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Multi-Objective based Adaptive Meta-Heuristic Algorithm for Optimal Multicast Route Selection in Wireless Ad-Hoc Network

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Abstract: ***Mobile Ad-hoc Network (MANET) built by a lot of mobile nodes which are communicated over remote channel without having any centralized administration and fixed infrastructure. Multicasting is a method to forward a data packet from one node to a number of receivers' node at a time. There are different challenges in a MANET because of restricted resources and dynamic network topology. Because of the node mobility, performance metrics of the network such as energy, delay, and bandwidth make uncertainty problems in MANET. These uncertainty problems affect the performance of optimal path selection between the source node and the number of destination nodes. So, in this paper, multi-objective based adaptive meta-heuristic algorithm is presented for optimal multicast route selection in MANET. Among the multicast routing paths, optimal routing path is selected using adaptive artificial fish swarm algorithm (AAFSA). For fitness calculation, three objective functions based on energy, delay and bandwidth are derived in this algorithm. Simulation results show that the performance of the proposed multicast routing protocol outperforms existing multicast routing protocols in terms of delivery ratio, delay, energy consumption and network lifetime.***

Keywords: Mobile Ad-hoc Network (MANET), Multicasting, optimal routing path, adaptive artificial fish swarm algorithm.

I. INTRODUCTION

A mobile ad hoc network (MANETs) is interconnected of mobile nodes with no centralized administration or any fixed base station. At whatever point a node is required for sending similar data to more than one destination at same time, multicasting is utilized. Multicasting is the transmission of data packets to gathering of at least zero hosts recognized by a solitary destination address [1-3]. The expanding notoriety of collective multimedia applications in the mobile market is empowering the help for multicast interchanges. In addition a few gathering focused activities like video conferencing, synergistic works, and every single other application which expects one-to-numerous or many-to-numerous services depend upon the multicast innovation.

In multicast communication, a source node forwards just a single packet with an address of group as a destination so it encourages bandwidth sparing, decreased delays and high adaptability. It is extremely valuable in versatile/wireless conditions where mobile nodes have restricted power. Accordingly, the multicast routing protocol turns into a functioning region of research [4-6]. In MANET, pre-set up centralized administration or wired or wireless foundation is superfluous. Along these lines, MANETs are especially significant and helpful in the zone without base station support, for example, battlefields or hazardous situations. In MANET, every mobile node has constrained resources, for example, channel bandwidth, node battery, and so forth. So as to boost the life of the systems, traffic ought to be sent by means of routes that can be staying away from nodes with low power.

There are several multicast routing protocols for a MANET exist but almost not consider the network metrics uncertainty issues [7]. Since, the network performance metrics such as end-to-end delay, channel bandwidth, and energy of the mobile nodes change very frequently in a wireless ad-hoc network due to high node mobility. Obvious, it is very difficult to control all these uncertainty issues at a time because there is no precise mathematical tool that can control all these uncertainty issues. So, to improve the network efficiency, optimal routing path is to be selected from the multicast routing paths.

Contributions of this proposed approach are described as follows:

- Initially, multicast routing paths are established between the source and the number of destination nodes. During the multicast route discovery phase, delay, energy, and bandwidth of intermediate nodes are updated in the routing table.
- After the establishment of multicast routing paths, an optimal routing path is selected from the multicast routing paths using multi-objective based adaptive artificial fish swarm algorithm (AAFSA) is presented. In this algorithm, multi-objective functions based on delay, channel bandwidth, and energy of the mobile nodes are derived to select the optimal path.
- The performance of this proposed approach is in terms of delivery ratio, overhead and network lifetime

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Rest of this paper is organized as follows.

Section 2 reviews some recent literature which focused research on efficient routing in the wireless ad-hoc network. Section 3 states problems faced by the network and solutions. Section 4 proposes multi-objective based adaptive artificial fish swarm algorithm for optimal multicast route selection in wireless ad-hoc network. Results of this proposed approach are discussed in section 5. Conclusion of this research work is described in section 6.

