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A Comprehensive Evaluation of Nature Inspired Routing Algorithm for Mobile Ad Hoc Network : DEA and BCA

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Abstract — This paper discussed about the comprehensive evaluation of nature inspired routing algorithms such as Dolphin Echolocation Algorithm (DEA) and Bee colony Algorithm (BCA) use for distance optimization. The influence of DEA and BCA algorithms on Quality of Service (QoS) performance matrices for Mobile Ad hoc Network (MANET) is analyzed. Ultimately with the help of DEA it is possible to achieve optimized routing path between source and destination nodes. Further this paper have the analysis of various results which gives the comprehensive evaluation of DEA algorithm and it is suitable for MANET for achieving good Throughput, packet delivery ratio, delay and overhand.

Keywords- *Dolphin Echolocation Algorithm (DEA); Bee colony Algorithm (BCA)* Mobile Ad hoc network*; Nature inspired algorithm; QoS.*

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I. INTRODUCTION

Recently, Mobile Ad hoc Network (MANET) has become well-liked, particularly for its less cost consumption for installation of infrastructure in the regions of poor network communications and terrain of tricky operation as MANETs are infrastructure less network [2]. The communication between two nodes is not depend on the fixed infrastructure, nodes communicate with each other without any fixed medium. MANET uses the multi-hop communication where each node acts as a host as well as router for forwarding the messages to the next node.

MANETs having the various characteristics like bandwidth constrained, energy constrained, less physical security and dynamic network topology etc. the changes in network topology occurred due to random domain change. Hence because of the topology change reason the major issue related to MANETs is routing. Due to the limited bandwidth of nodes, the source node and destination node may have to communicate via mediator nodes [5]. As in case of multi-hop routing, for forwarding packets from one node to another node in the network which require some sort of routing protocol to take the routing decisions. Each nodes in MANET carry out both network control and routing duties and thus generate both user and application traffics. The nodes in MANET are used to provide connectivity as well as various services that the nodes communicate directly with one another in peer-to-peer fashion.

A routing protocol for MANET [6] is composed of a routing algorithm with a set of rules that monitor the functions and operation of the network. Routing protocols of MANET are divided in three groups: Table driven or Proactive, on demand or Reactive and Hybrid [4]. On demand protocols do not store all paths, but paths are created each time they need to send a data. If source node wants to send a data to destination node then this source node evokes process to search a path. After the path is created, it is maintained by nodes. These are Dynamic Source Routing (DSR), Ad-hoc on demand distance vector (AODV), Associatively-Based routing (ABR), Temporally-Ordered Routing Algorithm (TORA), Dynamic MANET On-demand (DYMO) and others. In a proactive routing protocol, each node periodically broadcasts its routing table to its neighbors, allowing all nodes to have a consistent network view. Due to current network topology in each node these protocols have the short response time in determining a short route from source to destination [1]. Protocols such as Destination Sequenced Distance Vector Routing (DSDV), Wireless Routing Protocol (WRP) present into this category. A hybrid protocol, such as Zone Routing Protocol (ZRP) combines the advantages of both proactive and reactive protocols. Each node proactively maintains a routing table for nodes within its zone and reactively finds a route to its destination if the destination node lies beyond its zone [9]. It is therefore essential to develop routing algorithms that are adaptive, robust and self-healing. Moreover, they should work in a localized way, due to the lack of central control or infrastructure in the MANET. Biological nature's self-organizing systems like insect societies and marine animals show precisely these desirable properties. Making use of a number of relatively simple biological agents (e.g., the ants, dolphins, bee and swarm particle etc) a variety of different organized behaviors are generated at the system-level from the local interactions among the agents and with the environment [10]. The robustness and ability to produce desire result of the collective behaviors of insect and animals societies with respect to variations of environment conditions is a key-aspect of their biological success. Because of these same properties, they have recently become a source of inspiration for the design of routing algorithms for dynamic networks [12].

