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A Weight-Based Clustering Algorithm is Used by Military Vehicles for VANET Communication

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Every vehicle node in a vehicular ad hoc network (VANET) denotes a mobile node that serves as an information transmitter, receiver, and router. VANET belongs to the mobile ad hoc network (MANET) subgroup and is associated with dynamic topology. Finding a viable solution for all VANET applications is the researchers' main task because dynamic network situations provide more complex problems than MANET topologies do. Cluster-based, geocast-based, topology-based, position-based, and broadcast-based routing protocols make up the six categories of routing protocols used in VANET. Unmanned military vehicles (UMVs) and autonomous robots are used in the modern warfare strategy to carry out risky military combat tasks. The military vehicles (MVs) exchange information with one another in order to complete the necessary military missions as a group. The suggested work uses a weight-based clustering technique to partition a rhombus-shaped area into numerous clusters for the purpose of communicating event data to the cars. Rhombus-shaped areas at intersections are particularly useful for clustering. Real-time average speed and degree are two weighted measures that were employed in the suggested method to select the cluster head (CH). The right CH can be selected in the network with the help of this effort. Instead of broadcasting the data, each car in a cluster sends it to the CH. The network performance for various protocols, such as Ad-hoc on-demand distance vector (AODV) and dynamic source routing (DSR), has been simulated using the SUMO and NETSIM simulators. This performance is shown in terms of packet delivery ratio, throughput, delay, overhead transmission, mean, and standard deviation. According to the proposed weight-based clustering algorithm, the assignments of the weights are based upon two parameters: vehicle speed and degree. The speed corresponds to the instantaneous speed of a vehicle, while the degree corresponds to the number of nearby vehicles that the sensors are unable to communicate with. The vehicle, which has the highest weight for the combined factors is made the cluster head (CH). The weight is adjusted dynamically in order to adapt to the changing speed and the number of active neighbours in real-time. The weight is attained using the following formula: $WT(i) = w1 \times deg(i) + w2 \times \mu n$; where deg(i) corresponds to degree (number of neighbouring vehicles), and μn, normalised speed. The weighting factors w1 = 0.4 and w2 = 0.6 are set so that the degree has lesser effect than speed in the consideration of selection of the cluster head.

Keywords: V2V communication, Cluster Head, Military Vehicle communication, V2I communication.

I. INTRODUCTION

Vehicles are now equipped with computers on wheels thanks to the development of micro hops and wireless communication technologies, often known as On-Board units (OBUs). The OBU is made up of a microcontroller, a GPS, storage devices, sensor devices, and a wireless transmitter that supports VANET.

Vehicles can presently connect to other vehicles and secure roadside structures while travelling on the road if

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they are equipped with OBUs and pass through a network of interconnected networks. Roadside units (RSUs) are cutting-edge infrastructure components that link to the internet backbone by transmit signals, just like base stations do. By positioning themselves at risky intersections of the road, like nodes or construction sites, the RSUs are meant to provide message dissemination, protection, and network constancy to vehicular networks. The dedicated short-range communications (DSRC) standard, a set of protocols and measures for vehicular trade data, has been given 75 MHz of colour band in the 5.9 GHz band in order to achieve this. Through the DSRC standard, real-time multimedia applications, including peer-to-peer (P2P) substance provisioning, can be deployed in the future, and many facilities can be provided. A comparable band has been distributed in Europe and Japan. Ad-hoc networks like VANETs are common, but they differ significantly from sensor networks, MANETs, and other transmit signal networks (Siddalingaih & Chandrika, 2018).

Because they are infrastructure-based, VANETs offer dependable communication services. These networks have quick connection times because to the high mobility of vehicles. For instance, if two vehicles are moving in the same general direction and starting from the same location, and if one of them is moving at a speed of 10 m/s faster than the other, their reliable link will only last for 25 seconds. In addition, the range of sending information to people via technology is between 150 and 200 m. Vehicles must be considered individually due to their restricted motion and reliance on one another. Exchange multi-hop pathways are helpful for confirming affiliations between vehicles over a long time because links can occasionally fail due to mobility. Security, traffic management, commercial ad distribution, driver assistance, web browsing, speech, games, and entertainment are among the applications that make up the VANET. Vehicles may contain multi-application units (AUs), which are integrated or portable communication devices with a variety of various applications and interfaces. These usages have different consistency, security, and hold-up conditions. The size of VANET is recognised to be capable of passing, expressing, achieving, and displaying the safety warning on the road. Due of this, numerous nations have already included this concept into their national driving laws [1]. Vehicles having wireless connectivity create a network of lines in VANETs. By moving sideways on the road, wires instinctively link with one another.

