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Shortest Path Routing in Mobile Ad-Hoc Networks Using Enhanced Artificial Bee Colony with Immigrants

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Abstract: Mobile Ad-hoc Networks (MANETs) are predominantly useful for serious circumstances, including military, law enforcement, emergency rescue and disaster recovery. MANET is a collection of autonomous self-organized nodes. They use wireless medium for communication. About 2 nodes can communicate directly or within each other transmission radius in a multi-hop fashion. Many conventional routing algorithms have been proposed for MANETs in early years. And also many meta heuristic optimization techniques like swarm intelligence algorithms are addressing the static shortest path in the realm of wireless network routing. The motion of MANET is dynamic and hence, the shortest path routing problem in MANET manifests into a dynamic optimization problem. The nodes are instilled with an awareness of the environmental conditions by making them operational through intelligence routing becomes a key concern, as it has a significant impact towards network performance. The study proposed to solve shortest path problem in MANETs using enhanced artificial bee colony optimization algorithm. MANETs are kept and considered target systems because they do represent the next generation wireless network. The results of experiment explicate that enhanced artificial bee colony is steadfast to adapt to the gradations in the environment.

Key words: Artificial bee colony, mobile ad-hoc network, shortest path routing, genetic algorithm, stead fast

INTRODUCTION

MANETs consist of a collection of wireless hosts spread across a geographical area, connected to each other via wireless links in the absence of any sort of infrastructure. They are self-organizing, self-configuring and self-healing wireless networks. Disaster recovery, conference and battle-field are some of the environments where MANETs can be applied that require a rapid deployment. Each wireless host can directly communicate with all the hosts located within its transmission range. When the destination is beyond the source node coverage, multi-hop communication is applied to successfully relay the data traffic to the destination through the intermediate hosts. The main challenge that routing algorithms have to face in ad-hoc networks is the frequent topology changes that occur due to mobility. Therefore, any routing scheme has to be robust to changes in topology and also needs to consider the power constraint that MANET nodes entail.

About 2 routing categories in wireless ad-hoc network can be distinguished: Topology-based and position-based or geographical routing. Topology-based routing protocols use the wireless links information to achieve data routing whereas position-based approaches, mainly, focus on the nodes location information in order to route the data traffic. Specifically, topology-based routing is discerned into reactive, proactive and hybrid protocols. The difference among these resides in the way the route from source to destination is determined. Reactive protocols discover the route to the destination when needed while proactive protocols determine routes in advance and maintain information about all the possible paths in the network. From the network's performance perspective, the impact of such difference can be observed, mainly in terms of delay and routing overhead. While reactive scheme require the path to be discovered before data packets can be exchanged between the communication's peers, a time delay introduced before the first packet to be transmitted. On the other side, proactive scheme generates high routing overhead by maintaining routing information of unused paths. Finally, hybrid protocols combines both schemes to achieve higher level of routing efficiency and network scalability by adopting proactive routing in local communication (intra-zone) and reactive routing in global communication (inter-zone).

The study explores shortest path routing problem on the dimension of topological routing. The shortest path routing probability endeavors to find shortest path in a specific source pertaining to a certain destination thereby

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minimizing the lost associated with the path. The determinants of search Dijkstra's algorithm, the breadth-first search algorithm, the Bellman-Ford algorithm and prove effective only in fixed infrastructure wired or wireless network and do showcase high computational complexities in real time communications in even changing network topologies (Ahn *et al*., 2001; Ahn and Ramakrishna, 2002; Ali and Kamoun, 1993; Branke, 1999, 2002).

The study emphasizes the implementation and application of ABC for the resolution of dynamic shortest path problem. To begin with an algorithm is designed specifically for dynamic shortest path problem. To maintain diversity a certain amount of population is generated with the gradation in topology, the novel design can help guides the search of solutions in the new ambiance. The routing path is mandatory to satisfy delay constrain, so Quality-of-Service (QoS) metric is needed as a guarantee to real-data delivery.