A. Dolphin Echolocation Algorithm (DEA).

This algorithm is inspired from hunting marine Dolphins. Dolphin can generate sonar like sound in the form of click and it send in different orientations and when this sound strikes an object, some part of the energy of the sound is reflected back to the Dolphin as echo [14]. Then, the Dolphin hears the sound and decides to make a decision of a particular direction at this time. Dolphin gets information about the range of distance and orientation of the prey. Hunting process is started and dolphin moves to towards prey, sending sound and receiving echo

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continue until Dolphin hunts the prey., in this process, the probability of hunting increases every time and search space decreases continuously. When the dolphin catches the prey, the probability of hunting is one hundred percent and search space is the lowest. Dolphins primarily investigate all around the search space to discover the prey [15]. The moment a dolphin approaches the target, the animal confine its search, and incrementally increases its clicks in order to concentrate on the location. The method simulates dolphin echolocation by restraining its exploration relative to the distance from the target [16].

B. Artificial Bee Colony Algorithm

The most noticeable behaviors in honeybee algorithm visible to us are the foraging of each individual bee [4]. The foraging process includes two main behaviors: recruitment of nectar source and abandonment of a source [7] [8]. It starts with some scout bees left the hive in order to search food source to gather nectar. After discovering the food (i.e., flowers), scout bees come back to the hive and inform their hive-mates about the richness of the flower and the distance of the flower to the hive (i.e., location) through a special movements called dance, which are round dance, waggle dance, and tremble dance depending on the distance information of the source. Typically, it dances on different areas in a try to advertise food locations (by touching her antennae) and encourage more remaining bees to gather nectar from her source [9]. After the dancing show, more foraging bees will leave the hive to collect nectar follow one of the dancing scout bees. Upon arrival, the foraging bee stores the nectar in her honey stomach and returns to the hive. The described process continues repeatedly until the scout bees discover new areas with potential food sources. The honeybee behavior is applied over the routing in MANET for route discovery [10].

C. Quality of Service (QOS)

In Mobile Ad-hoc Network providing QoS is more difficult than a wired network. The objective of QoS routing is to identify paths that have adequate resources to satisfy a set of constraints and at the same time attain efficiency in resource utilization [12]. QoS is stated in terms of end-to-end performance over the network which includes various parameters such as end-to-end delay, bandwidth, energy, throughput, packet delivery ratio, and jitter. Energy in MANET is defined as battery power in the nodes. The parameter end-to-end delay refers to the time taken for a packet to be transmitted over a network from source to destination. It comprises of processing delay, queuing delay, transmission delay and propagation delay. Bandwidth is the maximum data transfer rate of the network. Throughput has defined the rate of successful message delivery across a communication channel. Providing multiple metrics solution is not an easy task in MANET. It can be solved by using an optimization method.

II. PREVIOUS WORK

Kenji Leibnitz et.al, in their paper “Bio-Inspired Robust Routing Protocol for Mobile Ad-Hoc Networks” discuss about the robustness issues [21] of a biologically inspired routing protocol for MANETs and the influence it has on the QoS in the system. Contrary to fixed network structures, MANET was susceptible to frequent topology changes due to the mobility and churn of the participating nodes. Their goal was to provide fast recovery from connectivity failures, as well as a fast reaction to path changes due to node mobility or churn. Their numerical results showed that the method also performs similarly well as the AODV reference model used in the simulations. However, when the node activity was subject to frequent changes due to their duty cycle, churn, or mobility, the number of required broadcasts can be reduced compared to AODV.

H.Lookman Sithic et. al. in their paper “Honey bee based QoS routing for MANETs” discussed about the challenges of mobile ad hoc network and [12] routing which is having a vital role in deciding the quality of service. They discussed about Artificial Bee Colony algorithm and said it is one of the swarm intelligence-based optimization techniques and finds out an optimal path from source to destination. Their proposed scheme on honey bee based QOS routing reduces an end-to-end delay by monitoring the path quality of the route.

