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Performance Analysis of Bio inspired Particle Swarm Optimization based Routing Protocols using QoS Parameters

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ABSTRACT: VANET is new technology for integrating ad hoc network WLAN and cellular technology which is abbreviated as Vehicular Ad Hoc Network. The concept of VANET is to achieve efficiency intelligent vehicle to vehicle communication, inter-vehicle communication and improve road traffic safety and efficiency. Routing protocols are classified as topology based and position based routing protocol depending on type of information used for routing. 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 generate network navigational decisions by centralized control obviating thereby reducing 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).

I. INTRODUCTION

A vehicular ad hoc network (VANET) is the 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 node 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 MANET with some unique properties. VANET become popular as the quantity of wireless equipments that can be used in vehicles are increases. Some of these products are global positioning system, laptops and cell phones. As wireless device increases in VANET hence the demand for vehicle-to-vehicle (V2V) and vehicle-to-roadside (VRC) or vehicle-to-infrastructure (V2I) communication will grow continuously. 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 in VANET with the help of Intelligent Transportation System (ITS). ITS is one of the major application of VANETs which consist of different applications such as control traffic flows, co-operative traffic monitoring, blind crossing, collisions prevention and providing information services with the help of nearby vehicle. 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 central authority that analyze them for controlling traffic flows so that 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. Providing Internet connectivity to vehicular nodes while on the move is the most important application of VANET, with the help of those users can send emails, download music, play online games etc.

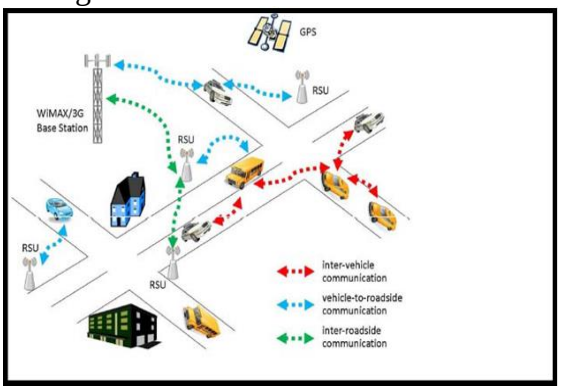

Fig 1. Architecture of VANET

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). The problem of gathering the traffic information for routing purpose VANET uses the fixed cellular gateway and this is connected to internet with the help of WLAN access point at traffic intersection. The possible solution for VANETs hybrid architecture consisting of is combination of WLAN, cellular network and ad hoc networks called as hybrid architecture [2].

In this paper, we combine SIFT & DREAM routing algorithm. The combination is adaptive to routing better. Also for improving the working of SIFT & DREAM we apply optimization technique like PSO to our developed routing protocol. Also make the comparison with DSDV routing protocol in NS-2. We choose the DSDV for comparison because it is also the distance based routing protocol. We have compare various parameter like delay, packet loss and energy consumption in NS-2.

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 perform packet forwarding using already available links information. 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 because as destination route already stored in background. But the low latency for real time application is disadvantage of this protocol. FSR, DSDV, OLSR, CGSR, TBRF and WRP are comes under the category of proactive routing protocol. In reactive routing protocol, route is established only when there is demand from nodes. If required route not available currently then it will initiate route request query phase. In reactive routing query packets are flooded into the network for the path search called as discovery phase and as the route is found the phase is completed. However it causes delay while initiating route request. The various types of reactive routing protocols are AODV, PGB, DSR and TORA. The hybrid protocol is introduced to minimize the problems like control overhead and the initial route discovery delay. The different 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 based 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 consists of particles having negligible volume and velocity, where each particle represents a potential solution [3].

II. DSDV, DREAM & SIFT DESCRIPTION

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

A. DSDV

It is also known as Table Driven routing protocol. It is based on classical Bellman-Ford algorithm. At the start every node in the network interchanges its own route tables to its neighbor node. If there is any change in routing table then according to those changes neighboring node update their routing table. For updating the routing table they use two type of packets- Full Dump Packet and Incremental Packet. Full Dump Packet keeps the track of information about every node in the network. These packets are transmitted periodically. Incremental Packet keeps update regarding the changes in node position of Full Dump Packet. Full Dump Packets also transmitted periodically and that stored in additional table. According to current entry in table routes are selected. DSDV is good for networks where nodes are less dynamic. There is wastage of bandwidth if the position of nodes changes in short interval of time because then it required more number of full dump packet.

