HYBRID META-HEURISTIC AOMDV-ACOPSO OPTIMIZATION ROUTING PROTOCOL IN MANET

Veepin Kumar
Research Scholar, Department of Computer Science & Engineering, IK Gujral Punjab Technical University, Jalandhar, Punjab, India
kumarvipi@gmail.com

Sanjay Singla
Professor, Dept. of CSE, GGS College of Modern Technology
Kharar(Mohali), Punjab, India,
dr.ssinglacs@gmail.com

ABSTRACT

MANETs are made up of nodes that uses routing protocols to transfer a packet from source to sink through store-and-forward method. These packets are sent through each intermediate nodes therefore transferring the data packets from source to sink is very expensive process. Traditional protocols also ignore energy usage in nodes when choosing route from source to sink node. Therefore, the need for an optimized path for communication amongst node has attracted the use of approaches like Ant-Colony Optimization (ACO) and Particle Swarm Optimization (PSO). In this research work, we are proposing ahybrid nature-inspired optimization technique based on ACO and PSO named as AOMDV-ACOPSO to enhance the performance of MANET routing. AOMDV is used to find the multiple data transfer paths from source to destination, where as hybrid ACO-PSO technique is used to select the best or optimum path from the multiple routes generated by the AOMDV. The performance of the suggested approach is analyzed and evaluate against the existing approaches in terms of Packet delivery ratio (PDR), energy consumption (EC), End to End(E2E) delay and throughput. Simulation results are generated by the NS2.35 and findings reveal that the proposed approach perform superior when compared to the existing techniques like AODV, AOMDV, ACO-AOMDV and PSO-AOMDV.

Keywords: **ACO,E2E delay, Energy Consumption, MANET, NS 2.35, Optimization, PDR, PSO, Routing Protocols and Throughput.**

1. Introduction

MANET is a network made up of wireless mobile hosts that creates a temporary network without the need for a specialized infrastructure or centralized control [1]. Nodes in the network are mobile, they self-organize and configure themselves. There are two types of communication approaches for wireless mobile nodes that are infrastructure-oriented and infrastructure-less. In an infrastructure-oriented structure, devices communicate with a base station that is connected to a fixed infrastructure, but in an infrastructure-less structure, nodes communicate without relying on any pre-existing network infrastructure. As the nodes in MANET are battery operated, a lot of the power gets exhausted because of the movement of nodes from one location to another which tends to the reduction of network lifespan [2]. Therefore, route selection for transmitting data from source to sink is the vital concern in MANET. Routing is a network technique for exchanging data between two host nodes [3]. A routing protocol keeps track of routing information for connecting and neighboring nodes. In MANET, there are three types of routing protocols: Proactive, Reactive, and Hybrid [4].Pro-active (Table-driven) protocol is one in which mobile node has its own routing table, which keeps track of routes to all possible destinations [5]. It has the disadvantage of not operating well in large networks since because it contains the information of all available route therefore, the routing table entries get too huge. Destination Sequenced Distance Vector (DSDV) and Global State Routing (GSR) are the examples of proactive protocol. In DSDV, a destination sequence number is assigned in the routing table and node will only include the new entry in the database if it contains a new route with a higher sequence number. GSR is based on Dijkstra's algorithm and extends the wired network link state routing. Reactive

(On-demand) protocol discovers the route only when there is requirement [6]. Route discovery is achieved by broadcasting route request packets over the mobile network. Dynamic Source Routing (DSR), Ad hoc on-demand multipath distance vector (AOMDV)and Ad hoc on demand vector (AODV) protocols comes under this category [7]. DSR focus mainly on two phases: route discovery and route maintenance. Route discovery phase determines the most optimal path for data transfer and route maintenance phase maintain the route for successful transfer of packets because MANET has a dynamic topology, there is a connection breakage, resulting in network failure between mobile nodes. AODV isbuilt on the concept of DSDV and DSR protocol [8]. To transmit an RREP back to the source, AODV uses routing table entries and to determine the freshness of routing information and to avoid routing loops, AODV uses sequence numbers kept at each sink node[8]. The AOMDV protocol is a multipath enhancement to the AODV. In route discovery phase, AOMDV extends the AODV protocol to find various paths between the source and sink. Multiple pathways that are computed in AOMDV are ensured to be loop-free and disjoint in nature [9].It uses alternate routes in the case of a route breakdown and a new route is discovered when all routes fail [10]. Multipath routing is an improvement over unipath routing, with the added benefit of handling network traffic, minimizing congestion, and enhancing reliability. The main disadvantage of reactive protocols is that nodes may have to wait longer for the route to be discovered. Hybrid routing protocol combines the benefits of on-demand and table-driven protocol. These protocols are adaptable in nature, they can change the zone and position of mobile nodes between source and destination. Zone Routing Protocol (ZRP) comes under this category [11]. In ZRP, the entire network is divided into zones, and tracked the location of source and sink. When the source and destination nodes are in the same zone, proactive routing is used and when they are in different zones, reactive routing is used to transmit data packets. Figure 1 represents the taxonomy of MANET routing protocols.

