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Nature Inspired Biological Computing (NIBC) Algorithm to Provide Quality of Service in Vehicular Ad-Hoc Network (VANET)

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ABSTRACT: Vehicular Ad-Hoc Network (VANET) will be solely focuses on to provide communication among moving vehicles till 2020. There is variety of wireless sources available to communicate during travelling. Also they transfer different size of files so to provide Quality of Service (QoS) there is a need of routing protocol which support variety of data transmission rate. This paper purposes Nature Inspired Biological Computing (NIBC) based routing algorithms which provide QoS. Three algorithms are proposed, which are based on Artificial Bee Colony (ABC), Bacterial Foraging Optimization (BFO) and Particle Swarm Optimization (PSO), NIBC techniques. Five performance parameters are selected to check the quality of service, theses are: packet delivery ratio, packet drop ratio, control overhead, average delay and throughput. NS2.34 is selected to carry out the simulations for variable transmission rates and variable speed. Results shown that NIBC techniques are more appropriate for handling the issues of VANET like: high mobility, rapid topology change and un-deterministic conditions.

KEYWORDS: Vehicular Ad-Hoc Network, Nature Inspired Biological Computing, Artificial Bee Colony, Bacterial Foraging Optimization, Particle Swarm Optimization, Performance Parameters and Quality of Service.

1. INTRODUCTION

Vehicular Ad-Hoc Network is very fast growing field of research. It is a combination of communication and computational techniques. Now days Internet on Things (IoT) is on boom so to provide quality of service researchers are designing various new algorithms for VANET communication. Communication in VANET depends on number of areas, among them routing is a most important area.

Routing is a technique which finds route between source and destination to provide data communication. The found route should be stable and short to provide better quality of service. Quality of service in routing can be measured by different performance parameters like packet delivery ratio, packet drop ratio, control overhead, average delay, throughput, jitter and etc [1]. Many researchers are doing work in this area. They are designing different routing algorithms by using different optimization techniques.

Optimization techniques are used to select best solution among the set of solutions. They are broadly classified into two categories: deterministic and stochastic algorithms. Deterministic algorithms do find global best solution but are CPU-intensive and use much computational time. Stochastic algorithms are used to overcome these disadvantages but without guarantee to find global best solution [2]. They use exploration and exploitation to search the best solution. Many of them uses nature inspired algorithms make a new class called Nature Inspired Biological Computing (NIBC). NIBC are based on individual's own organization and distributed controlling. They have features like diversity, dynamic, complex, vigorous and experience to resolve the hard and complex problems [3]. Due to these features they are adaptable for VANET scenarios and improve the performance of VANET. VANET is an attracting area for researchers. They are trying different methods to improve the performance of VANET.

Tiecheng Wang et al, used existing traffic infrastructure to form cluster network. Packet delivery ratio improved by using one hop range and packet transmission through the intersection only, but delays increased [4]. Yun Ge et al, maintains a k-hop vicinity routing table. When the source node and the destination node are in same vicinity it uses proactive routing. They achieved high packet delivery ratio and short average path length. Hop count increases with density so control overhead also increases [5]. Jing Zhao et al, designed an algorithm which is based on the idea of carry and forward and used predictable mobility. They achieved high packet delivery ratio, low delay and overhead. When density is low routing loop increased which increased packet drops [6]. C. Kathirvel et al, established link reliability to reduce packet drop ratio. The combination of VANET and UMTS is used for longer connectivity among nodes. Cluster based topology is used and results shown increase in packet delivery ratio and decrease in packet drop ratio but overhead increased [7]. L. A. Hassnawi et al, investigate and analyzed the effect of different packet size and different packet rate on the performance of VANET. They used AODV routing protocol and shown that transmitting large packet increased the efficiency of packet transfer at the cost of packet drop. When packet rate increased the packet drop ratio also increased [8]. Nizar Alsharif et al, used centric cellular networks to provide more reliable communication but increased data explosion and network overhead [9]. Salim Bitam et al, designed a multipath routing protocol and used artificial bee colony optimization technique to provide quality of service. Designed protocol outperformed over AODV and DSDV in terms of packet delivery ratio and delay but overhead is more [10]. Jamal Toutouh et al, set optimal parameters of OLSR using NIBC techniques. NIBC algorithms outperformed in terms of different parameters over OLSR in most of the taken cases. Packet delivery ratio and normalized routing load is improved but end-to-end delay is more compare to traditional OLSR [11]. K.N. Patel et al, designed an algorithm which forward the data packets based on trustworthiness of the neighbor nodes. They handle the packet drop attack and improved the packet delivery ratio and packet drop ratio but control overhead increased.

