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BEMRP: AN ADAPTIVE BIO INSPIRED ENERGY AWARE DYNAMIC MULTIPATH ROUTING PROTOCOL FOR MANET

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ABSTRACT

MANET (Mobile Ad-hoc Network) is an infrastructure less self configuring wireless ad-hoc network in which nodes act as routers themselves. Routing in MANET is an exigent problem which draws researcher's vision, due to huge mobility of nodes, dynamic topology and lack of central point like base station or servers. The traditional unipath routing protocols uses single route reply from the destination node along the first reverse path to establish a routing path. In high mobility, single pre-decided reverse path can be cut off and route reply message from destination to source may be lost. In this case, source node needs to reinitiate the route discovery procedure which leads to increase in communication delay, energy consumption as well as decrease in packet delivery ratio. The mobile nodes in the MANET are typically powered by limited energy reservoir. As each node in a MANET performs the routing function for establishing communication link, the death of even a few of the nodes due to energy exhaustion might affect the service in the entire network. The ABC (Artificial Bee Colony) algorithm is a new meta-heuristic population based optimization technique inspired by the intelligent foraging behaviour of honeybee swarms. In this paper a new adaptive Bio Inspired Energy Aware Dynamic Multipath routing protocol (BEMRP) has been proposed in which destination node sends multiple route replies and establishes multiple routes between source and destination nodes. The proposed protocol applies Artificial Bee Colony optimization Technique for effective route establishment process in MANET. Simulation results show that the proposed protocol achieves high reliability, better packet delivery ratio, stability, low latency and outperforms traditional routing protocols by reducing energy consumption, overhead and delay.

Key words - ABC (Artificial Bee Colony), Energy Aware, MANET, Multipath, Reverse Path,

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I INTRODUCTION

MANET (Mobile Ad-hoc Network) is a distinct kind of network which has minimum or nullified backbone infrastructure. Due to high mobility of nodes, the routing problem in ad hoc networks becomes thornier. Many routing protocols have been proposed for MANET. These routing protocols are classified as proactive routing protocols (table driven) and reactive routing protocols (on-demand).In proactive routing protocols the nodes have to exchange the routing information periodically and calculate the routes continuously between any nodes in the network, regardless of route requirements. This leads to the wastage of energy and bandwidth, which is not desirable in MANET where the resources are, constrained [1]-[5]. On the other hand, on-demand routing protocols don't exchange routing information periodically. Instead, the route discovery procedure is carried out only on demand of routes between nodes [1],[6]-[8]. Due to dynamic topology changes in ad hoc networks, links between nodes are not permanent. In occasions, a node cannot send packets to the intended next hop node and as a result packets may be lost. Loss of packets in a single path may affect on route performance in different ways . Among these packet losses, loss of route reply brings much more problems, because source node needs to re-initiate route discovery procedure. A drawback of existing on-demand routing protocols is that their main route discovery mechanisms are not well concerned about a route reply message loss. More specifically, most of today's on-demand routing is based on single route reply message. The lost of route reply message may cause a significant waste of performance.

Prior performance studies [2],[7] have shown that on-demand protocols have better overhead savings in comparison with their proactive counterparts. However, on-demand approach is not without problems. Since routes are computed only on-demand, route discovery latency can add to the end-to-end delay, unless a previously computed "cached" route is available.

Most of the on-demand routing protocols of MANET uses the shortest path method for data transmission. The continuous usage of a single path will drain the battery power. The power failure of a mobile node not only affects the node itself but also the overall network lifetime.The mobile nodes in the MANET are typically powered by limited energy reservoir.

Buffering of data packets during the route discovery process can also contribute to packet losses due to buffer overflow. With single path routing, this problem becomes severe as the network becomes more dynamic. Frequency of route discoveries increases with increase in the rate of link failures. Also, since each route discovery incurs substantial packet overhead, its frequency impacts performance. The frequency can be controlled by computing multiple paths with a single route discovery. This will improve the overall performance.

