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Efficient and Reliable Routing Algorithm to Enhance Connectivity in Disaster Scenario: ABC Algorithm

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Abstract: ***Management of a disaster and emergency situation is a challenging task. Noisy and damaged environments and the limited power transmission make the scenario impracticable to support the quick rescue measure operations. Through this paper our aim is to review technological solutions for managing disaster using wireless sensor networks (WSN) via disaster detection and alerting system, and search and rescue operations. In this paper we proposed Artificial Bee Colony (ABC) Algorithm to match the different characteristics of wireless sensor network deployment process, which will be optimum for real time dynamic network functioning and for maintaining connectivity even in disaster conditions. The effectiveness of proposed method is measure in terms of throughput, end to end delay, packet delivery ratio, routing load and average energy consumption. Simulations for this work are carried out over the NS2 simulator.***

Keywords: Disaster Prediction, Wireless Sensor Networks, Disaster Management, Artificial Bee Colony algorithm, Optimization etc.

1. Introduction

In recent years the world has experienced a number of catastrophic natural disasters such as earthquake, flood, hurricane, typhoon, tsunami, etc. These incidents of mass destruction irrespective of the whether natural calamities or man-made catastrophes cause a huge loss of money, property and lives due to non-planning on the part of the governments and the management agencies. Emergency communication modules in large-scale disaster struck areas is deployed by using wireless ad-hoc networks which requires no centralized networks.

A WSN is formed by deploying sensor nodes in an application area forming an infrastructure of sensor or measurement, computation, and communication elements to instrument, observe, and react to events in a specified environment. In most real-time deployment solutions, they demand self-organizing capabilities to keep track of the dynamic domain. The main benefits of such a configuration is the spatial diversity they provide, enabling applications such as target detection & tracking as it moves throughout the sensor field; weapon targeting and area denial Such networks are suitable for a wide variety of applications such as surveillance, precision agriculture, smart homes, automation, vehicular traffic management, habitat monitoring, disaster detection, etc [1]. Bio-inspired principles have found their way into WSN R & D due to the appealing analogies between biological systems and large network. The dynamics of many biological systems and the laws governing them are based on a surprisingly small number of simple rules, yielding collaborative & effective mechanisms for resource management, task allocation, and synchronization without any central controlling element. Artificial Intelligence (AI) is a concept of study and research for finding relationships between cognitive science and computation theories. Such
Artificial Bee Colony Algorithms give simple solutions to WSN Deployment problems is one such.

Many natural systems of the most creatures in the world are very rich topics for the scientific researchers and developers. However, a simple individual behaviour can cooperate to create a system able to solve a real complex problem and perform very sophisticated tasks. In realty there are many patterns of such systems like ant colonies, bird flocking, fish shoaling, animal herding, bacterial growth, bee colonies, swarm intelligence and human neuron system.

We have studied the many recent routing protocols for wireless sensor networks with different goals. The problem with many routing algorithms is that they minimize the total energy consumption in the network at the expense of non-uniform energy drainage in the networks. In many cases, the lifetime of a sensor network is over as soon as the battery power in critical nodes is depleted. Hence to overcome this problem recently the new method was presented in A-star algorithm. In A-star algorithm, the proposed method seeks to investigate the problems of balancing energy consumption and maximization of network lifetime for WSNs [2]. However this proposed method has not be evaluated against the network scalability as well as network routing performances, hence this allows us to do the further research in this same area.

Connectivity issue in disaster conditions can also be observed as topology problem. In Topology problems objective is to find optimal topology to optimize several parameters. NS2 provides the simulation and research supports for the wired networks, wireless networks by using TCP, and UDP, IP, and CBR patterns of the communications. NS2 is made of two parts basically such as NS means network simulator and other one is NAM means network animator. NS is used to simulate all the protocols like commonly used IP protocols over the wireless as well as wired networks. On the other hand, the network animator tool is used to visualize the simulation of the networks in the form of actual communication patterns. NAM supports the wired network simulation fully as compared to wireless simulation which is possible only partially with the NAM.

The use of NS-2 to evaluate the fitness function is very interesting since it allows the designer to model the communication layers and the signal propagation models. The implemented topology control was able to calculate the suitable node's coverage area to minimize the energy consumption. Using the technologies like CPP and OTCL, NS2 is developed as the completely object oriented network simulator. The class hierarchy which is presented in the C++ and OTcl interpreted is very much supported by the network simulator in which there is one to one mapping in between the class in the interpreted hierarchy and compile hierarchy.