II. RELATED WORKS

In this section, some recent literature which focused efficient route establishment in wireless ad-hoc network. N.Papanna, A.Rama Mohan Reddy and M. Seetha [8] have proposed Energy Efficient Lifetime Aware Multicast Route Selection scheme which was abbreviated as EELAM. The authors aimed to increase the lifetime of the network by selecting the energy-efficient routing path. To achieve this aim, they have presented an adaptive genetic algorithm based multicast route discovery scheme. In this approach, multicast routing topologies was adapted with the genetic algorithm. Using this algorithm, intermediate nodes with minimum energy and maximum residual energy was selected as optimal nodes. This proposed approach was implemented in the platform of Network Simulator. The implementation results showed that the proposed approach has achieved better delay, throughput, and energy efficiency. Wafa Alkhabbaz, Amr Alasaad and Meshal Alshaye [9] have presented Bayesian inference scheme for selecting optimal routes in wireless ad-hoc networks. They aimed to improve the routing protocol performance by enhancing resources such as power and bandwidth. They seemed to achieve their aim by presenting Bayesian inference based probabilistic method. In the proposed scheme, nodes utilized wireless channel's transmission characteristic for listening the topology of the network. This proposed approach was simulated in the MATLAB. By presenting this approach, the authors have reduced the number of control messages and power consumption. Dinesh Chander and Rajneesh Kumar [10] have proposed QoS aware Cross-Layer Multicast Routing in Mobile Ad-Hoc Networks. Overall performance of the network may decrease due to the individual performance behavior of various layers in communication. So, the authors aimed to improve QoS of the network. To attain this aim, they have presented Cross-layer Multicast Routing which was abbreviated as CLMR with a tree-based multicast routing protocol. This proposed CLMR utilized the performance of application layer, routing layer and physical layer for QoS aware communication. They simulated their proposed approach in the platform of NS2. Because of this proposed approach, they have reduced energy consumption and delay as well as they have increased throughput. Dipika Sarkar, Swagata Choudhury and Abhishek Majumder [11] have proposed improved Ant-AODV based efficient route selection for Mobile Ad-Hoc Network. In this literature, the authors focused to select the optimal path in Mobile Ad-Hoc Network. To achieve this objective, they have presented an innovative scheme for selecting optimal path using the hybrid techniques Ant Colony Optimization (ACO) based Ad-hoc On-Demand Distance Vector (AODV) protocol. Using this proposed ant colony based AODV, optimal route was chosen for data delivery with pheromone value. In this approach, route's pheromone value was estimated using path reliability, residual energy, and congestion. The approach selected the path with highest pheromone value. This proposed approach was simulated in NS2 simulator. By presenting this approach, they have achieved a better delivery ratio, delay, and throughput.

De-gan Zhang, Yu-ya Cui and Ting Zhang [12] have proposed OLSR protocol based on innovative quantum-genetic in Mobile Ad hoc Network. The performance of the routing protocol in MANET changes rapidly due to the distributed control, self-organization and mobility and also the availability of network resources decreases. So, the authors aimed to present an innovative routing protocol in MANET. To achieve this aim, they have proposed a novel quantum genetic-based OLSR protocol which was abbreviated as OG-OLSR. In the approach, multi-point relay sets of OLSR protocol were optimized with proposed augmented Q-Learning algorithm. This proposed approach was implemented in the MATLAB platform. Simulation results showed that the proposed protocol was highly efficient and reliable. V. V. Mandhare and V. R. Thool [13] have proposed a Metaheuristic scheme based QoS Routing establishment for Mobile Ad-hoc Network. The authors aimed to solve the problem of Quality of Service Routing in MANET. To overcome this problem, they have presented multi-constrained Metaheuristic algorithm based Quality of Service Routing in MANET. In this approach, they have presented the Cuckoo Search (CS) algorithm for choosing an optimal path. In this algorithm, they have used three various parameters such as hop count, residual energy and routing load for calculating the fitness value. The authors simulated their proposed approach in the platform of NS2. They have achieved better QoS routing metrics by presenting their proposed approach. M. Rajesh and J. M. Gnanasekar [14] have presented Physical Routing Protocol based on path surveying in Wireless Ad Hoc Networks. Significant features of Wireless network compromises the communication link among the mobile nodes. Most of existing physical routing protocols failed to maintain stable links when the packet is transmitted across the network so that packet drop and delay are increased. So, to solve this issue, they have proposed physical routing protocol based on path observation which was abbreviated as POPR in the wireless ad-hoc network. This proposed routing protocol considers relative direction, distance and relay node with density of traffic for transmitting the data to the destination. This proposed approach was simulated in the NS2 simulator. By presenting this approach, they have achieved better average packet delay and delivery ratio. Ajay Kumar Yadav and Sachin Tripathi [15] have presented Load Balanced Multicast Routing Protocol design in Wireless Mobile Ad-hoc Network. The authors aimed to reduce the wastage of the resources in MANET. Toa achieves this aim, they have proposed a traffic load balanced multicast routing protocol which was abbreviated as LBMRP. In this approach, mobile nodes are categorized into number of groups and for individual group a tree was created to attain efficient data transmission.

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They have simulated their approach in the platform of NS2. Simulation results showed that the proposed approach increased network lifetime and decreased the network overhead.

III. PROBLEM STATEMENT AND SOLUTIONS

In MANET, multicast routing protocol plays an important role in enhancing the network efficiency and resources such as energy and bandwidth. However, due to the rapid changes of node mobility, resources, and reliability, the performance of the multicast routing protocol may decrease. To solve this challenge, recent research works [8] [10] [15] have been presented and are reviewed in the previous section. Although that literature achieved better performance in terms of throughput, delivery ratio, and bandwidth utilization, the network may consume more energy and packet delivery time due to the number of transmissions in the routing path. Also, due to the high mobility of nodes in the network, the performance metrics such as bandwidth, energy and delay may change rapidly. So, to overcome these problems, among the multicast routing paths an optimal routing path is to be selected. Even though many researchers have presented novel techniques [9] [11] [13] for selecting optimal routing path in MANET, a meta-heuristic algorithm with high accuracy and convergence speed is to be presented for optimal routing path selection.

