN environment. Our proposed clustering adopts Variant based Clustering (VbC) scheme where Chaotic Crow Search (CCS) algorithm is utilized for CH election.
- In order to achieve high throughput in data transmission, our NSSC carried out collision avoidance with the aid of Adaptive CSMA/CA algorithm which adaptively changes the back-off time.
- Our novelty is presented in safety message broadcasting which mitigates the broadcast storm effectively. For this purpose, NSSC performs Segment based Forwarder Selection (SFS) method where best forwarder is selected through Fuzzy-Vikor (FV) algorithm.
- In regard to prove performance of the NSSC, we validate the performance using succeeding metrics such as

reachability, average number of collision, duplicate data packets, latency, packet delivery ration and throughput.

C. RESEARCH OUTLINE

Outline of our research work is concise as follows: Section 2 deliberates the prior works present in VSN with their limitations. Section 3 demonstrates problems occur in previous works that are related to VSN. Section 4 explains brief study of our NSSC with our proposed algorithms. Section 5 explains numerical results obtain from our simulation environment and also compare it with existing methods. Finally, section 6 concludes our contribution and also affords some comments on our future work.

II. STATE OF ART WORK

In this section, prior works that are related to the vehicular environment is exemplified. Furthermore, it designates the various approaches that are developed in the vehicular network. This section further sub-divided into two that are benefits and demerits of the existing works.

A. CLUSTERING

Ghada *et al.* [31] have introduced the Double Head Clustering (DHC) method for vehicular network which is referred as the movement based clustering algorithm. Here, CH selection considers multiple metrics that are speed of the vehicle, direction, and position. Besides, it also considers other metrics associated to the link quality including the signal-to-noise ratio (SNR) and the link expiration time (LET). Hence, DHC method increases the cluster stability and efficiency.

Regin and Menakadevi [32] have pointed out the dynamic clustering mechanism in vehicular network based on the node density. Density based Dynamic Clustering (DBDC) mechanism is used to determine the node density. Dynamic clustering process is enabled whenever node density exceeds the threshold value. Henceforth, it attains better scalability even in high density scenario.

Fahad *et al.* [33] have offered Grey Wolf Optimization (GWO) to cluster the vehicles in the network. Here, GWO algorithm is used to select the optimal CH in vehicular environment. Here, CH elected based on the four factors that are speed, position, location and direction. Therefore, it increases the clustering efficiency in vehicular network.

Ren *et al.* [34] have suggested Unified Framework for Clustering (UFC) in vehicular environment. UFC mechanism comprises of two major parts that are CH selection and Cluster formation. CH selection is performed by estimating probability of being CH where succeeding metrics are considered that are link lifetime and link expiration time. Therefore, UFC is adaptable to any network scale environment.

Kittusamy *et al.* [35] have offered an Enhanced Whale Optimization (EWO) method in vehicular networks. Initially, it constructs the clusters based on the Adaptive Weighted Clustering (AWC) algorithm. Here, EWO is used to elect the CH in formed clusters. EWO estimates fitness function for each CH. Vehicular node which achieves higher fitness is selects as CH. Thus reduces the frequent formation of clusters.

Joshua *et al.* [36] have pointed out reputation oriented weighted clustering protocol (RWCP) in Vehicular environment. RWCP considers the upcoming metrics that are direction of vehicles, position, velocity and reputation in order to stabilize the cluster. Here, Multi Objective Firefly Algorithm (MOFA) is utilized to enhance the parameters of the RWCP.

Ishtiaq *et al.* [37] have presented the Moth Flame Optimizer (MFO) for intelligent clustering in the vehicular network. This algorithm considers the mobility of the vehicle to select the optimal cluster head for clustering process. For this purpose, it estimates the fitness function for each vehicle present in the network. The vehicle which has highest fitness function is selected as the cluster head. The elected cluster head forms the clusters in the network.

Wang and Chen [38] have presented the Efficient Data Gathering and Estimation (EDGE) in VSN. The EDGE method pursues the dynamic partition procedures in VSN network using region quad tree algorithm. It comprises three phases that are adjustment phase, gathering phase and estimating phase. In adjusting phase, grids are merged, split according to the sensed data from the one grid. Gathering phase, vehicular nodes receives beacon signal to sense respective grid. In estimation phase, quality index of the air is estimated.

Hu *et al.* [39] have presented the Integrity Content Offloading (ICO) technique in the VSN. This work proposes two offloading procedures that are direct link and relay assisted path respectively. In direct link offloading, vehicular nodes are directly offload data into the RSU. In relay assisted path based offloading; vehicular nodes send data to the RSU via two hop relay nodes. Relay vehicles are selected by computing distance to the sink node in its communication range. Finally, minimum distance node is selected as relay vehicle to offload data to the RSU.

Sadou and Bouallouche-Medjkoune [40] have pointed out message delivery in Hybrid Sensor and Vehicular Network (HSVN). Herein, sensor nodes are deployed between two RSU nodes. Sensed data from the sensors are provided to the RSU node, if there is no vehicle passing in its sensing range. RSU sends sensed data to the sink node via vehicular nodes which is selected using mathematical linear programming. The proposed mathematical linear programming considers distance metric to select vehicular node.

B. COLLISION AVOIDANCE

Al-Absi *et al.* [41] have introduced efficient mechanism for vehicular communication. In order to reduce data collision among different vehicles, distributed MAC mechanism is introduced. It provides individual time slots to each vehicle thus reduce the collision effectually. Therefore, it enhances the throughput via reducing the collision.

Sahoo and Sheu [42] have suggested collision free MAC for data transmission. Here, CSMA slots are allocated to each node in order to reduce the collision due to transmission of packets in at same time. In addition to it, it also generates 3D markov chain methodologies to investigate the throughput of the network. In order to allocates slots to the vehicles.

Rajeshwar Reddy and Ramanathan [43] have introduced an efficient MAC layer based data communication in vehicular network. Here, CSMA/CA algorithm is utilized to provide time slots to the vehicles. During the allocated time slots period, vehicles transmit their data to its head node thus reduces the data collisions.

Nie *et al.* [44] have offered quality based data gathering in VSN. Here, two algorithms are utilized that are Deviation Detection (DD) and Mixed Integer Linear Programming (MILP). MILP algorithm achieves optimal solution by collecting all data form the vehicles whereas DD algorithm achieves efficient solution by updating vehicle frequency and proportion of the vehicles.

Yuan *et al.* [45] have suggested cost effective sensing in VSN. Cost effective sensing model utilizes the probabilistic matrix model to reveal the status of the environment. The matrix factorization technique is used to decrease the amount of uncertainty exist in an unsensed data. With spatial temporal correlation of the sensed data, sensing task is only allocated to the small subset of sensing area.

