



Improved MANET Routing Protocols Performance using Optimization Methods

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Abstract

A Mobile Ad-hoc Network (MANET) is a combination of mobile nodes that contact and cooperate with one another without depending on any predefined infrastructure. Reactive protocols are on-demand routing protocols detect the routes between sender and receiver. These protocols do not keep any network topology information and there is no need to exchange routing information periodically so it saves much control overhead. Particle Swarm Optimization (PSO) algorithm is an inspired algorithm because it imitates the sociological behavior associated with bird crowd. PSO similar the other evolutionary algorithms based on population; PSO start with random solutions of the population. Bat algorithm (BAT) is a metaheuristic algorithm and its idea comes from the echolocation conduct of microbats, with disparity pulse averages of emission and loudness, used for global optimization. To address the problem of find in MANET optimal solution, BAT and PSO are used in this work by implementing 300000 scenario using AODV and DSR. After obtaining the results from these algorithms in comparison with DSR and AODV, it turns out that the use of optimization algorithms shows good results through increasing the packet delivery ratio and the reduction the delay and drop packets.

Keywords: Ad-hoc; MANET; DSR; AODV; Optimization; PSO; BAT.

1. Introduction and Research Background

Wireless ad-hoc network does not base on a pre-defined infrastructure, which means the nodes interact with another node without any intermediate device so it's called as an ad-hoc network. Each node participates in routing by forwarding data for other nodes, so the determination of which nodes forward data is made dynamically on the basis of network connectivity. [1]. In this type of network routing is done on a hop by hop basis.

1.1 Ad-hoc Networks

Mobile Ad-hoc Network (MANET) is a new kind of wireless connection between nodes. In MANET there is no need for fixed infrastructure can be developed by using a wireless link which connecting diverse mobile nodes. When there is no alternatives are obtainable to create a network the Ad-hoc network is the

proper choice, this characteristic makes it hard to make a network with no need to any existing infrastructure. Typical challenges of MANET contain routing, bandwidth constraints, low power devices, hidden terminal and security [3]. Vehicle Ad-hoc Network (VANET) is a sub category of the MANET. In this technology the vehicles represent the nodes to create a mobile network. Every vehicle acts as a wireless router or node so this allows the vehicles to connect and create a wide range of the network [4]. Flying Ad-hoc Network (FANET) is a collection of Unmanned Air Vehicle (UAVs) contact with one another without access point requirement, but they need at least one of them to be connected to a ground base or satellite. UAVs work with no need to human intervention, such as autopilot. UAVs can fly independently or can be operated far away. Previously, UAVs were piloted aircrafts remotely and generally used for military operations/applications. Fig. 1 shows Mobile ad-hoc network. It consist of hosts configured wirelessly so they have their own transmission domain [2].

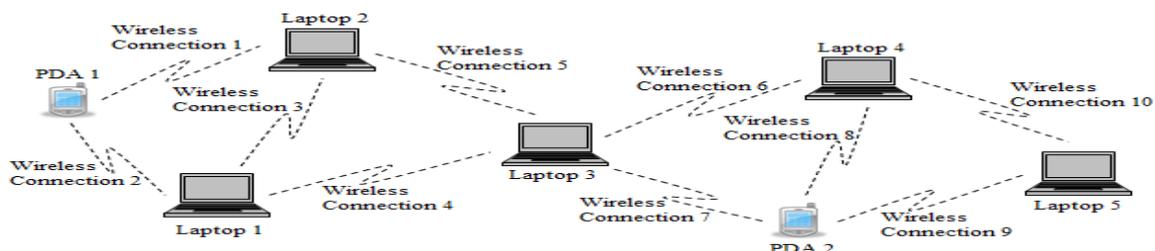


Fig. 1: Mobile Ad-hoc Network

1.2 Reactive Protocols

Ad Hoc on-Demand Distance Vector (AODV) is a packet routing protocol designed for use in mobile ad hoc networks (MANET).