IV. MULTI-OBJECTIVE BASED ADAPTIVE META-HEURISTIC ALGORITHM FOR OPTIMAL MULTICAST ROUTE SELECTION

A. Overview

In this approach, multicast routing paths are established between one source node and the number of destination nodes using a multipath routing protocol. Initially, multicast routing paths are established between the source and the destinations using conventional multicast routing protocol. Energy efficiency, success rate and resources of the network will be reduced due to the number of transmission in the routing path between the source node and the number of destinations. So to overcome this issue, the multicast routing protocol is to be enhanced by selecting optimal math from the multicast routing paths. In this approach, for optimal route path selection, a multi-objective based adaptive artificial fish swarm algorithm is presented. For fitness calculation, bandwidth, delay, and residual energy are considered. By performing this algorithm, an optimal solution or optimal path is selected. Finally, the source node starts to forward the data through this selected path.

B. Basis of Multicast routing protocol

The base of the multicast routing protocol includes two phases that are route discovery and route reply phases. Every node in the ad-hoc network has routing table which maintains the information of neighboring nodes such as source id (S_{ID}), destination ID (D_{ID}), next-hop node ID (NH_{ID}), bandwidth (B), delay (D) and residual energy (RE). Figure 1 shows the structure of the routing table.

Source ID (S_{ID})	Destination ID (Dn_{ID})	Next hop node ID (NH_{ID})	Bandwidth (B)	Delay (D)	Residual energy (RE)

Figure 1: Structure of the routing table

***Multicast route discovery phase*:** In this phase, the source node discovers multicast routing paths towards the number of destination nodes in the network. At first, the source node forwards the route request (RREQ) packet to the neighbor nodes which are in its communication range. This packet includes the following information: *source id* (S_{ID}) which denotes the address of the source node, *destination ID* (Dn_{ID}) denotes the addresses of the number of destination nodes, *message unique ID* (MU_{ID}) which identifies the duplicate RREQ packets. R_{infor} denotes information of whole routing path from the source node to the number of destinations, D_T denotes the total delay in the routing path, B_T denotes the total bandwidth of the routing path and *RE* denotes the residual energy of the routing path. Figure 2 shows the structure of the RREQ packet.

S_{ID}	Dn_{ID}	MU_{ID}	R_{infor}	D_T	B_T	RE

Figure 2: Structure of the RREQ packet

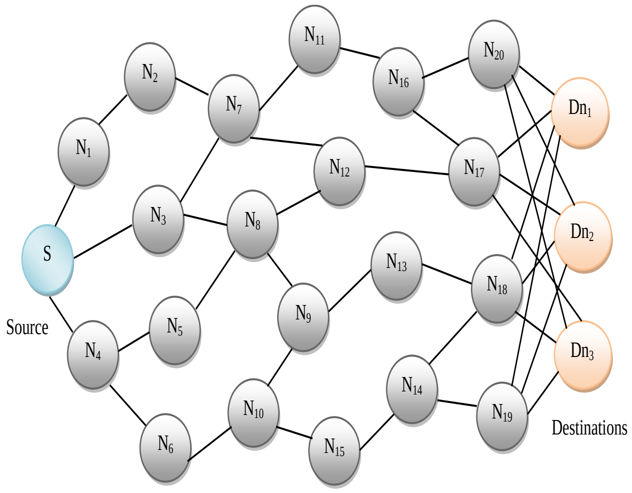

Figure 3: Multicast route discovery

The Figure 3 shows the route discovery phase. As shown in the figure, the source node (S) wants to forward the data packets to the number of destinations Dn_1, Dn_2, and Dn_3. Initially, the source node (S) forwards the RREQ packet to the neighboring nodes N_1, N_3 and N_4. After receiving the RREQ packet, these nodes update their current value of bandwidth, delay and residual energy in the routing table. Then, each node compares its ID with the destination node IDs which carried by the header of RREQ packet. If the destination node ID matches with the node ID, route discovery process will be terminated. Otherwise, the nodes

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N_1, N_3, and N_4 again forwards the RREQ packet to their neighbor nodes and proceed the same procedure until finding the destination node.

***Multicast route reply phase*:** After receiving the RREQ packet, the number of destination nodes forwards the route reply (RREP) packet to the source node through the routes where the RREQ packet carried out. This RREP packet includes the following information: {S_{ID}, Dn_{ID}, RP_{info}, MU_{ID}} where RP_{info} denotes the reverse path to carry RREP packet. After receiving the RREP packet, the source node starts to the number of destination nodes. Figure 4 shows the structure of RREP packet.