Lyu *et al.* [46] have offered the efficient congestion control in the vehicular network. It utilizes the two machine learning algorithms for link perception learning such as Naïve Bayes and Support Vector Machine (SVM). Apart from these algorithms, it also utilizes the TDMA method to allocate timing slots to the vehicular nodes to transmit their data packet to congestions.

Zakaria *et al.* [47] have proposed new model for enhancing the throughput of the network through re-configuration processes. Here, the new algorithm contributes on re-routing and channel assignment in wireless mesh network in order to reduce the re-configuration and increase the throughput.

C. SAFETY MESSAGE BROADCASTING

Sarmad Shah *et al.* [48] have pointed out Time Barrier based Emergency Dissemination (TBED) in vehicular network. In this, emergency data is disseminated through time barrier mechanism which reduces the dissemination overhead. This method works based on the super node according to timely disseminate the safety messages. Using this approach farthest node rebroadcast the message which can more distance.

Tian *et al.* [49] have introduced the emergency message broadcasting using the Distributed Position based Protocol (DPP) in vehicular network. Here, enhanced location based protocol is utilized to broadcast the emergency message among huge scale vehicular environment. Using these proto-col emergency messages is only broadcasted to the interested region and rebroadcast of the messages is based on the information incorporated in the communication.

More *et al.* [50] have suggested an Efficient Message Broadcasting (EMB) in vehicular network. In this, emergency message broadcasted via selected optimal disseminator through the computation of weight value. Herein, weight factor is computed using average speed metric. The vehicle with good score is selected as the best disseminator for emergency messages.

Bi *et al.* [51] have introduced Safety Message Broadcast (SMB) systems in vehicular network. Multiple MAC layer protocols are investigated in this work such as cluster based broadcast, neighbor knowledge based broad-cast, probability based broadcast, cross layer based broad-cast and location based broadcast.

Feng *et al.* [52] have introduced Safety Message Broadcast Strategy (SMBS) in vehicular network. Safety message is transmitted by electing optimal forwarder. Optimal forwarder is elected based on the priority of each vehicle. Highest priority vehicle broadcast the safety message to the neighbor vehicle in order to transmit safety in-formation to all neighbor vehicles.

Zhang *et al.* [53] have suggested an Adaptive Link Quality based Safety Message (ALQSM) dissemination method in vehicular network. In this, the score oriented priority distribution method is utilized to select an optimal forwarder. This reduces the contention during emergency broadcasting among different vehicles.

Chaqfeh *et al.* [54] have pointed out efficient safety data dissemination in vehicular network. For which, it proposes the Multi directional Data Dissemination Protocol (MDDP). MDDP disseminates the safety message based on the consideration of position of the vehicles. MDDP broad-cast safety message effectually in order to avoid frequent vehicle accidents.

Balador *et al.* [55] have offered the supporting beacon based event driven message transmission in the vehicular network. It proposes the three distinct methods for the event driven message transmission. They are dedicated phase for event-driven messages, event-driven message transmission without token, and event-driven message transmission upon token reception.

Hoang *et al.* [56] have presented efficient message dissemination techniques under emergency condition. Here, the emergency messages are disseminated with the aid of the relay present in the network. It also sets the time slots to reduce the delay occurred during the emergency dissemination.

Nguyen *et al.* [57] have concentrated on the Store Carry Forward (SCF) scheme for the emergency message dissemination. Herein, source vehicle sends warning message to the SCF vehicles that are exists in its communication range. SCF vehicle broadcast warning message to its neighbors and carries this information until it new neighbor is arrived.

D. RESEARCH GAPS IN EXISTING WORKS

This section describes the research gaps of aforesaid studies related to the vehicular network. Table 1 illustrates the research gaps of the existing works in terms of clustering, collision avoidance and emergency dissemination.

TABLE 1. Research gaps of existing works.

Topics	Methods	Research Gaps
Clustering	DHC, DBDC, GWO, UFC, AWC, RWCP	Cluster formation is inconstant; this leads to frequent formation of clusters and link losses.
Collision Avoidance	Distributed MAC, CSMA/CA, MILP	Fixed time slot; this leads to slot wastages and collisions.
Safety Broadcasting	TBED, EMB, DPP, SMB, SMBS, ALQSM, MDDP	Heavy broadcast storm; since blind broadcasting procedures is used.

From above discussed studies, it is noticed that none of the works have concentrated on clustering with respect to collision avoidance. These limitations are resolved in our proposed NSSC method with effective algorithms.

III. PROBLEM DEFINITION

In this part, we deliberate the problems that are present over the VSN environment in detail. Our network comprises of vehicles ($v_1, v_2, \ldots v_n$), Road Side Sensors (RSS) ($RSS_1, RSS_2, \ldots RSS_n$), RSU and Sink node.

In this work, we define two major problems that are broadcast storm (occurred during safety message broadcasting) and data collisions (occurred during data transmission among vehicles). These problems are discussed in upcoming studies. We initially concentrated on problems that are happened by partitioning the VSN network [38]. This way of partitioning the network is only applicable to the unobstructed scenarios thus reduces the network performance. Distance based relay selection leads to loss in sensed data transmission due to breakable communication between relay vehicles and RSU [39], [40]. Sensed events are initially classified in vehicular nodes and again it is classified in RSU. This way of classifying the event tends to high complexity in decision making and also consumes more bandwidth [58]. During safety message broadcasting, vehicular nodes receive many duplicate warning messages thus leads to broadcast storm [57]. It also induces data collisions during transmission of packets. In order to model problems that are exists in previous VSN, our proposed NSSC method expect to reach succeeding objectives that are:

- Formation of stable clusters in VSN to tackle bottlenecks related to the frequent link losses and CH rotations.
- Minimizing collisions during data transmission between CM and CH
- Reducing broadcast storm while broadcasting safety message to the neighbor vehicles.

IV. NSSC MODEL

This NSSC model describes the proposed method in detail with our proposed algorithms.

A. SYSTEM OVERVIEW

The major hurdles in safety message dissemination and data transmission is resolved in proposed NSSC method. Our network comprises of four types nodes that are Vehicles with Active Sensor Node, RSS (Passive Sensor Node), Road Side Unit (RSU) and Sink node in figure 2. Our network is divided into multiple stable clusters in order to avoid frequent link losses. To attain this, proposed model implements VbC scheme that elects CH using CCS algorithm using two different metrics that are Mobility and Connectivity metrics. Mobility metric is updated using Circle Variant and Connectivity metric is updated using Gauss Variant. In order to avoid data collision occurred during transmission of data between CH and CM, our method proposes Ada-CSMA/CA algorithm with adaptively change the back-off time by considering buffer size. To broadcast safety message without broadcast storm, Segment based SFS scheme is carried out which selects optimal forwarder using FV algorithm with succeeding metrics consideration that are node degree, position, forwarding probability and delay.