The DSDV protocol requires representing the position of current neighboring node itself in routing table. The entries in the routing table change regularly so each node in the network need to advertise the

change in updating of routing table to the neighboring node. Also when there is request from other node so it is responsibility of that node to providing updated routing information. This algorithm has ability to determine the shortest number of hops for obtaining a rout to a destination. If some time there is no need of any host node in the network and it is in sleep mode then protocol does not disturb it unnecessarily. In this way even if the destination node not within the range of communication, a mobile node exchange data with any other mobile node in the group. If the notifications of other mobile node are done at layer 2 by any particular node then DSDV will work with whatever higher layer (e.g. Network Layer) [4].

B. DREAM

DREAM protocol is basically used in unstructured architecture which uses algorithm of restricted flooding. Each node in the network floods a location packet called as control packet with the help of location table which consist of information about the location of all the nodes in the network. Control packet required for updating the information maintained by its neighboring nodes. Control packets transmitted by each node consist of coordinate of that node along with its time and speed which is use full for updating the location of node in the table maintain by each node. DREAM updates the frequency of location table which is determining with the help of principle of distance effect. In other words the more updates sends to nodes which are closer to other nodes. According to the change in moving speed of the source node *S* node adjusted the frequency of control packet.

During transmission of message from source node *S* to destination node *D*, it firstly searches for the location table and from this location table it retrieves the geographical position of node. If the direction of destination node is valid, source node *S* send the message to one hop neighbors in forwarding area. Suppose information about the location of destination *D* is not available then it starts the recovery procedure. In recovery process it flooded the packets partially or entirely in the network in order to reach *D*. When the node *A* receive the message, it firstly checks whether it destination node or not. *A* sends an acknowledgement to source node after it indentify the destination node. Otherwise, each node repeats the same processes until it reached to *D*. For 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 known as excepted zone. The radius of this zone is set to $(t1 - t0)vmax$, where $t0$ is the timestamp of the position information that *S* has about *D*, $t1$ is the current time, and $vmax$ is the local known mean speed that the node *D* may travel in the network. After the expected zone is determine, the forwarding zone is define by node *S* 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*. As expected zone is determined then *S* sends the packet to all its neighbors in the forwarding zone [5].

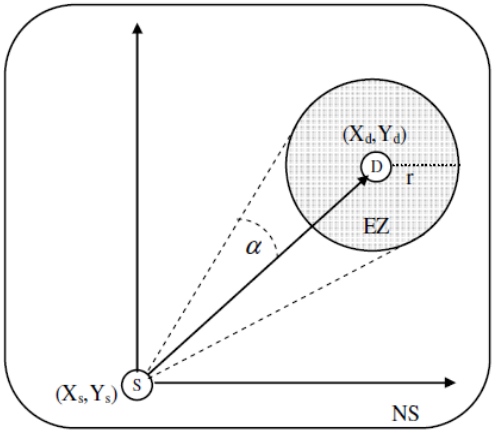

Fig 2. Expected Zone (EZ) within the network space (NS)

In DREAM we can reduce the occupied bandwidth by exchanging the node co-ordinate so there is no need of changing the complete link state or distance vector information. DREAM performs well in dynamic ad hoc network by using the distance effect principle [6].

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

- It uses the principle of distance effect which makes it bandwidth and energy efficient. Each control message carries only the coordinate of a node, which are small as compared to the control messages used by proactive protocols.
- Each control packet propagates away from its source in a specific direction hence it is loop free.
- It is robust, means that each data packet reaches its destination by choosing independent routes.
- It is an adaptive to the mobility, since the frequency depends on the mobility rate.