In contrast to other types of ad hoc networks, VANETs can be distinguished by the quality of node movement. Therefore, an efficient routing protocol's structure is crucial for VANETs. VANETs have constrained bandwidth resources, and the network topology is subject to frequent change. Keeping routes to every node is therefore not necessary. The effective routing time is decreased by the dynamic topology modification. In a similar vein, it slows down routing information operation (Siddalingaih & Chandrika, 2017).

As a result, VANETs benefit more from on-demand routing systems of rules that specify the proper conduct and procedures to be followed in formal settings. Route Maintenance and Path Innovation are the two operations that these protocols often comprise. The route discovery process is initiated when a source node that lacks routing information in its routing table wants to establish a route to the target node. By flooding, the source node sends routing request packets to a group of individuals or businesses that are interconnected and collaborate with one another. The target node broadcasts a route response packet to the source node when this packet reaches the destination node. The origin node and end node of this system are connected by a turnaround path. The path will be triggered to continue processing when the node changes and if any connections on the first path can be severed. When a VANET needs a routing protocol to handle fluctuations in size or shape, AODV routing solutions are precisely used (Siddalingaih & Chandrika, 2017).

The main features of the proposed algorithm are the improvement of cluster stability through the selection of those vehicles that maintain high speeds and high degrees. This mechanism decreases the volume of communications to the outside by reducing unnecessary vehicle-to-vehicle broadcasts, which other clustering methods may apply. As for the delay, it is the weight-based selection of the CH that enables fast communication within the clusters, which in turn leads to lower end-to-end delay, especially in mobile scenarios. This was verified in the simulation results when

DSR fared better than AODV in terms of throughput and delay.

Cluster-based techniques group vehicles into clusters for task subdivision in order to provide communication services with the least amount of network infrastructure. Cluster heads (CHs) are crucial to the cluster formation process in VANET clustering. There are numerous approaches to construct a cluster using input metrics. Cluster member (CM) refers to the member car of a cluster (Zhou *et al.*, 2017; Allal & Boudjit, 2012). In order to detect CHs in vehicle ad-hoc networks dynamically, weight-based cluster method has been developed. In comparison to a traditional network scenario, sensor networks generally have a number of limitations.

Therefore, it is inappropriate to apply the weight cluster algorithm to a wireless sensor network because it does not take into account factors like transmission rate, power, or energy (Zhou *et al.*, 2017).

In (Bello *et al.*, 2019), writers looked at a dynamic open key framework for VANETs to distribute the power of the focal affirmation among a group of certificate authorities (CAs) that are selected dynamically. Dynamic CAs make decisions using a clustering technique, with CHs acting as testament experts. It is anticipated that these specific nodes will act as the registration authority (RA). A different form of clustering technique with two-tier topologies was described in (Senouci *et al.*, 2018) and is known as a mobility infrastructure-based VANET (MI-VANET). Due to their greater overlapping radio range and the fact that they are stationary in relation to one another, buses are used as the communication backbone (as they depart at interval of 15 minutes). Lower tier vehicles must initially register for communication with the closest vehicle. Therefore, a vehicle (source car) must first provide the information to its registered vehicle (source bus) using a method called mobile infrastructure registering before it may deliver the information to another vehicle (MIRG) Because of MI-VANET, clusters are now more accessible to one another, and simulation results show that the network throughput has increased and the predominant data delivery ratio has increased (Senouci *et al.*, 2018). According to Gazdar *et al.* (2010), VANETs have recently drawn more attention as viable solutions to improve both travel comfort and dynamic and preventive security when out and about. The class of driving can be improved significantly in terms of time, distance, and safety if cars are given information about such events or activity circumstances as they happen. Finding the most efficient path for data transmission is one of the primary issues facing VANET.