B. CLUSTERING

Primarily cluster is formed using the VbC scheme which comprises of two sequential processes that are CH selection and cluster formation.

1) CH ELECTION

CH is elected using CCSA algorithm which is new natural inspired optimization algorithm which is inspired by the crow search mechanism for hiding their food. Our CCSA algorithm incorporates chaotic theory in order to avoid local optimal solution in CH election. Chaotic theory comprises of different chaotic maps where we select two best chaotic variants that are circle and gauss.

To the best of our knowledge, we are first in using CCSA in VSN to elect optimal CH. Here, CH is elected based on the two different metrics that are mobility and connectivity metrics. Mobility (M_m) metrics are relative position, speed and maximum acceleration. Connectivity (C_m) metrics are node connectedness and PDR. These metrics are described as follows:

a) Relative position (R_p) - It is used to measure the position traversed by a vehicle over a certain period. Since, high mobility of vehicle affects the stable cluster formation.

b) Speed ($\mathcal{s}$) - It is significant metric to evaluate the speed of the vehicle. Since, high speed vehicle induces frequent selection of CH. By considering this parameter, our VbC scheme avoids frequent selection of CH.

c) Maximum Acceleration (Max_a) - It defines the rate of change of speed of the vehicle with respect to the time. It is used to support stable cluster formation in high mobile environment of our VSN.

d) Node Connectedness ($\mathcal{N}_c$) – Node connectedness metric is used to evaluate the count of the neighbor nodes. This metric is used to select an optimal CH with high communication capabilities.

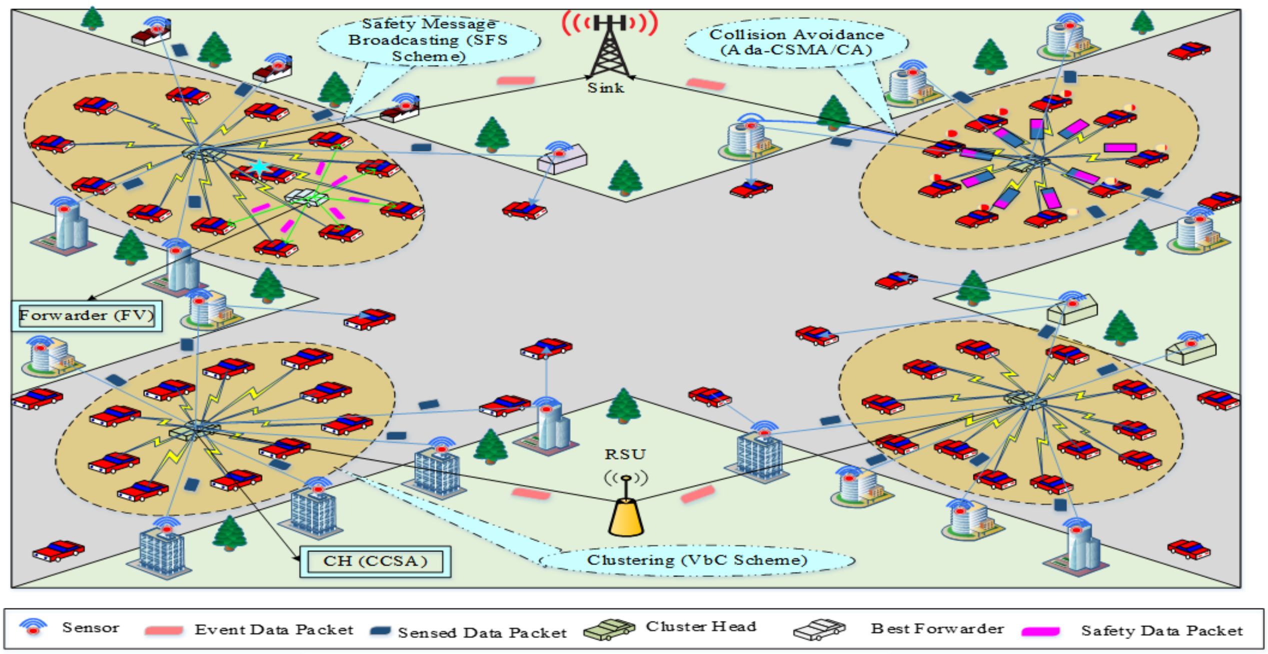

FIGURE 2. **Architecture for NSSC.**

e) PDR – PDR metric is used to know the packet delivery capability of the vehicular node. With the aid of this metric, we select optimal CH with high PDR rate.

With the consideration above parameters, CCSA selects an optimal CH. CCSA begins with setting adjustable parameters and crow positions (y) are initializes randomly. Fitness function is evaluated using below expression:

$$F(y) = \frac{\mathcal{N}_c + PDR}{Max_a + R_p + s} \tag{1}$$

The new position of the crow is updated using the two chaotic variants such as circle and gauss. Here, circle variant is used to update the mobility metric and gauss variant is used to update the connectivity metric. Circle variant is expressed as follows:

$$P_{y+1} = mod(P_y + d - \left(\frac{e}{2\pi}\right) sinc(2\pi P_y)) \tag{2}$$

where, $d = 0.2, e = 0.5$. Gauss variant is expressed as follows:

$$P_{y+1} = \begin{cases} 1: & P_y = 0 \\ \dfrac{1}{mod(P_y|1)}: & Otherwise \end{cases} \tag{3}$$

With the usage of these two variants, CCSA updates the crow positions. These variants are performed well in updating of crow new position compared to other variants in the chaotic theory and also provide high accuracy in CH election.

Algorithm 1 illustrates the CH election procedure of proposed CCSA briefly. From this procedure, VbC scheme elects optimal CH.

Algorithm 1 for CCSA

Initialize—*m, AP, fl and tMax*
Initialize—Crow position y randomly
Evaluate—fitness using equ. (1)
While($t < tMax$)
{
For(j=1: j≤ m)***do***
{
Get—chaotic map K.
If ($K_i \geq AP^{i,t}$) **then**
$y^{j,t+1} \leftarrow y^{j,t} + K_j \times fl^{j,t} \times (N^{i,t} - y^{j,t})$
Else
$y^{j,t+1}$ ←Random position of search Space
}
Check—feasibility of the $y^{j,t+1}$
Evaluate— new crow position ($F(y+1)$)
Update—crow position using equ. (2) and equ (3)
}
Best CH.