Akhil Dubey et. al. in their survey paper “Artificial Bee Colony Based Energy Efficient Routing Protocols in MANET: A Survey” discussed about [10] network overhead in MANET due to this overall network degradation. So for healing this problem they did survey on swarm intelligence based algorithms for energy optimization in MANET. They given the comprehensive study of energy efficient routing based on artificial bee colony optimization. They describe the behavior of the bees and artificial bee colony algorithm. Then further they discuss bio inspired or predictive routing for MANETs.

Mustafa Tareq et. al in their research article "Mobile Ad Hoc Network Energy Cost Algorithm Based on Artificial Bee Colony”, studied about node distance and transmission power further they studied swarm intelligence technique through the artificial bee colony (ABC) algorithm to optimize the energy consumption in a dynamic source routing (DSR) protocol in MANET, their proposed [1] algorithm is called bee DSR (BEEDSR). The Artificial Bee Colony (ABC) algorithm is used to identify the optimal path from the source to the destination to overcome energy problems. Finally the performance of the BEEDSR algorithm is compared with DSR and bee-inspired protocols (BeeIP). They found The BEEDSR algorithm is superior in performance than other protocols in terms of energy conservation and delay degradation relating to node speed and packet size.

E. Hemalatha Jai Kumari et. al. in their research paper “Dynamic Shortest Path Routing In Mobile Ad-hoc Networks Using Modified Artificial Bee [11] Colony Optimization Algorithm” discussed about Modified Artificial Bee Colony Optimization (MABCO) algorithmic techniques used to find the global optimum value in a given space. They shown this is a good technique for identifying multiple stable paths between source and destination nodes. Their proposed technique overcome all these problems and given optimal solution in cyclic as well as acyclic changing environment. Modified Artificial Bee Colony optimization and Artificial Bee Colony optimization can be compared based on their computational efficiency and the quality of solution. MABCO outperforms ABCO in both criteria, especially in computational efficiency for the non-linear problems with continuous variables.

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Ali Ebrahimnejad et.al, in their paper "A novel artificial bee colony algorithm for shortest path problems with fuzzy arc weights" [20] discussed about shortest path (SP) problem which is a network optimization problem with a wide range of applications. They propose an artificial bee colony (ABC) algorithm to solve the fuzzy SP (FSP) problems with fuzzy arc weights. They presented a wireless sensor network (WSN) problem and demonstrate the applicability of the proposed method and exhibit the efficiency of the procedures and algorithms.

Bhushan T. Dhok et.al, in their paper "Optimization of Cluster Based Routing Protocol Using Bee Colony Optimization for VANet" discussed about Bee colony [5] optimization techniques used to improve maximum result under given condition. In their paper VANET play vital role for road side safety and to solve the emergency situation. The communication between vehicles is done by using cluster based routing protocol i.e. CBLR and HCR and compare its results. They applied Bee Colony Optimization techniques on this protocol to achieve maximum results. Finally various performance matrixes have been calculated by varying no of vehicles (nodes).

Ramanjyot Kaur, in their paper "Swarm Intelligence based Routing Algorithms for MANETs: A Review" discussed about many conventional routing algorithms adopted by MANET, discussed about Swarm Intelligence (SI) based algorithm which are bio-exhilarated [6] and also discusses various optimization techniques which have been used for routing in MANET's such as Bee Colony Optimization, Ant Colony Optimization. Further author said the proportional distribution of traffic to different routes is the main advantage of Bee Ad hoc and the major disadvantage of Bee Ad hoc is the use of source routing as they adopt vector routing. Further, to get efficient and effective routing protocols for MANET real constraints/environmental conditions are required to consider, tune and maintain.

Gautam M. Borkar i et. al. in their research paper "Secure Routing Environment with Enhancing QoS in Mobile Ad-Hoc Networks" discussed about a [15] net based multicasting routing scheme to discover all possible secure path using Secure closest spot trust certification protocol (SCSTC) and the optimal link path is derived from Dolphin Echolocation algorithm (DEA). Their numerical results and performance analysis clearly describe that their provided proposed routing protocol generates better packet delivery ratio, decreases packet delay reduces overhead in secured environment.