The paper is divided in five sections and they are organized as follows; section 2 shows the flowchart of used NIBC techniques: artificial bee colony optimization, bacterial foraging optimization and particle swarm optimization. Simulation results explain in the section 3 and section 4 defines the conclusion of the proposed work.

2. FLOWCHART OF USED NIBC TECHNIQUES

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Nature has features like diversity, dynamic, complex, vigorous and captivating experience to resolve the hard and complex problems. Nature resolves the complex problems by using basic phenomena and conditions. It doesn't require any knowledge of the search space. Nature always try to find the optimal solution by maintain balance between its various components. NIBC are based on repetitive improvement of population to find local and global solutions. It also uses randomization. Three NIBC algorithms have been used in this paper and their flowchart are explained below:

I. Artificial Bee Colony Optimization (ABC): In ABC system, artificial bees fly around in a multidimensional search space and searches for the food. ABC system combines exploration and exploitation process [12]. Fig. 1 has shown the flowchart of ABC algorithm in zone based routing for VANET.

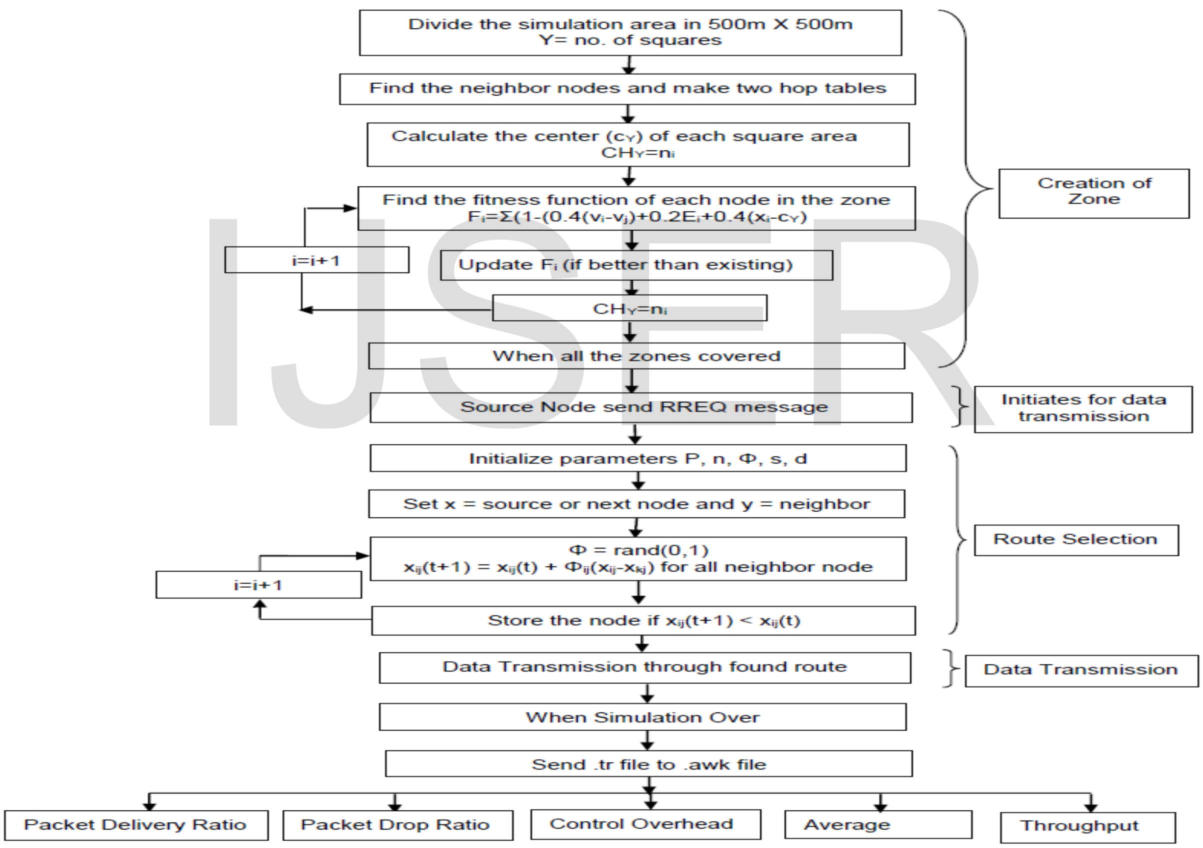

Fig. 1 Flowchart of ABC algorithm in zone based routing for VANET

Initially the network divided into small zones of size 500m x 500m. Then zone head is selected for each zone on the basis of fitness value. Fitness value of each node is calculated based on the relative velocity of that node with neighbor nodes, energy of node and the distance of the node from the center of zone. The node having highest fitness value selected zone head. Initially each node itself is a zone head. When a node wants to send data, it initiate for route selection, and sends RREQ message. ABC algorithm is used for route selection and some parameters are initialized for that, theses parameters are: P (search space), Φ random number between 0 and 1, s (source node), d (destination node) and n (total number of nodes). It uses relative position of node to find the route. Following equation is used to find the next node. Here k is the neighbor node of node j.