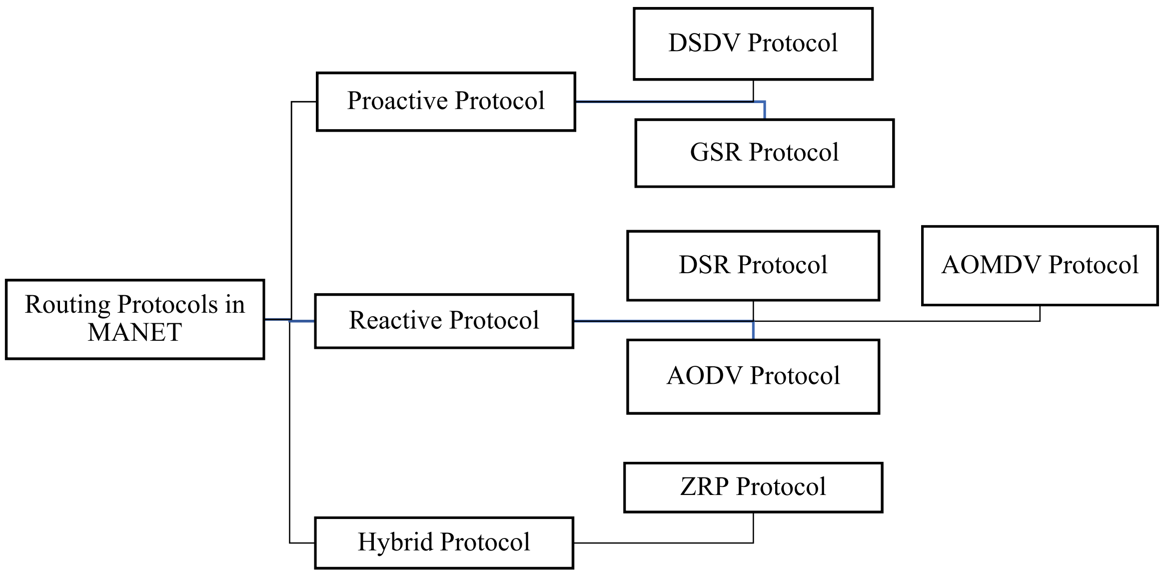

Fig. 1: Taxonomy of MANET routing Protocols

One of the most significant issues faced by MANET in recent decades has been the efficient use of energy in various field. Effective utilization of energy includes saving energy or reducing network energy consumption to make it appropriate for long-distance communication. Several strategies for creating energy-efficient communication networks have been developed in recent decades, but it remains a difficult issue [12].Recently, there has been a surge in interest in using swarm intelligence (SI) or nature-inspired algorithms for enhancing the performance of MANET in terms of energy efficiency and network lifespan. SI is a computational intelligence technique that entails the collective behavior of intelligent agents that interact with one another in a dispersed environment to solve a problem in the order to obtain a global solution. SI techniques are used in nature by ant colony, birds flocking, animal herding, and fish schooling to create an effective routing algorithm for MANET. Two of the most widely used SI approaches for path discovery in MANET are ACO and PSO. Many researchers use the ACO algorithm to create optimized multipath routing solutions in MANET. The domain of ant algorithm examines models generated from observations of real ant’s behavior and uses these models as a source of inspiration for the development of unique algorithms for solving optimization and distributed problems. Several features of ant colony behavior have inspired several types of ant algorithms, including foraging and cooperative transportation [13]. The use of chemical compounds created by ants is used to mark some favorable path that should be followed by other members of the colony. The chemical compound is known as Pheromone. When compared to longer paths, several ants in shorter paths have higher pheromone trails, resulting in higher density and more uniqueness. Pheromone trails are diminished as the rate of evaporation increases. The ACO algorithm begins with parameter setup and pheromone networks. This is repeated recursively on the cycle until the first ant's path is constructed, and then the ant's path is formed continually using local search. The pheromone network is finally updated [14].

PSO is a population-based SI approach that was emulated by the behavior of birds or a school of fish to solve the optimization problem since all agents or particles retain information of optimal solutions and share it [15]. Thus, PSO can be applied to the solution space to proceed towards the near optimal solution. If the algorithm has reached convergence, the best solution is obtained. The position and velocity of the particles have an impact on whether the algorithm has reached convergence. Because of unique searching method and ease of implementation, PSO has been used to solve a variety of real-world problems [16]. PSO algorithm starts by creating a population of particles. After creating the population, evaluate the position of each particle. If the current position of a particle is better than its prior best position, update it and get the particle's best position. After finding the best position, update particle velocities and move the particles to their new positions. This procedure is repeated until the stopping criteria is met. The following is a breakdown of the research work structure: Section 2 covers the literature review based on optimization techniques which improves the network's energy efficiency and lifespan. Section 3 discuss the suggested approach; section 4 analyzes the performance of proposed technique and finally section 5 discuss the conclusion of the research work.

2. Literature Review

A lot of research has already been done on routing protocols and optimization techniques therefore performing a thorough study and analysis of previous work is very important. Z. Sun et al. [17] suggested a multi-objective ACO based secure routing protocol for WSN. Their goal is to increase security by deploying wireless nodes with low energy consumption. In general, ACO-based techniques simply analyze the routing path's optimality, but they have also considered energy usage in addition to the routing path. S. Janaki Raman [18] proposed a hybrid ACO and Artificial Bee Colony Optimization approach for cluster selection in the Internet of Things. Each IoT device in their network serves as a sensor network node. The cluster head is chosen depending on a variety of factors such as distance, load, energy and delay. F. de Rango et al. [19] examines the performance of reactive protocols using equal load and environmental variables parameters. Analysis is done in term of two performance measures i.e., average E2E delay and PDR. The simulation results demonstrate that as the network expands, the average E2E delay rises, and as the pause period rises, the mean E2E latency decreases, however as the size of network gradually increases, the mean loop detection time increases. A. S. Nasab et al. [20] suggested a PSO-based energy-efficient routing strategy. They evaluated delay and energy as two limitations for minimizing the PSO problem. PSO outperforms the Genetic Algorithm (GA) in terms of identifying the optimum path with the least amount of energy usage, according to their simulation results and a comparison analysis. D. Rupérez Canas et al. [21]proposed a hybrid ACO Routing (HACOR)method is based on ACO, which analyses ant behavior while acquiring food and incorporates SI principles. HACOR acts in a multipath manner since it establishes many paths to transfer data to the destination. It is also adaptable because it adjusts to change in traffic and network situations. When generating a route with all visited nodes, researchers don't utilize the evaporation approach like simple-ACO and instead use the free-loop method. HACOR employs Disjoint-Link option therefore any alternate routes that emerged because of this procedure are disjoint. P. Ramesh et al. [22] suggest that the route-establishing phase uses the standard AODV routing protocol to detect multiple pathways between the source and sink. The trust metrics such as residual energy, PDR, and node queue length are used to determine the optimal path which results in minimizing the Packet loss and delay. Finally, thelion optimization algorithm is used to choose the best path out of all the available choices. With the network having 200 nodes and a transmission radius of 250 meters, the proposed technique is implemented, and the nodes are spread out over an area of 1000*1000 m2, and the packet size is set to 512 bytes.

