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Cost Optimization Approach for MANET using Particle Swarm Optimization

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Abstract— This paper present the approach require to increase the QoS of MANET network using particle swarm optimization algorithm. To improve data communication between two nodes we propose an efficient algorithm for AODV protocol using PSO where instead of suppling all default parameter with default value of AODV protocol we try to provide selective parameters with optimum value so that overall requirement of control packet get decrease that in turn result in to increase quality of service parameters of MANET. For the enhancement of reliability and reduction of cost, node speed control mechanism is implemented using PSO, The given method which is use for simulation, reduces the overall loss of data and also make transmission effective. We have also tested the performance of network by changing data rates and the speed of the node.

Keywords- Distance vector routing, Particle swarm optimization, Throughput, End to End Delay, Routing load

I. INTRODUCTION

MANET becomes famous in wireless transmission due to its unique characteristics and diverse applications. Unlike traditional networks with fixed infrastructure, it is self-configuring and dynamic network, where mobile devices, or nodes, can communicate with each other directly, forming temporary connections on-the-fly without relying on any centralized infrastructure [6]. The decentralized nature of MANETs makes them particularly suitable for scenarios where establishing a pre-existing infrastructure is impractical, costly, or simply not feasible.

They enable seamless communication in situations where conventional networks might be unavailable or unreliable. From disaster recovery operations and military tactical communications to vehicular networks and remote sensor deployments, MANETs play a crucial role in bridging communication gaps and enabling data exchange in dynamic and unpredictable environments.

The challenges in routing within MANETs arise due to node mobility, limited power, varying link qualities, and the need for adaptability to changing network topologies. Researchers have explored a plethora of routing protocols, ranging from reactive protocols proactive protocols and hybrid approaches, each attempting to strike a balance between efficiency, scalability, and robustness.

Moreover, in MANETs, the role of optimization techniques cannot be overlooked. Researchers have been exploring swarm intelligence-based algorithms, genetic algorithms, and other bioinspired approaches to address issues related to route optimization, network management, and energy efficiency [5]. The aim is to develop protocols and mechanisms that can dynamically accept the changing behavior of the network while optimizing performance parameters.

We embark on an exploration of MANETs, focusing on the design and evaluation of a novel routing protocol that leverages Particle Swarm Optimization (PSO) use to improve efficiency and adapting power of data transmission within the network. We aim to contribute to the body of knowledge by investigating the performance of the PSO-based protocol and comparing it against traditional routing protocols under various scenarios. Additionally, we delve into the influence of key AODV parameters on the protocol's performance, seeking to identify optimal configurations for different network settings.

By the end of this study, we endeavor to offer valuable insights into the potential of PSO as a viable optimization technique for MANETs, shedding light on the opportunities and challenges in leveraging swarm intelligence for improving the performance of the network. As the demand for seamless and resilient communication continues to grow in our increasingly mobile world.

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II. RELATED WORK

It is also possible to improve QoS of the network by collecting data using energy efficient method using mobile data collector for wireless network [1]. Mobile adhoc network having high mobility, topologies are dynamic, network is distributed across the globe and operated without centralized administrator which make it difficult to provide better Quality of service which is require in the network [2]. There are various protocol develop for mobile adhoc network and wireless sensor network with the help of bio-inspired methods. It is an algorithm which add routing capacity from the social behavior of ant colonies, honey bee dancing, bird flocking. It provide you surety to handle issues created by wireless network [3].

It is good to developed cluster based mechanism for transmission of data to the source station. All node normally send their data to its cluster node now cluster node transmit it to the base station after collection from all node. Here they have created correlation model to filter out node on the basic of correlation value before adding to cluster [4]. They try to find out issues, latest research problems for AODV protocol and try to find out design objectives of AODV protocol [5].

AODV routing protocol which doesn't get affected by the bandwidth, delay and cost of the actual network and its routing table contain normally one route from source to destination node. They try to provide multiple path using particle swarm optimization approach. They compare four PSO based algorithms, linear decline, inertia weight, shrinkage factor and chaos and find out that ACPSO can find out optimal path easily and quickly [6].

The optimized PSO implemented using a mutation operation in place of non-uniform. It is added with LAR protocol to increase performance of network using network [7]. Then Algorithm get compared with AODV routing protocol and energy efficient BPSO to find out energy utilization of both the protocol by comparing with the available energy [8].

It is related to finding dynamic priority scheme which is used to select most suitable next hop by identifying them from various priority based on network condition. Result obtain by simulation shows that proposed method give better performance compare to existing geographical routing protocols by considering various parameters like PDR, end to end delay and routing overhead[9].

The Hybrid-K-means-PSO technique which is implemented to enhance the network lifetime and throughput. It is also used to reduce the size of dead node and energy consumption in the network [10].

It describe the way of finding children of a node in order to find out shortest path that is useful to have maximum life of a node. Proposed link life prediction algorithm find out life of a node so that path can be created using maximum life of a node so transmission can be done for maximum amount of time [11]. It is advisable to use power optimized cross layer design based protocol for reduction of loss of energy and boost the life of the network for long duration data transmission [12].