$$x_{ij}(t+1) = x_{ij}(t) + \Phi_{ij}(x_{ij}-x_{kj}) \quad (1)$$

here, $\Phi = rand(0,1)$, by default we have taken the value of $\Phi = 1$, it only changes randomly when node stuck in a loop. x_{ij} is the position difference between current node i and neighbor j, means

$$x_{ij} = [(x_i - x_j),(y_i - y_j)] \quad (2)$$

When destination node found the RREP message sent back to source node and data transmission starts through found route.

II. Bacterial Foraging Optimization (BFO): BFO based on foraging behavior of E.coli bacteria. Bacteria do tumbling and swimming to communicate about favorable and unfavorable conditions. It checks gradient of nutrient by chemotaxis process. It uses multi-optimal functions to find best solution and it is population-size independent. Bacteria search for nutrients in a manner to maximize energy obtained per unit time [13]. Fig. 2 has shown the flowchart of BFO algorithm in zone based routing for VANET. Initially the area is divided into small zones and zone head is selected as explained in ABC algorithm. Here also some parameters initialized for finding route. These are: P (search space), n (total number of nodes), Mc (twice the chemotactic steps), c (number of zone heads), r (reproduction index), e (elimination index), x (source node or current node) and y (neighbor node). First two factors mobility factor and signal strength factor is calculated to find out the cost of each neighbor node. According to the cost the next node is selected.

$$MF(y) = \left(1 - \frac{|d_t(y) - d_{t-1}(y)|}{R}\right) \quad (3)$$

Here $d_t(y)$ and $d_{t-1}(y)$ is the distance between current node and neighbor node at time t and t-1 respectively. R is transmission range. Low relative movement gives large mobility factor. y is a neighbor node. Mobility Factor initialized to 0.

$$SSF(y) = \left(1 - \frac{RX_{Threshold}}{RX_{Power}}\right) \quad (4)$$

Here $RX_{Threshold}$ is reception threshold power and RX_{Power} is received the signal power of neighbor node y. SSF initialized to 0. High received power gives high signal strength factor.

