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Artificial Bee Colony Algorithm with Watchdog Mechanism for secure Data Transferring in Wireless Networks

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ABSTRACT

In a dynamic network, routing is a very challenging because of the topology of the network is not fixed. This paper involves Artificial Bee Colony (ABC) Algorithm for finding shortest path in a dynamic mesh networks. The ABC optimization algorithm is a population-based search algorithm which applies the concept of social interaction to problem solving. The ABC algorithm is inspired by the collective behavior of bees to find better food sources around the hive and this biological phenomenon when applied to the process of path planning problems, it is found to be an excelling in solution quality as well as in computation time. The effectiveness of the paths has been evaluated with the parameters such as tour length, bee travel time by using Artificial Bee Colony (ABC) Algorithm. After finding the path, Watchdog mechanism is used to transfer the message with more securely in the network. Thus the pursued approach gives the best result for finding the shortest path in a shortest time for moving towards the goal in more effective way with high security.

Keywords

Routing, Path planning, Shortest path, Artificial Bee Colony (ABC) Algorithm, Watchdog Mechanism.

1. INTRODUCTION

In wireless mesh network, routing is a major problem because of the dynamic nature of the nodes in the network. Thus finding the shortest path and sending the data with more optimal one in a wireless mesh network is difficult. There are many routing algorithms and approaches that are used to find the shortest path but, the path that are given by those algorithms and approaches may not be optimal and more feasible.

Many approaches had certain limitations such as inefficiency in solving larger scale combinational and/or highly nonlinear problems and their inflexibility to adapt the solution algorithm to a given problem. Thus a given problem is modeled in such a way that a classical algorithm has to make several assumptions which might not be easy to validate in many situations. So that the interest of the scientific community switched to the intelligent techniques such as Genetic Algorithms, Swarm Intelligence approaches. Many of the researches are inspired by the nature to develop new algorithmic models to solve different problems especially in the field of optimization.

A branch of nature inspired algorithm which are known as Swarm Intelligence are focused on insect behavior so as to develop some meta-heuristic which can imitate the way insects used to solve their problems. Bonabeau has defined swarm intelligence as any attempt to design algorithms or to the distributed problem solving devices which is inspired by the collective behavior of social insect colonies and other animal societies. Swarm Intelligence consists of many algorithms such as Ant Colony Optimization, Particle Swarm Optimization, Wasp Nets and Fish Schools.

2. RELATED WORK

C.W. Alm and R.S.Ramakrishna have proposed an approach using a genetic algorithm to the shortest path routing problem. This GA based shortest path algorithm exhibits a much better quality of solution (i.e., the route optimality) and a much higher rate of convergence than other algorithms. A population-sizing equation that facilitates a solution with the desired quality was also developed.

A.W. Mohemmed et al. have proposed a PSO-based search algorithm for a priority-based indirect path-encoding scheme is used to widen the scope of the search space and a heuristic operator is used to reduce the probability of invalid loop creations during the path construction procedure. It was claimed that the PSO-base shortest path algorithm is superior to those using GAs. However, all these algorithms address only the static shortest path problem. When the node mobility occurs, the network topology changes, they will consider it as a new network and restart the algorithms over the new topology.

S. Aravindh et al. have proposed a hybrid of Ant colony optimization algorithm and Genetic algorithm for routing in packet switched data networks. An Ant algorithm is found to reduce the size of routing table where else the Genetic algorithm cannot use the global information of the network. Hence, the combination of ACO and GA algorithms, which makes the packets to explore the wireless mesh network independently and helps in finding path between pair of nodes effectively. These algorithms create initial population, forwards current node, access fitness and generate the new population using the genetic operators and update routing table.

3. ARTIFICIAL BEE COLONY ALGORITHM

Artificial bee colony (ABC) algorithm is an optimization algorithm based on the intelligent behavior of honey bee foraging. This is a population based optimization technique which was first introduced by Dervis Karabonga in 2005, and is based on inspecting the behaviors of real bees on finding nectar amounts and sharing the information of food sources to the other bees in the hive. These specialized bees try to maximize the nectar amount stored in the hive by performing efficient division of labor and self-organization.