Related works: Many search algorithms were formulated for solving shortest path routing problem but artificial bee is extensively presented for solving the shortest path routing problem studies on simulation reflect that an algorithm is imperative in respect of optimality and convergence and the quality of solution has been found to be feasible than other deterministic algorithms.

It is proposed to employ a Modified Hopfield Neural Network (MHNN) for study. Information is used bit by bit at peripheral neurons coupled with highly correlated information at local neurons, thereby helping it attain faster convergence and better rout optimality than Hopfield Neural Network (HNN) based algorithms. When a genetic algorithm approach was presented to shortest path routing problem, computer simulations inferred that ABC based algorithms did exhibit a higher rate of convergence than other algorithms (Branke *et al*., 2000; Cheng *et al*., 2009; Cobb and Grefenstette, 1993; Dasgupta and McGregor, 1992; Das and Martel, 2009; Din, 2005; Grefenstette, 1992; Lee *et al*., 2008; Lewis and Ritchie, 1998).

MATERIALS AND METHODS

Models for shortest path routing: In this study, a network model is presented and the formulation of the shortest path model takes into place. MANET operation is considered into a fixed geographical region. It is modeled on cundirected and connected topology graph where G_0 (V_0, E_0) where, V_0 represents the set of wireless nodes (i.e., routers) and E_0 represents the set of communication links connecting 2 neighboring routers falling into the radio transmission range. A communication link (i, j) cannot be used for packet transmission until both node i and j have a radio interface each with a common channel. The communication link cannot be used for the purpose of packet transmission unit node and interface in a common channel. The channel assignment does not fall under the scope of the study and the transmission of message on wireless communication link would lead to remarkable delay and cost. Here, researchers review some notations that researchers use throughout this study:

G_0 (V_0, E_0)	=	The initial MANET topology graph
G_i (V_i, E_i)	=	The MANET topology graph after the ith change
s	=	The source node
r	=	The destination node
P_i (s, r)	=	A path from s to r on the graph G_i
d_l	=	The communication link (l) transmission delay
c_l	=	The communication link (l) cost
$\triangle$ (P_i)	=	The total transmission delay on the path P_i
C (P_i)	=	The total cost of the path P_i

The shortest path routing problem is summarized, as in a network of wireless routers delay upper node, source node it is endeavored to find delay bound least path on the graph of topology. Some nodes are either hibernated or activated depending on the conservation of energy. This results in the change of network topology gradation. The objective is to find optimal delay constrain past topological changes.

Bio inspired optimization algorithms: Optimization is an art of selecting the best alternative among a given set of options or it can be viewed, as one of the major quantitative tools in network of decision making in which decisions have to be taken to optimize 1 or more objectives in some prescribed set of circumstances. Optimization is a regularly used in mathematical problem for all engineering applications. It means discover the best possible solution. Optimization algorithms are a deterministic or stochastic in nature. Former methods to solve optimization problems require enormous computational time and program length.

This is the motivation for employing bio inspired stochastic optimization algorithms as computationally efficient alternatives to deterministic approach. Meta-heuristics are based on the iterative improvement of either a population of solutions (as in evolutionary algorithms, swarm based algorithms) or a single solution (e.g., tabu search) and mostly employ randomization and local search to solve a given optimization problem.

The real beauty of nature inspired algorithms lies in the fact that it receives its sole inspiration from nature. They have the ability to describe and resolve complex relationships from intrinsically very simple initial conditions and rules with little or no knowledge of the search space. Nature is the perfect example for optimization. It is closely examined each and every features or phenomenon in nature it always finds the optimal strategy. It is still addressing complex interaction among organisms ranging from microorganism to fully fledged human beings. It is balancing the ecosystem. It is maintaining diversity, adaptation, physical phenomenon. Even though, the strategy behind the solution is simple the results are amazing.