C. SIFT

SIFT is also known as reactive source-based scheme, where trajectory is calculated when needed. Trajectory is the one type of digital map differently express and this map already stored the memory of nodes. SIFT uses the broadcast transmission instead of point-to-point transmission. Trajectory based forwarding is a combination of source based routing and greedy forwarding. Approximate trajectory is defines by source node and intermediate node helps to make geographical greedy forwarding along the trajectories. The source node determines the proper shortest and fastest dissemination path with the help of GPS and digital map. Trajectory based forwarding has less data packet overhead as compare to position based forwarding. In case of trajectory based forwarding, if there is no vehicle on one path then it uses another path for delivering the message. Trajectory-based forwarding offers a better performance as compared to GPSR, because in VANET with the help of trajectory we can overcome the obstacles that produce the barrier to data packet.

Each node in the network receives a packet independently and also takes the decision for forward it or not based on nodes position, the last position of transmitting node and the trajectory. This reduces control overhead to negligible level, this implies that SIFT sends no control packet. When the node receives the packet it sets a timer depends on its position with respect to position of last transmitting node and also trajectory. Node sets the shorter timer according to closer trajectory. If the case of duplicate packet is

occurred before the timer expire then timer is stopped and it dropped that packet. If the duplicate of packet is not form then it transmits the packet when the timer expires. Packets header consist of information about the trajectory and the coordinates of the last node which forwarded the packet. Generally, digital maps are use to obtain trajectories. There is no need for intermediate node to get information from neighbor because it will get all the required routing information from the packet header. Hence there is no exchange of control packets between intermediate nodes and neighboring nodes. This problem is very interesting in highly dynamic environment [7].

Single Stream Trajectory

In case of considering the whole case of trajectory we are considering that packet is forwarded along a single stream trajectory which is also known as an ordered sequence of straight segments. In this case when each node receives the packets it sets a timer according to the position of node with respect to the position of transmitter and trajectory.

$$Tout = \Gamma (DT / DL) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where D_T is the distance between node and the closest trajectory segment, D_L is the distance from last node that transmitted the packet and Γ is a constant which represent the time unit. If there is generation of duplicate copy of packet before the timer expire then timer will not allow the entry of packet and it gets stopped and this packet is deleted from queue. Else, if the duplicate copy of packet is not form then after the timer expire, the packet is transmitted by the help of Medium Access Control i.e. (MAC) layer. Due to this, the packet is forwarded by the node and it required minimum Tout, which shows that node is at best position in the network also close to the trajectory. This packet carried the information which consists of the trajectory, the coordinates of the last node, packet sequence number and hops count. To avoid repetition, every node requires maintaining a list of recently received packets along with source ID and sequence number. SIFT can be developed by the help of MAC protocol i.e. multiple access control scheme, but its performance is depends on the characteristic of the MAC. In SIFT it is necessary that each of the neighboring node receive the packets for increasing the efficiency of protocol. Most of time what happen no node receive the packets, so the transmitting node detect the problem and retransmit the packet. Similarly source routing is also the important issue of any protocol. In trajectory based protocol it is depend on number of segment. The forwarding node in trajectory modifies its trajectory information by not increasing the segment [8].

Forwarding Strip

As the transmission range is limited if we consider above procedure many nodes in the network tried to forward a packet. As shown in Fig.3, node C is at best position, hence it forward a packet receiving from node A. so due to this node D and node b does not required the transmission for the same packets. So node C stops to receive same packet from node D and node B. But node C cant stops the transmission of packet from node E and node F because it is not in the range of node C. this condition may causes the duplication of packet which are travelling along the parallel trajectories at distance of original trajectories. This trajectories will merge again therefore limiting the waste of network resources due to duplicated packet transmissions [9].