It is also difficult to find out effect of malicious node and guard nodes on the network so in this research malicious node get analyzed and effect of malicious node reduce over the network. Simulation perform using in particle swam optimization intrusion detection response system performance of network observed using parameters like PDR and throughput [13].

It is batter not to use pso approach only for finding shortest and relevant path so if calculation of hop count and energy used for transmission get done which enhance performance of network in terms of reliability and adaptability. Researcher propose PSO-AODV to satisfy QoS requirement of MANET [14].

Mobility prediction and delay prediction can be done using optimized link state routing protocol for UAV network. It is also possible to use kalman filter algorithm to find out stable neighbor node which is used as a multipoint relay that in turn help to provide stability to routing protocol used for transmission [15].

It is better to use not only characteristics of APSO but also of FSS to make FZAPSO for dense network routing with minimum delay and power used for transmission to expand life of the MANET [16].

A lot of work has also been performed in the field of security using PSO based approach. It is helpful to find out threats and vulnerability of the network [17]. It is also possible to deal with security aspect like intrusion detection and management of security of key using pso. Confidentiality and vulnerability also detected using particle swarm optimization algorithm [18].

The creation of fault tolerant routing protocol using pso provide fault tolerance system which can be used to deal with the critical issues of adhoc mobile network[19]. Node transmit packet between different hope creates issue of delay and dynamic movement also create issue of loss of packets it can be handle using proposed protocol [20].

Life time of network can be primary goal and that is achieved using various packets forwarding technique between various areas (Zone) in order to do effective utilization of resources [21]. Issues of routing load, power consumption in manat can be dealt using optimization technique developed using genetic behavior of particles [22]. Routing overhead also created due to high mobility of the network [23]. Transmission of packet have certain objective so objective needs to be successfully achieved by the transmission protocol if issue arise that can be handle using multiple objective handling capability of PSO [24].

If traffic created properly while creating mobile network there are less chances of issues like packet loss, increase in delay. So if load balancing done properly in the network performance of network get increase for that optimization algorithm plays and

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effective role [25]. Qos of service is requirement of any network. So based on that requirement of network parameter get analyzed and strategies develop to improved performance of selected parameters [26].

Sometime it is good to send data not only by using protocol of one layer but if cross layer approach is used for transmitting data in adhoc netwok reduce error of delay in packet, drop of packet and optimized overall performance of the network[27]. Selection of speed and path for transmitting packet is important for better utilization of available resource and performance of the network. PSO can be used for taking better routing decision and improving efficiency in terms of transmission [28]

III. AODV ROUTING PROTOCOL WORK MECHANISM

This protocol is used to provide multi hop routing between source node and designation node. It is reactive type of routing protocol where source node initiate route discovery only when it is demanded by network to have path from source to destination. On another side proactive type of routing protocol create routing table of directly connected node even though transmission is not take place between source and destination node. This types of protocol continuously sense the channel and maintain the routing table.

AODV routing protocol path finding and maintain procedure carried out using following phases:

i) Discovery of Route

ii) Maintenance of Route

Here when source node have data to transmit source node first of all check its own routing table if route available then it immediately start communication between the nodes. If path doesn't exit then as per the first phase route discovery procedure carried out. This process broadcast route request (RREQ) message.

Now intermediate nodes start accepting RREQ message and search for the path to destination. If intermediate node found it create a path and route reply message forward to directly connect intermediate node. The process continue till the path to the destination node reveal.

Duty of intermediate node note only to search the path but it also maintain the hop count value (intermediate node size between source node and destination node). It gives idea about how many intermediate node exist between source node and destination node. It also create routing table which contains the entry of total number of hop, source node address, address of the next hop it is equal to neighbor node address from which message is received.

Each entry created in routing table have some lifetime. If it is not used within a given duration then that entry get removed from the table. So through this destination node get idea about source node and it will create RREP message.

Now reverse process takes palace RREP message transmitted using unicast facility to the nearest of from the originator of the RREQ message that is found out from the routing table entry of the origin node. Intermediate node start receiving RREP message start incrementing hop count entry by one. Now when source node receive the reply then source node can decide distance up to destination node using total hop count. This way complete route discovery process take place.

During the second phase which is route maintenance phase. It is basically performed by source node usually when intermediate node or destination node leave the network and route error message received by the source node.

Now source node send route error message as per the hop count to all the neighbor node intermediate node update its routing table entry to infinity for the final node or hop node. Now source node again initiate route discovery process.

