International Journal of Engineering Research and General Science Volume 3, Issue 1, January-February, 2015
ISSN 2091-2730

Particle Swarm Optimization based Routing Protocol for Vehicular Ad Hoc Network

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Abstract - VANET is new technology for integrating ad hoc network, wireless LAN i.e. WLAN and cellular technology which is abbreviated as Vehicular Ad Hoc Network. The main aim of VANET is to achieve efficiency intelligent vehicle to vehicle communication, inter-vehicle communications and improve road traffic safety and efficiency. Depending on the type of information used for routing, they can be classified into two categories: topology based and position-based. To improve the data delivery performance in large scale network we propose the combination of SIFT and DREAM. We have also analyzed the Particle Swarm Optimization (PSO) technique on SIFT & DREAM protocol so as to improve the performance of routing protocols considering different parameters. PSO is a population based optimization technique use for finding optimum solution. PSO technique is originated from social behavior bird flocking. In PSO optimum solution is obtained from the behavior of bird. Since PSO uses for network centric localization purpose, this approach generates network navigational decisions by obviating centralized control thereby reducing both the congestion and delay

Keywords— Vehicular ad hoc network, DSDV, Trajectory based routing, Topology based routing, Position based routing, Trajectory based forwarding, Particle Swarm Optimization (PSO)

INTRODUCTION

A vehicular ad-hoc network (VANET) is a new immerging technology in ad hoc network that is becoming even more popular than the original ad hoc concept. VANET structure is built on mobile connectivity between cars and automobile equipment that informs the drivers about status of road or other necessary travel information. As density of vehicles on the road going increases day by day, new technology is imagine providing facilities to the passengers including emergency warning, safety application, assistance to the drivers etc. The VANET has capacity to reduce traffic congestion and improve the safety of the roads. It consists of dynamic nodes with wireless transcribing equipments. In MANET consist of wireless mobile nodes that can dynamically and freely self organized into temporary and arbitrary network topologies which allows nodes or devices to form a network without any pre-existing infrastructure. While many challenges like dynamic topologies, limited bandwidth, limited energy and many more remains unsolved. Vehicular ad hoc network (VANET) is a sub class of MANET with some unique properties. As number of wireless equipments that can be used in vehicles are increases so for supporting such product VANETs have emerging out these days. Some of these products are global positioning system, laptops and mobile phones. As mobile wireless networks and devices become increasingly important, the demand for Vehicle-to-Vehicle (V2V) and Vehicles-to-Roadside (VRC) or Vehicle-to-Infrastructure (V2I) Communication will continue to grow. VANET environment is challenging for developing efficient routing protocol because of some dissimilar properties like road pattern restriction, dynamic topology, mobility model, no restriction on network size, infinite energy supply and so on[1].

Efficient vehicle to vehicle communication is possible with the help of VANET so it enables the Intelligent Transportation System (ITS). ITS is the major application of VANETs which includes a variety of applications such as control of traffic flows, co-operative traffic monitoring, blind crossing, prevention of collisions and nearby information services. Intelligent transport system (ITS) that represent a range of applications like on analysis of traffic jam, traffic observation, global positioning system, traffic observation, analysis of traffic jam, management of traffic system, and diversion of routes which support the traffic scenario. As an example, existing roadside unit observing density of traffic on the roads and send all the information related to traffic to a central authority that analyze them to control traffic flow so that the traffic jam can be avoided. If an accident occurs on the road, the nearby vehicles will share this information to roadside units that then sends warning messages to the oncoming vehicles or communicate with emergency response unit. Another important application for VANETs are providing Internet connectivity to vehicular nodes while on the move, so the users can send emails, download music, or play back-seat passenger games.