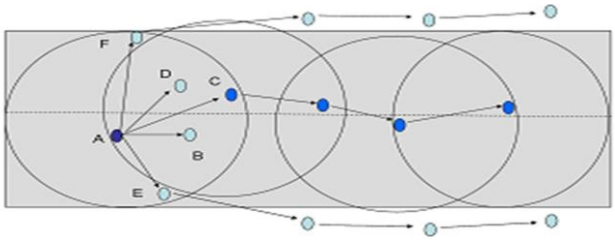

Fig.3 Forwarding Strip

III. Particle Swarm Optimization

Particle Swarm Optimization (PSO) is developed by Kennedy and Eberhart in 1995. It is population based stochastic optimization technique. The use of PSO algorithm is to determine optimum solution. In PSO algorithm, according to social behavior of bird flocking an optimal solution is determine. The basic aim of PSO is discovering patterns, for that birds fly synchronously and also change the direction according to change in pattern for regrouping in problem space. PSO consist of group of individual called as "particles". These particles for obtaining the best solution search in the multidimensional search space. The effective solution can be obtained by using previous information of the group and information of the particles. Each particle adjusts its current velocity according to position of current best particle in population and previous best position of particle for achieving the better performance. 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 discrete time step *t*. When the particle moves it get some velocity and its original position is changed, i.e.

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

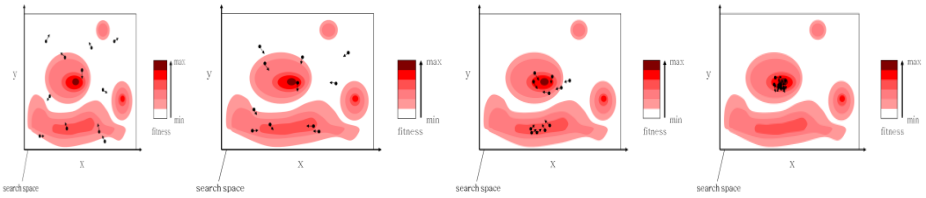

Fig 4. Birds Behavior

The equation represents the velocity vector that carries the optimization process and gives the related knowledge of the particle and socially interchanges information from the neighborhood particles. Each particle having its positional best value called as *pbest.* The experimental knowledge of particle is directly proportional to the *pbest.* There are basically two concept of PSO algorithm, namely *pbest* and *gbest.* In global best (*gbest*) the entire swarm acts as neighborhood of particle. The entire particle in swarm updates the particle velocity for obtaining the information with the help of star topology.

In case of personal best (*pbest*) PSO, the network forms by using ring 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].

1. 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 set up square area of 300m*300m for performing simulation using NS-2. With the help of IEEE 802.11 MAC layer, vehicles are able to communicate with each other. 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

IV. EXPERIMENTAL RESULTS

Here we use the network simulator-2 for simulation of various routing protocol and comparison. In this paper we are comparing the simulation result of normal DSDV, normal DREAM+SIFT, POS_DSDV, PSO_DS. By considering the parameter like Delay, Jitter Rate, Packet loss, Packet Delivery Ratio, Normalized Network Load, Control Overhead and Energy. 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 result is given in form of graph as follows. The graph is representing in versus of number of nodes changes. As the number of nodes changes the parameter also have the change in graph values. To apply these ant colony optimization there are two steps. Which are to be considered as path searching and shortest path selection, In path searching certain ants are moves to find the food which are nothing but forward ants, once these forward ants get food they moves towards their nest which are called to be backward ants. While coming back to the nest they leave a pheromone substance so that other ants follow that path to reach their food which is nothing but shortest path. According to density of pheromone with different paths the highest density of pheromone is said to be the shortest path.

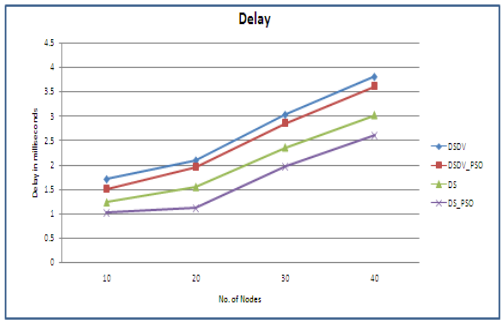

Fig. 5 Delay in millisecond

Delay is defined as the time required to successfully delivery of packets from source node to destination node. Fig.5, shows the graph of delay in millisecond which is compared with the number of nodes. In our paper from graph we analyse that the delay of DSDV is more as compared to DS. For reducing the delay we applied the PSO algorithm to both protocol. After applying the PSO form graph we can say that the delay is reduced at certain level. From complete graph we can say that the DS_PSO has less delay as compared to DSDV_PSO, normal DSDV and normal DS [12].