Multiple paths can be useful in improving the effective bandwidth of communication pairs, responding to congestion and bursty traffic, and increasing delivery reliability. In QoS routing in wired networks, multipath routing has been widely developed[5]. These protocols use table-driven algorithms (link state or distance vector) to compute multiple routes. Studies show however, that proactive protocols perform poorly in mobile networks because of excessive routing overhead [2],[5],[7],[13],[14]. Most of the Multipath routing in ad hoc networks protocols build multiple

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routes on demand, but the traffic is not distributed into multipaths; only one route is primarily used and alternate paths are utilized only when the primary route is broken.

In addition, metaheuristic algorithms start to emerge as a major player for multiobjective global optimization, they often mimic the successful characteristics in nature, especially biological systems. The ABC (Artificial Bee Colony) algorithm is a new meta-heuristic population based optimization technique inspired by the intelligent foraging behaviour of honeybee swarms [9]-[12].

In this paper, a new adaptive Bio Inspired Energy Aware Dynamic Multipath routing protocol (BEMRP) has been proposed in which destination node sends multiple route replies and establishes multiple routes between source and destination nodes. The proposed protocol applies Artificial Bee Colony optimization Technique for effective route establishment process in MANET. It works on the principle of collective intelligence and emergence of artificial honey bees. It's application in ad-hoc networks involves swarming agents (honey bees) hopping node to node, analyzing the residual energy of that nodes and provide the optimal path and minimize the routing overhead and also provides QoS guarantees with an ability for enhanced scalability.

II ARTIFICIAL BEE COLONY ALGORITHM

Artificial Bee Colony (ABC) algorithm, proposed by Karaboga in 2005 for real parameter optimization, is a recently introduced optimization algorithm and simulates the foraging behavior of bee colony [9]-[12].The minimal model of swarm-intelligent forage selection in a honey bee colony that ABC algorithm adopts, consists of three kinds of bees: employed bees, onlooker bees, and scout bees. Half of the colony comprises employed bees and the other half includes the onlooker bees. Employed bees are responsible from exploiting the nectar sources explored before and giving information to the other waiting bees (onlooker bees) in the hive about the quality of the food source site which they are exploiting. Onlooker bees wait in the hive and decide a food source to exploit depending on the information shared by the employed bees. Scouts randomly search the environment in order to find a new food source depending on an internal motivation or possible external clues or randomly.

Main steps of the ABC algorithm:

(1) **cycle** = 1

(2) Initialize the food source positions $\mathbf{x_i}$, $\mathbf{i = 1, \ldots SN}$

(3) Evaluate the nectar amount (fitness function $\mathbf{fit_i}$) of food sources

(4) Repeat

(5) Employed Bees' Phase

For each employed bee

Produce new food source positions $\mathbf{V_i}$

Calculate the value $\mathbf{fit_i}$

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Apply greedy selection mechanism

End For.

(6) Calculate the probability values $\mathbf{p_i}$ for the solution.

(7) Onlooker Bees' Phase

For each onlooker bee

Chooses a food source depending on $\mathbf{p_i}$

Produce new food source positions $\mathbf{V_i}$

Calculate the value $\mathbf{fit_i}$

Apply greedy selection mechanism

End For

(8) Scout Bee Phase

If there is an employed bee becomes scout

Then replace it with a new random source positions

(9) Memorize the best solution achieved so far

(10) cycle = cycle +1.

(11) Until cycle = Maximum Cycle Number

III BEMRP : PROPOSED ROUTING PROTOCOL

The proposed protocol (BEMRP) discovers multiple routes on-demand using a reverse route discovery procedure by applying ABC optimization technique.

The phases of the proposed routing protocol are

- Route Discovery
- Route Updation
- Route Maintenance

3.1 Route Discovery Phase

- The source node first floods the route request (RREQ bees to all of the neighbouring nodes towards the destination node. This process is repeated by all the neighbouring nodes. Duplicate copies of the path request may reach the intermediate nodes. In this case, the nodes checks for redundancy and drops the redundant packets ,if any. This method is followed for the reverse path request processing also.
- Upon the receipt of first route request message, the destination node first appends the RREQ packet information to its own routing table and after that the reverse route request bees are inturn rebroadcasted to all of its neighbours as done previously by the source node.