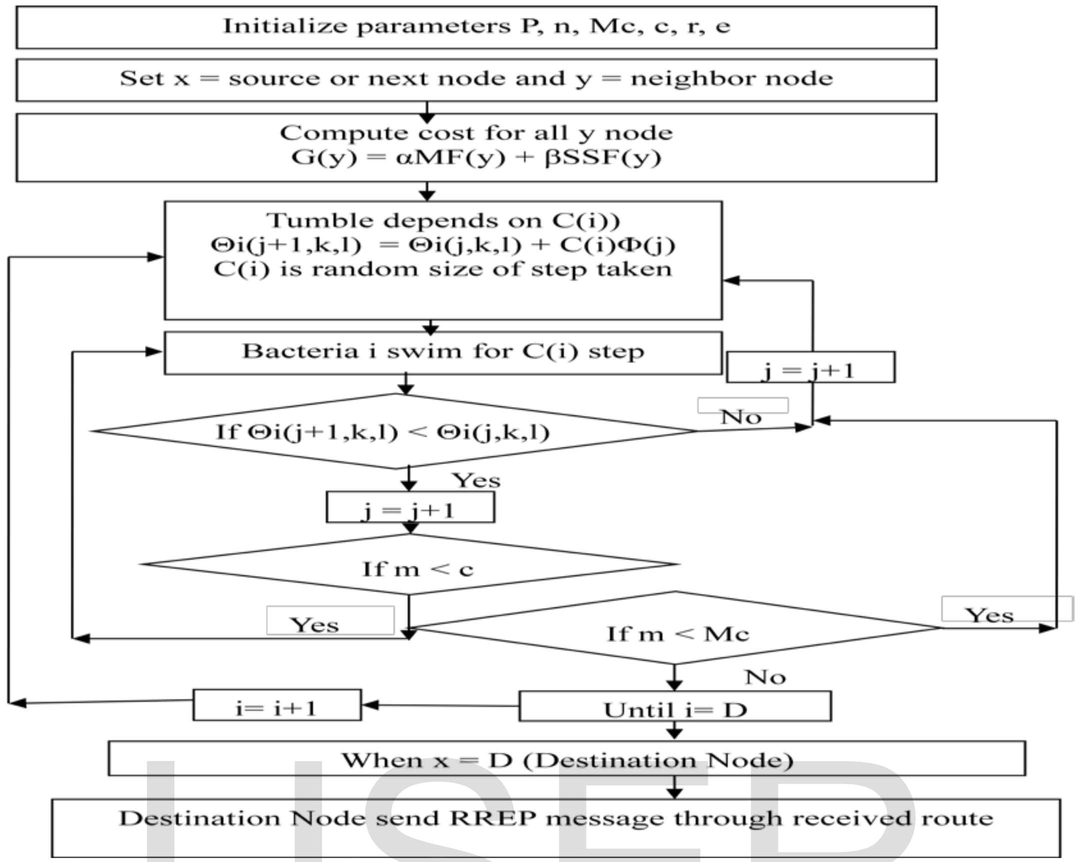

Fig. 2 Flowchart of BFO algorithm in zone based routing for VANET

Now the cost of each node has been checked and the node having highest cost value is dispersed. If any node continuously not dispersing any neighbor node, than there are chances that the node gets stuck in local best solution. To handle this situation we do tumbling using following equation.

$$\Phi i(j+1,k,l) = \Phi i(j,k,l) + C(i)\Phi(j) \quad (5)$$

III. Particle Swarm Optimization (PSO): It is a population based stochastic optimization technique for the solution of continuous optimization problems. It is inspired by social behaviors in flocks of birds and schools of fish. Particles always search for good solution in search space. Each particle is a solution and remembers its best position. Position is basically an objective function. Particle changes its velocity to find optimal solution. PSO has been applied to many different problems of artificial/engineering swarm intelligence system [8]. Fig. 3 has shown the flowchart of PSO algorithm in zone based routing for VANET.