A. S. Mohammed et al. [1] computes the fitness value of the nodes by considering fuzzy clustering optimization approach which uses fuzzy parameters. Cluster head (CH) selection is done based on the fitness value. This technique has been improved to handle unknown scenarios such as CH failure, topology changes, and CH energy depletion. If there are any inconsistencies, the node that discovered the problem will restart CH selection using the device remaining residual energy and the amount of data transferring by that mobile node. D. N. Shashidhar et al. [2] suggest a new approach that relies on Cuckoo Optimization Method and TOPSIS multi-criteria algorithm to reduce energy usage. The proposed approach can be used in complex situations, and it considers four essential variables: available bandwidth, remaining energy, movement speed, and the number of steps required for routing. The TOPSIS multi-criteria method was used to choose appropriate groups for the purpose of relaying data packages. The Cuckoo Optimization Algorithm was utilized to find the shortest path between the relay groups.

S. Sarhan et al. [23] proposed an optimization technique named as EHO-AOMDV that works in four stages: node classification, path discovery, path maintenance, and data load balancing. The goal of the node classification phase is to optimize node energy by dividing nodes into two clans based on nodal energy (the separation operator). By propagating RREQ signals from source to sink, AOMDV protocol is used in the route discovery phase to locate multilink disjoint paths, establishing many reverse paths at both intermediate and destination nodes. The energy of all nodes is reevaluated in the path maintenance phase by updating the operator, and all discovered paths are arranged in descending order in the data load balancing step, with the maximal nodal residual energy of each path computed using the minimal nodal residual energy of all nodes on the path. S. K. Nivetha et al. [24] For a given network architecture, the proposed technique employs ACO to locate all feasible pathways from every source to sink. Once the set of possible routes are discovered based on the pheromone, the resulting population form the starting population for the genetic algorithm phase. Using the fitness function and genetic processes, the optimum paths for any source-destination pair are found from the initial population. A fitness function with the lowest required bandwidth is developed in addition to the node energy required for the given data flow. The genetic algorithm cycle is repeated until either the desired number of generations is reached, or no unique children are created. To increase the energy efficiency of the Optimized Link State Routing protocol (OLSR), M. A. Jubair et al.[25] presented a new Bat Optimized Link State Routing (BOLSR) protocol. OLSR and the Bat Algorithm use the same approach to discover the path by sending and receiving signals. The BOLSR protocol was developed because of this symmetry, and it discovers the optimum path from a source node to a destination node based on the energy dynamics of the nodes. Tri Kuntoro Priyambodo et al. [26] investigated how to improve MANET performance. In order to achieve their goal, they investigated various routing protocols. PDR, throughput, delay, packet loss, EC, and routing overhead were the key metrics used to assess performance. The results reveal that OLSR protocol has a lower delay than the AODV protocol, however the AODV protocol outperforms the OLSR protocol. Table 1 shows the research findings and simulator used of some commonly used optimization techniques.

Table 1. Research findings and simulator used of some commonly used optimization techniques

Name of Author and Year of Publication	Optimization Methodology	Simulator Used	Performance Metrices	Research Outcome
D. Rupérez Cañas et. al, 2013	HACOR	NS3	Average E2E delay, jitter, overhead in number of bytes and packets, PDR and throughput	HACOR outperforms AODV on all performance parameters, but the overhead of packets in HACOR is larger than in AODV.
P. Ramesh et. al., 2018	Lion Optimization Algorithm	NS2	PDR, latency, energy consumption and network lifespan	The proposed method conserves a significant amount of energy, resulting in a longer network lifetime.
A. S. Mohammed et. al., 2020	fuzzy clustering optimization approach	NS-2.35	Network lifetime, Average E2E delay and PDR	By addressing uncertainty, the fuzzy constraints clustering optimization technique achieves the goal of extending network lifetime.
D. N. Shashidhara et. al., 2019	Cuckoo Optimization Algorithm	Opnet	Average E2E delay and Throughput	Through the selection of more stable channels with increased levels of energy, the approach was able to improve the overall efficiency of the network and the accuracy of data package delivery.

S. Sarhan et. al., 2021	Elephant Herding Optimization	NS-3	Routing overhead, EC, PDR, E2E delay, Number of dead nodes	EHO-AOMDV attained higher PDR withless routing overhead whereas average EC and E2E delay in AOMDV has outperformed the proposed protocol.
S. K. Nivetha et. al., 2016	ACO GA hybrid metaheuristic approach	NS 2.34	PDR, E2E delay, average residual node energy, hop-count, and routing overhead	When the node pause duration is quite long, the suggested hybrid technique enhances MANET routing performance while satisfying QoS criteria.
M. A. Jubair et al. , 2019	BOLSR	MATLAB	routing overhead ratios, EC, and E2E delay	BOLSR has the lowest overhead ratio, delay, and energy consumption as it selects a robust path of nodes with the optimal energy.

3.Proposed Methodology

In MANET, communication is one of the primary sources of energy consumption. As a result, in order to extend the network lifespan, the routing protocol must be optimized which selects the optimal path.As a result, in our proposed technique, AOMDV protocol is used to select multiple paths from source to sink and SI techniques are utilized to locate the best route among all of them. SI-based solutions are capable of resolving a wide range of routing issues. During route discovery phase if a node receives a duplicate route request, then it implies alternate reverse path and if a node accepts all of these duplicate route request packets, then routing loops will be formed. Therefore, in proposed technique AOMDV-ACOPSO, AOMDV uses advertised hop count to prevent loop formation and guarantee loop freedom. The advertised hop count is the greater hop count of all accessible routes at that node and as the sequence number changes, the advertised hop count is updated. After selecting the multiple paths, the proposed algorithm incorporates all the parameters of ACO and PSO which assist to find the optimized path among multiple paths. The basic idea underlying is to calculate the fitness function over an initial population and then calculate the fitness of a new population iteratively, which is achieved by performing operations on populations. Finally, we may compare all of the solution to the optimal one to determine which solution is the best. The best solution provides us the population's optimal values, which can be utilized to discover the best routing path. The proposed algorithm makes advantage of PSO to improve the ACO algorithm's features, therefore the output of ACO algorithm will act as the input for PSO algorithm. The ACO method is improved in order to discover the shortest path. Not only does the suggested approach reduce the number of paths in the ACO, but it also discovers the shortest path among the longest. The combination of ACO and PSO algorithms produces better results than either ACO or PSO alone. The pseudocode of proposed AOMDV-ACOPSO is as follow:

- Input: Nodes and their energy level
- Output: Energy Efficient nodes
- Use AOMDV to find the multiple routes from source to sink
- Set the parameters and pheromone trial of ACO.
- Update the quantity of pheromones based on node residual energy
- While (not met closing condition) do
  create ant solutions by applying local search
  find fitness value corresponding to each ant
  find best solution and update pheromones trails using equation 2
  End while
- Multiple routes are created by ACO
- Now generate random population of particles
  Repeat
  For all particles
  Evaluate fitness value for local and global solutions
  Update velocities and positions of each particle using equation 3 and 4 given below
  Select best position
  End For
  Until stopping criteria
- The process is finally completed when the best set of particles is returned.