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- When broadcasted Reverse-RREQ message arrives to intermediate node, it will check for redundancy. If it already received the same message, the message is dropped, otherwise forwards to next nodes.
- At each intermediate node, the residual energy of that node is attached to the Reverse RREQ bees.
- Upon receiving the multiple route replies from the destination, the source node selects two paths with higher cumulative node residual energy and distribute the data transmission in them.
- After the link establishment, the source node will issue command to put the neighbouring nodes in sleep state;hence the node remaining energy will expand for long period.

3.2 Route Updation Phase

As the energy level of nodes in MANET usually decreases once if they are involved in data transmission, it has to be updated as the data transmission proceeds. In order to maintain an updated path list, the source node floods R-Req-Bees at regular intervals through the selected paths (N) to collect the current Energy level of nodes in each path. Then the paths are again ranked with the new collected values and the first best two paths with higher cumulative energy value are selected for data transmission.

3.3 Route Maintenance Phase

A node generates or forwards a RERR for a destination when the *last* path to the destination breaks. Then BEMRP removes the busted route from the list and redirect the data packets in the backup path. Avoidance of re-route discovery contributes to reduction in overhead.

IV EXPERIMENT RESULTS

The proposed routing protocol BEMRP is simulated using NS2. The simulation parameters of BEMRP are given in table 1.

Table1. BEMRP Simulation Parameters

Parameter	Value
Simulation Terrain Dimension	1500 X 1500 meters
Transmission Range	200 m
Mobility model	Random way point
Node Speed	0-30 m/s
Routing protocols	AODV, BEMRP
MAC	IEEE 802.11 DCF
Simulation Time	300 Sec

Traffic Source Model	Constant Bit Rate
Channel Data Rate	2 Mbps
Initial energy	20 Joules

4.1 Performance Analysis

4.1.1 Performance Metrics

The proposed routing protocol BEMRP is compared with AODV protocol.

The following key performance metrics are considered for the evaluation of the proposed protocol:

- ***Packet Delivery Ratio*** — Ratio of the data packets delivered to the destination to those generated by the source; or a related metric received throughput in kb/sec received at the destination.
- ***Average end-to-end delay*** of data packets —this includes all possible delays caused by buffering during route discovery, queuing delay at the interface, retransmission delays at the MAC, propagation and transfer times;
- ***Mobility Speed*** — the varying speed of the mobile nodes
- ***Remaining Energy:*** It is measured as the total amount (in Joules) of remaining battery energy at the end of the simulation period.

(A) Packet Delivery Ratio

Figure 1 expounds that the new proposed protocol's packet delivery ratio regarding the mobility speed is high when compared to the existing protocol AODV.