Figure 1 show the flow chart of adhoc on demand distance vector routing protocol

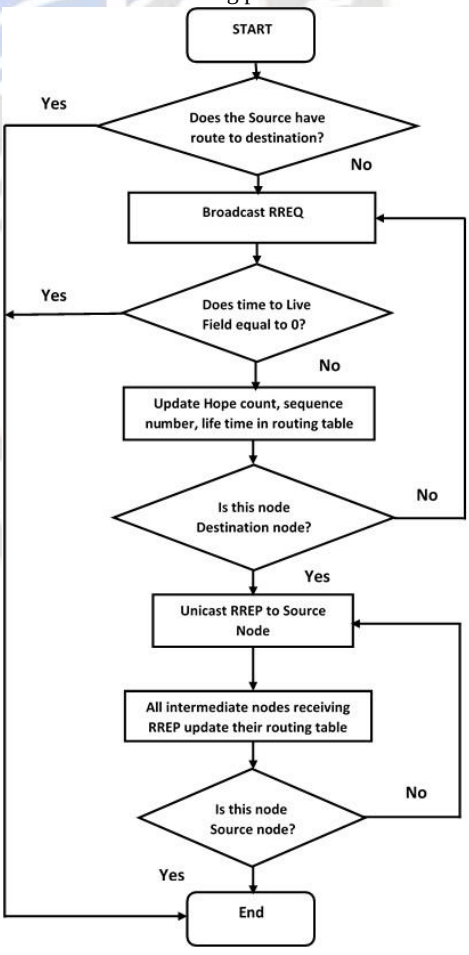

Figure 1: Flowchart of AODV route procedure

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IV. PARTICLE SWARM OPTIMZATION WORK MECHANISM

This algorithm is of probabilistic category it is based on population. It is developed by observing grouping behavior of bird and fish.

Here each swarm is consider as one particle with its independent speed and location. Now decision of best position and speed of particle is based on the highest fitness value of the particles which is calculated using fitness function show in equation (1) and (2). Following step are used to find out best speed and location of particles.

Step I. Initialization of particles in the search space

Step II. Evaluation of each particle performance

Step III. Particle fitness value is optimum than current pbest then fitness value is set as a new pbest.

Step IV. Updating location and speed of particles.

In this algorithm parameters are not encoded and decoded into binary strings compare to other genetic algorithm where they user real number [12]. This feature make this algorithm powerful and easier to implement. Here it use random real number and spread it among the particles.

For objective function search space is calculated by arranging the space of individual agents called particles. It create vector of each individual particle movement path [9]. The movement of particles are divided into two parts:

i) A speculative component;

ii) A irrevocable component.

Particles are moving in the search space by considering global best g* location and its own location yi*. It can move randomly within the search space by considering available location. Now during movement particle find new best location which is better than existing one. Particle update new location and other particle also compare it with their current location and update the same if it is the best one. Global best location finding process repeatedly carried out till the number of iteration decided gets over [13].

Current best location is mention using yi*(t) for particle I and current global best at t is $gl^* \approx \min \{f(yi)\}$ for (i = 1, 2, ..., n).

Given equation is used to find out best speed and location of the particle in the search space[11].

$$v_i^{t+1} = v_i^t + C1\, \varepsilon_1 [g^* - y_i^t] + C2\, \varepsilon_2 [y_i^{*(t)} - y_i^t] \quad (1)$$

$$y_i^{t+1} = y_i^t + v_i^{t+1} \quad (2)$$

Here

- yi^t is particle i position vector at time t
- v_i^t is particle i velocity(speed) vector at time t
- ε_1 and ε_2 are two random vector, there entry is between 0 and 1.
- C1 and C2 are constant their values are C1 =C2 = 2.

Please find below pseudo code for PSO algorithm.

PSO Algorithm

f (y), $y = (y_1 \ldots y_d)^T$ is consider as an Objective function

Location y_i and v_i velocity of n particles get initialized.

Find g* from min $\{f(y_1) \ldots f(y_n)\}$ (at t=0)

While (criterion)

For loop for particles (n) and dimensions (n)

Creation of fresh particle velocity v_i^{t+1}

Searching for fresh particle locations $y_i^{t+1} = y_i^t + v_i^{t+1}$

Apply Objective function at new locations y_i^{t+1}

Deciding individual particle y_i* current position

End for

Current global best g* obtained after interaction

Do increment of one in time t

End while

Final result output is y_i* and g*.

Particles velocity at starting of operation $v_i t = 0$.

V. PROPOSED WORKFLOW

We have tried to supply optimized value to AODV protocol instead of default value so for that with the help of PSO algorithm after performing step as mention below we can get optimized value. Procedure of obtaining optimized value is mention as step 1 to 9.

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Table 1: AODV parameter and selecting range

Parameter	Default Values	Range
TIMEOUT OF ROUTE	3.0S	[1…10]
HELLO LOSS ALLOWED	2	[1…10]
MY_ROUTE_TIMEOUT	2	[1…10]
DIAMETER	35 Nodes	[1… 40]
TRAVERSAL TIME OF NODE	0.04 s	[0.01…1.00]
MAXIMUM REQUEST TRY	2 tries	[1…10]
TTL START	1.0 s	[1… 10]
TTL INCREMENT	2.0 s	[1… 10]
TTL THERSHOLD	7.0 s	[1… 20]

PSO algorithm performed as per the step given below.