2) CLUSTER FORMATION

After completion of CH election, stable cluster is formed in order to avoid frequent link losses. Elected CH broadcasts the election message to its neighbor nodes. Neighbor node transmit join request to its CH. CH receives join request and estimates link stability of the neighbor node. Highest link stability node only selected as CM. Link stability is estimated using the below expression,

$$L_s = \int (di * f(\mathbb{t})) \tag{4}$$

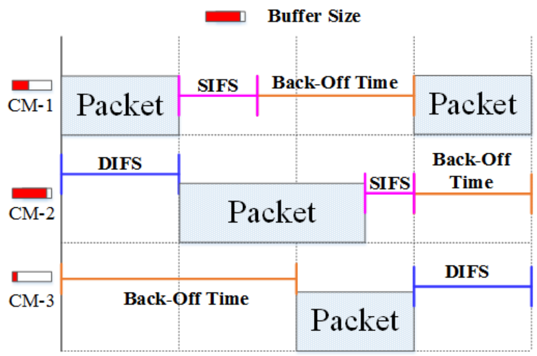

FIGURE 3. Ada-CSMA/CA procedure.

where, *di* represent the distance between the CH and neighbor node. $f(t)$ represents the duration of the link being connected over time t. This way of forming clusters results in stable communication between CH and CM. As a result, we avoid data losses and also enhance the throughput and PDR in data transmission.

C. COLLISION AVOIDANCE

In order to reduce the data collisions occurred during the transmission between CH and its CMs, our NSSC method proposes Ada-CSMA/CA algorithm.

Proposed Ada-CSMA/CA algorithm executed in the CH which allocates back-off time for each member in adaptive manner. Here, back-off time for each member is allocated based on the buffer size of each member. Buffer size parameter is used to evaluate the number of the packets to be transmitted in upcoming transmission. It can be evaluated using below expression,

$$B_s = \frac{P_n}{Q_l} \tag{5}$$

where, P_n represents the total number of packets and Q_l represents the total queue length. In addition to it, CH also changes the contention window size adaptively based on the presence of vehicles in each cluster. Hence, our NSSC method performed well for both high and low density scenario.

Figure 3 demonstrates the procedure of Ada-CSMA/CA algorithm where three CM are considered. From the above figure, it is noticed that CM-1 has high buffer size. Hence, it has low back-off time to transmit its packet to the CH. And then, CM-3 has very low buffer size, so that it has high back-off time compared to the other members CM-1 and CM-2. DIFS is DCF Inter Frame Spacing (DIFS) which is defined as the time delay before transmitting packets to the destination. SIFS is Shortest Inter Frame Spacing which is described as the time delay after transmitting packet to the CH. This way of transmitting sensed data to the CH avoids data collisions during transmission.

Thus, enhances the performance of NSSC in terms of successful data transmission.

D. SAFETY MESSAGE BROADCASTING

Safety message broadcasting is significant process in VSN in order provide safety driving to the vehicular users. To address the broadcast storm problem in safety message broadcasting, our proposed method executes the SFS scheme which selects optimal forwarder to broadcast safety message.

If any vehicle supposed to accident in the road, then it implements SFS scheme to broadcast safety message to its member. SFS scheme initially segments the transmission range into the square region as depicted in figure 4. And then, it divides the square region into two that are front and back regions. Furthermore, these regions are split into left and right diagonal regions.

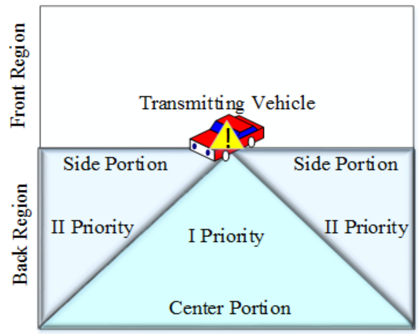

FIGURE 4. Segment of transmission range of source vehicle.

The prime benefit of segmenting transmission range into square is to evade the transmissions of the same data packet by the neighbor vehicles (that are close to each other) located in the different segments. We focus on back region of the segmented square since, safety message is necessary to the vehicles that are moving towards the accidental area. Back region comprises of three portions that are center portion and two sider portions.

Figure 5 depicts the safety message broadcast mechanism of out proposed NSSC. Vehicles present in the center portion are most appropriate and adequate to carried out safety message broadcast process with reduced number of transmissions. From the center portion, we select optimal forwarder using FV algorithm. If center portion does not have any vehicle, then we select forwarder from the side portion in parallel manner which reduces the latency in safety message broadcasting. FV algorithm is fuzzy hybrid Multi-Criteria Decision Making (MCDM) model. Here, fuzzy is used to compute weight for each criterion (C). Here, we consider four metrics to select optimal forwarder that are node degree, position, forwarding probability and delivery delay. These metrics are described as follows:

1 Node degree (C_1): It is significant metric in forwarder selection. Since, it defines the ability of vehicle to broadcast safety message to the wide range of vehicles.
2 Position (C_2): It is used to know the current speed of the vehicle since selection of high-speed vehicle leads to reduction in reachability.

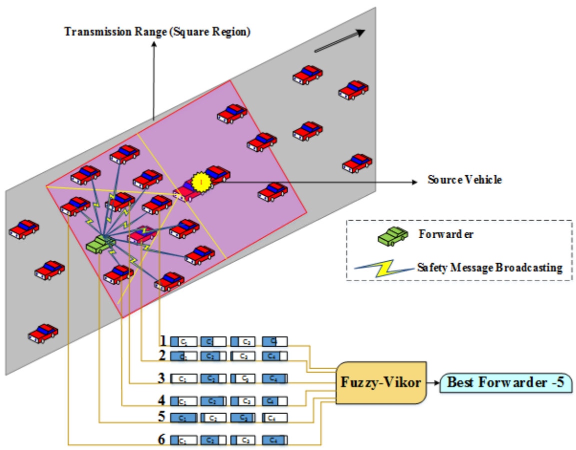

FIGURE 5. Safety message broadcast mechanism.

3 Forwarding Probability (C_3): It is used to select forwarder with high forwarding ability. This metric is considered because most of the vehicles does not having capability to forward the vehicle.

4 Delivery Delay (C_4): This metric is used to estimate the delivery delay of the vehicle to broadcast the safety message.

It plays vial role in reducing latency in safety message broadcasting.

Decision matrix of FV algorithm is expressed as follows:

$$X = \begin{matrix} A_1 \\ A_2 \\ A_n \end{matrix} \begin{bmatrix} x_{11} & x_{12} & \ldots x_{1n} \\ x_{21} & x_{22} & \ldots x_{2n} \\ x_{m1} & x_{m2} & \ldots x_{mn} \end{bmatrix} \tag{6}$$

where, $A_1, \ldots A_m$ indicates the alternatives to be chosen and C_1, C_2, C_3, C_4 indicates the evaluation criteria.