In ACO, kth ant moves from node u to node v with probability is shown below in Eq (1).

$$P_{uv}^{k} = \frac{(\tau_{uv}^{\alpha})\left(\eta_{uv}^{\beta}\right)}{\Sigma z \epsilon allowed (\tau_{uv}^{\alpha})\left(n_{uv}^{\beta}\right)} \tag{1}$$

Where,

P_{uv}^{k} = Ant's probability of travelling from node u to node v
τ_{uv}^{α} = Total Pheromone deposit by ant on path uv
η_{uv}^{β} = Value of path uv

And the equation for updating the value of pheromones trails calculated by Eq(2).

$$\tau_{uv} \leftarrow (1-\rho)\tau_{uv} + \rho\, \Delta\tau_{uv} \tag{2}$$

Where,

τ_{uv} = Total Pheromone deposit by ant on path uv
$(1 - \rho)$ = Pheromone Evaporation Rate
ρ = Residual Pheromone coefficient

Whereas. the velocity and position of the particles are solved using the Eq(3) and Eq(4):

$$Vuv\,(t + 1) = W\, v(t) + C1r1\,(pBest(t) - Xuv\,(t)) + C2r2(gBest\,(t) - Xuv(t)) \tag{3}$$

$$Xuv\,(t + 1) = Xuv\,(t) + Vuv\,(t + 1) \tag{4}$$

Where,
Vuv (t + 1) = Particle's velocity
Xuv (t + 1) = Particle present position
t = number of iterations
Wuv =Inertia weight
C1, C2 = awareness and gregarious learning factor
r1, r2 is the random number whose values lies between 0 and 1
pBest, gBest = Personal and Global best of particle

In the proposed approach, the above steps are carried out to identify the optimal route among the multiple paths created by the ACO. PSO algorithm is employed in the suggested approach to discover the optimal path. The flowchart for the proposed algorithm is as follow:

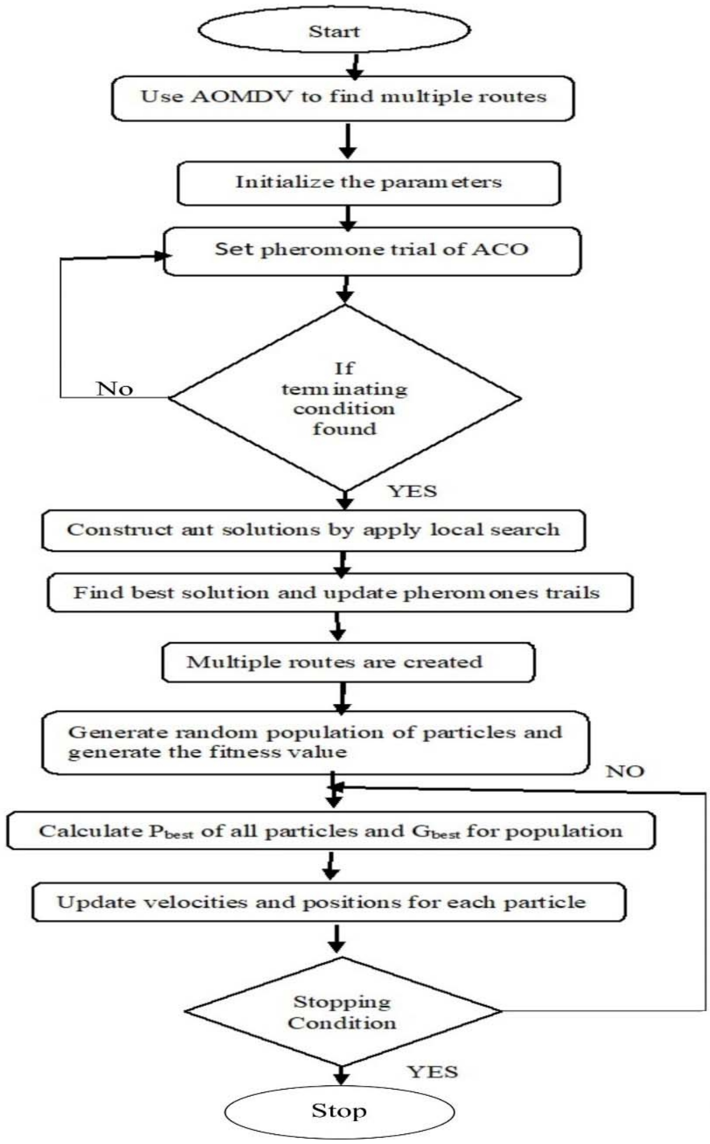

Fig 2.Flowchart for AOMDV-ACOPSO algorithm

4. Performance Analysis of AOMDV-ACOPSO

For the performance analysis of proposed approach, the following performance measures are used:

E2E delay: It is the average time taken for packets to be successfully transmitted from source to sink[27]. It can be computed by Equation 5:

$$\textit{End to End delay} = \sum_{j=1}^{n}((Dj - Sj))/n \tag{5}$$

where D stands for destination and S stands for source.

Throughput: It refers to how much data the destination receives in a certain length of time[28]. It is expressed in kbps and calculated by Eq. 6.

Throughput= (the number of bytes received* 8 / the time taken for simulation) *1000 kbps (6)

PDR: It is the proportion of total packets received by the sink node (P_R) to total packets sent by the sender node (P_S)[29] shown below in equation 7.

$$PDR = (P_R / P_S) * 100 \tag{7}$$

Energy Consumption (EC): It is the quantity of energy utilized by nodes during the simulation time[30]. This is determined by computing the energy level of each node at the end of the simulation by equation 8.

$$\textit{Energy Consumption} = \sum_{j=1}^{n}(init(j) - ener(j)) \tag{8}$$

4.1 Simulation Parameters

The performance of proposed and existing techniques is evaluated in a variety of simulation parameters. For simulation, the NS2.35 network simulator tool is utilized because it provides accurate implementations of several network protocols. Our method AOMDV-ACOPSO has been evaluated against other routing protocols and optimization techniques such as AODV, AOMDV, ACO-AOMDV, PSO-AOMDV. With a node count from 20 to 100 and deployment area of 1000*1000 m^2 the proposed and existing techniques are implemented. Table 2 below, lists the simulation parameters.