Step 1: Initialization of the population (y_i) as 10 random sets of nine parameter as input. Search space is consider using nine parameters as per the table 1. Where i=1, 2, 3...10.

Step 2: Repeat steps 3 to 7 as per the loop.

Step 3: ten sets (y_i) fitness function value is calculated using network simulator as a solution set given in figure 3.

Step 4: During first iteration the $pbest_i$ and pi are set equal to solution set and y_i respectively. Current position of i^{th} set in nine dimension search space denotes by y_i. During next iteration fitness value from solution set obtained for y_i and compared with $pbest_i$. If it is better than current $pbest_i$ than current pbesti replace by value from the solution set.

Step 5: Now value of i assigned to g from minimum $pbest_i$. Where i belongs to 1 to 10.

Step 6: Particle velocity is set to zero at initial stage. Next velocity and position is calculated as per the equation 1 and 2 respectively.

Step 7: After 20 iteration condition is check to terminate the loop.

Step 8. After 20 successful iteration loop terminated.

The above algorithm generate optimized value as per the table 2.

Table 2: AODV parameters default value and Optimized Value

Parameter	Default Values	Optimized values
TIMEOUT OF ROUTE	3.0S	8
HELLO LOSS ALLOWED	2	6
MY_ROUTE_TIMEOUT	2	6
DIAMETER	35 Nodes	42
TRAVERSAL TIME OF NODE	0.04 s	0.09
MAXIMUM REQUEST TRY	2 tries	4
TTL START	1.0 s	1
TTL INCREMENT	2.0 s	3
TTL THERSHOLD	7.0 s	3

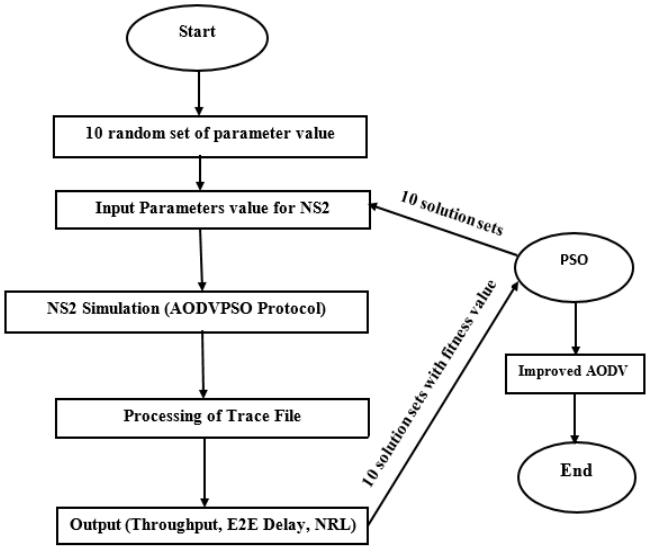

Figure 2: Flow chart of Proposed AODV_PSO implementation

As shown in figure 2 particle swarm optimization algorithm used to find out parameters optimized value from the available set of parameter. It find out with the help of fitness function given in equation (3). Simulation scenario will take parameters from PSO and supply parameters one by one to AODV_PSO. Now network simulator takes parameters given in table 3. The procedure of taking parameters from PSO is performed by the system. Now simulation gives global information in the form of trace file. Using trace file calculation of the QoS parameters performed and using that fitness function result is obtain. Find the below line for fitness function

Fitness function: Wt1(Throughput)-(Wt2(E2ED -Wt3(NRL)) (3)

Main task of above fitness function is to increase Throughput, and to reduce both the NRL and E2ED. Wt1, Wt2 and Wt3 is used to observe the effect of Quality of service parameter on the fitness value. Wt1, Wt2 and Wt3 values are taken as 0.5, 0.25, and 0.25 respectively. Hence Throughput given more priority than E2ED and NRL. It happen because we are increasing the throughput and reducing the other parameters (NRL, E2ED).

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Table 3: Parameter for Simulation

Parameter for simulation	Value
Area of simulation	1000 m X 1000 m
Maximum Nodes	50,75,100,125,150
Mobility Model	Random Waypoint
Traffic Source	CBR
Pause Time	500s
Maximum Speed	50 m/s
Size of Packet	512 bytes
Transmission range	250 m
Traffic rate	8 packet/s

VI. IMPLEMENTATION AND RESULTS ANALYSIS

We have done simulation as per the parameters given in table4. Here we have used python programming language for getting optimized value as shown in table 2 and that is given as an input to AODV protocol as show in Figure 3. NS-2.35 is used for simulation to improve QoS of MANET. We have try to analyze Performance of network against various node speed, data rate and node size.

6.1 Simulation by varying node speed

Table 4 shows the parameter used for simulation by varying node speed.

Table 4: Parameter for varying speed of nodes

Parameter for simulation	Value
Area of simulation	1000 m X 1000 m
Maximum Nodes	50 Nodes
Mobility Model	Random Waypoint
Traffic Source	CBR
Pause Time	500s
Maximum Speed	50,75,100,150 m/s
Size of Packet	512 bytes
Transmission range	250 m
Traffic rate	8 packet/s

Here we have varied node speed to analyze performance of protocol by keeping other parameters constant. Usually speed of node gives better result in terms of reducing delay between nodes so observations are made that is explain in subsequent figures.