The fuzzy weight values for each criterion are calculated based on the importance of the each criterion. Weight of each criterion is estimated using the below expression,

$$\tilde{W}_i = \frac{\tilde{S}_i}{\sum_{i=1}^{n} \tilde{S}_j} \tag{7}$$

where, $\tilde{S}_i$ indicates the standard deviation for each criterion. It can be estimated as follows:

$$\tilde{S}_i = \sqrt{\frac{1}{Z} \sum\nolimits_{i=1}^{Z} (\tilde{x_{in}} - \bar{\tilde{x}}_n)^2} \tag{8}$$

where, $\bar{\tilde{x}}_n = \frac{1}{Z} \sum_{i=1}^{n} \tilde{x_{in}}$, Z represents the total number of alternatives. Fuzzy best ($\tilde{x}_j^+$) and worst values are estimated using below equations,

$$\tilde{x}_j^{+} = \max_i \tilde{x_{ij}} \tag{9}$$

$$\tilde{x}_j^{-} = \min_i \tilde{x_{ij}} \tag{10}$$

Linear normalization of the fuzzy matrix is represented by the score values $\tilde{H}_i$ and $\tilde{G}_i$ as follows:

$$\tilde{H}_i = \sum\nolimits_{i=1}^{n} \tilde{W}_i \left(\frac{\tilde{x}_j^{+} - \tilde{x_{ij}}}{\tilde{x}_j^{+} - \tilde{x}_j^{-}}\right) \tag{11}$$

$$\tilde{G}_i = \min_i \left[\frac{\tilde{x}_j^{+} - \tilde{x_{ij}}}{\tilde{x}_j^{+} - \tilde{x}_j^{-}}\right] \tag{12}$$

Based on these expressions index VIKOR is estimated which is computed as follows:

$$\tilde{Q}_i = u\frac{\tilde{H}_i - \tilde{H}^-}{\tilde{H}^+ - \tilde{H}^-} + (1-u)\frac{\tilde{R}_i - \tilde{R}^-}{\tilde{R}^+ - \tilde{R}^-} \tag{13}$$

where, u represent the weight in the strategy of maximum group utility which is assigned as a value of 0.5. These values are arranged in descending order in order to rank each alternative. Lastly, high rank vehicle is elected as forwarder to transmit the safety message to its neighbor vehicle. This way of broadcasting safety message avoids broadcast storm, reduces latency and also enhances the reachability.

V. EXPERIMENTAL RESULTS

In this part, detailed analysis and investigations of proposed NSSC method is discussed. For this purpose, this section is further divided into four aspects that are simulation scenario, validation metrics, comparative analysis and results discussion.

A. SIMULATION SCENARIO

Our NSSC method is implemented in Omnet++ (Network Simulator) and SUMO (Traffic Simulator) with veins model. Veins model is capable to execute both SUMO and Omnet++ in analogous manner. Veins framework incorporates a comprehensive models to make vehicular network simulations as realistic as possible without losing speed. Parameters that are utilized in simulation environment are discussed in table 2.

Figure 6 demonstrates the simulation environment of proposed NSSC method. It comprises of passive sensor nodes, vehicles with active sensor nodes, RSU and Sink nodes.

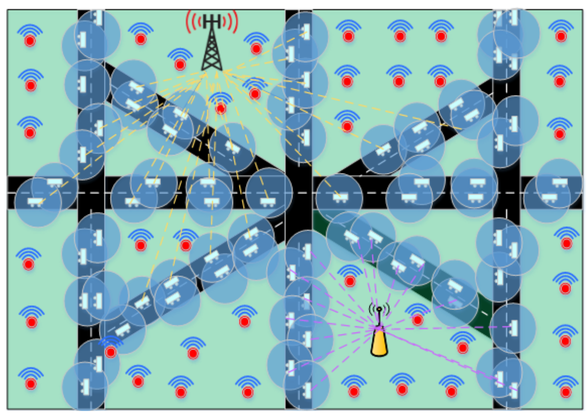

FIGURE 6. Simulation environment of NSSC.

Our simulation environment comprises of 100 vehicular nodes, 200 sensor nodes, 1 RSU and 1 Sink node over 2.5Km range of simulation area. The vehicular nodes present in the VSN are transmit their sensed data to the RSU or Sink node using a one hop communication through Cluster head node. In simulation network, vehicles follow TraCI mobility

TABLE 2. Simulation parameters.

Parameters	Value
Simulation Area	2500*2500M
Simulation Time	800S
Simulation versions	
Omnet++	4.6
SUMO	0.21.0
Veins	4.7
Network Model	
Number of vehicles	100
Number of RSU	1
Coverage area of the RSU	1000*1000M
Number of Sink	1
Number of Sensor Nodes	200
Communication Standard	IEEE 802.11P
Mobility Model	
Mobility Model	TraCI Mobility
Propagation Model	Nakagami
Vehicle Mobility	50km/hr. (Max.)
Transmission Range	250m
Packet Model	
Traffic Type	Constant Bit Rate (CBR) with TCP/UDP
Total Number of Packets	20000 (approx.)
Number of Safety Packets	1000 (approx.)
Packets Interval	1s
Packet Size	512bytes
CCSA Parameters	
M	32
fl	4
AP	0.15
Upper Bound	1
Lower Bound	0
tMax	52

to move along the road sides. In this, vehicles are communicating through IEEE 802.11p standard which comprises of greater potential including the huge data rate, low latency, and so on.

B. VALIDATION METRICS

The performance of NSSC is evaluated using six validation metrics that are reachability, average number of collisions, duplicate data packets, latency, packet delivery ratio and throughput.

1) REACHABILITY

This metric demonstrates the capability of the method in terms of number of vehicles that are conscious of an event. In general, reachability is described as the proportion of vehicles that are efficaciously acquiring the broadcasted data packets ($S_{r,v}$) with respect to the total number of reachable vehicles (T_v). This is mathematically illustrated as follows:

$$Reachability = \frac{S_{r,v}}{T_v}. \tag{14}$$

2) AVERAGE NUMBER OF COLLISIONS

It signifies the average number of collided data packets. This metric is used to measure the successful data transmission potential of the proposed method.

$$Average\ Number\ of\ Collisions = \frac{C_p}{t_p} \tag{15}$$

where, C_p indicates the collided packets and t_p indicates the total number of transmitted packets.

3) DUPLICATE DATA PACKET

This metric is significant to investigate the robustness of the proposed safety message broadcasting scheme. It designates the average number of duplicated data packets that are acquired in each vehicle within the safety zone region of the VSN.

4) LATENCY

It is noteworthy metric to estimate the efficacy of the NSSC safety message broadcasting model in regards of the delay. This metric represents the time spent by a broadcasted data packet from its origin vehicle to the designated vehicle through network.

$$Latency = \frac{P_s}{R_t} \tag{16}$$

where, P_s indicates the size of the packet and R_t indicates the transmission rate.