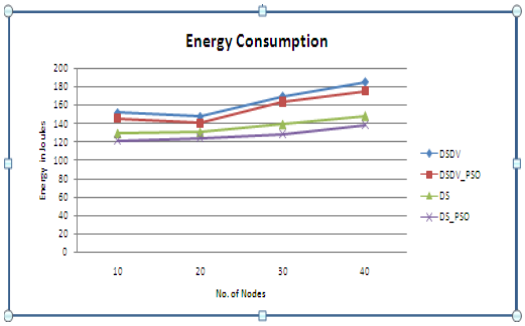

Fig 6. Energy consumption

Fig.6, represent the graph of energy consumption. Energy consumption is defined as the amount of energy required for transmitting the packets over the network from source to destination. From graph we calculate that the amount of energy consume by DSDV is more as compared to DS. For reducing the energy consumption we apply the PSO algorithm to both protocols. After applying the PSO from graph we can say that the amount of energy consumption is reduce for certain level. From complete graph we can say that the performance of DS is better than DSDV [12].

Packet loss is defined as the amount of packets gets dropped while transmitting the packets between source node and destination node. Fig 7, represent the graph of packet loss. From graph we can say that the packet loss is more in case of DSDV and less in DS. For improving this parameter we apply the PSO to protocol. After applying PSO the packet loss is is reduced. From complete graph we can conclude that packet loss is very less in case of DS_PSO as compared to normal DSDV, normal DS and DSDV_PSO [12].

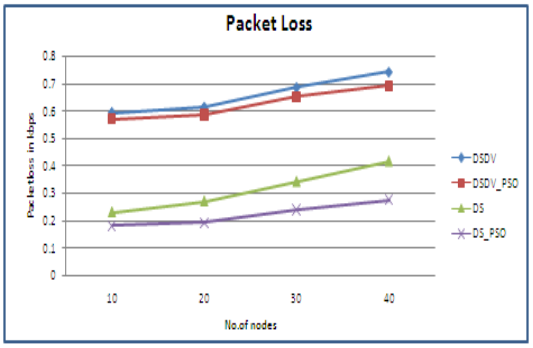

Fig.7 Packet Loss

Fig.8, represent the graph of control overhead. Control overhead is the number control packets required to successfully transfer the packets to destination. The graph is put between the control packets in kbps and number of nodes changing from 10 to 40. From graph it is clearly indicate that the performance of DS is better than the DSDV and after applying the PSO it again improve the performance of DS as compared to DSDV. Hence we can say that the performance of DS_PSO is better than normal DSDV, normal DS and DSDV_PSO.

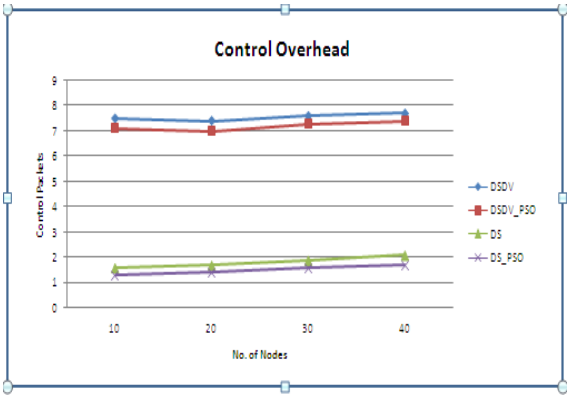

Fig.8 Control Overhead

Normalized routing load is the number of routing packets transmitted per data packets send to the destination. Fig 9, represent the graph of normalized routing load. From graph it can be calculated that normalized load of DSDV is more among remaining protocol. For reducing this we applied the PSO. After applying the PSO we can say that the normalized routing load of DS_PSO is less as compared to normal DSDV, normal DS and DSDV_PSO. Which will indicate that DS and DS_PSO has better performance as compared to DSDV and DSDV_PSO.