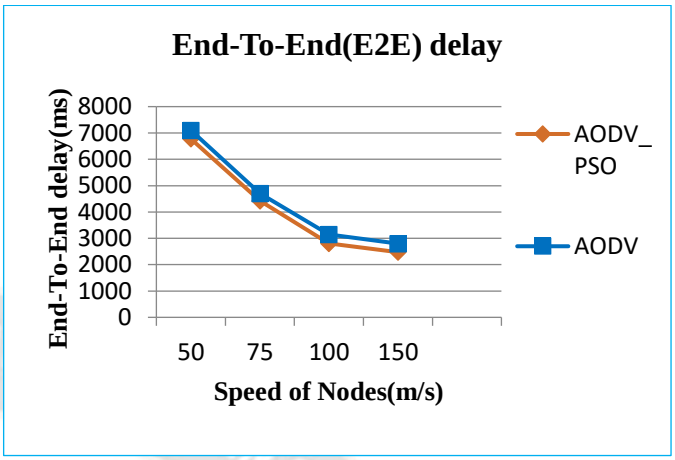

Figure 3: End to End delay for various speed of node

As shown in Figure 3 performance of AODV protocol underperform with respect to AODV_PSO protocol as we increase in node speed. Here end to end delay between nodes get decrease. It happen as node come close to each other quickly so total distance between node get decrease which help to save overall transmission time between sender and receiver node.

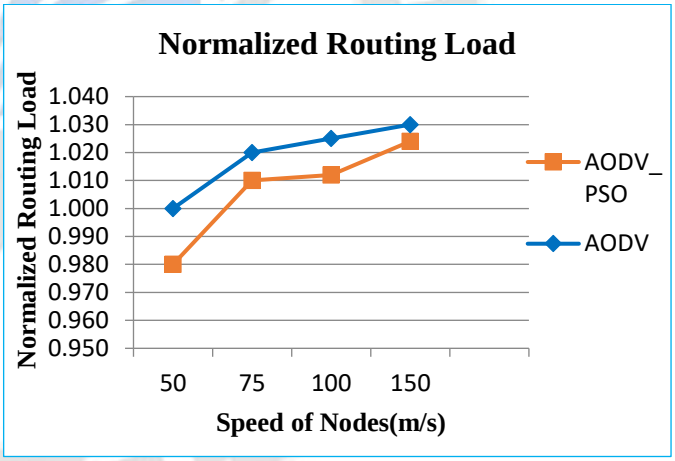

Figure 4: NRL for various speed of node

Figure 4 shows that normalized routing load get increase when we increase node speed because control packet size get increase due to volatility of network. There are also more chances of packet loss.

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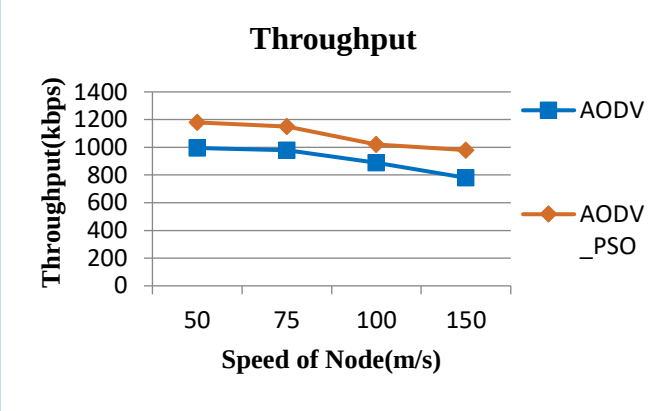

Figure 5: Throughput for various speed of node

Figure 5 shows that throughput of network get decrease with increase in node speed. There is slight reduction in throughput for speed 50 and 75 but as we increase speed to 100 and 150 major fall found in the performance.

6.2 Simulation by varying data rates

Following parameter as given in table 5 consider for simulation using data rates

Table 5: Parameter for varying data rates

Parameters for simulation	Value
Area of simulation	1000 m X 1000 m
Maximum Nodes	50
Mobility Model	Random Waypoint
Traffic Source	CBR
Pause Time	500s
Maximum Speed	50 m/s
Size of Packet	512 bytes
Transmission range	250 m
Traffic rate	4 packet/s, 8 packet/s, 12 packet/s, 15 packet/s

Here we have try to change the data rate of transmission in order to observe requirement of control packet and also how many packet get drop and successfully get transmitted.