Artificial bee colony optimization: Based on the behavior of the bees in nature, various swarm intelligence algorithms are available. These algorithms are classified into two; foraging and mating behavior. Artificial bee colony is a predominant algorithm simulating the intelligent foraging behavior of a honeybee swarm, proposed by Karaboga and Basturk. In ABC algorithm, the colony of artificial bees contains 3 groups of bees: employed bees, onlookers and scouts (Karaboga and Basturk, 2008; Karaboga, 2005).

A bee waiting on the dance area for making a decision to choose a food source is called on looker and one going to the food source visited by it before is named employed bee. The other kind of bee is scout bee that carries out random search for discovering new sources. The position of a food source represents a possible solution to the optimization problem and the nectar amount of a food source corresponds to the quality (fitness) of the associated solution. A swarm of virtual bees is generated and started to move randomly in 2-dimensional search space. Bees interact when they find some target nectar value.

Enhanced Artificial Bee Colony Optimization (EABCO) Algorithm for Shortest Path Routing Problem (SPRP): The following steps are repeated until a termination criterion is met:

- Calculate the nectar amounts by sending the employed bees on to the food sources
- After sharing the information from employed bees select the food sources by the onlookers and determine the nectar amount of food sources
- Determine the scout bees and send them to find out new food sources

Pseudo code for EABCO algorithm:

- Initialize population with random solutions
- Repeat
- Place the bees on their food sources
- Place the bees on their food sources depending on their nectar amount
- Send the scouts to the search area for discovering new food source
- Memorize the best food source found so far
- Until requirement are met

EABCO with immigrants: In stationary environments, convergence at a correct pace is absolutely what researchers have a tendency to expect for EABCOs to find the optimum solutions for several optimization issues. However for Dynamic Optimization Problems (DOPs), convergence some times becomes an enormous downside for EABCOs, as a result of ever-changing environments sometimesneed ABC on keep a definite population diversity level to take care of their ability. To deal with this downside, the random immigrants approach may be a quite natural and straight forward method (Mohemmed *et al*., 2008; Mori and Nishikawa, 1997; Morrison, 2004). It had been planned by grefenstette with the inspiration from the flux of immigrants that wander in and out of a population between 2 generations in nature. It maintains the variety level of the population through commutation some people of this population with random people known as random immigrants, each generation. On that people within the population ought toget replaced, sometimes there are 2 strategies: Commutation random people or the worst ones (Morrison and De Jong, 2000), so as to avoid that random immigrants disrupt the continued search progress an excessive amount of particularly through out the amount once the setting does not amendment, the quantitative relation of the quantity of random immigrants to the population size is sometimes set to alittleprice, e.g., 0.2. Supported the on top of thought, AN immigrants approach known as elitism-based immigrants is planned for ABCs to deal with DOPs.

However in a very slowly dynamic atmosphere, the introduced random immigrants could divert the looking out force of the basic principle throughout every atmosphere before a modification happens and thus could degrade the performance. On the opposite hand, if the atmosphere solely changes slightly in terms of severity of changes, random immigrants might not have any actual impact even once a modification happens, as a result of people within the previous atmosphere should be quite slot in the new atmosphere. Supported the on top of thought, associate immigrants approach, referred to as elitism-based immigrants is planned for ABCs to handle DOPs (Oh *et al*., 2006; Oppacher and Wineberg, 1999; Parrott and Xiaodong, 2006; Parsa *et al*., 1998; Perkins, 2001).

Incorporating immigrants schemes to enhanced artifical bee colony algorithms: The application of immigrant's schemes has been found efficient for ABCs for DOPs. The principle is to introduce new individuals into the current population by replacing a percentage of individuals in the population. The percentage should be relatively small because a high percentage may lead the algorithm into a too high level of diversity. High diversity does not continually mean sensible good performance on DOPs, as a result of it should lead the algorithmic program into organization. In this study, researchers apply immigrant's schemes into the ABC algorithm to maintain a certain level of diversity in the population and enhance its dynamic performance. However, researchers use a memory where the onlooker bees of the current iteration replace the unhealthier bacteria of the old iteration. Moreover, a percentage of immigrants replace the least onlooker (worst) of the current population. The advantages of using a memory are closely related to the survival of bees in a dynamic environment where no onlooker can survive in >1 iteration. This way, there is no need to develop any repair algorithm (apart from the best fitness values of the previous iteration for the elitism-based immigrant scheme) because the changes do not affect the bees stored. Furthermore, there is one main concern that involves immigrants schemes, i.e., way to generate immigrants.