AODV supports both unicast and multicast routing. This protocol establishes the route from source to destination when there is a need for this link by using its control packets Route Request (RREQ) and Route Reply (RREP). Route Error (RERR) control



packet used on route maintenance operation. [5]. Dynamic Source Routing (DSR) is one of the reactive protocols which are on demand routing protocols. Like in AODV the work of the Protocol summarizes in two parts: route discovery which is used for setting up routes and route maintenance which are used for monitoring of those routes respectively. DSR does not depend on the information in the intermediate nodes and instead of that use source routing.

1.3 Meta-Heuristics

Meta-heuristics are the most recent evolution in search methods for solving complex optimization problems that increase in business, commerce, industry and many other areas. Also, it uses concepts inspired from artificial intelligence, biological, mathematical, natural and physical sciences improve their performance [7]. Particle Swarm Optimization (PSO) is an optimization algorithm representing as a swarm of particles that inspired from the behavior of flocking birds. It gets the best solution from through the movement in an N dimensional search space. Every particle in the swarm has two values, one for the current position and the other for its velocity. The movement of particles obtained from these values where the velocity calculated and added to the previous position to get new the position. The particle has a memory to save its best position (Pbest). While (Gbest) mean the global best which calculated by the PSO during the monitoring the best value and its location for each particle in the swarm. [8]. BAT Algorithm is one of the algorithms that rely on optimization and arithmetic intelligence. This algorithm operates on the principle inspired by echolocation behavior of microbats. The algorithm uses frequency, speed and location for each bat in the swarm in all iterations in the specific dimension in the search space. The position represents the vector of solutions to the problem. The best solutions are stored during the frequent search process [9].

In addition to this introduction and research background, this article contains the following:

Section 2: present related work about energy optimization and network optimization with comparison between them.

Section 3: explains the metaheuristic algorithms and illustrate the proposed system.

Section 4: Introduces the results and evaluates the proposed system.

Section 5: Presents conclusion.

2. Related Work

The most related works for MANET optimization lay on two categories:

2.1 Energy optimization:

which means reduced energy consumption of battery-powered for each node in the network.

Wen-kuang Kuo and Shu-hsien [11] Chu present our numerical results of applying our proposed BB algorithm to energy efficiency optimization of a MANET. Add to that they compared between the proposed algorithm (BB) with another one and the result show that the proposed algorithm good performance Keep in mind computational complexity.

Radhika D. Joshi and Kirti Aniruddha Adoni [12] this paper proposed an algorithm on modified Optimized Link State Routing (OLSR) to minimize the consumption of the energy for each node in the network. This proposed algorithm always chooses energy optimized path so it's clearly the average range of nodes stay alive from 10 to 25%, but at the same time there is growing in the routing overhead.

The main interest in MANET is energy optimization & trustworthy communication. Manjinder Kaur and Lalit Mann

Singh [13] minimize the energy consumption by using dynamic clustering or residual energy connotation & perform routing protocol for trustworthy communication.

2.2 Network optimization:

Network optimization plays a crucial role as information technology is growing at massive rates with business users who produce large amount of data so there is a large consumption in network bandwidth.

Kamaldeep Kaur and Lokesh Pawar in [14], this paper display some of Optimization approaches which fall into the category of biologically inspired algorithms like Genetic algorithms, Particle Swarm Intelligence, Ant Colony Optimization, Artificial Bee Colony Optimization, Artificial Neural Networks and Bacterial Foraging Algorithm.

Al-Ghazal, M. et al. in [15], this paper works on algorithm which is based on genetic algorithm (GA) and cluster head gateway switching protocol (CGSR) by which it can be improved routing in clustering algorithm. Genetic algorithm (GA) keeps up to date state information about the neighboring network and GA mechanisms make systems to be self-configured. Genetic algorithms discover the best path from sender to receiver in the network, but it is not necessary to be the shortest path, also it allows a node to update routing information fast and efficiently to set local topology which constantly changing, initiating fewer link fractures and increasing lower MAC layer overhead.