Table 2. Details of Simulation Parameters

Parameters	Value
Type of Channel	Wireless
Radio Propagation model	Two-way Ground
Mac Type	Mac/ 802_11
Antenna model	Omni Antenna
Length of Queue	50
Nodes no.	20,40,60,80,100
Nodes Speed	20
Area	1000m*1000m
Traffic type	CBR
Simulation Time	80s
Routing Protocol	AODV, AOMDV
Speed Type	Uniform
Pause Time	5s
Pause Type	Uniform

4.2 Throughput: Throughput is the most important performance statistic for any routing approach.Fig.3 and Table 3 shows the result of throughput for AODV, AOMDV, ACO-AOMDV, PSO-AOMDV and proposed AOMDV-ACOPSO optimized routing protocol with node size vary from 20 to 100.

Table 3. Throughput vs number of nodes

Number of Nodes	AODV	AOMDV	ACO-AOMDV	PSO-AOMDV	AOMDV-ACOPSO
20	7000	7500	8000	8100	11500
40	7000	7500	8000	8100	11500
60	5000	6000	7500	7610	10350
80	6000	7000	8000	8200	11500
100	7000	7500	8000	8210	12100

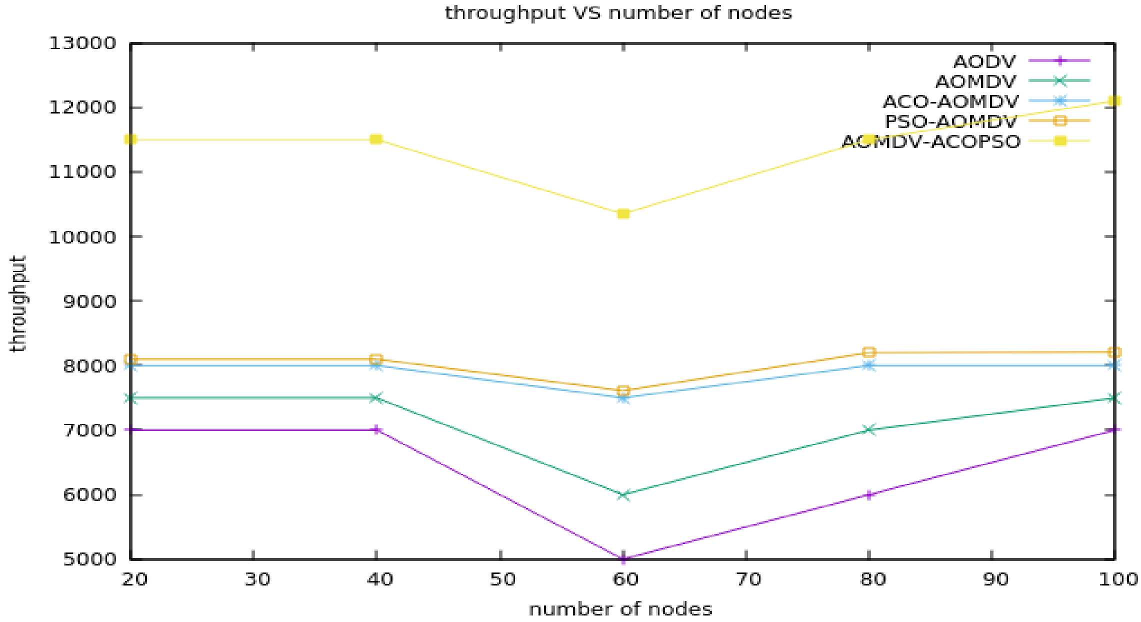

Fig.3. Throughput vs number of nodes

The results of the simulation show that as the size of network increases from 20 to 100 node, the proposed technique achieves a higher throughput than AODV, AOMDV, ACO-AOMDV, PSO-AOMDV. Throughput increases in proposed technique because of optimal path selection among the multiple pathways generated by AOMDV. The performance of ACO-AOMDV and PSO-AOMDV in terms of throughput is quite similar as there is very slight variation in their values, however AODV has very less throughput as compared to other techniques.

4.3 E2E Delay: Fig.4 and Table 4 shows the experimentation findings of E2E Delay for AODV, AOMDV, ACO-AOMDV, PSO-AOMDV and proposed AOMDV-ACOPSO optimized routing protocol with node size ranging from 20 to 100.

Table 4. E2Edelay vs number of nodes

Number of Nodes	AODV	AOMDV	ACO-AOMDV	PSO-AOMDV	AOMDV-ACOPSO
20	0.38	0.37	0.35	0.32	0.24
40	0.38	0.37	0.35	0.32	0.22
60	0.38	0.36	0.32	0.28	0.18
80	0.35	0.33	0.3	0.25	0.18
100	0.3	0.28	0.3	0.24	0.17