5) PDR

It is utilized to compute the performance of the NSSC work in terms of the successful data delivery. It represents the ratio of the successfully received packets at the destination vehicle ($S_{d,v}$) with respect to the number of generated packets at source vehicle ($t_{s,v}$). It can be expressed as follows:

$$PDR = \frac{S_{d,v}}{t_{s,v}} \tag{17}$$

6) THROUGHPUT

This metrics designates the amount of data effectively transferred between source and destination vehicle in given time period. This metric illustrates the efficacy of the proposed method in terms of the packet transmission. It is generally estimated in bits every second or packets every second. It can be expressed as follows:

$$Throughput = \frac{N_b}{\mathcal{T}} \tag{18}$$

where, N_b represents the number of packets transmitted in $\mathcal{T}$ specific time period.

C. COMPARATIVE ANALYSIS

This section compares the simulation results of existing methods and our proposed method with the use of six validation metrics as discussed earlier. We compare our proposed method with existing methods including EDGE [38], ICO [39], HSVN [40], TBED [48] and SCF [57].

1) ANALYSIS ON REACHABILITY

Reachability metric is used to evaluate the performance of safety message broadcasting scheme of proposed NSSC. Performance of the reachability is simulated by varying number of vehicles.

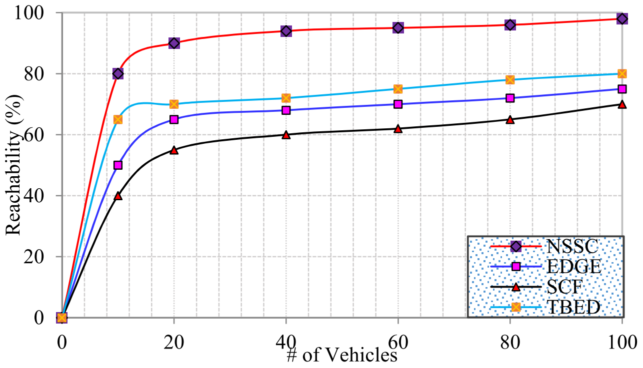

FIGURE 7. Comparison on reachability.

Figure 7 shows that comparison of reachability with respect to the existing methods EDGE, TBED and SCF. NSSC method shows better performance by attaining maximum reachability expressly at increase in number of vehicle. By reason of pursuing novel SFS scheme. It selects the best forwarder to broadcast safety message to the neighbor vehicles that avoids broadcast storm problem. For this purpose, it carried out FV algorithm which provides better performance in selecting optimal forwarder. By contrast, existing methods like EDGE and SCF achieves less reachability compared to NSSC. This is because of their poor performance in safety message broadcasting. SCF achieves low reachability since it simply broadcast safety message to all vehicles present over the emergency zone thus leads to broadcast storm. Meanwhile, EDGE and TBED also achieves less reachability due to lack of emergency detection over its surrounding. Thus reduces the reachability compared to the proposed NSSC.

2) ANALYSIS ON DUPLICATE DATA PACKET

Duplicate data packet metric provides the robustness of the NSSC in terms of the broadcasting the safety message. In accord to validate this metric, we simulated by varying number of vehicles.

Figure 8 demonstrates that performance of NSSC is better compared to the existing methods. This is because of our novel SFS scheme. If any accident or emergency situation is known by vehicle, then it segments communication range into square form. And, it selects optimal forwarder from the back region of the square segment.

Since, safety message must be dispatched to the vehicles that are moving in the direction of emergency region. Finally selected forwarder only transmits safety message to the neighbor vehicles. Thus reduces the duplicate data packet reception in vehicles. By contrast, EDGE, TBED and SCF methods achieves high duplicated data packet receiving ratio

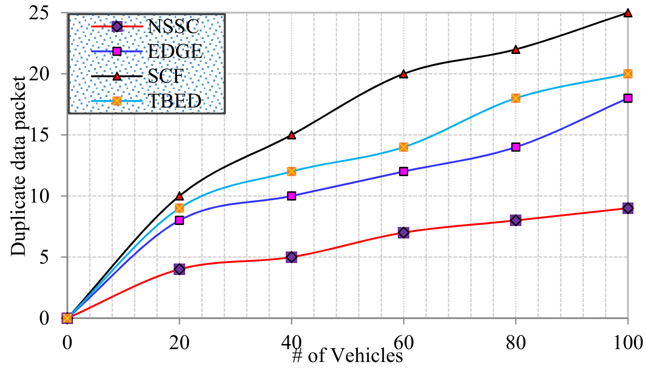

FIGURE 8. Comparison on duplicate data packet.

compared to the proposed NSSC. The reason for this is that, safety message is broadcasted by all vehicles that are present over the emergency area. As a result, number of duplicate data packet receiving is increased drastically. From this analysis, we conclude that our method achieves less data duplicate data packet reception compared to existing methods.

3) ANALYSIS ON LATENCY

Latency metric is noteworthy in safety message broadcasting which evaluates the performance of NSSC in terms of the time. For this purpose, we validated performance of latency by varying number of vehicles in the network.

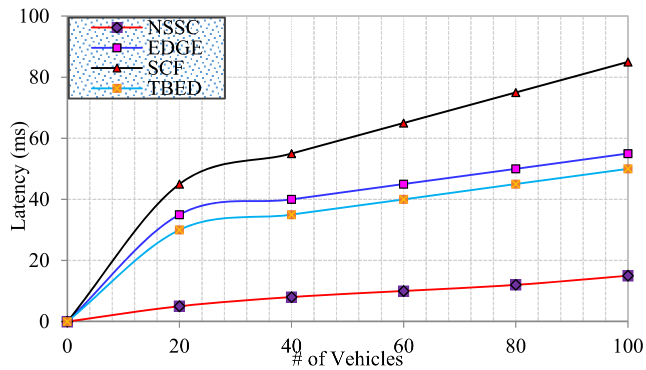

FIGURE 9. Comparison on latency.

Figure 9 demonstrates that simulation results comparison of NSSC and existing methods in terms of the latency. It is observed that, performance of the NSSC is better compared to the existing methods including EDGE, SCF and TBED. This is because of selecting optimal forwarder in SFS scheme. For this purpose, it executes FV algorithm which considers succeeding metrics to select optimal forwarder that are node degree, position, forwarding probability and delay. Here, delay metric is used to reduce the broadcasting latency. This way of selecting forwarder results in less latency in safety message broadcasting of NSSC. Meanwhile, existing methods like SCF and EDGE achieves high latency in safety message broadcasting. Due to lack of optimal forwarder selection in safety message broadcasting that leads to increase

TABLE 3. Comparisons on efficiency of safety message broadcast mechanism.