The weight-based clustering method for rhombus-shaped networks is proposed in this work utilising the average vehicle speed and degree. Due of CH's lack of stability, cars move at a constant pace under the current technique. The suggested technique uses a rhombus-shaped clustering path with nearby cars' transmission ranges of (150–200m), making it extremely useful for CH stability and reducing overhead transmission. Using an intersection path in the shape of a rhombus has improved vehicle clustering. There are eight lanes and four central intersections on a rhombus-shaped path. A cluster is formed by each lane, and each cluster has four to 10 cars in it. We can simply evaluate the relative speed and degree of the cars along the rhombus-shaped path thanks to the clustering technique's superior effectiveness compared to other clustering methods. Utilising SUMO's NETSIM interface, we used the proposed work's results as a basis for our analysis. Industry 5.0 is a term that keeps coming up more and more as smart cities around the world implement technologies to optimise their traffic. Industry 5.0 will mix different talents to produce intelligent solutions. The future of smart city traffic will be based on VANETs, autonomous vehicles, and Industry 5.0.

In terms of simulations, the SUMO (Simulation of Urban Mobility) and NETSIM tools were utilised. The algorithm was tested in different scenarios consisting of manned and unmanned military vehicles. These simulations demonstrated the efficiency of the clustering algorithm against the packet delivery ratio, throughput, delay, and network overhead, as presented in the results section of this manuscript.

II.VANET ROUTING PROTOCOL

It is established through the advancement of the vehicles and uses topology-based routing protocol link statics. Before transferring information packets, it is necessary to search for or save a path from sender to receiver. On a path matrix, this routing technique is based. The choice of a path from transmitter to destination in this routing strategy depends on related linkages data that have previously been gathered by the vehicle (proactive/table-driven) or searched for when needed (reactive/on-demand) (Siddalingaih & Chandrika, 2017; Luo *et al.*, 2010). Finding or preserving a route from transmitter to receiver is compulsory before delivery of information packets (Siddalingaih & Chandrika, 2017; Luo *et al.*, 2010).

Each vehicle can pinpoint its precise location and geographic region (as satellite system and global navigation). It is pointless to send the packet information despite the full path's knowledge. Geographic-based protocol is another name for them (Siddalingaih & Chandrika, 2017; Raw *et al.*, 2010; Lin *et al.*, 2010). Each vehicle has the ability to identify its geographical position, similar to the Global Navigation Satellite System, and we can measure vehicle geographic information inside the relay selection system. Transferring the information here would be pointless given the route's expertise.

Vehicles having similar features, such as those moving in the same direction and at about the same speed, can be grouped using a cluster-based routing system. The cluster-head is elected to oversee the cluster and manage inter-cluster connections. Without a cluster head, intra-cluster communications are linked directly (Lin *et al.*, 2010). Multi-hop wireless communication across an autonomous mobile environment is provided via a geocast protocol (no infrastructure is required). It was first created for MANETs and then swiftly modified for mesh networks, wireless sensor networks (WSNs), and VANETs. To reach all vehicles on the network, broadcast routing systems employ a straightforward flooding technique. Utilising various relay selection strategies can reduce message overhead (Lin *et al.*, 2010; Raw & Lobiyal, 2010).

III. CLUSTERS CONNECTIVITY

Two vehicles, I and j, are regarded as neighbours if their separation is smaller than the transmission range, or the DSRC communication range. The quantity of vehicles that are directly connected to a certain vehicle determines its level of connection. The number of neighbours of node I at time t is determined as follows [3], as indicated in Eq (1).

$$\sum \text{dist}(i, j, t) < \text{Transmission range (node i)} \quad (1)$$

If a link is made between the vehicles I and j at time t, the value of dist I j, t) exists; otherwise, it does not. One of the key aspects of mobility for cars travelling on the road is speed. Vehicle velocities are presumed to follow a normal distribution in free-flowing traffic conditions. Eq. (2) [3] provides the probability density function (pdf).

$$\text{pdf} = \frac{1}{\sqrt{2 * 3.14 * \alpha^2}} e^{\frac{-(V-\mu)^2}{2\alpha^2}} \quad (2)$$

Where the mean speed is represented by, and the standard deviation of the vehicle speeds is represented by. As a result, the car that is travelling at the same speed as its neighbours will receive preferential consideration to become a CH. The mean speed of all the nearby cars is expressed by Eq. (3) as follows [3].

$$\mu_{nei=\sum_{i=0}^{n}\frac{d}{t}} \quad (3)$$

The node position Np is given in Eq. (4).

$$Np=(xt,) \quad (4)$$

Where the coordinates for the vehicles' positions are represented by xt and yt. Eq. (5) [3] provides the average speed (AvgSpeed) of all the vehicles.