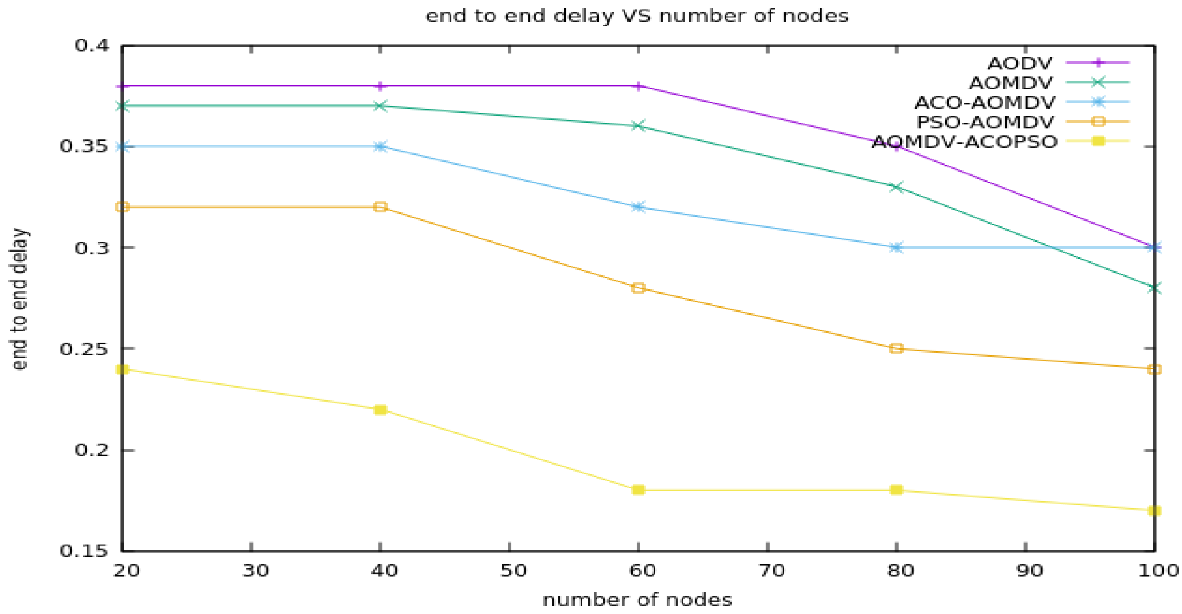

Fig4. E2Edelay vs number of nodes

Comparing with AODV, AOMDV, ACO-AOMDV and PSO-AOMDV, the simulation results show that AOMDV-ACOPSO performs best in terms of E2E delay when the size of network gradually increases from 20 to 100 due to the selection of optimum path for data transfer. It is also observed from above figure and table that AODV has higher end-to-end delay than other techniques. This is most possibly because in AODV nodes may have to wait longer for the route to be discovered which result in a delay for successful transmission of packets from source to sink node.

4.4 Energy Consumption: Fig.5 and Table 5 shows the simulation results of existing techniques and proposed optimized routing protocol when node size vary from 20 to 100.

Table 5. Energy Consumption vs Number of nodes

Number of Nodes	AODV	AOMDV	ACO-AOMDV	PSO-AOMDV	AOMDV-ACOPSO
20	60	58	55	53	48
40	65	60	55	54	48
60	70	70	58	55	49
80	75	68	59	56	50
100	80	75	59	57	52

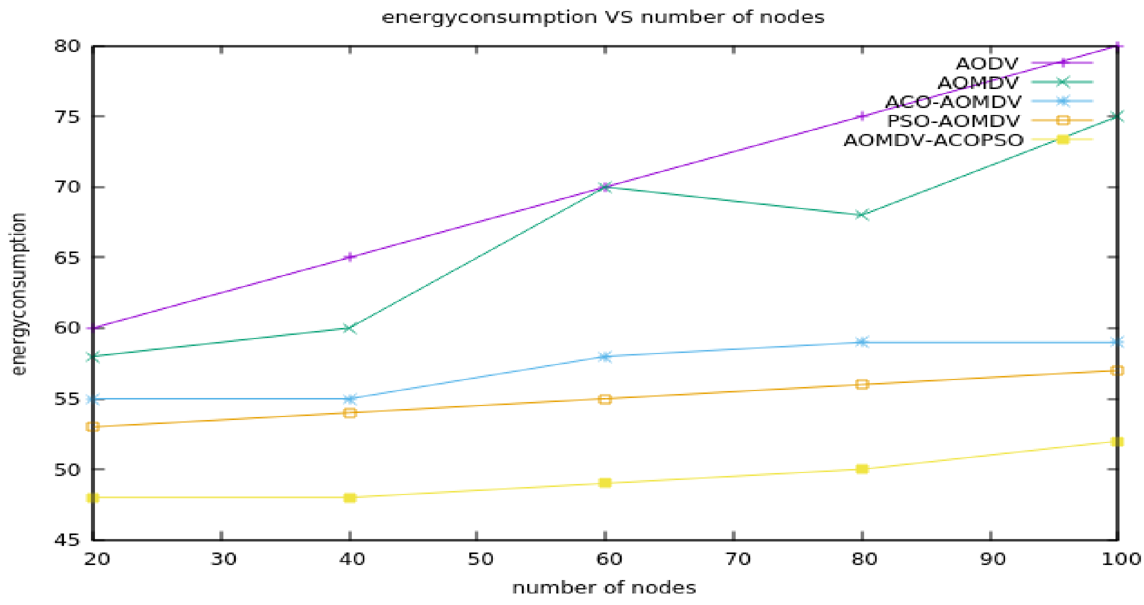

Fig.5. Energy Consumption vs Number of nodes

In comparison to existing techniques, the proposed optimization technique achieves better energy efficiency and node stability due to less energy consumption and successful packet delivery from source to sink node. Reducing energy usage is required to balance the energy of nodes and extends network lifetime. The most stable route for data transfer is determined using the proposed technique, which helps to reduce the probability of link breakages and responds better to changes in network topology. However, AODV consumes a lot of energy when compared to other techniques since nodes in AODV may have to wait longer for the route to be discovered, resulting in energy consumption and a shorter network lifetime.

PDR: Fig. 6 and Table 6 compares and analyses the PDR of the proposed technique and existing technique. In figure, X-axis represents the number of nodes, and the Y-axis indicates the PDR.

Table 6. PDR vs Number of nodes

Number of Nodes	AODV	AOMDV	ACO-AOMDV	PSO-AOMDV	AOMDV-ACOPSO
20	78	80	85	88	92
40	77	79	85	89	92
60	75	78	83	86	91
80	76	79	84	88	92
100	77	78	85	89	92