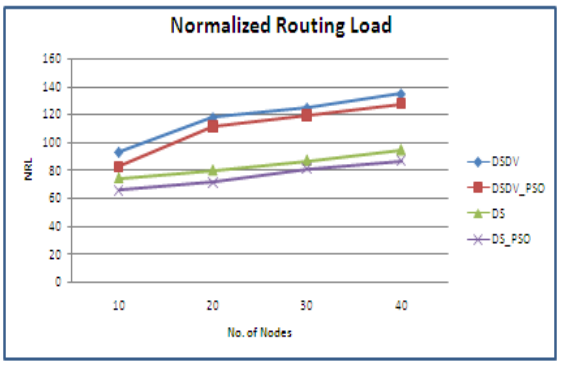

Fig.9 Normalized Routing Load

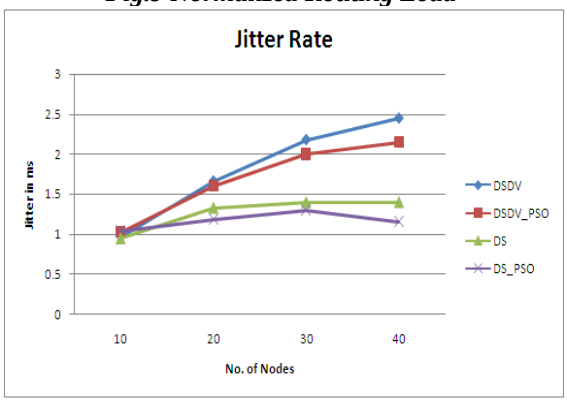

Fig.10 Jitter Rate

Jitter rate is defined as the delay minus min delay. Fig.10 shows the graph of jitter rate in which on Y axis jitter in millisecond is given and on X axis the number of nodes from 10 to 40 is given. From graph we can say that initially the jitter rate for every protocol is nearly equal. As the number of node is increases the jitter rate of DSDV also increases. From graph we can say that the performance of DS is better as compared to DSDV. Also after applying the PSO the performance of DS is increases. Hence from overall graph we can say that DS_PSO has better performance as compared to normal DSDV, DSDV_PSO and DS.

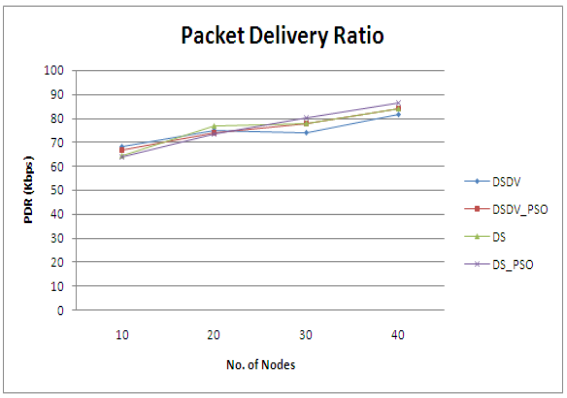

Fig.11 Packet Delivery Ratio

PDR nothing the ratio of number of packets transmitted to the number of packets delivered. Fig 11, shows the graph of PDR. From graph it can be say that initially from 10-20 nodes DSDV had less PDR as compared to DS, but as the nodes are increases the PDR of DS is increase and the PSR of DSDV is reduced. Similarly after applying the PSO the DS_PSO had greater PDR which indicate the better performance of our protocol as compared to DSDV.

V. CONCLUSION AND FUTURE WORK

Classical ad-hoc routing schemes like DSDV experiencing more delay, more energy consumption, more packet loss, more control overhead, more normalized routing load, ,more jitter and more PDR than position based routing protocol like DREAM+SIFT because they use more efficient routing techniques. In DREAM+SIFT, SIFT does not sends any kind of control message that's why 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 DS_PSO becomes a very suitable forwarding protocol for VANET. In future we can continue the same work by using the different optimization algorithm like combination of genetic algorithm and PSO algorithm to get better performance.

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