Karthikeyan, D. and Dharmalingam, M. in [16], this paper use ant colony optimization (ACO) algorithm that inspired from the nature. In MANETs, the routing algorithms are developed facilely with this technique. In this technique, the independent agents interact with one another and their collaboration behavior is studied to get a given solution by finding the best global solution. An algorithm based on energy efficient routing is proposed for MANETs to increase the lifetime of the system by reducing energy consumption of nodes.

Alireza, S. et al. in [17], this paper suggests an algorithm based on the PSO algorithm in MANET for multicast routing. The PSO algorithm has higher performance and speed than GA based multicast routing. In multicast routing the main focus is on energy consumption efficiency and delay. Generally means that choosing the node within lower energy consumption and constructing a multicast tree with lower delay. Here, the issue was formulated as a PSO problem. A novel multicast routing algorithm depends on the PSO algorithms was suggested.

K. Sumathia and A. Priyadarshini [10] this paper presents the enforcement of Adaptive HELLO messaging scheme to get the information on the link between sender and receiver and monitor the link state with the using of dynamic on demand routing protocol to decrease the energy consumption to specific rang.

Nancharaiiah, B. and Mohan, B.C in [18], this paper use ACO and PSO. In ACO, ant's works as mobile agents to give the best optimal path and prepare input to PSO. In PSO the position and velocity of particle choose best over previous one by considering the low cost and delay. The collection of these two performs better than ACO. PSO detects the best solution through the particle's position and velocity with the objective of cost and lower End-to-end delay. This hybrid algorithm shows better performances when compared to ACO algorithm.

Anuj, K. and Harsh, S in [19], this paper focus mainly on the most challenging task which is the routing. ACO which is based on the flock intelligence is a useful approach by which routing algorithms are developed facilely. The ants find the best path, by releasing chemical material called pheromone. MANETs and ants have many similarities like their configuration, physical structure and origin of the route. This technique from collective intelligence is utilized in the ad-hoc network of researchers.

Zulfiqar Ali and Waseem, S. in [20], this paper focus on two approaches which are relying on swarm intelligence ACO and

PSO. These algorithms provide loop free routing and multipath in the ad hoc networks.[26] All different routing algorithms based on flock intelligence in MANETs: GPS/Ant Line Routing Algorithm (GPSAL), Node Neighbor Number Algorithm (NNNA) and Accelerated Ants Routing (AAR). All these approaches are Metaheuristic in nature and provide optimized routing.

Shah, S.K. and Vishwakarma, D.D. in [21], this paper suggests ANN optimization technique which is used in the reactive routing protocol (AODV). In this the frequency of the Hello period between two events is specified to examine the network performance. Needless traffic may happen due to updating information at some time interval. Accordingly, to make the efficient performance of the network, it must set the time interval of these messages to be adaptive. Updating information in some fixed time periods may cause unnecessary wireless network traffic, so they use the time interval for these messages to get a better network performance.

Harpreet K., Jasmeet S. in [22], this paper works on a bacterial foraging optimization algorithm (BFOA) which is a bio inspired optimization algorithm. This algorithm inspired from the behavior of bacteria. A new protocol BFAODV is suggested, which represent outcome from AODV protocol when BFOA algorithm is utilized on it. This protocol improves various metrics related to performance of the network and it also decreases overhead of neighbor discovery processes and energy consumption.

E. Hemalatha, J. and Dr. Kannammal in [23], this paper works on ABC optimization technique in MANET to get best route discovery. This technique detects the global optimum value and works on the precept of artificial honey bee's collective intelligence. The ABC Optimization algorithm has shown to be a good technique for recognizing steady routs between source and destination nodes. Table (1) shows the summarization of optimization methods with Ad-hoc protocols.