S_{ID}	Dn_{ID}	MU_{ID}	RP_{infor}

Figure 4: Structure of the RREP packet

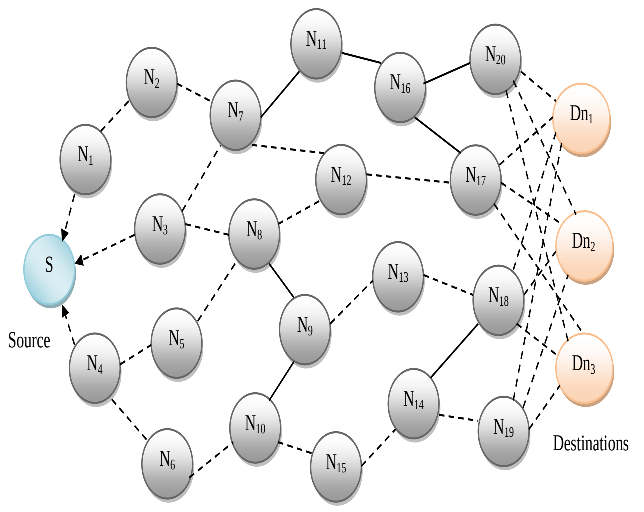

Figure 5: Multicast route reply

The **Figure 5** shows the route reply phase. As shown in the figure, the destination nodes forward the RREP packet to the neighbor nodes N_{17}, N_{18}, N_{19} and N_{20} which are identified with the support of header of RREQ packet. After receiving the RREP packet, the neighbor nodes again forward the packet across the network until finding the source node. After the completion of whole process, the source node forwards the data packet through the established routing path.

Due to the number of transmissions, some nodes in the routing paths may lose their energy and they lead the transmitted packet to loss. Besides, the success rate of the transmitted data packet will be reduced to the longest routing path in the network. To overcome these issues, optimal routing path is to be selected among the multipath. So, in this paper, the source node in the network selects the optimal path with the proposed adaptive artificial fish swarm algorithm (AAFSA). Description of optimal path selection using AAFSA algorithm is given in the following section.

C. Optimal path selection using the AAFSA algorithm

Basic of Artificial Fish Swarm Algorithm

AFSA calculation was presented by Li in 2002 and it performs dependent on the conduct of fish swarm. The nature fish swarm is scanning for chasing the food source in like manner this algorithm foraging for getting the global optimal solution. Every artificial fish in AFSA pursues four performances that are searching, swarming, following and random performances to acquire the optimal solution. Let artificial fishes or candidate solutions are initialized in *d* dimensional space as follows:

$$U = \{ u_1, u_2, \ldots, u_d \} \qquad (1)$$

Where, y_d denotes the artificial fish's position in d^{th} dimension. Fitness of the artificial fish is estimated and is described as follows:

$$A = f(U) \qquad (2)$$

Where, *A* denotes the objective function or fitness. Distance between U_i and U_j is represented as $D_{ij} = \| U_i - U_j \|$, *Visual* represents the artificial fish's perception range or visual distance and *step* represents the forwarding step of the artificial fish. Following sections describe the performances of artificial fish.

***Searching performance*:** The current position of an artificial fish is represented as U_i and it chooses j^{th} position U_j which in its visual distance randomly. Fitness of both U_i and U_j are compared. If fitness of U_j is superior to that of U_i, then it moves *Step* to the direction of $(U_j - U_i)$. Otherwise, random performance is performed. In random performance, the artificial fish tries to choose next position U_j randomly again and checks whether the selected position achieves the moving condition or not. The random performance is continued if the moving condition is not achieved by the selected position. The searching performance rule is described as follows:

$$\tilde{U}_i = \begin{cases} U_i + Step * \dfrac{U_j - U_i}{D_{ij}} * rand, & \text{if } A_j \text{ superior to } A_j \\ \text{Random performance}, & \text{otherwise} \end{cases} \qquad (3)$$

Where, $\tilde{U}_i$ denotes the artificial fish's new position and *rand* denotes the random number within the interval [0, 1].

***Swarming performance*:** Each artificial fish U_i in the swarm searches the central position U_c of the m_f number of artificial fish in its visual distance. The artificial fish U_i forwards to the central position U_c if (A_c/m_f) is superior to $(\delta * A_i)$. Otherwise searching performance is performed. The swarming performance rule is described as follows:

$$\tilde{U}_i = \begin{cases} U_i + Step * \dfrac{U_c - U_i}{D_{ic}} * rand, & \text{if } (A_c/m_f) \text{ is superior to } (\delta * A_i) \\ \text{Searching performance}, & \text{otherwise} \end{cases} \qquad (4)$$

Where, δ denotes the crowd factor within the interval [0, 1].

***Following performance*:** In this performance, the artificial fish U_i chooses the local best solution represented as U_{best}. It is ahead of a step in the direction $(U_{best} - U_i)$ if (A_{best}/m_f) is superior to $(\delta * A_i)$. Otherwise, searching performance is performed. The following performance rule is described as follows:

$$\tilde{U}_i = \begin{cases} U_i + Step * \frac{U_{best} - U_i}{D_{i,best}} * rand, & if\ (A_{best}/m_f) \text{ is superior to } (\delta * A_i) \\ \text{Searching performance}, & otherwise \end{cases} \quad (5)$$

***Random performance*:** In this performance, the artificial fish chooses a position randomly. If the fitness of the selected position is superior to the current position of the artificial fish, then it moves to the selected position.