III. PROPOSED DOLPHIN ECHOLOCATION ALGORITHM (DEA) FOR MANET

The Dolphin Echolocation Algorithm is nature inspired algorithm in this the hunting technique of dolphins is utilized. For hunting and direction finding dolphin generates the genetic sonar and with the analysis of sonar in the form of echo dolphin finds the exact location and direction of the prey. Analysis of the echo is the crucial task while finding the direction and path. With the help of this technique optimized shortest path is discovered between source and destination in MANET. With the help of the optimized shortest path QoS also able to achieve and it is essential in MANET. Partially optimization problems are solved with the help of Dolphin Echolocation Algorithm in dynamic topology changing environment. DEA searched the particularly large space for candidate solution it is applied to the best node present in the MANET, further the shortest distance path with best nodes are selected for data transfer from source to destination. It minimizes the routing overhead and further reduces the traffic and optimized the process and finds the best path [15].

A. Dolphin Echolocation algorithm for optimized Path Selection

The important steps of dolphin echolocation algorithm for discrete optimization are as follows [15]:

Initialize nodes (number of echolocations) in a Mobile Ad-hoc Network.

For echolocation i, this is at distance (i)

Initialize the Secure routes with a uniformly distributed random vector(u_1, u_2)

$$V = W * v + y_1 * u_1 * (p - x) + y_2 * u_2 * (g - x)$$

This update uses a weighted sum of the following:

(i) The previous velocity V is found by speed packet
(ii) The difference between the current distance and the best distance the particle has seen $(p - x)$
(iii) The difference between the current distance and the best distance in the current

DEA Algorithm steps

Step 1: (Initialization)

Set u_1 = 0;

Set u_2 = 0;

Set V_0 ← *Velocity of Packet Speed;*

Set Q_0 ← argmin v(v_0)

Start the routing process at the initial state L_0;

Step 2(Find Accumulative fitness for possible routes)

for u_1 =1 to the number of Routes

for u_2 =1 to the number of variables

find the position of L (u_1, u_2) in j-th column of the

Alternatives matrix and name it as A.

for u_3= -Re to Re

$$AF_{(A+u_3)u_2} = \frac{1}{Re} * (Re - |u_3|) \text{ Fitness } (u_1) + AF_{(A+u_3)u_2}$$

Step 3 (Find the best route):

for u_2 = 1: Number of Variables

for u_1 = 1: Number of Alternative routes

if u_1 = The best route (u_2)

AF_{u_1,u_2} = 0

End

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Dolphin Echolocation Algorithm is initialized with a group of secure paths and then searches for an optimal route solution by updating generations. Each echolocation is updated by the best solution that has been achieved previously and the best value is tracked by the dolphin rules obtained currently by any paths in the population and its global best [15]. The bound of the inertial range option is use for providing a satisfactory solution that eventually is discovered. The Dolphin Echolocation algorithm significantly reduces the traffic overhead, computation complexity and reduced the route failure between nodes that minimize the routing overhead.

IV. COMPARISON OF RESULTS AND DISCUSSION

This section presents an overall comparison of Nature inspired categories of Mobile Ad hoc Routing protocols such as Dolphin Echolocation algorithm and Bee colony algorithm utilized for optimized link selection between nodes. Various performance matrices used for analysis are described below:

A. Throughput:

The amount of data transfer from source node to destination node in a specified amount of time i.e. average number of bits delivered per second (Kbps). Calculated as:
Throughput = (Packet Size / (stopTime - startTime))*(8/1000)

B. Packet Delivery Ratio:

It is the ratio of the amount of data packets delivered to the destination and total number of data packets sent by source. Calculated as:
PDR = (Received Packets / Packets Sent) * 100