Table 1: Summarization of the MANET protocols with Optimization methods

Paper No.	Authors	Method	Performance Evaluation	Protocol
14	Kamaldeep Kaur and Lokesh Pawar	PSO, ACO, ABC, ANN and BF.	Survey on network optimization in MANET.	
15	Al-Ghazal, M. et al.	genetic algorithm	-Routing information -overhead	CGSR
16	Karthikeyan, D. and Dharmalingam, M.	ACO	-Energy efficiency, -robustness -reliability -PDR	AODV
17	Alireza, S. et al.	PSO	-energy efficiency -delay	Multicast routing.
10	K.Sumathia and A.Priyadharshinib	On-demand routing protocol	-Energy efficiency -delay	Reactive routing
18	Nancharaiah, B. and Mohan, B.C	ACO and PSO	-End-to-end delay -Communication cost	Routing protocols
19	Anuj, K. and Harsh, S	ACO	-end to end delay -routing overhead	AODV, DSDV, DYMO, DSR
20	Zulfiqar Ali and Waseem, S.	ACO and PSO	-routing overhead -route optimality -energy efficiency	AODV,ZRP
21	Shah, S.K. and Vishwakarma, D.D.	ANN	-throughput -node density	AODV
22	Harpreet K., Jasmeet S.	BFOA	-energy consumption -overhead	AODV, DYMO.
23	E. Hemalatha, J. and Dr. Kannammal	MABCO	- PDR -delay -Jitter -Throughput	Routing protocols

3. Research Methodology

The purpose of this study is to find the best solution from thousands of scenarios in DSR and AODV protocols in MANET environment. First, the scenarios have been implemented in network simulator (ns2) after that Java has been used to read the files that contain input network parameters and output evaluation parameters to prepare structured data. The optimization algorithm will apply to this data to get the best solution and run it in the ns2.

3.1 Particle Swarm Optimization (PSO)

PSO is one the optimization algorithms rely on population randomness. PSO first proposed by Kennedy and Eberhart by implementing the algorithm on the simple social sample, start with a number of random solutions (particles), each particle has a velocity in a range defined by the user, to optimize the value of the cost function which is evaluated at the position of the particle.Each particle developed repeatedly in the search space trying to get a better solution in the following method:

$$vk(i + 1) = wvk(i) + c1r1[Pbestk - xk(i)] + c2r2[Gbest - xki]. \quad (1)$$

$$xk(i + 1) = xk(i) + vk(i + 1) .. \quad (2)$$

In equation (1) the (x) represent the position and (v) represent the velocity of particle which represented in (k) in the iteration (i), c1, c2 are stable acceleration equal to 2, r1 and r2 are independent random numbers in the range (0,1) and *Pbest* is the best position of a particle and *Gbest* is the best position of the swarm.*Pbest* represent the best position where the cost is lower value in its search history [24]. In this work these equations have been used to change the position of the particle until the best cost have been obtained which leads to the best solution.

3.2 BAT Algorithm

In 2010 Yang proposes Bat Algorithm [9]. Bat algorithm used to solve optimization problems by simulating the behavior of bats, which depend on the echolocation of the microbats to update its position and velocity to get appropriate to live. This algorithm

work iteratively and in each iteration the position of each bat updated depends on the velocity and hertz number of sound wave. In network optimization, the position vector of bats represents the parameters of the problem to be solved. In all iteration, position and velocity for every bat in the swarm will be measured depending on previous velocity, frequency and global information. BAT algorithm uses following equations to update velocity and position:

$$F[i] = F[\min] + (F[\max] - F[\min])\beta . \tag{3}$$

$$Vt[i] = Vt - 1[i] + (Xt[i] - X[g])F[i] . \tag{4}$$

$$Xt + 1[i] = Xt[i] + Vt + 1[i] .. \tag{5}$$

Where, F (i), F (min), and F (max) represent the hertz of the sound wave of microbat at time t. β is a random vector and its value range from 0 to 1 [25]. X (g) is the current global best solution for each bat. The global best solution X (g) of the swarm is calculated after finishing all the iterations [9].