Random immigrants genetic algorithm: The Random Immigrants Genetic Algorithm (RIGA) algorithm uses an immigrant's scheme where bees are generated by reproduction. It evolves a population of candidate solutions through selection and variation. New populations are generated by first probabilistically selecting relatively fitter individuals from the current population and then performing crossover and mutation on them to create new off-springs. This process continues until some stop condition becomes true, e.g., the maximum allowable number of generations tmax is reached. Usually with the iteration of the Genetic Algorithm (GA), individuals in the population will eventually converge to optimum solutions in stationary environments due to the pressure of selection. Every iteration these immigrants also replace the worst fitness in the memory as in RIGA. This immigrants scheme transfers knowledge from old environments and thus, may be beneficial when changes are small to medium. Furthermore, it may be suitable in slowly changing environments, since it needs sufficient time to locate a good optimum which can be useful to the new environment since the global optimum may be similar.

Random immigrants EABCO: The Random Immigrants EABCO (RIABCO) algorithm uses an immigrant's scheme where fitness values are generated randomly in onlooker and replaces the worst fitness values from onlooker of the current population stored in the memory. It is understood that the continuous modification of such algorithms is smart only if environmental changes of a problem are small to medium. This is as end effect of particular proven fact that the previous environment has lot of possibility to be similar with the new one. After a change occurs, transferring information from the old environment may provide a good solution efficiently. Considering this argument, RIEABCO may be suitable when changes are not slight, since it provides diversity without considering any knowledge from the old environment. Moreover, it may be suitable in fast changing environments where information from the past may not be useful, since the algorithm does not have adequate time to converge onto a high-quality solution in order to gain knowledge.

RESULTS AND DISCUSSION

In this first scenario, mobile ad-hoc network consisting of 150 nodes placed randomly using uniform distribution in an area of 1000×1000 m^2 is considered for simulation study. The nodes in the network have the transmission range of 60-70 m and a channel capacity of minimum 750 Kbps to maximum 2 Mbps. The mobility model Random Way Point (RWP) in this each node is randomly placed in the simulated area and remains stationary for a specified pause time. It then randomly chooses a destination and moves there at velocity chosen uniformly between a minimum velocity and maximum velocity. Each node independently repeats this movement pattern through the simulation.

First, consider that the population size as 20 and maximum number of generations as 10. The immigrant algorithm for EABCO converges when the maximum numbers of generations is reached. It is observed that the comparisons of RIGA and RIEABCO schemes, RIEABCO had the best fitness value as compared to the RIGA schemes. This fitness value of the chromosome showed the best optimal path selection to route the packets.

Table 1 shows the comparison of RIGA and RIEABCO, depending upon the values of average fitness of given generation of chromosomes.

Table 1: Comparison of RIGA and RIEABCO

No. of generations	RIGA	RIEABCO
1	0.329	0.446
2	0.403	0.495
3	0.537	0.624
4	0.649	0.682
5	0.755	0.795
6	0.841	0.935
7	0.912	0.965
8	0.931	0.968
9	0.951	0.987
10	0.963	0.998