C. End to End Delay:

The time interval between packet send by the source node and receiving by the destination node, which includes the processing time and queuing time. Calculated as:
EED = (Time packet received - Time packet sent) /
Total number of packets received

D. Routing Overhed:

Routing Overhead is the number of routing packets required for network communication. Calculated as:
Routing Overhead = Number of Control packets /
Number of message sent

The Table I shows the comparative performance analysis of Throughput, Table II shows the comparative performance analysis of End to End Delay, Table III shows the comparative performance analysis of Routing Overhead and Table IV shows the comparative performance analysis of Packet delivery ratio with respect to number of nodes for Dolphin Echolocation algorithm, Ant Colony Algorithm and Bee colony algorithm,

TABLE I. THROUGHPUT ANALYSIS

No. of Nodes	Algorithm Name	
	Dolphin Echolocation Algorithm	Bee Colony Algorithm
10	165.5477	1369.43
20	268.3466	1336.28
30	568.8674	1386.75
40	648.7864	1543.36
50	879.1574	1545.35
60	940.4568	1468.56
100	1574.7889	1288.21

TABLE II. END TO END DELAY ANALYSIS

No. of Nodes	Algorithm Name	
	Dolphin Echolocation Algorithm	Bee Colony Algorithm
10	19.6123	22.6385
20	20.5563	30.3721
30	20.9596	30.2013
40	21.8327	21.5249
50	22.1757	20.6958
60	22.9468	18.3072
100	24.9575	17.4244

TABLE III. ROUTING OVERHEAD ANALYSIS

No. of Nodes	Algorithm Name	
	Dolphin Echolocation Algorithm	Bee Colony Algorithm
10	19.1214	21.9523
20	20.9452	22.7463
30	22.9543	23.4543
40	23.3525	23.9094
50	15.6578	25.9085
60	17.9674	27.6927
100	22.0786	29.5241

TABLE IV. PACKET DELIVERY RATIO ANALYSIS

No. of Nodes	Algorithm Name	
	Dolphin Echolocation Algorithm	Bee Colony Algorithm
10	89.3453	96.2929
20	92.0435	95.7752
30	92.1635	94.6429
40	92.4435	93.9405
50	93.2742	92.7458
60	94.0235	89.2639
100	94.9934	81.8595

Following graphs in Figure 1, Figure 2 and Figure 3 shows the comparison of performance matrices with respect to the above algorithms.

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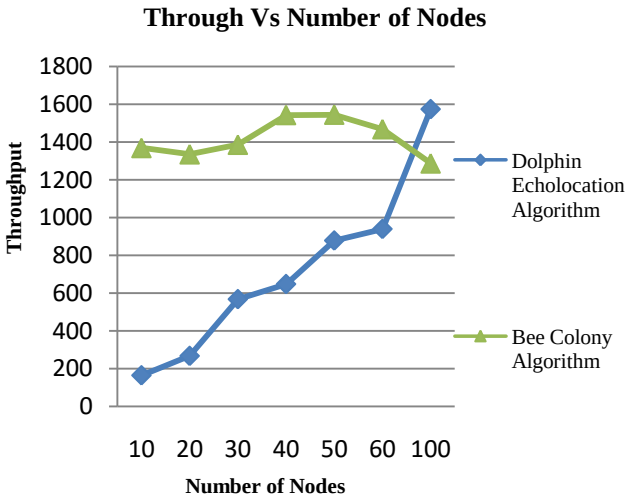