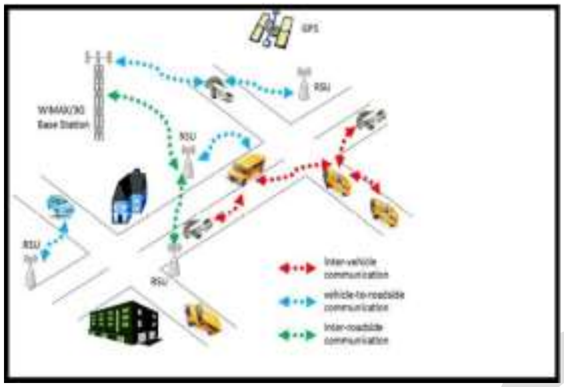

Fig 1. Architecture of VANET

There are two broad categories of wireless network: first one is infrastructure wireless network and another infrastructure less wireless network also known as ad-hoc network. In infrastructure network the main component are Base Stations (BSs) and Access Point (APs). If we consider an communication between different client on network nodes on wired network segment is first sent to the wireless BSs or APs. The wireless APs performs the forwarding of data to appropriate destination. Different wireless client on ad hoc network send their data directly to each other. In these network no wires, no communication infrastructure and no central controllers are required. If the nodes are moving vehicles then this type of network is said to be "Vehicular Ad-Hoc Network" i.e. (VANET). For routing purpose and to gather traffic information from vehicles VANETs may use fixed cellular gateways and WLAN access point at traffic intersections to connect to the internet. The possible solution for VANETs hybrid architecture consisting of is combining cellular, WLAN and ad hoc networks together called as hybrid architecture [2].

In this paper, we combine PSO algorithm with SIFT & DREAM routing algorithm, which can be adaptive to routing better. Then, according to mechanism we make combination of SIFT & DREAM along with PSO and realize it in NS-2. Finally systematic simulation is done and result is compared with DSDV protocol in the same simulation condition

1. Routing in VANET

Routing Protocol is nothing but determine the way of sending and receiving packets between mobile nodes which have significant role in terms of the performance in VANET. According to route update and position accusation method routing protocol can be classified as Topology based routing protocol, Position based routing protocol, Cluster based routing protocol, Geo cast routing protocol and Broadcast routing protocol. Topology based routing protocol use links information that exists in the network to perform packet forwarding. They are further divided into Proactive, Reactive & Hybrid Protocols. The proactive routing tries to capture complete network topology information at each node. Because of all routes are already in routing table there is little delay to transmission of data. The main advantages of proactive routing protocol are there is no need for route query phase. The another advantage of proactive routing protocol is that there is no route discovery since the destination route is stored in the background, but the low latency for real time application is disadvantage of this protocol. The various types of proactive routing protocols are: FSR, DSDV, OLSR, CGSR, WRP, and TBRPF. In contrast, reactive protocol provides a route only when it is necessary for a node to communicate with each other. If required not available currently then it will initiate route request query phase. Reactive routing consists of route discovery phase in which the query packets are flooded into the network for the path search and this phase completes when route is found. However it causes delay while initiating route request. The various types of reactive routing protocols are AODV, PGB, DSR, TORA, and JARR. The hybrid protocols are introduced to reduce the control overhead of proactive routing protocols and decrease the initial route discovery delay in reactive routing protocols. The various types of hybrid protocols are ZRP, HARP. Several works in mobile ad hoc networks have shown that nature inspired (bio inspired or swarm intelligence) algorithms inspired by insects or birds such as ant colony based optimization (ACO) and Particle Swarm Optimization (PSO), can be successfully applied for developing efficient routing algorithms. These algorithms have a quantity of advantages compared to other routing algorithms. For example, they reduce the routing overhead by sharing local information for future routing decisions. They also offer many paths enabling selection of another route in case of link failure on the previously selected path. A PSO algorithm maintains a swarm of particles, where each particle represents a potential solution. In analogy with evolutionary computation paradigms, a swarm is similar to a population, while a particle is similar to an individual [3].

I. DSDV, DREAM & SIFT DESCRIPTION

In this section there is a brief description of working of DSDV (Distance Sequence Distance Vector Routing), DREAM (Distance Effect Routing Algorithm for Mobility) & SIFT (Simple Forwarding over Trajectory).

A. DSDV

International Journal of Engineering Research and General Science Volume 3, Issue 1, January-February, 2015
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It is Table Driven routing protocol which is used in VANET and is based on classical Bellman-Ford algorithm. At the start every node broadcasts its own route tables to its neighbor node. The neighbor nodes update their routing table with the help of two type of packets- Full Dump Packet and Incremental Packet. Full Dump Packet contains information about every participating node in the network. These packets are transmitted periodically after a certain time of interval. Incremental Packet consists of updated change in nodes position since last Full Dump Packet. These packets are transmitted periodically in short interval of time and are stored in additional table. Routes are selected with the latest entry in the table. DSDV is good for networks where nodes are less dynamic. If position of a nodes are changes in short interval of time, its performance goes down because more Full Dump Packets are needed to send in the network, resulting into wastage of bandwidth.