3.3 Algorithm of PSO – BAT

The algorithmic steps for the proposed MANET routing based on PSO-BAT which shown in the figure(2) is explained as follows:

- Step 1:** Choose network parameters sequentially (number of nodes, Number of connections, rate of speed).
- Step 2:** Set the results of scenarios as dataset to algorithm.
- Step 3:** Generate network parameters randomly and check it with the dataset.
- Step 4:** Retrieve evaluation metrics (Packet Delivery Ratio, Drop packets, Delay).
- Step 5:** Compute position and velocity of the current Particle or bat agent using equation (1) and (2) in PSO and equation (4) and (5) in BAT.
- Step 6:** If all the updates are performed then end the process, and
- Step 7:** If no optimal solution is achieved after step 2 then move to next agent and repeat from step 3 to 6 to perform optimization.

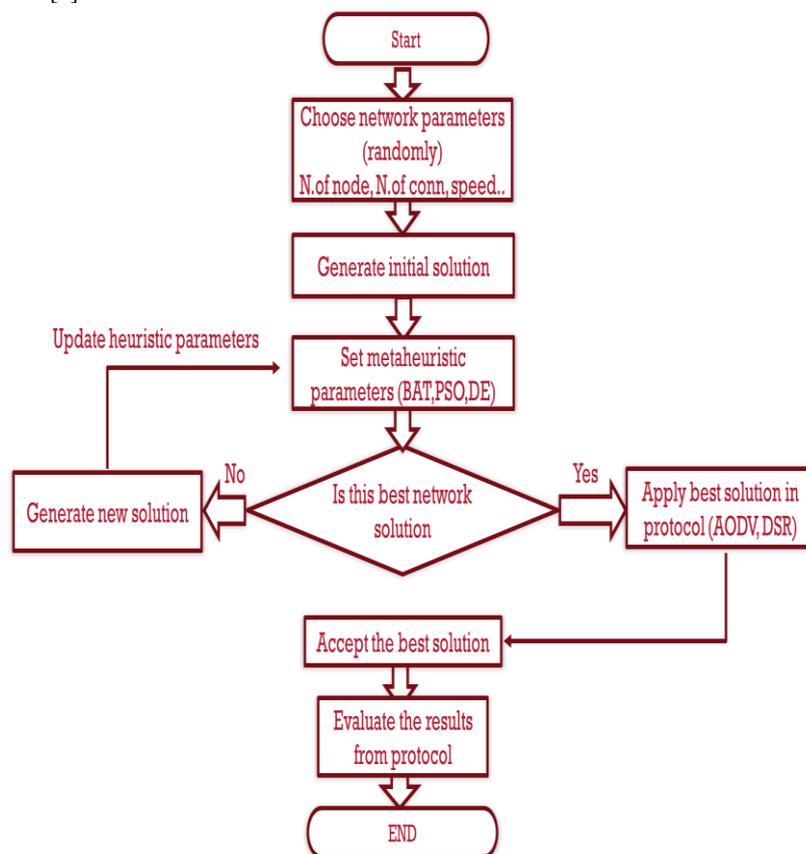


Fig. 2: Flowchart Proposed MANET routing based on PSO-BAT

4. Implementation Results

The results run based on 300000 scenarios for each protocol with different network parameters which were increased sequentially. Nodes in the network follow pursue mobility model. The nodes are linked with one or more neighbors in order to communicate. The transmission range is fixed for each node. Path establishment between nodes is enabled by AODV or DSR. The parameters used for the analysis of our proposed work is shown in Table 2

Table 2: Simulation Environment

Simulation parameters	Value
Channel	Wireless Channel
Phy	Wireless Phy
Propagation	Two-Ray Ground
dimension of the topography	1500*1500