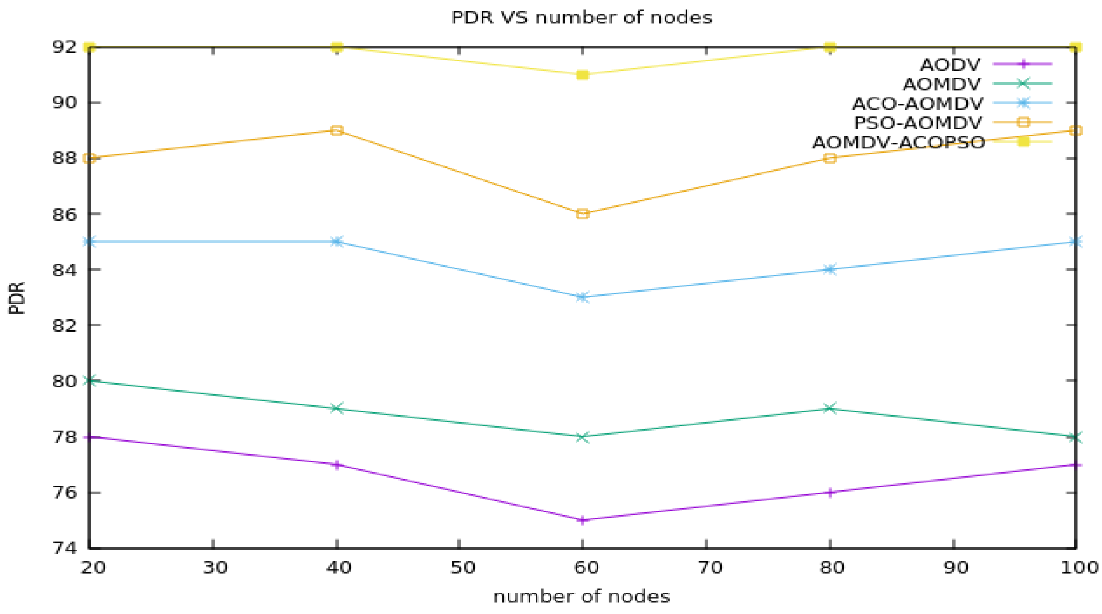

Fig.6. PDR vs number of nodes

The PDR examines at how many packets are sent and received by the node. The routing and optimization technique becomes more reliable as the packet delivery rate increases. The AOMDV-ACOPSO has a greater PDR than the existing approaches, as evidenced by the experimental findings. The presence of major trust measures and the selection of optimal routes are the primary reasons for the suggested technique superior performance. The proposed technique has a low latency rate because it selects the optimal route rather than the shortest route. The shortest path may comprise fraudulent nodes, whereas the best route is made up of secure nodes. Experimental results show that AODV has a very high PDR as compared to other techniques because it takes a more time to identify a route which leads in a longer time to deliver the packet.

5. Conclusion

Wireless devices having no predetermined infrastructure create MANET. In MANET,data transfer from a source to a sink is an important and complex task due to its dynamic topology. There has been a rise in interest in applying SI or nature-inspired techniques to improve the energy efficiency and network lifespan of MANET networks. ACO and PSO are two of the most widely used SI techniques for path discovery in MANET.In this research work, we introduce AOMDV-ACOPSO, a hybrid optimization technique that always chooses the optimal route for data transfer rather than the shortest path. AOMDV protocol generates the multiple paths from source to sink node and ACOPSO technique is used to select the optimized route among all the routes generated by it. Experimental analysis is done using NS2.35 and simulation results of proposed technique is compared with AODV, AOMDV, ACO-AOMDV and PSO-AOMDV in which suggested approach outperforms the existing techniques in terms of PDR, E2E delay, Energy Consumption, and Throughput.

Conflict Of Interest

The authors have no conflicts of interest to declare.

References

[1] A. S. Mohammed, S. Balaji B, S. B. M. S, A. P. N, and V. K, “FCO — Fuzzy constraints applied Cluster Optimization technique for Wireless AdHoc Networks,” *Comput. Commun.*, vol. 154, no. February, pp. 501–508, 2020, doi: 10.1016/j.comcom.2020.02.079.

[2] D. N. Shashidhara, D. N. Chandrappa, and C. Puttamadappa, “A Novel Location Aware Content Prefetching Technique for Mobile Adhoc Network,” *Procedia Comput. Sci.*, vol. 171, no. 2019, pp. 1970–1978, 2020, doi: 10.1016/j.procs.2020.04.211.

[3] S. Kumar, M. Goyal, D. Goyal, and R. C. Poonia, “Routing protocols and security issues in MANET,” *2017 Int. Conf. Infocom Technol. Unmanned Syst. Trends Futur. Dir. ICTUS 2017*, vol. 2018-Janua, pp. 818–824, 2018, doi: 10.1109/ICTUS.2017.8286119.

[4] S. R. Azzuhri, M. B. Mhd Noor, J. Jamaludin, I. Ahmedy, and R. Md Noor, “Towards a Better Approach for Link Breaks Detection and Route Repairs Strategy in AODV Protocol,” *Wirel. Commun. Mob. Comput.*, vol. 2018, 2018, doi: 10.1155/2018/9029785.

[5] A. Singh and D. Chadha, “A Study on Energy Efficient Routing Protocols in MANETs with Effect on Selfish Behaviour,” *Int. J. Innov. Res. Comput. Commun. Eng.*, vol. 1, no. 7, pp. 1386–1400, 2013.

[6] S. S. Joshi and S. R. Biradar, “Communication Framework for Jointly Addressing Issues of Routing Overhead and Energy Drainage in MANET,” *Procedia Comput. Sci.*, vol. 89, pp. 57–63, 2016, doi: 10.1016/j.procs.2016.06.009.

[7] J. Patel and H. El-ocla, “Energy efficient routing protocol in sensor networks using genetic algorithm,” *Sensors*, vol. 21, no. 21, 2021, doi: 10.3390/s21217060.