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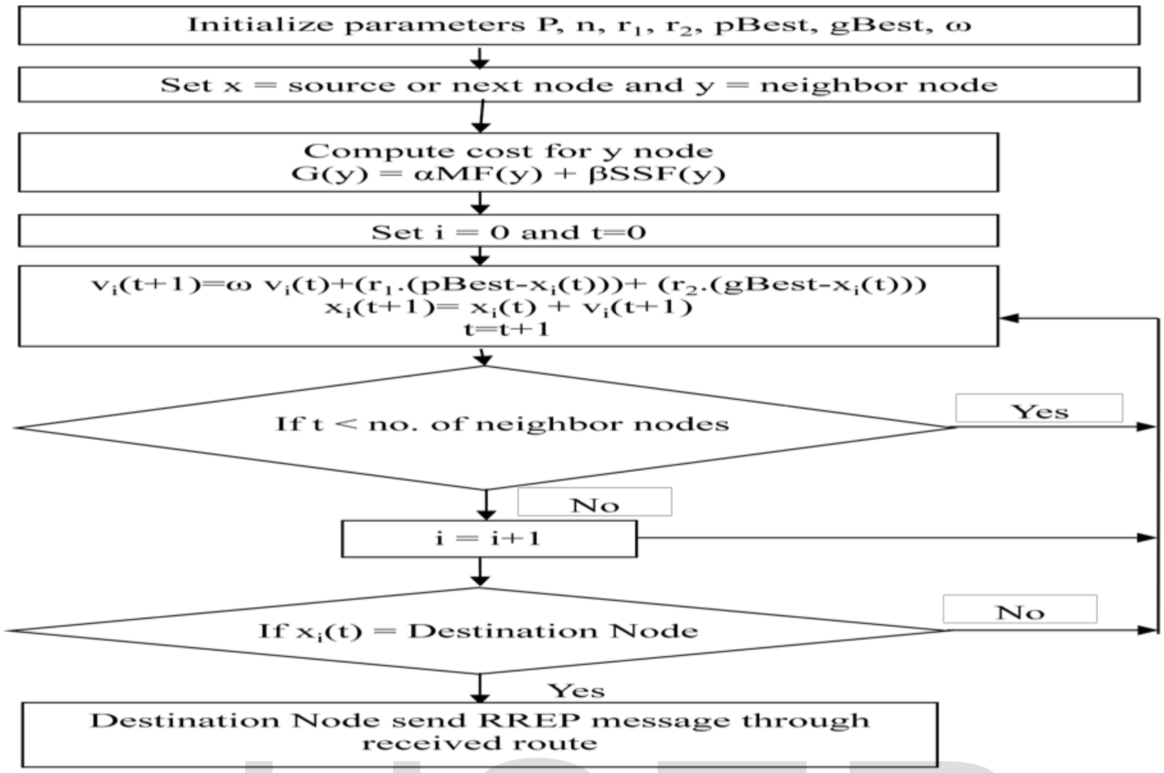

Fig. 3 Flowchart of PSO algorithm in zone based routing for VANET

After dividing the area and finding zone head when any node sends RREQ message first the position difference between the source and destination node has been calculated. Now the velocity and position has been modified depending on the cost value and the position difference in the direction of destination node using following equations and selects the next node. When next node is destination node, it sends RREP packet to source node and data transmission starts through found route.

$$v_i(t+1)=\omega\, v_i(t)+(r_1.(pBest-x_i(t)))+(r_2.(gBest-x_i(t))) \quad (6)$$

$$x_i(t+1)= x_i(t)+ v_i(t+1) \quad (7)$$

3. SIMULATION RESULTS

The simulation is carried out for ten combinations. In first five combinations transmission rate changes from 100 Kbps to 500 Kbps with the difference of 100 Kbps at speed 5m/s. In next five combinations speed changes from 5 m/s to 25 m/s with the difference of 5 m/s at transmission rate 100 Kbps. Simulation is carried out in ns2. Results are shown in terms of performance parameters.