Mac	802_11
Antenna	Omni Antenna
Simulation time	50
Simulator	NS2
Number of nodes	15-300

The proposed work is employed on DSR and AODV protocols illustrate its effectiveness in network evaluation metrics. The performance of proposed hybrid (PSO - BAT) algorithm is compared against AODV, DSR. The proposed algorithm is evaluated using the network parameters PDR, Drop packets and delay:

4.1 DSR

The results for the DSR, PSO-DSR, and BAT-DSR protocol are presented in the table (3). It is clear that the hybrid of PSO

with DSR protocol is better than the DSR and DSR-BAT in term of PDR, delay and drop packet.

Table 3: Comparison of DSR and new techniques with respect to various parameters

Technique	Scenarios	PDR(Kbps)	Delay(ms)	Drop (packets)
DSR	15-100	73.26	26.74	7.09

4.1.1 Packet Delivery Ratio (PDR)

PDR means the ratio of packets sent successfully to the receiver. The high value of PDR means the best scenario. It is cleared from the figure (3) that the value of the PDR is increased using PSO-

	100-200	63.47	34.49	9.33
	200-300	61.55	22.86	10.45
PSO-DSR	15-100	91.53	17.78	7.85
	100-200	89.79	9.41	7.17
	200-300	97.58	7.66	6.35
BAT-DSR	15-100	81.79	20.15	6.78
	100-200	84.04	18.85	6.2
	200-300	78.33	20.38	6.24

DSR and BAT-DSR because it searches for the optimal solution. Equation (6) used to calculate the PDR:

$$PDR = (Received / Sent) \times 100 \quad (6)$$

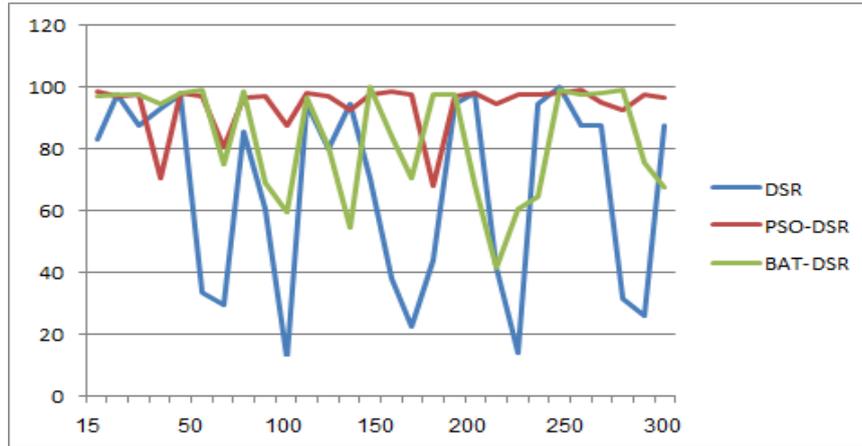


Fig. 3: The PDR for the DSR, PSO-DSR and BAT-DSR

4.1.2 Delay

Delay is one of the important metrics which means the whole time the packet takes until it reaches its destination. It is clear from

figure (4) that the time of the delay using PSO-DSR and BAT-DSR is reduced. Equation (7) used to calculate the Delay:

$$Delay = \frac{\text{sum of the time spent to deliver packets for each destination}}{\text{number of packets received by the all destination nodes}} \quad (7)$$