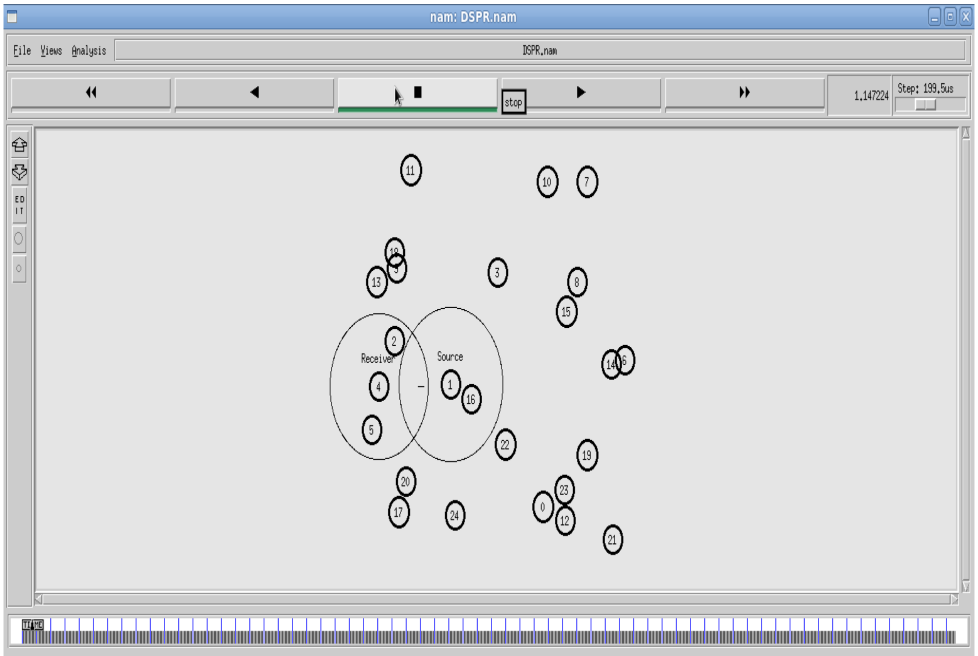

Fig. 1: Initial network topology

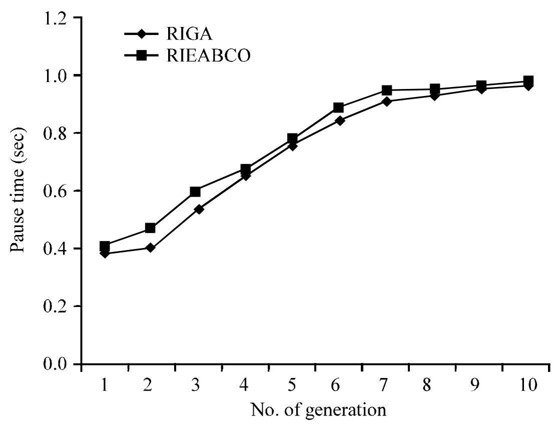

Fig. 2: Comparison result of quality of solution for RIGA and RIEABCO

The experimental setup defined from 0-50 sec and varies the pause time as the independent variable. The scout bee rate at each node was set to 48 Kbps. NS2 simulator is considered to implement the proposed routing protocol. Figure 1 shows the initial network topology created using RWP model.

Figure 2 shows the comparison result of the quality of solution for RIGA and RIEABCO scheme without knowledge base approach and with knowledge base approach, respectively.

The RIGA and RIEABCO converge when the maximum numbers of generations is reached. It is observed that RIEABCO schemes had the best fitness value as compared to the RIGA schemes. This fitness value of the chromosome showed the best optimal path selection to route the packets. Figure 2 shows the comparison result of the quality of solution for RIGA and RIEABCO schemes with knowledge base approach, respectively.

CONCLUSION

This study investigates the application of ABCs for solving the SPRP in MANETs. A SPRP Model is built up in this study. A specialized EABCO is designed for the SP problem in MANETs. Several parameters that have been developed and compared for ABCs for general DOPs are adapted and integrated into the EABCO to solve the SPRP in MANETs. The immigrant's schemes show their power in acyclic dynamic environments and the memory related schemes beat other schemes in cyclic dynamic environments. Then, extensive simulation experiments are conducted based on a large-scale MANET constructed in this study to evaluate various aspects of EABCO variants for the DSPRP.

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