Author	Method	Key Objective	Research Remarks [Average]		
			Reachability (%)	Duplicate Data Packet	Latency (ms)
Wang et al. [38]	EDGE	To gather and estimate sensed data	70	12	45
Truc et al. [57]	SCF	To employ store carry forward scheme	62.4	18	65
Syed et al. [48]	TBED	To timely disseminate emergency message	75	15	40
Proposed METHOD	NSSC	To mitigate broadcast storm and data collision	**95**	**5**	**10**

in latency. In contrast, TBED method achieves less latency compared to the SCF and EDGE methods, since it selects best forwarder node to broadcast safety message. Even though, latency of TBED is high compared to the NSSC owing to lack of parameter consideration. It is seen that performance of the NSSC is better in latency compared to the SCF, EDGE and TBED methods. The table 3 defines the comparisons on efficiency of safety message broadcasting of proposed NSSC and existing methods SCF, EDGE and TBED.

4) ANALYSIS ON AVERAGE NUMBER OF COLLISION

Average of number of collision metric plays substantial role in sensed data transmission which signifies NSSC performance in terms of the collision. This metric performance is validated by varying the number of vehicles.

Figure 10 describes the comparison of NSSC and existing methods such as EDGE, ICO, SCF, TBED and HSVN. It is noticed that, proposed NSSC method achieves better performance compared to the other existing methods. The reason for this that, NSSC proposes Ada-CSMA/CA based collision avoidance mechanism which is executed by each CH in the network. It allocates time slots to its member with the aid of Ada-CSMA/CA. Here, Ada-CSMA/CA changes the back off time adaptively for each member based on its buffer size. Thus reduces the data collision effectively and provides proper number of slots to each member without wastage and contractions. In the meantime, existing methods like ICO, SCF, TBED and HSVN doesn't concentrate on the proper data transmission and collision avoidance techniques. It transmits sensed data without consideration problem of being collide thus induces more losses in transmitted sensed data.

Likewise, EDGE also achieves high data collision owing to lack of proper data transmission between vehicles. Therefore, our NSSC performance better in reducing average number of collisions as compared to the existing methods.

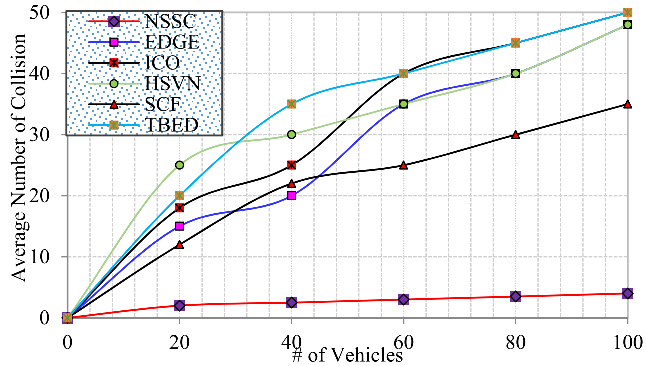

FIGURE 10. Comparison on average number of collision.

5) ANALYSIS ON PDR

PDR metric is important to validate the performance of NSSC in regards of the successful packet delivery. According to validation, PDR is evaluated under modifying number of vehicles in the network.

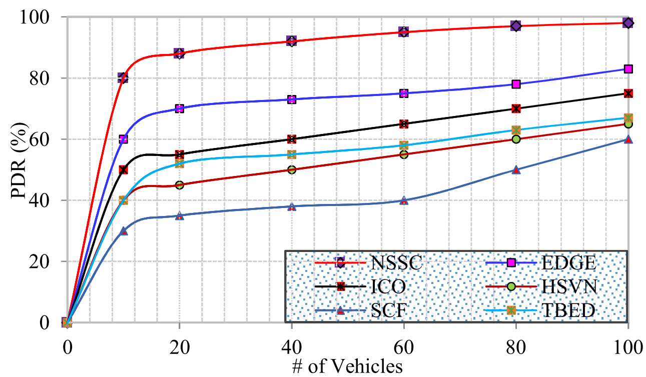

FIGURE 11. Comparison on PDR.

Figure 11 represents the performance comparison of NSSC in terms of PDR. From this figure, it is perceived that PDR is increased as increase in the number of vehicle. The reason for this is that the growth in the number of vehicles improves the probability of vehicles being connected with the network thus in turn avoids the link losses. PDR of the NSSC is high since our method establishes stable clustering by using VbC scheme. VbC scheme selects best CH using CCSA algorithm and then cluster is formed in stable manner. This way of performing clustering leads to the reduction in frequent link losses among CH and CM which tends to increase in PDR. Whereas, existing methods like EDGE, ICO, SCF, TBED and HSVN are obtained less PDR compared to NSSC. This is because of occurring of concurrent link losses due to high mobile nature of vehicle. Frequent link losses reduce the packet delivery by inducing packet losses. As a result, existing methods achieves less PDR compared to the NSSC.

6) ANALYSIS OF THROUGHPUT

Throughput metric is noteworthy process to the measure the performance of NSSC in terms of the data transmission over network. In regard to measure performance of the throughput, we simulated by varying density of the vehicles.

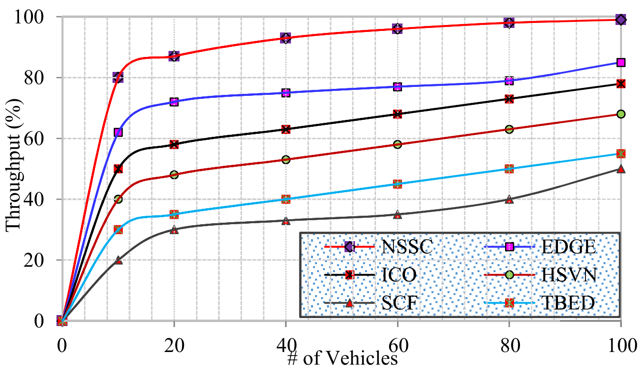

FIGURE 12. Comparison on throughput vs # of vehicles.

Figure 12 exemplifies the comparison of simulation results with respect to the existing and NSSC methods. From this figure, it is observed that throughput is increased with respect to the increase in vehicular density. It is happened due to enhancement in ability of data transmission while increase in vehicle. Our NSSC method forms cluster based on the link stability metric thus upsurges the number of successful data transmission in the designed network. And CH is elected based on the mobility and connectivity metrics that avoids frequent CH rotations. Hence, NSSC reduces the frequent formation of the clusters via forming stable clusters. Therefore, NSSC achieves high throughput compared to the existing methods. Meanwhile, existing methods like EDGE, ICO, SCF, TBED and HSVN. Since, these methods don't rely on link oriented parameters while transmitting packets to the designated node. Consequently, there exist frequent link losses during packet transmission. As a result, existing methods achieve less throughput compared to the proposed NSSC. The table 4 illustrates the comparisons on efficiency of network performance of proposed NSSC and existing methods EDGE, ICO, SCF, TBED and HSVN.