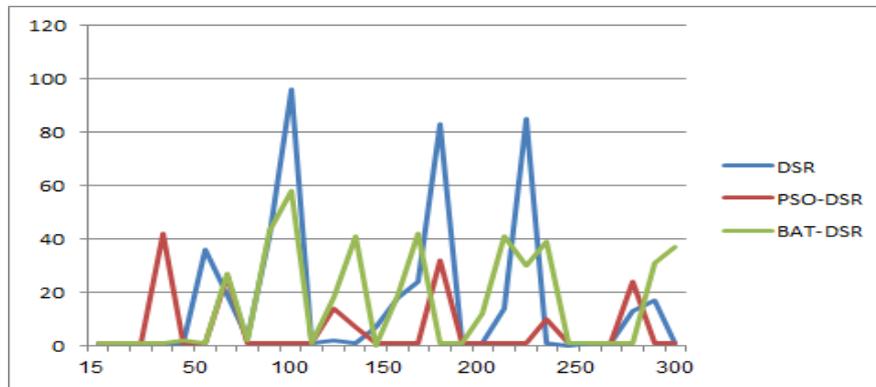


Fig. 4: The Delay for the DSR, PSO-DSR and BAT-DSR

4.1.3 Drop Packet

Drop packets mean the packets that sent from the sender and does not arrive its destination. Figure (5) shows the reduction of drop

packets using PSO-DSR and BAT-DSR. Equation (8) used to calculate the Drop Packets Rate (PDR):

$$DPR = \frac{\text{number of packets sent} - \text{number of packets received}}{\text{number of packets sent}} \quad (8)$$

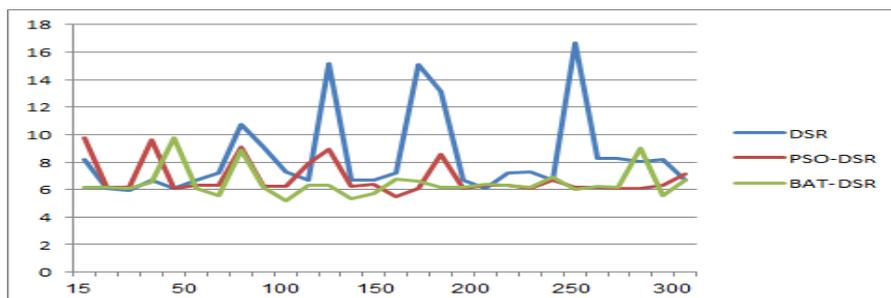


Fig. 5: The drop packets for the DSR, PSO-DSR and BAT-DSR

4.2 AODV

The results for the AODV, PSO-AODV, and BAT-AODV protocol are presented in table (4). It is cleared that the hybrid of PSO-AODV and BAT-AODV are better than the AODV in term of PDR, delay and drop packet.

Table 4: Comparison of AODV and new techniques with respect to various parameters

Technique	Scenarios	PDR(Kbps)	Delay(ms)	Drop (packets)
AODV	15-100	70.13	446.83	21.16
	100-200	97.07	282.63	9.83

	200-300	96.12	315.08	35.07
PSO-AODV	100-15	83.46	224.08	8.4
	100-200	95.33	159.06	6.1
	200-300	97.7	217.9	18.77
BAT-AODV	100-15	85.71	236.24	6.7
	100-200	90.5	87.45	5.6
	200-300	98.86	191.86	11.83

AODV Likes the DSR, after implementing the algorithms on the dataset it is obvious to recognize the high packet delivery ratio in comparison with the AODV in the figure (6).

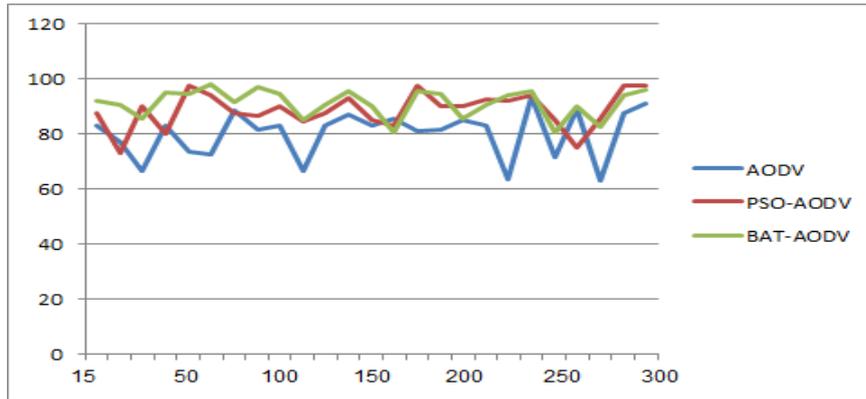


Fig. 6: The PDR for the AODV, PSO-AODV and BAT-AODV

Also, it can recognize the reduction of Delay in the figure (7).