The DSDV protocol requires each mobile station to represent, to each of its current neighbors, its self routing table. The entries in this list may change regularly over time, so the advertisement must be made rarely enough to ensure that every mobile computer can almost always locate every other mobile computer of the collection. In addition, each mobile node agrees to relay data packets to other node upon request. This algorithm places a premium on the ability to determine the shortest number of hops for a route to a destination; we would like to avoid unnecessarily disturbing mobile hosts if they are in sleep mode. In this way a mobile node may exchange data with any other mobile node in the group even if the target of the data is not within range for direct communication. If the notification of which other mobile node are accessible from any particular node in the collection is done at layer 2, then DSDV will work with whatever higher layer (e.g. Network Layer) protocol might be in use [4].

B. DREAM

DREAM protocol is a restricted flooding communication protocol used in unstructured architectures. Each node in the network may maintain a location table about all the nodes in the network and frequently floods a location packet, called as control packets. Which are required to update the information maintained by its neighboring nodes. Each location packet submitted by a node *A* to other nodes to update their location tables contains *A*'s coordinates along with its speed and the time the location packet was transmitted. DREAM uses the principle of distance effect in which by using the distance of the registered nodes, update frequency of location tables is determined. In other words the more updates sends to nodes which are closer to other nodes. The frequency of sending a control packet is adjusted based on the moving speed of the source node *S*.

When source node *S* wishes to send the message to destination node *D*, initially it looking for its location table and retrieve its information related to geographical position. If the destination direction is valid, *S* sends the message to the all one hop neighbors in the forwarding direction. If location information of destination *D* is not available then a recovery procedure must be executed by flooding partially or entirely the network in order to reach *D*. When the node *A* receive the message, it firstly checks whether it destination node or not. If it identifies the destination node then node *A* sends an acknowledgement to the source node. Otherwise, *A* repeats the same processes by sending it to all one hop neighbors in the direction of *D*. Each nodes repeats same process, until it reached to *D*. To determine forwarding zone in the direction of node *D*, the source node *S* calculates the excepted zone which contain *D*. As shown in Figure 2 the circle around the position of *D* is an excepted zone. The radius of this zone is set to $(t_1 - t_0)v_{max}$, where t_0 is the timestamp of the position information that *S* has about *D*, t_1 is the current time, and v_{max} is the local known mean speed that the node *D* may travel in the network. After determining the expected zone, the node S define its forwarding zone which is the region enclosed by an angle α starting from vertex S and sides of S are tangent to excepted zone calculated for D and then sends the packet, to all its neighbors in the forwarding zone [5].

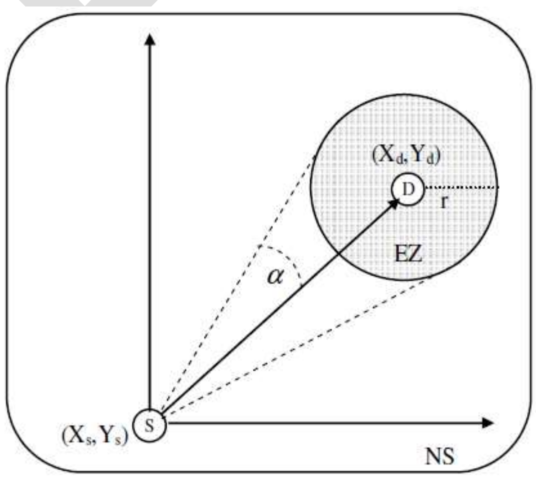

Fig 2. Expected Zone (EZ) within the network space (NS)

In DREAM it is an advantage that we can exchange nodes co-ordinate instead of changing complete link state or distance vector information which is helps in reducing the occupied bandwidth. DREAM uses the distance effect principle as discuss above, it can perform well in dynamic mobile ad hoc networks. [6]

DREAM (Distance effect routing algorithm for mobility) achieves the following properties:

- It is a bandwidth and energy efficient. Each control message carries only the coordinates and the identifier of a node, thus being small as compared to the control messages used by proactive protocols (that have to carry routing table) and to those used by reactive protocols (that have to carry an entire route).
- It is inherently loop-free, since each data message propagates away from its source in a specific direction.
- It is robust, meaning that the data message can reach its intended destination by following possibly independent routes.
- It is an adaptive to the mobility, since the frequency with which the location information is disseminated depends on the mobility rate.