[8] T. Nema, A. Waoo, P. S. Patheja, and S. Sharma, "Energy Efficient Adaptive Routing Algorithm in MANET with Sleep Mode," no. 4, pp. 2–6, 2012.
[9] M. K. Marina and S. R. Das, "Ad hoc on-demand multipath distance vector routing," *Wirel. Commun. Mob. Comput.*, vol. 6, no. 7, pp. 969–988, 2006, doi: 10.1002/wcm.432.
[10] Ip. Aggarwal and E. P. Garg, "AOMDV Protocols in MANETS : A Review," *Int. J. Adv. Res. Comput. Sci. Technol. (IJARCST)*, vol. 4, no. 2, pp. 32–34, 2016.
[11] J. Wang, E. Osagie, P. Thulasiraman, and R. K. Thulasiram, "HOPNET: A hybrid ant colony optimization routing algorithm for mobile ad hoc network," *Ad Hoc Networks*, vol. 7, no. 4, pp. 690–705, 2009, doi: 10.1016/j.adhoc.2008.06.001.
[12] Z. E. Ahmed, R. A. Saeed, A. Mukherjee, and S. N. Ghorpade, *Energy optimization in low-power wide area networks by using heuristic techniques*. INC, 2020.
[13] E. Osagie, P. Thulasiraman, and R. K. Thulasiram, "PACONET: ImProved Ant Colony Optimization routing algorithm for mobile ad hoc NETworks," *Proc. - Int. Conf. Adv. Inf. Netw. Appl. AINA*, pp. 204–211, 2008, doi: 10.1109/AINA.2008.77.
[14] R. Challenges, "A Survey of Modern Ant Colony Optimization Algorithms for MANET :," vol. 9, no. 05, pp. 952–959, 2020.
[15] P. Kumari and S. K. Sahana, "Swarm Based Hybrid ACO-PSO Meta-Heuristic (HAPM) for QoS Multicast Routing Optimization in MANETs," *Wirel. Pers. Commun.*, vol. 123, no. 2, pp. 1145–1167, 2022, doi: 10.1007/s11277-021-09174-9.
[16] S. Sengupta, S. Basak, and R. Peters, "Particle Swarm Optimization: A Survey of Historical and Recent Developments with Hybridization Perspectives," *Mach. Learn. Knowl. Extr.*, vol. 1, no. 1, pp. 157–191, 2018, doi: 10.3390/make1010010.
[17] Z. Sun, M. Wei, Z. Zhang, and G. Qu, "Secure Routing Protocol based on Multi-objective Ant-colony-optimization for wireless sensor networks," *Appl. Soft Comput. J.*, vol. 77, pp. 366–375, 2019, doi: 10.1016/j.asoc.2019.01.034.
[18] S. Janakiraman, "A hybrid ant colony and artificial bee colony optimization algorithm-based cluster head selection for IoT," *Procedia Comput. Sci.*, vol. 143, pp. 360–366, 2018, doi: 10.1016/j.procs.2018.10.407.
[19] F. de Rango, P. Lonetti, and S. Marano, "MEA-DSR: A multipath energy-aware routing protocol for wireless Ad Hoc Networks," *IFIP Int. Fed. Inf. Process.*, vol. 265, pp. 215–225, 2008, doi: 10.1007/978-0-387-09490-8_19.
[20] A. S. Nasab, V. Derhami, L. M. Khanli, and A. M. Z. Bidoki, "Energy-aware multicast routing in manet based on particle swarm optimization," *Procedia Technol.*, vol. 1, pp. 434–438, 2012, doi: 10.1016/j.protcy.2012.02.097.
[21] D. Rupérez Cañas, A. L. Sandoval Orozco, L. J. García Villalba, and P. S. Hong, "Hybrid ACO routing protocol for mobile Ad hoc networks," *Int. J. Distrib. Sens. Networks*, vol. 2013, 2013, doi: 10.1155/2013/265485.
[22] P. Ramesh and M. Devapriya, "An optimized energy efficient route selection algorithm for mobile ad hoc networks based on loa," *Int. J. Eng. Adv. Technol.*, vol. 8, no. 2, pp. 298–304, 2018.
[23] S. Sarhan and S. Sarhan, "Elephant Herding Optimization Ad Hoc On-Demand Multipath Distance Vector Routing Protocol for MANET," *IEEE Access*, vol. 9, pp. 39489–39499, 2021, doi: 10.1109/ACCESS.2021.3065288.
[24] S. K. Nivetha and R. Asokan, "Energy efficient multiconstrained optimization using hybrid ACO and GA in MANET routing," *Turkish J. Electr. Eng. Comput. Sci.*, vol. 24, no. 5, pp. 3698–3713, 2016, doi: 10.3906/elk-1404-413.
[25] M. A. Jubair *et al.*, "Bat optimized link state routing protocol for energy-aware mobile ad-hoc networks," *Symmetry (Basel).*, vol. 11, no. 11, 2019, doi: 10.3390/sym11111409.
[26] Tri Kuntoro Priyambodo, Danur Wijayanto, and Made Santo Gitakarma, "Performance Optimization of MANET Networks through Routing Protocol Analysis," *Computers*, 2020.
[27] K. Nisar *et al.*, "QoS Analysis of the MANET routing protocols with Respect to Delay, Throughput, & Network load: Challenges and Open Issues," *14th IEEE Int. Conf. Appl. Inf. Commun. Technol. AICT 2020 - Proc.*, 2020, doi: 10.1109/AICT50176.2020.9368835.
[28] A. M. Abd Elmoniem, H. M. Ibrahim, M. H. Mohamed, and A.-R. Hedar, "Ant Colony and Load Balancing Optimizations for AODV Routing Protcol," *Int. J. Sens. Networks Data Commun.*, vol. 1, pp. 1–14, 2011, doi: 10.4303/ijsndc/x110203.
[29] D. Sinwar, N. Sharma, S. K. Maakar, and S. Kumar, "Analysis and comparison of ant colony optimization algorithm with DSDV, AODV, and AOMDV based on shortest path in MANET," *J. Inf. Optim. Sci.*, vol. 41, no. 2, pp. 621–632, 2020, doi: 10.1080/02522667.2020.1733193.
[30] A. Wong Yoon Khang *et al.*, "Qualitative-based QoS performance study using hybrid ACO and PSO algorithm routing in MANET," *J. Phys. Conf. Ser.*, vol. 1502, no. 1, 2020, doi: 10.1088/1742-6596/1502/1/012004.

Authors Profile

Veepin Kumar obtained his Bachelor of Technology in Computer science and Engineering degree from Kurukshetra University, Kurukshetra, India, in 2006 and Master of Technology in Computer science and Engineering degree from Guru Jambheshwar University of science and Technology, Hisar, India, in 2010 and currently a Ph.D. student in, IKG Punjab Technical University, Jalandhar, India. He is working as assistant professor in KIET Group of Institutions Ghaziabad, India. His research interest is Computer Network and Mobile Adhoc Network.

Dr. Sanjay Singla is Working as Principal and Professor in GGS College of Modern Technology, Kharar(Mohali), Punjab, India. He has more than 17-year experience in teaching research and administration. He has supervised more than 20 M.Tech theses and 6 PH.D Students. He has more than 80 papers published in UGC, Scopus and ESCI journals. He has participated more than 40 Conferences and FDP in India and abroad. His area of interest is Soft Computing, Software Testing, Software Engineering and Database System.