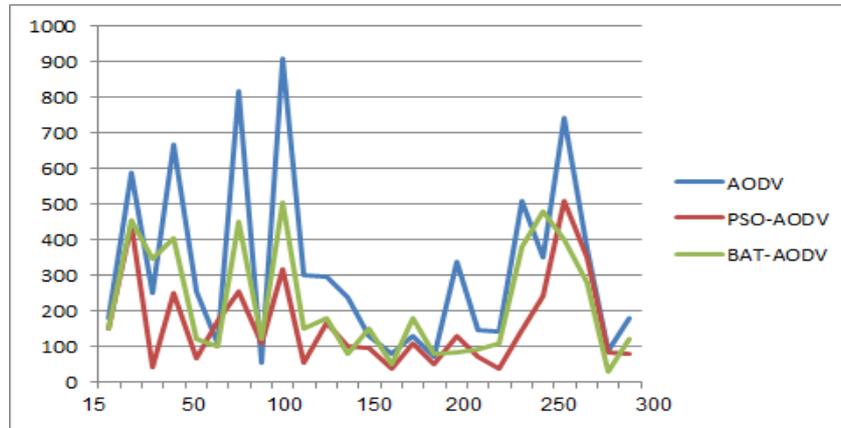


Fig. 7: The delay for the AODV, PSO-AODV and BAT-AODV

Also, it can recognize the reduction of Drop packets in the figure (8).

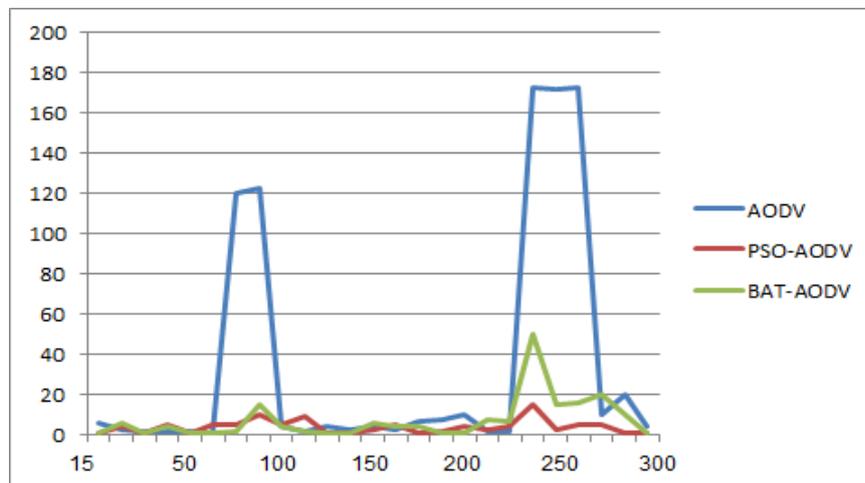


Fig. 8: The drop packets for the AODV, PSO-AODV and BAT-AODV

5. Conclusion

The computational results show that using swarm-based algorithms is possible to choose the best solution for the performance of the AODV and DSR routing protocols regarding routing PDR, delay, and dropped packet. The metaheuristic algorithms have the ability to find the best network metrics so it have been used it to improve the performance of choosing the best solution from 300000scenarios. The PSO and BAT algorithms are simulated using NS2 software and the results are compared with AODV and DSR using delay, PDR, and dropped packet as parameters. The results show that the PDR are increased while delay and dropped packet decreased.

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