$$\text{AvgSpeed}\frac{1}{r}\sum_{t=1}^{T}\sqrt{(x_t - x_{(t-1)})^2 + (y_t - y_{t-1})^2}(5)$$

where the terms total real time (T) and instant real time (t) are used, respectively. In Eq. (6)[3], the normalised speeds (μn) of all the vehicles are provided.

$$\mu_{n=\frac{v_{i-AvgSeed}}{\sigma}} \quad (6)$$

Where vi stands for the speed of the vehicle. Using Eq. (7), each node determines if it is suitable to become a CH (WT(i)) [3].

$$WT(i)=w1deg(i)+w2\mu n \quad (7)$$

i=1,2,3……30; w1=0.4, w2=0.6; w1+ w2=1

When the surrounding vehicles are different, deg(i) = Sum of the Adjacent Vehicles. Each parameter has two weighting factors, designated as w1 and w2. As a CH, the vehicle with the highest weight value is chosen.

IV. PROPOSED METHOD

The automobiles in this piece are separated into a rhombus-shaped space with communication clusters at intersections. All other cars receive messages from a vehicle whenever it detects information, which lowers their energy use. The current method of vehicle communication maintains a cluster of nearby nodes, which takes up space and increases network overhead. As a result, it is ineffective to deliver the message to nearby automobiles. In the proposed work, each cluster's event information is broadcast to the cars via several clusters. Each vehicle transmits data to the CH rather than broadcasting. For the purpose of choosing the CH, we have measured the vehicle speed, the average vehicle speed, and the percentage of vehicles with respect to real-time. When a military vehicle detects a specific piece of information, it sends the data to the CH, who then sends it on to the other CHs so that all vehicle nodes can get it. This lowers network overhead and boosts the network's effectiveness. The suggested work's flowchart is depicted in below algorithm.

Step 1: [Start the algorithm]
    Begin
Step 2: [Creation of rhombus]
    Make a rhombus in the N*N region.
Step 3: [Divide the rhombus shape area]
    With the use of intersection junctions, divide the rhombus-shaped area.
Step 4: [Identification of vehicle]
    Event Vehicle Identify
Step 5: [Make clustering]
    Clustering technique based on weights
Step 6: [Degree measurement]
    Evaluate the proximity of the nearby vehicle
Step 7: [Calculate the average speed]
    Real-time mobility measurement of the vehicle's average speed
Step 8: [Calculate the weight of the vehicle]
    Make a weight calculation for each vehicle.
Step 9: [Selection of vehicle]
    Choose vehicle with maximum weight
Step 10: [Cluster head]
    Construct a cluster head
Step 11: [Deliver the data]
    Cluster head to cluster member data delivery.
Step 12: [Repeat the procedure]
    Continue until each vehicle receives event data.
Step 13: [Finished the algorithm]
    End.

Algorithm for deciding the cluster head and broadcasting the details

Input for the algorithm: number of vehicles, speed of vehicles, average speed, tym, edges

Out of the algorithm: cluster connectivity

```
for I=0 to number of vehicle then
    if distance(I,j,k) < range of transmission then
ni=nj=i+1 message transfer taken place
        Calculate the degree of each vehicle and average speed of vehicle
    else
        Message not transfer
    endif
    if(each vehicle speed is approximately equal to average speed)
        Nearest speed vehicle will become cluster head
    else
        Not becoming cluster head
    endif
    Calculate weight [Normalised the speed of vehicle]
    if(normalised speed = max value)
        Normalised vehicle speed will become cluster head
    else
        Not becoming cluster head
    endif
endfor
Broadcasting information in cluster and calculate all parameters.
```

V. RESULTS OF THE RHOMBUS-SHAPED NETWORK SIMULATION

The proposed clustering algorithm was put into practice on SUMO while it was interacting with NETSIM via the medium access control method of 802.11p. 30 vehicles were used in the simulations, which were run over manned and unmanned vehicles in a rhombus-shaped inter-cluster and intra-cluster course. 8 nodes and 16 edges make up the cluster in Figure1, which is divided by 4 junctions (jneE16-19). In a rhombus-shaped region, four traffic lights are employed with a central junction (0.32km). Better clustering path is provided by the junction of a rhombus-shaped area. Table I and Table II, respectively, include settings for the VANET simulation and vehicle nodes.

The distance between a vehicle's mean speed and that of its neighbours is depicted in Figure 4. The car that has the closest mean speed to its neighbours will, therefore, be given the highest priority to become a CH. Figure 4 shows the CH broadcast of data to all vehicle nodes.