The honey bees from the colonies that extended over a very long distance, in order to exploit the food sources in a multiple directions. The nectar sources with large amount of nectar that can be extracted with minimum difficulty are visited by more number of the bees while the nectar sources with less amount of nectar are discarded. The foraging begins by the scout bees which are sent to collect nectar. The search starts randomly by the scout bees from one source to another. When the scout bees reach the hive, they deposit the amount collected and goes to the dance floor to perform waggle dance. This type of dance is the sole medium of communicating the information about the most promising nectar source to all other bees in the hive. This mysterious dance contains three pieces of information about the source: direction in which it is found, distance from the hive and the quality of nectar. When the food source exists at a distance less than 50 meters, then the scout bees perform round dance. On the other hand, if the food source exists at a distance greater than 50 meters, then the bees perform waggle dance.

After watching the waggle dance, unemployed bees (onlooker bees) follow the scout bee to promising nectar source to collect nectar. This waggle dance process helps all the bees to collect nectar in efficient and faster way. The quality of food source is continuously monitored by the bees so as to propagate this information in the next waggle dance. The three agents in Artificial Bee Colony are:

- The Employed Bee
- The Onlooker Bee
- The Scout Bee

The employed bees are associated with the specific food sources, the onlooker bees watching the dance of employed bees within the hive to choose a food source, and the scout bees searching for food sources randomly. The onlooker bees and the scout bees are the unemployed bees. Initially, the scout bees will discover the positions of all food sources, thereafter, the job of the employed bee starts. Artificial employed bees would probabilistically obtain some modifications on the position in its memory to target a new food source and find the nectar amount or the fitness value of the new source. Later, the onlooker bee evaluates the information taken from all artificial employed bees and then chooses a final food sources with the highest probability related to its nectar number. If the fitness value of the new one is higher than the previous one, then the bee forgets the old one and memorizes the new position. This is called as greedy selection process. Then the employed bee whose food source has been exhausted becomes a scout bee to search for the further food sources once again.

In ABC, the solutions represent the food sources and the nectar quantity of the food sources corresponds to the fitness of the associated problem. The number of employed and onlooker bees is same, and this number is equal to the number of food sources. Employed bees whose solutions cannot be improved through a predetermined the number of trials that was specified by the user of the ABC algorithm and called "limit", become scouts and their solutions are abandoned.

In this algorithm, the employed bee produces a modification in the position (i.e. solution) in its memory and checks the nectar amount (fitness value) of that source (solution). The employed bee then evaluates this nectar information (fitness value) and then chooses the food source with the probability related to its fitness value.

$$\text{Fitness (F)} = \frac{dis_{max} - dis_i}{\sum_{j=1}^{j=m+1} dis_{max} - dis_j} \quad \text{i=1....m+1}$$

dis_i — Length of i^{th} path

dis_{m+1} — Length of initial path

dis_{max} — Maximum length of all m+1 path

Movement of the Onlookers: Probability of selecting the sources,

$$P_i = \frac{F(\theta_i)}{\sum_{k=1}^{s} F(\theta_k)} \qquad (1)$$

P_i : Probability of selecting the i^{th} employed bee.

S : No. of employed bees

θ_i : Position of the i^{th} employed bee.

F(θ_i) : The fitness value

Calculation of new position:

$$x_{ij}(t+1) = \theta_{ij}(t) + \emptyset(\theta_{ij}(t) - \theta_{kj}(t) \quad (2)$$

x_i : Position of the onlooker bee

t : Iteration number

θ_k : Randomly chosen employed bee

j : Dimension of the solution

$\emptyset(\blacksquare)$: Series of random variables in the range[1,1]

Movement of Scout bees:

$$\theta_{ij} = \theta_{j\,min} + rand\,(\theta_{j\,max} - \theta_{j\,min}) \quad (3)$$

r : random number and rand ϵ[0,1]

4. METHODOLOGY

The general method of the ABC algorithm is as follows:

Bee Initialization Phase

Set the Loop

Employed Bee Phase

Onlooker Bee Phase

Scout Bee Phase

Memorize the best solution found

Until the loop is terminated

The pseudo-code for the Artificial Bee Colony algorithm is

1: Load training samples

2: Generate the initial population

3: Evaluate the fitness value

4: set cycle to 1

5: repeat

6: FOR each employed bee {

Produce new solution

Calculate the fitness value

Apply greedy selection process}

7: Calculate the probability values

8: FOR each onlooker bee {

Select a solution depending on the probability values

Produce new solution

Calculate the fitness value

Apply greedy selection process}

9: If there is an abandoned solution for the scout bee

Then replace it with a new solution which is randomly produced by (step 7)

10: Memorize the optimal solution

11: cycle=cycle+1

12: Until cycle=MCN

The essential control parameters in the Artificial Bee Colony Algorithm are the number of food sources which is equal to the number of employed/ onlooker bees (Colony Size), the working to onlooker bee rate, the value of the limit (L) and the number of cycles or the number of iterations (MCN) that are required to terminate the program.

The implementation of Artificial Bee Colony algorithm for solving shortest path problem is explained with the help of flow-char shown in fig.1. The control parameters are set in the initialization phase such as colony size, iteration number (bee travel time), the working to onlooker bee rate. By computing the probabilities, the bees will work and draw the next node to obtain the path and memorize the best solution found so far using greedy selection process.

Finally the bees become scout bees and the number of working bees is updated, that is the employed bee which is exhausted becomes the scout bee again.

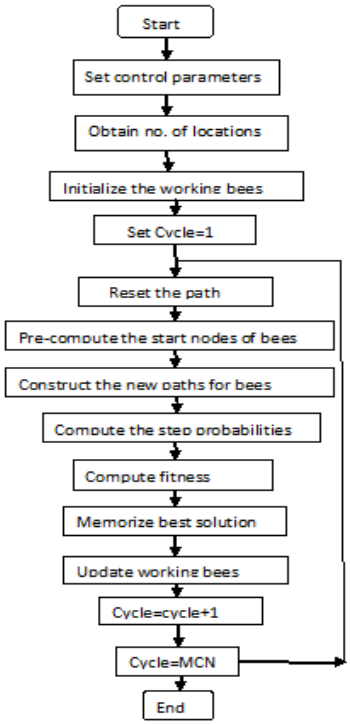

Fig.1 Flowchart of ABC algorithm

The optimization loop is terminated when the numbers of iterations are completed and the best result is obtained.

5. WATCHDOG MECHANISM

Watchdog is a kind of behavior monitoring mechanism which is the base of many trust systems in wireless network. The Watchdog mechanism only evaluates its next-hop's behavior and propagates the evaluation result to other nodes by broadcasting, which is neither energy efficient nor attack resilient. The basic idea of watchdog is that a node monitors whether its next-hop neighbor forwards the packets it just sent by overhearing. If the packet is not forwarded within a certain period, the neighbor is regarded as misbehaving in this transaction. When the misbehaving rate surpasses certain threshold, source is notified and following packets will be forwarded along other route.

Following the traditional watchdog mechanism, the extended version makes the node aware of all its neighbors' behavior when MAC control packets are enabled. Node monitors its neighbor's forwarding behavior by observing its CTS and subsequent DATA packets. When the interval exceeds certain threshold, the forwarding behavior is regarded as failed. The misbehavior is punished by restricting the injecting packet of misbehaved node. But the misbehaved node is not excluded from the wireless network instead; it can recover when the punishment is enough for its misbehavior. The extended watchdog mechanism is low energy-cost and resilient to many attacks.

6. CONCLUSION

In this paper, Artificial Bee Colony algorithm is presented by considering a new approach. The Artificial Bee Colony Algorithm can be used to solve several optimal problems. It is aimed to minimize the length of the tour and find the optimal path. The Artificial bee colony algorithm is highly flexible and can be effectively used to find shortest path by considering very few control parameters as compared with the other heuristic algorithms.

7. FUTURE WORK

The Future scope might incorporate the comparative study of Artificial Bee Colony (ABC) Algorithm with the other optimization algorithms to find more optimal solutions with watchdog mechanism for secure data transferring in wireless network.

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