Optimal path selection using Adaptive AFSA algorithm

As AFSA algorithm has many advantages such as high accuracy, flexibility, and high convergence speed, it is chosen for optimal routing path selection. Nevertheless, this algorithm faces some difficulties to attain an optimal solution that is described as follows.

In this algorithm, each artificial fish performs four performances to attain the best solution. Nevertheless, only the best performance is chosen depending on the artificial fish moving condition. The optimal position U_{best} is recorded in the bulletin after each comparison. Although AFSA is used to overcome the optimization issues, it faces some difficulties to obtain the best solution because of the number of performances. So, in this paper, only two major performances are presented that are searching performance and mating performance. Because of the presence of mating performance, the proposed algorithm is called as Breeding Artificial Fish Swarm Algorithm (BAFSA) or Adaptive Artificial Fish Swarm Algorithm (AAFSA). Using this proposed algorithm, optimal path is selected from the multiple paths. The following section describes the optimal path selection using AAFSA algorithm.

As the number of transmissions occurs through the multiple paths, data rate of the network is improved. Nevertheless, a few routing paths may lose its energy efficiency and success rate. So, to overcome these issues, an optimal path is to be selected from the multipath. For optimal path selection, AAFSA is proposed. Phases of this algorithm are described as follows:

***Initialization*:** Initially, the parameters utilized in this algorithm such as *Step*, *Visual*, m_f, and δ are initialized. Then the positions of artificial fishes or candidate solutions are initialized with the population size N. Candidate solution of this approach is the optimal routing path (R_i) between source S and the number of destinations Ds. Initialization of the solutions can be specified as

$$U_N = \{R_{N1}, R_{N2}, \ldots\ldots, R_{Nd}\} \quad (6)$$

Here, R_{Nd} represents the routing path of N^{th} population in d dimensional space.

***Fitness or Food concentration*:** After the initialization of the artificial fishes or routing paths, fitness of the artificial fish is calculated. This fitness is evaluated based on the delay, bandwidth and residual energy of routing paths.

The total delay (D) of the j^{th} routing path between the source (S) and the number of destinations (Dns) is calculated as follows:

$$D(j) = \sum_{i=1}^{n} d_{ij} \quad (7)$$

Where, i denotes the n number of nodes participated in the jth routing path and d denotes the delay of each node in the jth routing path.

The total bandwidth (B) of the j^{th} routing path between the source (S) and the number of destinations (Dns) is calculated as follows:

$$B(j) = \sum_{i=1}^{n} b_{ij} \quad (8)$$

Where, b denotes the bandwidth of each node in the jth routing path.

The total residual energy (RE) of the j^{th} routing path between the source (S) and the number of destinations (Dns) is calculated as follows:

$$RE(j) = \sum_{i=1}^{n} re_{ij} \quad (9)$$

Where, re denotes the residual energy of each node in the jth routing path.

By using these multi-objective functions (7), (8) and (9), fitness function of this algorithm is described in the following equation.

$$Fitness_j = \begin{cases} Max\left(\frac{1}{D(j)}\right) & \forall j \\ Max(B(j)) & \forall j \\ Max(RE(j)) & \forall j \end{cases} \quad (10)$$

According to equation (10), if the routing path satisfies the minimum of total delay and maximum of total bandwidth and total residual energy, it is selected as an optimal routing path between source and the number of destinations.

***Update the solution*:** After calculating the fitness to the position of the artificial fish, it will be updated to the next position. Depend on the modified performances such as searching performance and mating performance, the artificial fish is updated to next position. These performances are described as follows:

***Searching performance*:** Initial position of an artificial fish is denoted as U_i. From the initialized positions of the artificial fishes or solutions, the global best position U_{best} which is recorded in the bulletin and also local best position U_{lbest} is assumed. The position which is near to the initial position of the artificial fish is attained by the following condition,

$$\tilde{U}_i = \begin{cases} U_i + Step * \frac{U_{lbest} - U_i}{D_{i,lbest}} * rand, & if\ (rand < \rho) \\ U_i + Step * \frac{U_{best} - U_i}{D_{i,best}} * rand, & otherwise \end{cases} \quad (11)$$

Here, ρ represents the probability of decision. It can be defined as follows,

$$\rho = \sqrt{1 - \frac{iter}{iter_{\max}}} \quad (12)$$

Where, *iter* and $iter_{max}$ represent the current iteration and maximum iteration. As defined in equation (11), the artificial fish is updated to the next position between U_i and U_{lbest} if the probability is greater than the random number. Otherwise, it is updated to next position between U_i and U_{best}.