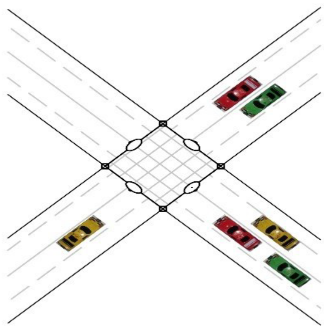

Figure 1. Rhombus-shaped area

Table 1. Vanet simulation parameters

Symbol	Parameter	Value/Type
N	Simulation tool Number of moving vehicles	SUMO, NETSIM
	Network size	Rhombus-shaped two-way lane
	Network Protocols	DSR, AODV
T	Time	100s
AvgSpeed	Average Speed	
deg	Sum of nearest vehicles	
	Vehicle speed	10 m/s
	Communication range	250-300 m
	Message type, Packet size	Unicast, Broadcast 1420
	Transmitted power, Lane length	100mW, 0.32km
CL-1	lane-1	gneE17-gnE17
CL-2	lane-2	gnE33-gnE3.4
CL-3	lane-3	gnE22.13-gnE21
CL-4	lane-4	gnE31-gnE32
CL-5	lane-5	gnE20.23-gnE19
CL-6	lane-6	gnE3.0-gnE29
CL-7	lane-7	gnE35-gnE36

Figures 2 and 3 show that in rhombus-shaped networks, throughput initially increases dramatically and then dramatically decreases after a period of time. This clearly shows that after a period of time, traffic is higher, and collision is more often in the network. The maximum throughput for 1-10 s is 15.53 Mbps in AODV and 23.15 Mbps in DSR. It is abundantly obvious that maximum link throughput in DSR is larger than in AODV. In comparison to AODV, the DSR protocol requires less time to reach its maximum throughput.

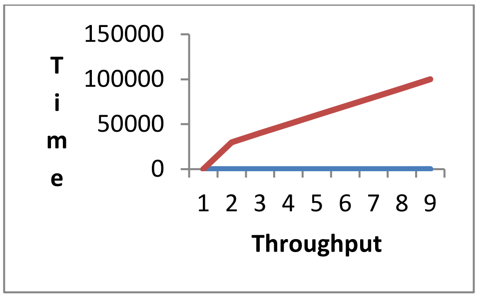

Figure 2. Overall link throughput of the network in DSR protocol

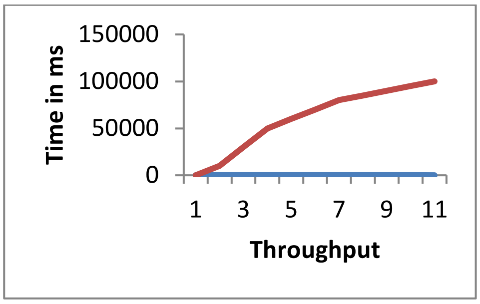

Figure 3. Overall link throughput of the network in AODV protocol

The following formulas are used to compute the packet delivery ratio (PDR):

$$PDR=\frac{Packetreceived}{packetssent}$$

The average link throughput and packet delivery ratio are shown in Figures. 4 and 5, respectively. DSR and AODV have higher packet delivery ratios and average throughput, respectively. The better the network performs, the greater the throughput and packet delivery ratio figures. We can see a reduced PDR value and improved link throughput in the DSR protocol. In less dense networks, AODV provides a higher PDR value than DSR. Figure 8 shows the typical end-to-end delay. In comparison to the DSR protocol, the AODV protocol has a longer delay. This shows that the packets took a shorter route.