C. SIFT

SIFT is a reactive source-based scheme, where trajectory is calculated when needed. Trajectory is nothing but the digital map expressed in different way and this map is assumed to be pre-stored in memory of nodes. SIFT uses broadcast transmission instead of point-to-point transmissions. Trajectory based forwarding is a hybrid forwarding strategy of source base routing and greedy forwarding. Source node defines the approximate trajectory and each intermediate node makes the geographical greedy forwarding along the trajectory. The source utilizes the GPS and digital map to define the trajectory of message i.e choosing the proper shortest and fastest dissemination path. In comparison with position based forwarding trajectory based forwarding has less data packets overhead. In case of trajectory based forwarding, if there is no vehicle on one path then message can be delivered by other path. Trajectory-based forwarding offers a better performance as compared to GPSR, because in VANET it is possible to build a trajectory that can account for obstacles that can produce a long detour of the data packet.

Each node that receives a packet takes the decision for forward it or not based which depends on its position, the last transmitter position and the trajectory. This reduces control overhead down to "0", that means SIFT sends no control packet. After receiving a packet, each node sets a timer according to its position with respect to the trajectory and the last transmitter position. The closer to the trajectory and the farther from the last hop a node is positioned; the shorter the timer is set. If there is copy of the same packet, forwarded by another node, is received before the timer expires, the timer is stopped and the packet is dropped. Elsewhere, the packet is transmitted when the timer expires. Thus, the node with the shortest timer will forward the packet. Packets are included into the header the trajectory and the coordinates of the last node that forwarded the packet. Generally, trajectories can be obtained from digital maps. Because intermediate nodes get all the required routing information from the packet header, they need not to know anything about its neighbors; hence they exchange no control packets. This problem is very interesting in highly dynamic environment [7].

Single Stream Trajectory

In this first we consider the simple case where the packet has to be forwarded along a single stream trajectory which is defined as an ordered sequence of straight segments. Here, each node, upon a packet reception, sets a timer according to its position with respect to the trajectory and the transmitter:

$$T_{out} = \ulcorner \ (D_T / D_L) \ \ldots\ldots\ldots\ldots\ldots\ldots \ (1)$$

Where DT is the distance between the node and the closest trajectory segment, DL is the distance from the last node that transmitted the packet, and $\ulcorner$ is a constant which representing the time unit. If a node receives another copy of the packet before the timer expires, then the timer is stopped and the packet is deleted from the forwarding queue. Else, when the timer expires, the packet is processed by the Medium Access Control i.e. (MAC) layer for transmission. As a result of this, the packet is forwarded by the node with the minimum Tout, i.e. the node in the best position is far from the last the node and close to the trajectory. The information needed by SIFT and information carried in the packets header includes: the trajectory, the coordinates of the last node visited the packet source identifier, the packet sequence number, and the hops count. To avoid cycles, each node have to maintain a list of recently received packets (source ID and sequence number). SIFT can be implemented over any MAC i.e. multiple access control scheme, but its performance depends on the characteristics of the MAC scheme used for it. Note that this forwarding approach is quite robust against transmission error and collisions because of its correct operation, it is sufficient that one of the neighbor nodes receives the packet. Moreover, in the unlucky cases where no node successfully receives the packet, so the transmitting node can detect the problem and then retransmit the packet. Similarly to source routing, the overhead to code the trajectory depends on the number of segments. Before forwarding a packet, the forwarding node modifies the trajectory information by keeping only the segments not yet travelled [8].

Forwarding Strip

Due to limited transmission ranges, the above procedure may enable more than one node to forward a packet. As shown in Fig.3 a packet transmitted by node A is first forwarded by node C (the node in the best position). Its transmission prevents node B and node D to forward the same packet, but not to the node E and node F that are out of reach from C. This situation may lead to generate duplicated packets which travelling in the network along "parallel" trajectories at a distance from the original trajectory at least equal to the transmission range. The trajectories, however, soon or later will merge again therefore limiting the waste of network resources due to duplicated packet transmissions [9].