Figure 13 shows the comparison of the throughput performance with the speed of the vehicle. From this figure, it is perceived that performance of the proposed NSSC is better when increase in the speed of the vehicle. This is because of our proposed CCSA based clustering process.

It selects optimal cluster head and forms the clusters effectually. This way of forming the clusters avoids the frequent link breakages among the vehicles. Thus improves the performance during the data transmission. Besides, we transmit the sensed data packet to the sink node or RSU through the cluster head node only. Besides, our proposed safety message dissemination also avoids collision during dissemination. This way of transmitting the data packets provides better throughput in the network. On the contrary, the existing methods like ICO, SCF, HSCN and TBED achieves less throughput when increase in the vehicle speed. This is because of their poor clustering process or lack of clustering process in the data packet transmission. And, their emergency

TABLE 4. Comparisons on efficiency of network performance.

Author	Method	Key Objective	Research Remarks [Average]			
			Avg. # of collision	PDR (%)	Throughput (%)	
					# of vehicles	Vehicles speed
Wang et al. [38]	EDGE	To gather and estimate sensed data	31.6	75	77	73
Truc et al. [57]	SCF	To employ store carry forward scheme	25	45	38	31
Syed et al. [48]	TBED	To timely disseminate emergency message	38	59	45	40
Hu et al. [39]	ICO	Relay assisted data transmission	35.6	65	68	62
Sadou et al. [40]	HSVN	To perform effective message delivery	36	55	58	52
Proposed Method	NSSC	To mitigate broadcast storm and data collision	**3**	**94**	**94**	**91.8**

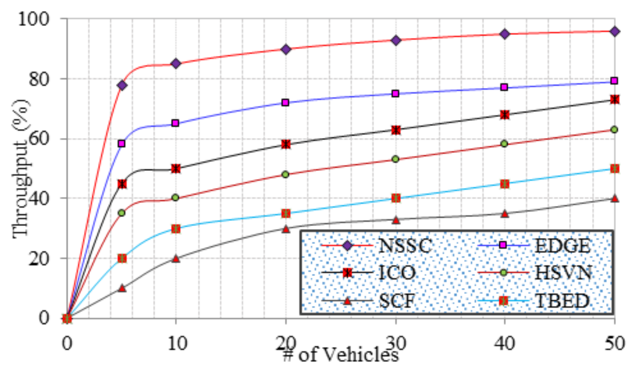

FIGURE 13. Comparison on throughput vs vehicles speed.

dissemination process also produces high data collisions. Hence, these methods achieve less throughput compared to our NSSC method.

From table 4, we noticed that our NSSC method outperforms other existing methods such as EDGE, ICO, SCF, TBED and HSVN. This shows efficiency of our NSSC method in network performance.

D. RESULTS DISCUSSION

This part deliberates the discussions on results obtained from simulation. Based on the validation results, proposed NSSC has performed as compared to the other techniques such as EDGE, ICO, SCF, HSVN and TBED. Our NSSC method increases reachability up to 30% compared to the existing EDGE and SCF method.

This is owing to the fact that the proposed NSSC is based on the SFS scheme which competes well in reachability. NSSC method reduces duplicate data packet up to 50% as compared to the existing methods EDGE and SCF. Due to usage if FV algorithm which selects optimal forwarder to broadcast safety message. The main hurdle in data transmission is collision which is reduced by NSSC up to 30% compared to the existing methods EDGE, ICO, SCF, TBED and HSVN. This is happened because of proposed Ada-CSMA/CA based collision avoidance technique which allocates slots to each CM based on their buffer size. Latency is major issue in safety message broadcasting which is decreased in NSSC method up to 55% compared to the TBED, EDGE and SCF methods. Since, we select optimal forwarder by considering multiple parameters which includes delay parameter also. Thus results in faster broadcasting of safety message to the neighbor vehicles. Our NSSC enhances PDR and throughput up to 30% compared to the other techniques including EDGE, ICO, SCF, TBED and HSVN methods. Owing to formation of stable clusters over network that avoids frequent link losses between vehicles.

VI. CONCLUSION

As a step toward designing of efficient VSN with reduced data collisions and broadcast storm, this paper proposes the NSSC. This comprises of three major processes that are clustering, collision avoidance and safety message broadcasting. In order to establish the stable clustering in VSN, NSSC method introduces VbC scheme which select optimal CH using CCSA algorithm and forms clusters with the consideration of link stability metric. Data collision avoidance is a major hurdle in VSN since it has frequent data transmission. In order to avoid this, NSSC executes Ada-CSMA/CA algorithm which allocates back-off time based on the buffer size. It also adjusts the contention window size based on the number of vehicles in cluster which improves the NSSC performance in high density scenario. Safety message broadcasting is executed through SFS scheme which selects optimal forwarder using FV algorithm in the squared region. As a result, broadcast storm is avoided during safety message transmission. At last, we validate the performance of the NSSC with six validation metrics that are reachability, PDR, throughput, latency, duplicate data packet and average data packet collisions. Performance of NSSC is compared with five existing methods such as EDGE, SCF, ICO, TBED and HSVN. From the comparison results, we conclude that our NSSC outperforms other existing methods.

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IBRAHIM S. ALKHALIFA received the bachelor's degree in computer science from the College of Computer and Information Sciences, Qassim University, in 2002, the first master's degree in advanced software engineering from the Advanced Informatics School, University Technology Malaysia, in 2008, and the second master's degree from the College of Engineering and Computing, University of South Carolina. He is currently pursuing the Ph.D. degree in computer science from the College of Computer and Information Sciences, King Saud University. He is also working with the Communication and Information Technology Research Institute, King Abdulaziz City for Science and Technology (KACST), Riyadh, Saudi Arabia, as an Academic Researcher. His research areas of interests are computer security, wireless sensor networks, and vehicular networks.

AHMAD S. ALMOGREN (Senior Member, IEEE) received the Ph.D. degree in computer science from Southern Methodist University, Dallas, TX, USA, in 2002. He worked as the Vice Dean of the Development and Quality with the College of Computer and Information Sciences (CCIS). He also served as the Dean for the College of Computer and Information Sciences and the Head for the Academic Accreditation Council, Al-Yamamah University. He is currently a Professor with the Computer Science Department, CCIS, King Saud University (KSU), Riyadh, Saudi Arabia, where he is also the Director of the Cyber Security Chair. His research areas of interests include mobile-pervasive computing and cyber security. He served as the General Chair for the IEEE Smart World Symposium and a technical program committee member in numerous international conferences/workshops, such as the IEEE CCNC, ACM BodyNets, and the IEEE HPCC.