I. Packet Delivery Ratio:

Table 1 has shown the performance of AODV and designed three NIBC algorithms in term of packet delivery ratio.

Table 1 Comparison in Terms of Packet Delivery Ratio

Packet Delivery Ratio								
Transmission Rate (Kbps)	Speed (m/s)	AODV	QoSBeeVANET	BFOZBR	PSOZBR	Improvement using QosBee with respect to AODV	Improvement using BFOZBR with respect to AODV	Improvement using PSOZBR with respect to AODV
100	5	0.378	0.338	0.418	0.317	-10.6%	10.6%	-16.1%
	10	0.385	0.356	0.448	0.336	-7.5%	16.4%	-12.7%
	15	0.336	0.365	0.460	0.355	8.6%	36.9%	5.7%
	20	0.378	0.399	0.482	0.398	5.6%	27.5%	5.3%
	25	0.383	0.410	0.522	0.429	7.0%	36.3%	12.0%
200	5	0.498	0.459	0.838	0.511	-7.8%	68.3%	2.6%
300		0.386	0.652	0.698	0.405	68.9%	80.8%	4.9%
400		0.317	0.568	0.601	0.327	79.2%	89.6%	3.2%
500		0.323	0.490	0.522	0.320	51.7%	61.6%	-0.9%

Analyzing table 1 it can be concluded that NIBC algorithms improved the performance of VANET in terms of packet delivery ratio.

II. Packet Drop Ratio:

Table 2 has shown the packet drop ratio of AODV, QoSBeeVANET, BFO and PSO in zone based routing for VANET. Here negative sign indicates low packet drop ratio, which shows improvement in performance. The table analysis shows that BFOZBR has minimum packet drop ratio. QoSBeeVANET has low packet drop ratio compared to AODV.

Table 2 Comparison in Terms of Packet Drop Ratio

Packet Drop Ratio								
Transmission Rate (Kbps)	**Speed (m/s)**	**AODV**	**QoSBeeVANET**	**BFOZBR**	**PSOZBR**	**Improvement using QosBee with respect to AODV**	**Improvement using BFOZBR with respect to AODV**	**Improvement using PSOZBR with respect to AODV**
100	5	0.644	0.614	0.530	0.644	-4.7%	-17.7%	0.0%
	10	0.638	0.608	0.496	0.638	-4.7%	-22.3%	0.0%
	15	0.634	0.604	0.477	0.624	-4.7%	-24.8%	-1.6%
	20	0.634	0.618	0.461	0.638	-2.5%	-27.3%	0.6%
	25	0.638	0.622	0.436	0.642	-2.5%	-31.7%	0.6%
200	5	0.345	0.436	0.128	0.445	26.4%	-62.9%	29.0%
300		0.477	0.348	0.259	0.477	-27.0%	-45.7%	0.0%
400		0.593	0.454	0.341	0.533	-23.4%	-42.5%	-10.1%
500		0.652	0.454	0.436	0.572	-30.4%	-33.1%	-12.3%

III. Control Overhead:

Table 3 shows the performance evaluation of AODV, QoSBeeVANET, BFO and PSO in terms of control overhead. Analysis of table shows that BFOZBR has minimum control overhead. QoSBeeVANET has also less control overhead compared to AODV.

Table 3 Comparison in Terms of Control Overhead

Control Overhead								
Transmission Rate (Kbps	**Speed (m/s)**	**AODV**	**QoSBeeVANET**	**BFOZBR**	**PSOZBR**	**Improvement using QosBee with respect to AODV**	**Improvement using BFOZBR with respect to AODV**	**Improvement using PSOZBR with respect to AODV**
100	5	36806	35785	40378	35746	-2.8%	9.7%	-2.9%
	10	37098	36013	40109	36012	-2.9%	8.1%	-2.9%
	15	37506	36493	41023	36489	-2.7%	9.4%	-2.7%
	20	37660	36936	41265	36936	-1.9%	9.6%	-1.9%
	25	38030	37004	41299	37005	-2.7%	8.6%	-2.7%
200	5	65038	69299	74442	68786	6.6%	14.5%	5.8%
300		93755	107630	95803	92879	14.8%	2.2%	-0.9%
400		115008	116090	111226	112113	0.9%	-3.3%	-2.5%
500		122358	134321	128679	119948	9.8%	5.2%	-2.0%