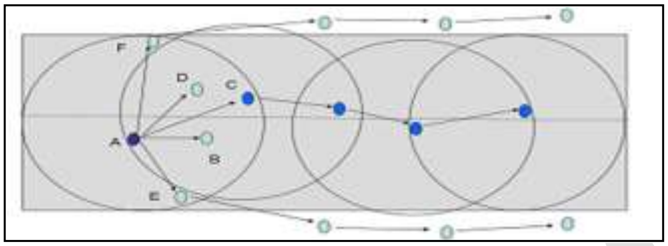

Fig.3 Forwarding Strip

2. Particle Swarm Optimization

Particle swarm optimization (PSO) is a population-based stochastic optimization technique developed by Kennedy and Eberhart in 1995. The use of PSO algorithm is to determine optimum solution. In PSO algorithm, an optimal solution is found from the social behavior of bird flocking. With the aim of discovering patterns that govern the ability of birds to fly synchronously and to suddenly change direction with a regrouping in an optimal formation. PSO consist of group of individual called as “particles”. The particles fly through multidimensional search space looking for best solution. The effective solution can be obtained by using common information of the group and information own by particles itself. For better performance, each particle adjusts its velocity time to time based on its current velocity with respect to its previous best position and also the position of current best particle in the population. For solving the optimization problems and combinatorial problems PSO algorithm is most useful [10].

A PSO algorithm maintains a swarm of particle represents the potential solution. In simple terms, particles are randomly fly through the multidimensional search space, the particle adjust its position according to its own experienced and that of its neighbors. Let *xi(t)* represent the position of particle i in the search space at a discrete time step t . When the particle moves it get some velocity and its original position is changed, i.e.

$$Xi(t+1) = xi(t) + vi(t+1)$$

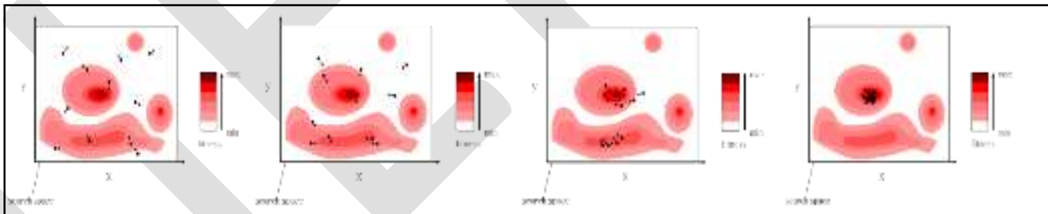

Fig 4. Birds Behavior

It is the velocity vector that drives the optimization process and reflects both the related knowledge of the particle and socially exchanged information from the particle's neighborhood. The experimental knowledge of particle is directly proportional to the distance of particle from its own best position known as *particle best (pbest)*. There are basically two concept of PSO algorithm, namely *pbest* and *gbest.* In global best (*gbest*) the neighborhood for each particle is entire swarm. The network establish in *gbest* PSO is by using star topology, in which the social particle velocity is updated regularly which gives information obtained from all the particle in swarm.

In personal best (*pbest*) PSO the network form by using ring social network topology where smaller neighborhood are define for each particle. In this network, information exchanged between the neighborhoods of particle, which provide local knowledge of the environment [11].

3. Performance Evaluation

Here we use the NS-2 simulator to analyze the performance of combined DREAM+SIFT and applying PSO optimization technique to DREAM+SIFT (DS) and DSDV. We analyzed performance of DREAM+SIFT with DSDV and PSO_DREAM+SIFT (PSO_DS) with PSO_DSDV on the basis of certain parameter like delay, energy, packet loss, network load and control overhead. We

International Journal of Engineering Research and General Science Volume 3, Issue 1, January-February, 2015
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perform the set of experiments for simulation area which is square 300m*300m using NS-2. Vehicles are able to communicate with each other using the IEEE 802.11 MAC layer. All the result is taken by varying the number of nodes in the network. The simulation parameter setting given in following table.