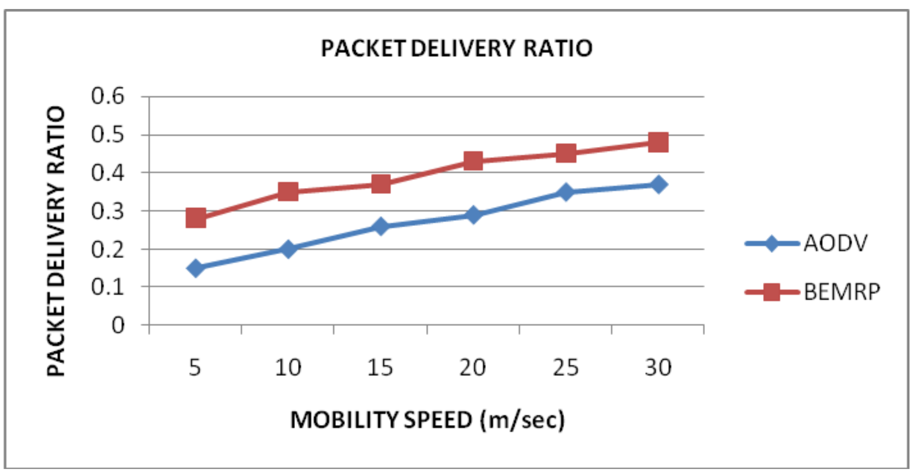

Fig 1. Packet Delivery Ratio Vs Mobility Speed

(B) Average end-to-end delay

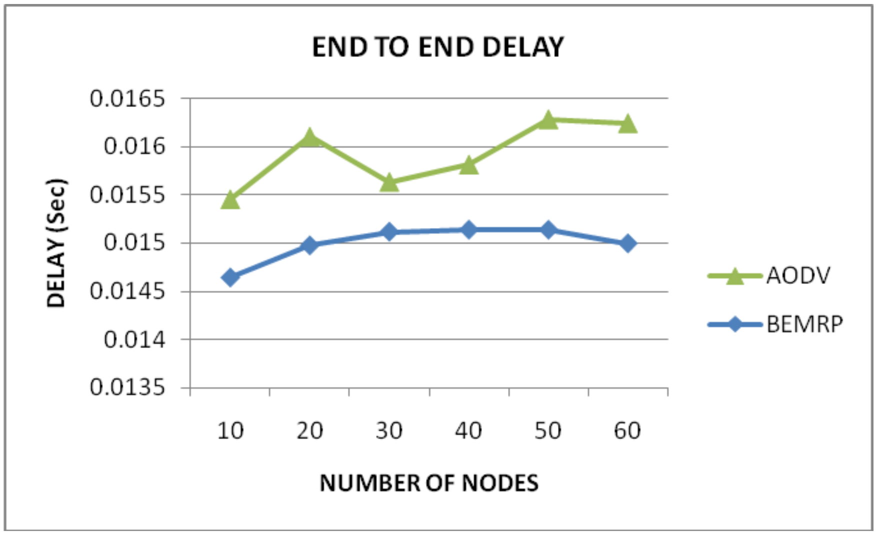

Fig 2. Delay Vs .Number of Nodes

From Figure 2 , it is evident that the End-to-End Delay of the new proposed protocol is less when compared to the existing AODV protocol.

(C) Total Energy Consumption

Figure 3 portrays the effect of total number of nodes against the total energy consumption for the two protocols. From the figure it is evident that nodes in AODV consumed more energy than the proposed protocol BEMRP. In BEMRP, the inactive nodes at each state are kept in power saver mode which leads to the energy preservation. BEMRP increases the network lifetime significantly.

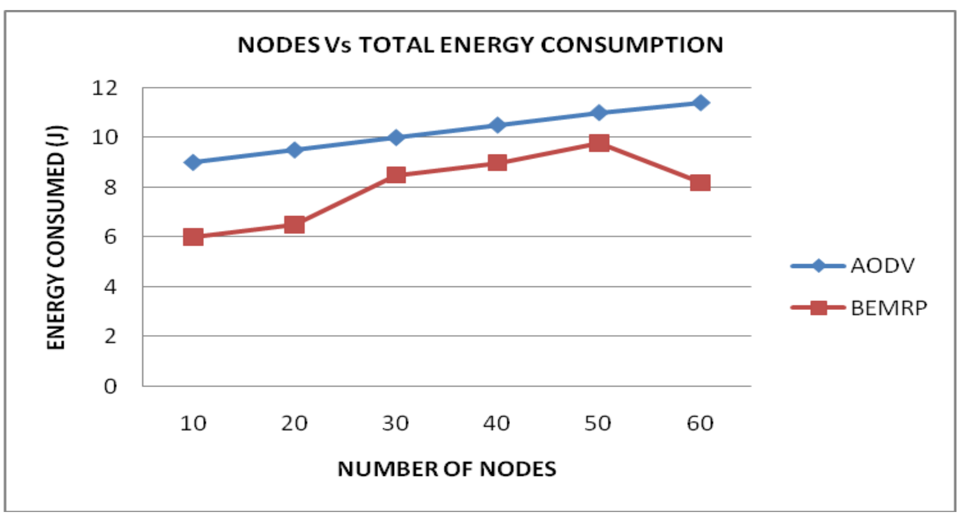

Fig 3. Total energy consumption Vs. No. of Nodes

V CONCLUSION

In this paper a new adaptive Bio Inspired Energy Aware Dynamic Multipath routing protocol (BEMRP) has been proposed in which destination node sends multiple route replies and establishes multiple routes between source and destination nodes. The proposed protocol applies Artificial Bee Colony optimization Technique for effective route establishment process in MANET. In order to select best reliable routes, proposed protocol considers Total Available Energy of all the nodes in that path. It also provides high energy efficiency and load balancing thus prolongs the network life time and makes up high reliability communications. The simulation results show that the proposed protocol is better than AODV in discovering and maintaining routes and outperforms AODV.

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