Mating performance: For the ability of reproduction of an artificial fish, selection operator, and crossover operator are included in this algorithm like Genetic Algorithm (GA). In this mating performance, the artificial fish with global best position (U_{best}) is selected as the female parent. The male parent is selected based on the probability of artificial fish that is proportional to the fitness of the artificial fish. It can be calculated as follows:

$$p_i = \frac{Fitness_i}{\sum_{j=1}^{N} Fitness_j} \quad (13)$$

According to equation (13), artificial fish with best fitness or probability (p_i) is selected as the male parent. After selecting the male and female parents, mating performance is started between them for the production of offspring. The mathematical expression of this offspring of artificial fish is described as follows:

$$U_{i,next} = U_{i,male} \times (1-rand) + U_{best,female} \times rand \quad (14)$$

Here, $U_{i,male}$ represents the male parent, $U_{i,next}$ represents the offspring or new solution. If the fitness of $U_{i,next}$ is greater than that of U_i, then $U_{i,next}$ is considered as the new position of the artificial fish (U_{new}). Otherwise, random performance is initiated i.e.,

$$U_{new} = \begin{cases} U_{i,next}, & if\ A_{i,next} \geq A_i \\ random\ performance, & otherwise \end{cases} \quad (15)$$

After getting the offspring of artificial fish, the fitness of offspring will be calculated. If the offspring satisfies the fitness, then the optimal solution is attained. Otherwise, the offspring will be updated using searching and mating performances. Finally, the source node S forwards the data to the destinations through the selected optimal path ($R_{optimal}$).

Algorithm: Procedure for selecting the optimal path using AAFSA
Input: Multicast routing paths (R_i), *Step*, m_f, $iter_{max}$, *rand*, δ and *Visual*
Output: Optimal path ($R_{optimal}$).

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1. Initialize the positions artificial fishes or solutions (multiple paths).
2. Calculate fitness for each solution using equation (10).

Searching performance:

3. **If** $rand < \rho$
4. **Then**

$$\tilde{U}_i = U_i + Step * \frac{U_{lbest} - U_i}{D_{i,lbest}} * rand$$

5. **Else**

$$\tilde{U}_i = U_i + Step * \frac{U_{best} - U_i}{D_{i,best}} * rand$$

6. **End**

Mating performance:

7. **If** $A_{i,next} \geq A_i$
8. **Then**

$$U_{new} = U_{i,next} = U_{i,male} \times (1-rand) + U_{best,female} \times rand$$

9. **Else**
   Random performance is initiated.
10. **End**
11. Steps 2-10 are continued until finding the optimal path ($R_{optimal}$).

V. RESULTS AND DISCUSSIONS

In this paper, multi-objective based adaptive artificial fish swarm algorithm for multicast route selection in MANET is proposed and this proposed approach is implemented in the platform of Network Simulator (NS2). Table I shows the simulation parameters of the proposed approach. In this simulation, 250 mobile nodes are used. These nodes perform in the simulation area 1000m X 1000m. Constant bit rate (CBR) traffic source is utilized for this simulation. IEEE 802.11 based MAC protocol is used. Size of the packet is 512 byte and the packet is transmitted in the rate of 500kbps. For multicast route establishment between the source node and destination nodes, Multicast Ad-hoc on-demand Distance Vector (MAODV) routing protocol is used. This routing protocol is enhanced by selecting the optimal path from the multicast routing paths using the proposed AAFSA based multicast routing protocol (AAFSA-MRP) algorithm.

Table I: Simulation settings

Parameters	Assumptions
No. of Nodes	250 mobile nodes
Area	1000m X 1000m
MAC	802.11
Simulation Time	200 secs
Traffic Source	CBR
Rate	500Kbps
Propagation	TwoRayGround
Antenna	Omni antenna
Packet size	512 byte
Routing protocol	MAODV
No. of Nodes	250 mobile nodes

A. Performance Analysis

In this section, the performance of the proposed AAFSA-MRP is evaluated in terms of delivery ratio, delay, energy consumption, and routing overhead by a varying number of mobile nodes and mobility of the nodes. Also, the performance of the proposed AAFSA-MRP is compared with that of the conventional Multicast Ad-hoc On-Demand Distance Vector routing protocol (MAODV) and On-demand Multicast Routing Protocol (ODMRP).

B. Performance-based on varying mobile nodes

In this section, performance metrics such as delivery ratio, energy consumption, network lifetime, delay and overhead of the proposed approach are evaluated by varying number of mobile nodes 50, 100, 150, 200 and 250.

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Figure 6 shows the comparison of the delivery ratio of the different routing protocols by varying mobile nodes. Although the source node transmits the data packet through the multicast routing paths to the number of destinations, delivery ratio of the network may decrease due to the loss of link quality. Thus, by selecting the optimal with the proposed AAFSA-MRP, delivery ratio of the network is increased. As shown in the figure, delivery ratio of the proposed AAFSA-MRP is increased to 19% & 91% than that of the existing multicast routing protocols MAODV and ODMRP.

The comparison between energy consumption and the number of mobile nodes for different routing protocols is shown in Figure 7. Due to the number of transmissions, energy efficiency of the routing paths may decreases that affect success rate of data transmission. So, to transmit the data packet seamlessly, the multicast routing protocol MAODV is optimized with the AAFSA algorithm. So compared to MAODV and ODMRP routing protocols, energy consumption of the proposed AAFSA-MRP is reduced to 39% and 60%. Figure 8 shows the comparison network lifetime of the different routing protocols for varying number of mobile nodes. Due to the selection of optimal routing path among the multicast routing paths, network lifetime of the proposed AAFSA-MRP is increased to 57% & 93% than that of the existing MAODV and ODMRP routing protocols.