Table I: Simulation Parameter Setting

Parameters	**Values**
Simulator	NS-2
Area	300m*300m
Number of Nodes	10-40
Packet Size	1000 bytes
Packet Interval	0.07 seconds

4. SIMULATION RESULT

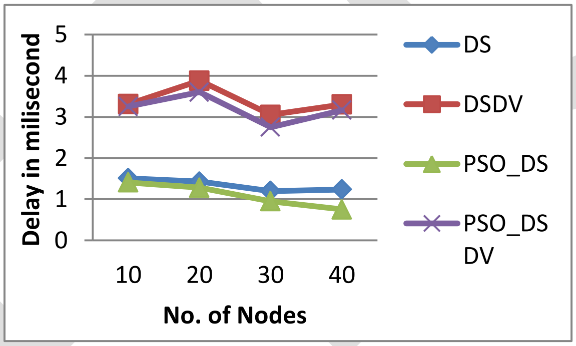

Fig 5. Delay Vs No. of Nodes

As shown in Fig.5, the graph is plotted between delay in millisecond and no. of nodes. The delay is defined as the time required arriving the packets at destination. From graph it can be say that the delay in case of normal DSDV is more as compared to normal DS. After applying the PSO algorithm the result is improved at some level. From graph the delay in case of PSO_DS is less as compared to PSO_DSDV. If we compared the PSO_DS with all three protocol we can said that the protocol PSO_DS have more efficiency as compared to DS, DSDV and PSO_DSDV. So the time required to arrive the packets at destination is less in case of PSO_DS hence it is more efficient as compared to remaining three protocols.

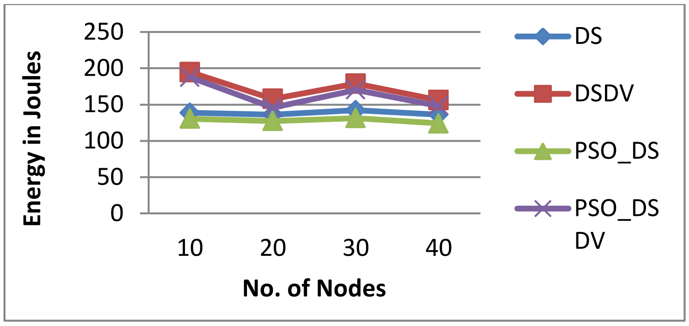

Fig 6. Energy Consumption

Energy consumption is nothing but the energy required by network for transmitting the packets between nodes. Fig. 6 shows the energy in joules for transmitting the packets over the network. From graph it is clear that DSDV consumes more energy as compared to DSDV. While after applying PSO algorithm the consumption of energy in case of both routing protocol get reduced by certain amount. The energy required by PSO_DS is less as compared to remaining three protocols. So we can say that the protocol PSO_DS is more efficient as compared to DSDV, DS and PSO_DSDV.

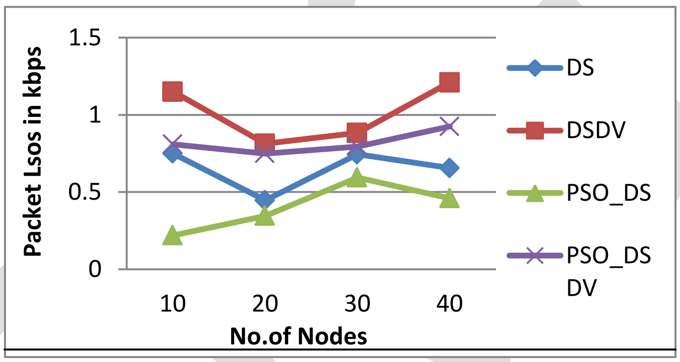

Fig 7. Packet Loss Vs No. of Nodes

Packet Loss is the number of packets gets lost during transmission of packets from source node to destination nodes. Fig.7 shows DSDV faces more number of packet loss as compared to DS. After applying PSO to both DSDV and DS the packet loss is minimize at some level. If we compared PSO_DS with the DSDV, DS and PSO_DSDV it shows the less packet loss. Hence we can say that the routing protocol PSO_DS is more efficient as compared to other routing protocols.

5. CONCLUSION

Classical ad-hoc routing schemes like DSDV experiencing more delay, energy consumption and packet loss than position based routing protocol like DREAM+SIFT because they use more efficient routing techniques. In the combination of DREAM+SIFT, SIFT does not sends any kind of control message but it helpful for solving the problems of control overhead. For making this combination more efficient we are applying an optimization technique i.e. Particle Swarm Optimization (PSO) to the combination of DREAM+SIFT. From result we can said that after applying PSO to routing protocol it increases the performance of DREAM+SIFT and it find to be more efficient as compared to DSDV. Hence PSO_DS becomes a very suitable forwarding protocol for VANET

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