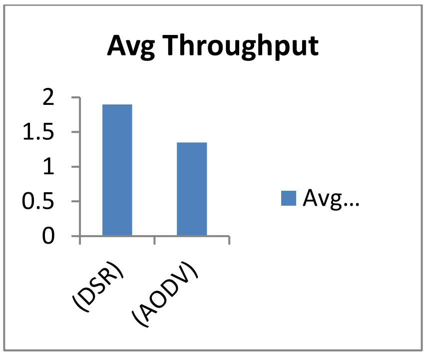

Figure4. Overall link average throughput for the different protocols

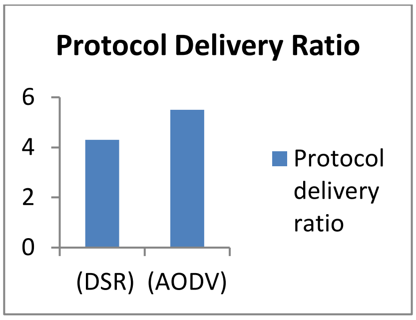

Figure 5. Packet delivery ratio for different protocols

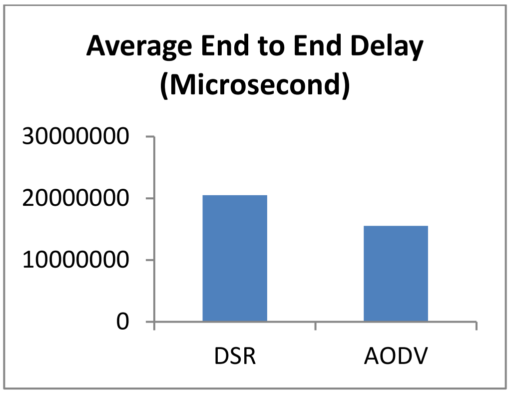

Figure 6. Overall Network Delay

The diversity of control packets sent between sources and destinations inside the network are referred to as overhead transmission. It is the proportion of total network packets to total overhead bytes transferred. According to Figure 7, the overall overhead for the AODV protocol is larger than it is for the DSR protocol. This shows that the AODV is not appropriate for greater mobility because it has a higher overhead than the DSR. For the network to be more reliable, overhead transmission should be kept to an absolute minimum.

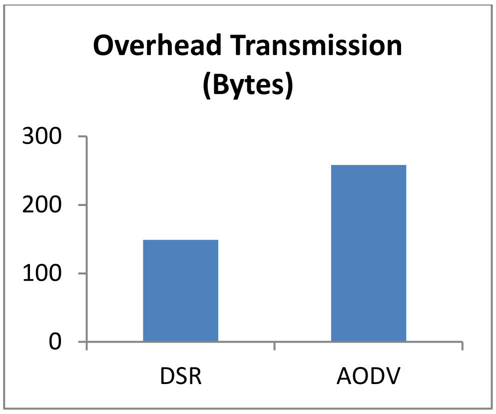

Figure 7. Overhead transmission of network.

The network's mean and standard deviation for the DSR and AODV protocols are shown in Figures 8 and 9. The mean and standard deviation are crucial aspects of the speed of a vehicle. The distance between each vehicle's present speed and the average speed of its neighbours can be calculated. The car that has the closest average speed to its neighbours will, therefore be given top priority to become a CH.

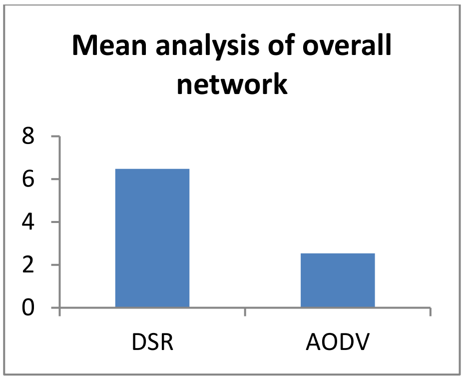

Figure8. Mean analysis of overall network

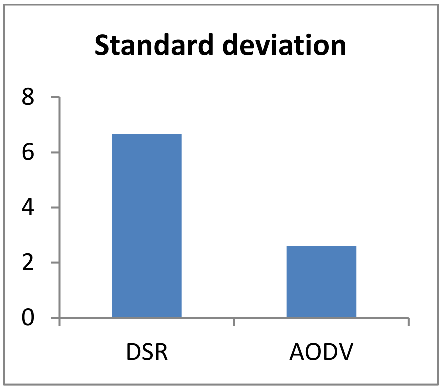

Figure 9. Standard deviation of network

VI. CONCLUSION

The rhombus-shaped area has been divided into several clusters using the weight-based clustering algorithm. The network's vehicles have been subjected to the suggested algorithm. Each of the seven clusters in the rhombus-shaped network has between 5 and 10 vehicles. Instead of broadcasting, each cluster vehicle sends data to the cluster head. By combining the weight value with the average speed and degree of each vehicle, the cluster head election is carried out. When a military vehicle notices a certain incident, it sends the information to the cluster head. Compared to the currently used methods, the one that is being provided is more trustworthy. In contrast to high throughput packet delivery ratio, mean, and standard deviation when transmitting the data through the cluster heads in different protocols, the cluster creation in the rhombus-shaped network using the provided method reduces network overhead and delay in different protocols.

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