Figure 1. Throughput Vs Number of Nodes Analysis

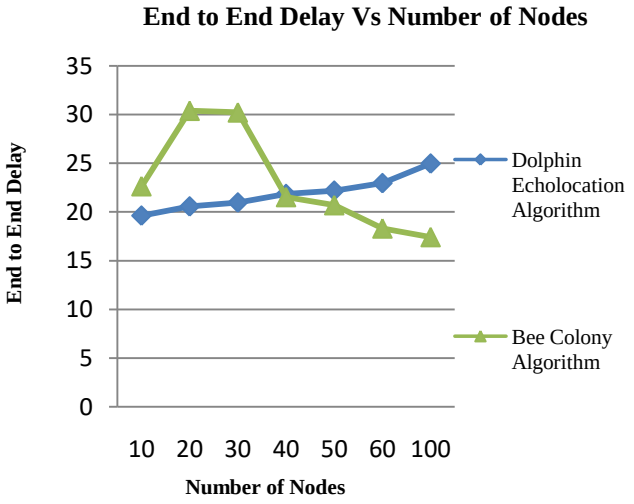

Figure 2. End to End Delay Vs Number of Nodes Analysis

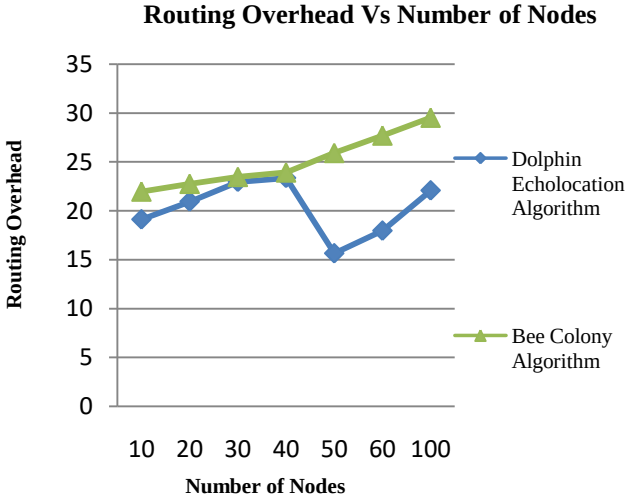

Figure 3. Routing Overhead Vs Number of Nodes Analysis

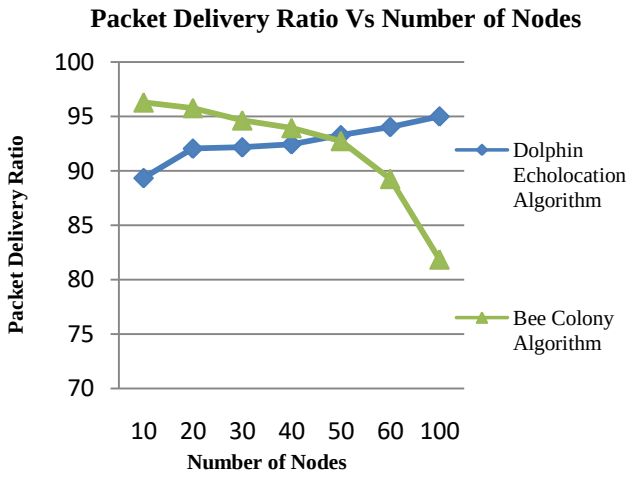

Figure 4. Packet Delivery Ratio Vs Number of Nodes Analysis

The Performance of DEA is analyzed by observing the graphs shown in figure 1 to Figure 4. The Throughput steadily increasing with respect to number of nodes as shown in Figure no. 1 while in other case it is decreasing or stable with respective of number of nodes. End to end delay is increasing as number of nodes increasing as shown in Figure no 2 while in other case it is decreasing or low. Routing overhead having variations but finally it come to at same level but in other case it rising and almost stable. Finally Packet delivery ration is almost stable for all algorithms but for DEA it is good.

V. CONCLUSION

This paper provides the comparative performance analysis of different nature inspired routing algorithms those are commonly utilized for efficient and optimized routing in Mobile Ad hoc network. The performance analysis of Dolphin Echolocation algorithm (DEA) and Bee colony algorithm (BCA) for routing in MANET has been done. For the performance analysis Quality of Service matrices such as Throughput, End to End Delay, Routing Overhead and Packet delivery ratio are considered. By analyzing the results it is observed that Dolphin Echolocation algorithm is efficient for routing. Hence the efficient and optimized routing in MANET can be achieved with the help of Dolphin Echolocation algorithm

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