Figure 9 shows the comparison between delay and number of mobile nodes for different routing protocols. As shown in the figure, the delay of the proposed AAFSA-MRP is reduced to 40% and 57% than that of MAODV and ODMRP. Because of the optimal routing path selection, the source node forwards the data packet to the number of destinations without any delay. The comparison of overhead of the different routing protocols for varying number of mobile nodes is shown in Figure 10. As multicast routing paths consume more routing overhead, it has been reduced by selecting the optimal routing path between the source node and the number of destinations. Compared to MAODV and ODMRP routing protocols, overhead of the proposed AAFSA-MRP is reduced to 32% and 70%.

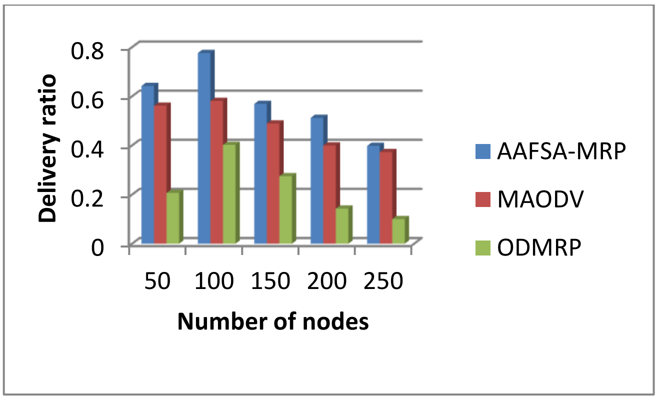

Figure 6: Number of nodes Vs Delivery ratio

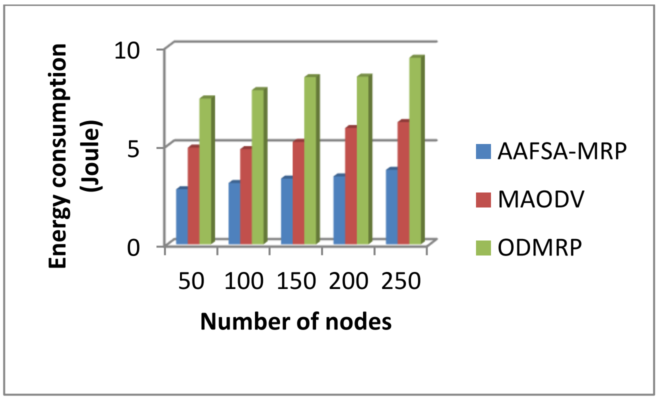

Figure 7: Number of nodes Vs Energy consumption

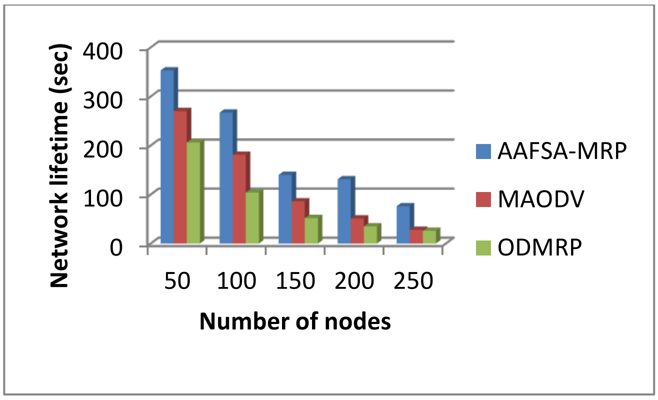

Figure 8: Number of nodes Vs Network lifetime

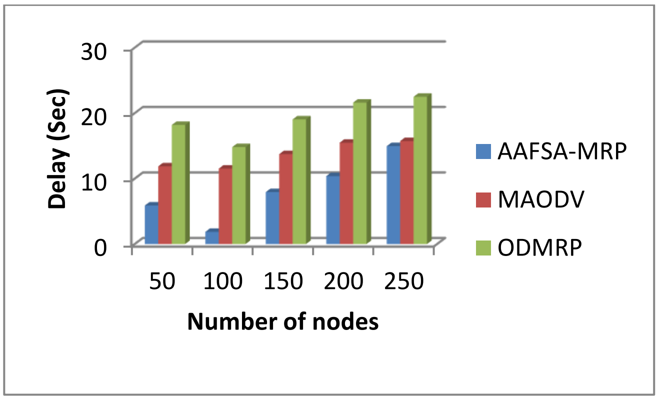

Figure 9: Number of nodes Vs Delay

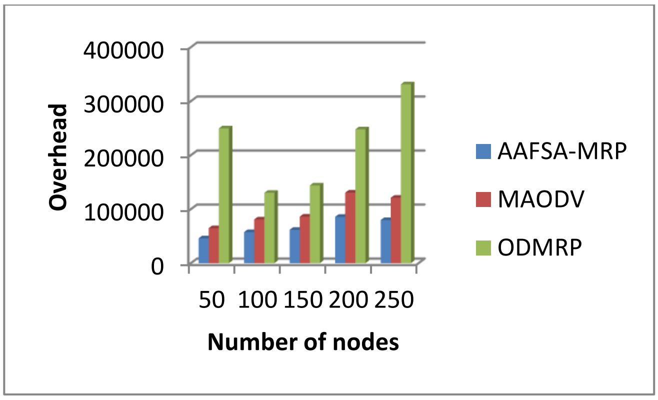

Figure 10: Number of nodes Vs Overhead

C. Performance-based on varying speed of the nodes

In this section, performance metrics of the proposed approach are evaluated by varying speed of the nodes 15, 30, 45, 60 and 75m/s. Figure 11 shows the comparison of the delivery ratio of the different routing protocols by varying speed of nodes. Due to the mobility of the nodes delivery ratio of the network decreases and also it makes some uncertainty problems in MANET. So, by presenting optimal routing path