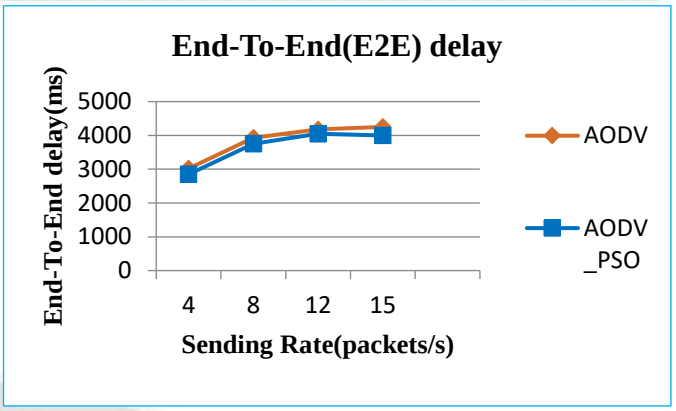

Figure 6: End to End delay for various data rates

Figure 6 shows the performance of AODV_PSO protocol and AODV for end to end delay as we increase traffic rate by keeping node size and all other parameters fixed. We observed that there is no more variation found in reduction of delay.

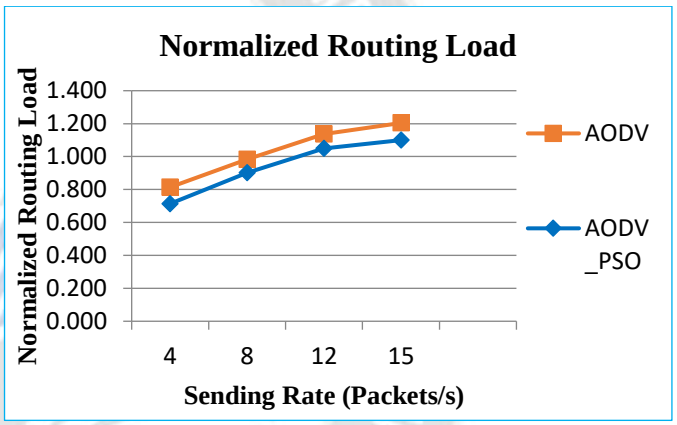

Figure 7: Normalized routing load for various data rates

Figure 7 shows the performance of AODV_PSO protocol and AODV for normalized routing load as we increase traffic rate by keeping node size and all other parameters fixed. We observed that there is major reduction in routing load due to increase in packet rate.

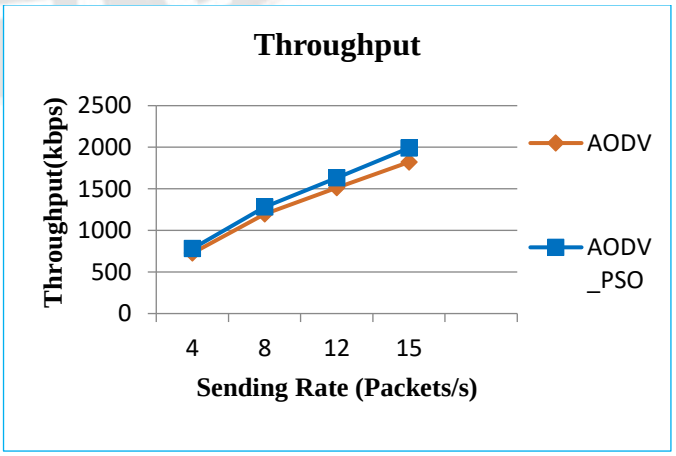

Figure 8: Throughput for various data rates

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Figure 8 shows the performance of AODV_PSO protocol and AODV for Throughput as we increase traffic rate by keeping node size and all other parameters fixed. We observed that there is slight variation in throughput for data rate 4 and 8 but for data rate 12 and 15 major improvement shown because even though there is a drop of packet overall packets are more so it make negligible effect on throughput.

Final simulation is perform as per the table 3 parameter data in order to calculate E2Edelay, Normalized routing load and throughput as show in figure number 9,10 and 11.

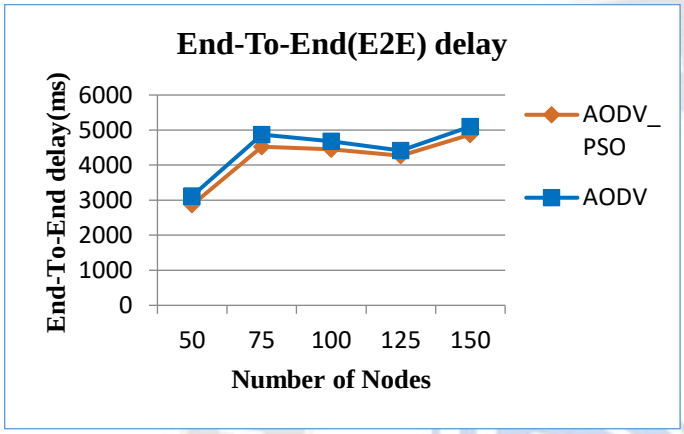

Figure 9: Performance test for End to End delay

Figure 9 describe the testing of network performance for quality of service parameter end to end delay. It show that with increase in node count end to end delay get decrease or inline which will not effect to much to the performance of the network.