IV. Average Delay:

Table 4 has shown the comparative analysis of AODV and designed NIBC algorithms. Results have shown that average delay is more in NIBC algorithm at 100 kbps transmission rate and variable speed. As the transmission rate increases the average delay decreases in NIBC compared to AODV.

Table 4 Comparison in Terms of Average Delay

Average Delay								
Transmission Rate (Kbps)	**Speed (m/s)**	**AODV**	**QoSBeeVANET**	**BFOZBR**	**PSOZBR**	**Improvement using QosBee with respect to AODV**	**Improvement using BFOZBR with respect to AODV**	**Improvement using PSOZBR with respect to AODV**
100	5	4.392	4.144	5.600	4.144	-5.6%	27.5%	-5.6%
	10	4.645	4.390	5.770	4.390	-5.5%	24.2%	-5.5%
	15	4.714	4.695	5.611	4.694	-0.4%	19.0%	-0.4%
	20	4.794	4.814	5.393	4.814	0.4%	12.5%	0.4%
	25	5.097	5.189	5.365	5.189	1.8%	5.3%	1.8%
200	5	5.661	4.361	1.610	4.894	-23.0%	-71.6%	-13.5%
300		6.892	4.971	3.411	5.989	-27.9%	-50.5%	-13.1%
400		7.212	5.544	4.413	7.099	-23.1%	-38.8%	-1.6%
500		7.615	5.902	5.365	7.588	-22.5%	-29.5%	-0.4%

V. Throughput:

Table 5 Comparison in Terms of Throughput

Throughput								
Transmission Rate (Kbps)	**Speed (m/s)**	**AODV**	**QoSBee VANET**	**BFO**	**PSOZBR**	**Improvement using QosBee with respect to AODV**	**Improvement using BFO with respect to AODV**	**Improvement using PSOZBR with respect to AODV**
100	5	16365	19925	16800	25392	21.8%	2.7%	55.2%
	10	18539	20162	18023	25945	8.8%	-2.8%	39.9%
	15	18929	21369	18498	26114	12.9%	-2.3%	38.0%
	20	18692	22532	19384	26348	20.5%	3.7%	41.0%
	25	19786	23498	20993	26687	18.8%	6.1%	34.9%
200	5	16490	18763	13482	25423	13.8%	-18.2%	54.2%
300		17132	19212	16844	25499	12.1%	-1.7%	48.8%
400		18545	20412	19335	25786	10.1%	4.3%	39.0%
500		19998	20989	20993	26076	5.0%	5.0%	30.4%

Analysis of the table 5 shows that Particle Swarm Optimized Zone Based Routing (PSOZBR) has maximum throughput. All the designed NIBC algorithms except Bacterial Foraging Optimized Zone Based Routing (BFOZBR) have high throughput compared to AODV.

4. CONCLUSIONS

Table 1 has shown that BFOZBR improved the performance of VANET in terms of packet delivery ratio for all the ten combinations. PSOZBR and QoSBeeVANET also improved the performance for most of the combinations. Table 2 has shown the same results that NIBC improved the performance of VANET in terms of packet drop ratio also. Control overhead is much in BFOZBR but PSOZBR and QoSBeeVANET have low control overhead compare to AODV. Average delay is less in NIBC if transmission rate increased from 100kbps. Throughput also high in NIBC compare to AODV so overall results shown that NIBC algorithms improved the performance of VANET to provide quality of service. In future the hybrid NIBC algorithms can be designed to further improve the performance of VANET to provide quality of service.

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