selection using the proposed AAFSA-MRP, delivery ratio of the proposed approach is increased to 13% & 96% than that of MAODV and ODMRP. Compared to MAODV and ODMRP routing protocols, energy consumption of the proposed AAFSA-MRP for varying speed is reduced to 48% and 61% as shown in Figure12. Figure 13 shows comparison delay of the different routing protocols for varying speed of mobile nodes. As shown in the figure delay of the proposed AAFSA-MRP is decreased to 43% & 59% than that of the existing MAODV and ODMRP routing protocols.

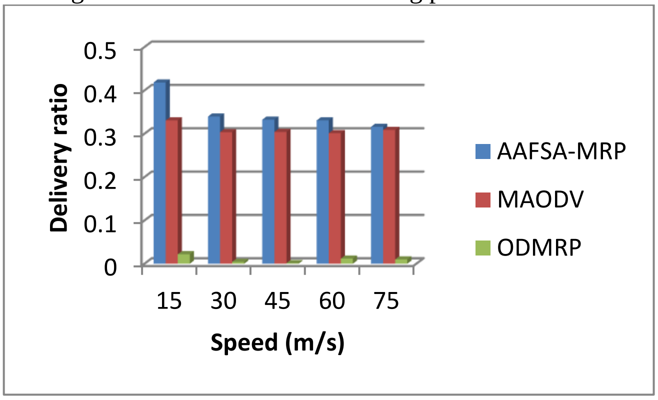

Figure 11: Speed Vs Delivery ratio

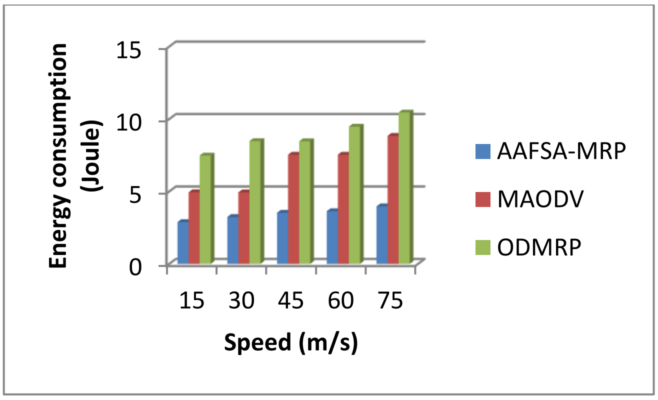

Figure 12: Speed Vs Energy consumption

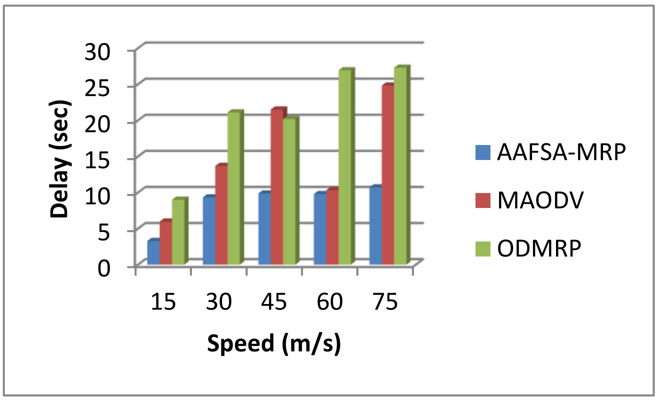

Figure 13: Speed Vs Delay

VI. CONCLUSION

In this paper, uncertainty problems that happened due to the mobility of mobile nodes are solved by selecting the optimal routing path among the multicast routing paths between the source node and the number of destinations using the proposed AAFSA-MRP protocol. In this approach, the conventional MAODV routing protocol is optimized with the proposed AAFSA algorithm which used multi-objective functions energy, delay, and bandwidth for selecting the optimal path. The performance of the proposed AAFSA-MRP protocol is compared with that of the existing routing protocols MAODV and ODMRP. Simulation results showed that the performance of the AAFSA-MRP outperformed that of the MAODV and ODMRP in terms of delivery ratio, network lifetime and energy consumption for varying number of mobile nodes and speed of the nodes.

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