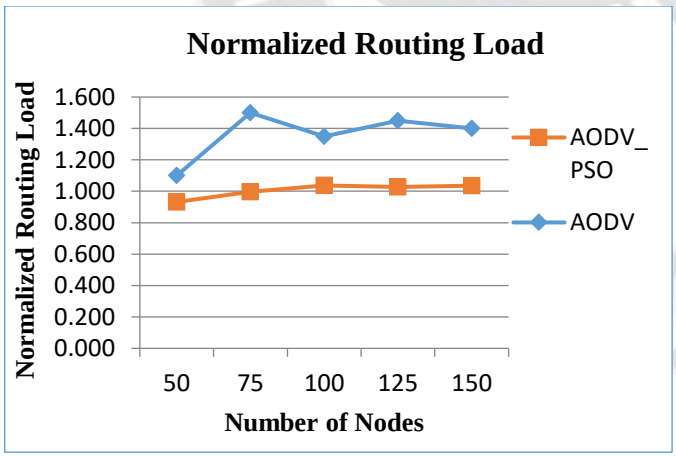

Figure 10: Performance test for Normalized routing load

Figure 10 describe the testing of network performance for quality of service parameter normalize routing load. It show that with increase in node count NRL get increase as it is difficult to deal with many control packet due to path creation and path loss, reestablishment of path, recreation of routing table.

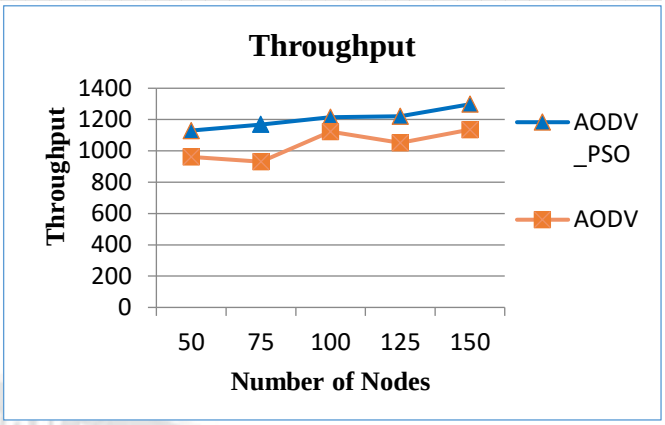

Figure 11: Performance test for Throughput

Figure 11 show that throughput of network get increase compare to default parameter when PSO apply to AODV protocol and when optimized parameter supply to AODV for implementation this QOS parameter perform well compare to simple AODV protocol.

VII. CONCLUSION

This study provide efficient system for MANET in terms of protocol. As process is divided in to two part first to obtain optimized parameter and second to simulate optimized parameter and default parameter for AODV and AODV_PSO. Result shows that AODV_PSO outperform AODV when we compare with the default value. Throughput increase when optimized value get supply. There is no more variation in end to end delay. We have analyze performance of network by varying node speed and data rate. In future it is also possible to evaluate performance of network by varying transmission range of node.

REFERENCES

[1] Roy, S., Mazumdar, N., & Pamula, R. (2021). An energy optimized and QoS concerned data gathering protocol for wireless sensor network using variable dimensional PSO. Ad Hoc Networks, 123. doi:10.1016/j.adhoc.2021.102669

[2] Rajput, N. S., Banerjee, R., & Sanghi, D. (2021). Gokulakirshnan San- thanam, Kapil Singhal, "Swarm intelligence inspired meta-heuristics for solving multi-constraint QoS path problem in vehicular ad hoc networks", Adhoc Network Journal, 123. doi:10.1016/j.adhoc.2021.102633

[3] Sharma, A. S., & Kim, D. S. (2021). Energy efficient multipath ant colony based routing algorithm for mobile ad hoc networks. Adhoc Network Journal, 113. doi:10.1016/j.adhoc.2021.102396

[4] Singh, M., & Soni, S. K. (2021). Network lifetime enhancement of WSN using correlation model and node selection algorithm. Adhoc Network Jour NAL, 114. doi:10.1016/j.adhoc.2021.102441

[5] Saini, T. K., & Sharma, S. C. (2020). Recent advancements, review analysis, and extensions of the AODV with the illustration

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of the applied concept. Ad Hoc Networks, 103. doi:10.1016/j.adhoc.2020.102148

[6] Guo, K., & Lv, Y. (2020). Optimizing routing path selection method particle swarm optimization. International Journal of Pattern Recognition and Artificial Intelligence, 34(12). doi:10.1142/S0218001420590429

[7] Abdali, T.-A. N., & Rosilah, H. (2020). Optimized Particle Swarm Optimization Algorithm for the Realization of an Enhanced Energy-Aware Location- Aided Routing Protocol in MANET. In MDPI. doi:10.3390/info11110529

[8] bin Saion, M. P. . (2021). Simulating Leakage Impact on Steel Industrial System Functionality. International Journal of New Practices in Management and Engineering, 10(03), 12–15. https://doi.org/10.17762/ijnpme.v10i03.129

[9] Verma, S. K., & Gupta, N. K. (2020). Energy Optimized Routing Protocol Based on Binary Particle Swarm Optimization successive Interference Cancellation for WSN. IJITEE, ISSN, 9(4, February), 2278–3075.

[10] Kim, B.-S., & Ullah, S. (2020). An enhanced geographical routing protocol based on multi-criteria decision making method in mobile ad-hoc networks. In Ad- hoc. Network Journal, 103.

[11] Kameswara Rao, B., & Chakravarthy, A. S. N. (2019). Optimized AODV Routing Algorithm in MANET for Maximizing the Network Lifetime. In IJRTE, ISSN, 8(2, July), 2277- 3878.

[12] Sivanantham, S., Balakrishnan, G., Jaidev, M., & Mahesh, S. (2019). Efficient and Opportunistic Routing in MANET using Link Lifetime Prediction. In ICOEI.

[13] Anish, K., Yamini, P., Suthendran, K., & Arivoli, T. (2019). Power Optimized Cross Layer design based Protocol for Performance Enhancement in MANETs. IEEE Publications.

[14] Dixit, S., & Singhai, R. (2019). Security Improvement of AODV Routing Protocol through IPSO-IDRS Mechanism for ad-hoc Networks. International Journal of Innovative Technology and Exploring Engineering, 8(12), 1009–1015. doi:10.35940/ijitee.K1489.1081219

[15] Anthony Thompson, Anthony Walker, Luis Pérez , Luis Gonzalez, Andrés González. Machine Learning-based Recommender Systems for Educational Resources. Kuwait Journal of Machine Learning, 2(2). Retrieved from http://kuwaitjournals.com/index.php/kjml/article/view/181

[16] Jagadev, N., & Pattanayak, B. K. (2019). Power aware routing for MANET using PSO. IJITEE, ISSN, 8(6, April), 2278–3075.

[17] Aini, Q. (May 2019). A Route Discovery of Dynamic Wireless Network Using Particle Swarm Optimization. Journal of Communications, 368–374. doi:10.12720/jcm.14.5.368-374

[18] Gupta, A., & Jha, S. (2019). Adaptive PSO-based routing protocol for mobile ad hoc networks. International Journal of Communication Networks and Distributed Systems, 22(3), 187-198.

[19] Wang, H., Cao, L., & Ma, J. (2019). Security analysis of PSO-based MANETs. Wireless Personal Communications, 108(1), 467-483.

[20] Bhandari, A., & Pandey, B. (2019). A PSO-based approach for enhancing security in MANETs. Journal of Computer Science and Technology, 19(4), 557-565.

[21] Roy, A., Das, S., & Das, A. (2019). PSO-based fault-tolerant routing in MANETs. Journal of Network and Computer Applications, 141, 84-95.

[22] Song, M., Liu, J., & Yang, S. (2018). A mobility prediction and delay prediction routing protocol for UAV networks. IEEE Publications. doi:10.1109/WCSP.2018.8555927

[23] Chaudhry, R., Tapaswi, S., & Kumar, N. (2018). Forwarding Zone enabled PSO routing with Network lifetime maximization in MANET. Applied Intelligence, 48(9), 3053–3080. Doi: 10.1007/s10489-017-1127-5.

[24] Prakash, C., & Agarwal, N. (2018). A PSO-based clustering approach for improving MANET performance. International Journal of Computer Science and Network Security, 18(7), 173-180.

[25] Whangkuanklang, V. ., Siangdang, Y. ., Kampagdee, M. ., Akkarakultron, P. ., Supamattra, S. ., Phasinam, K. ., & Watcharinrat, D. . (2023). An Scientific Approach of Design and Development of a Garlic Peeling Machine. International Journal of Intelligent Systems and Applications in Engineering, 11(3s), 115–118. Retrieved from https://ijisae.org/index.php/IJISAE/article/view/2548

[26] Devi, K. R., & Singh, S. (2018). Performance evaluation of PSO-based routing in MANETs. Journal of Wireless Communications and Mobile Computing, 16(12), 1347-1359.

[27] Agarwal, P., & Sharma, R. (2018). PSO-based multi-objective optimization for MA-NETs. International Journal of Advanced Research in Computer Science, 9(5), 110-117.

[28] Mandal, S., Bhattacharya, A., & Ghosh, S. (2018). Load balancing using PSO in MANETs. Journal of Ambient Intelligence and Humanized Computing, 9(5), 1779–1790.

[29] Kaur, S., & Kumar, M. (2017). PSO-based QoS routing in MANETs. Procedia Computer Science, 115, 108-114.

[30] Saha, S., Chakraborty, S., & Ghosh, S. (2017). PSO-based cross-layer routing in MA-NETs. International Journal of Ad Hoc and Ubiquitous Computing, 24(2-3), 166-178.

[31] Ghosh, S., Pradhan, C., & Das, S. (2017). PSO-based optimized routing in MANETs. International Journal of Ad Hoc and Ubiquitous Computing, 25(4), 285-296.