2. Proposed Approach

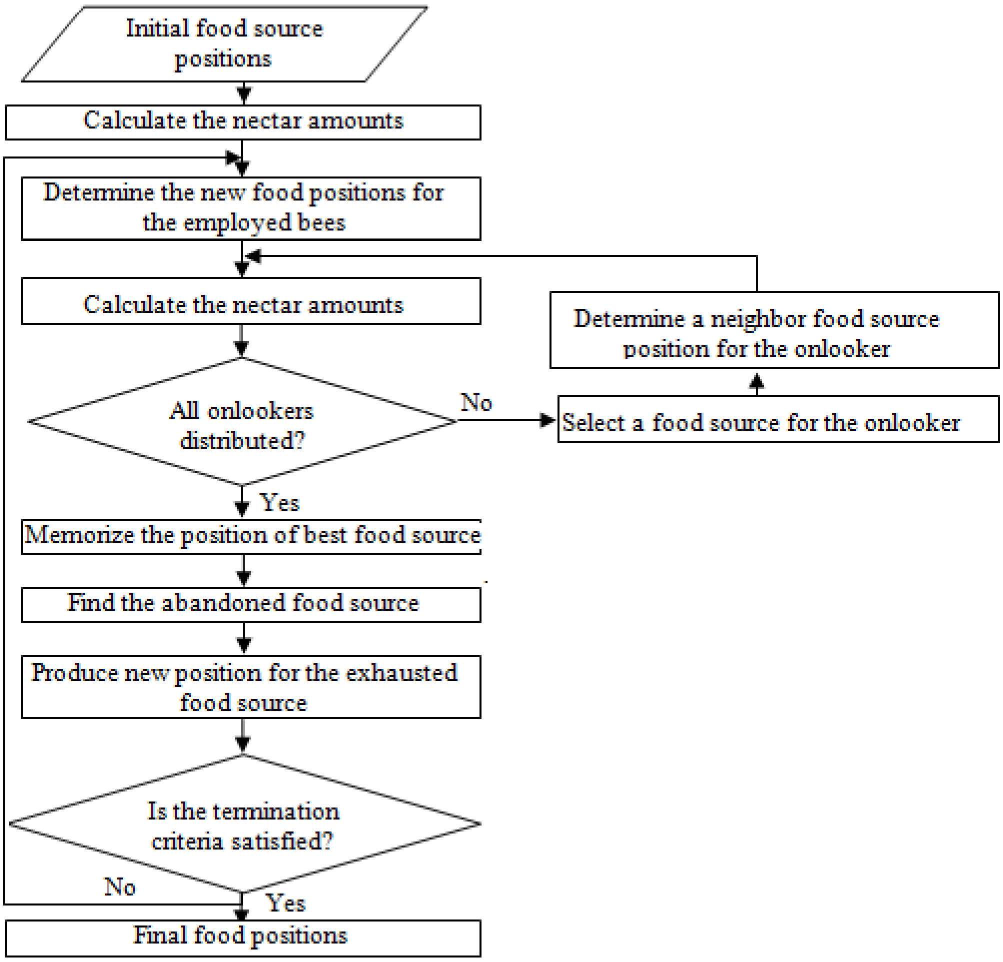

Figure 1: Flow Chart of ABC Algorithm.

Due to the complexity of the problem and the number of parameters to be considered, a Artificial Bee Colony algorithm combined with the network simulator NS-2 is proposed for managing a disaster. Artificial Bee Colony (ABC) algorithms are set swarm intelligence algorithm. It is widely used by research and academics in order to simulate both wired and wireless networks. NS-2 is used to evaluate fitness function. OTCL and C++ is programming used. Bonn motion is freely available mobility generator. It creates and analyzes mobility of nodes in network. Results can be verified with help of c program to check weather desired optimal outcome has been achieved or not. If desired optimal outcome is not achieved then new generation are again created. A flowchart of artificial bee colony system has been proposed as seen in Fig. 2. This paper proposes a new optimization algorithm that uses the bee behaviour in food forging as the functions to be used by the processing engine.

In the following subsections present these two scenarios:
- The Behaviour of Scout Scenario
- The Behaviour of Forger Scenario

3. Bio-Inspired Algorithms Comparative Study

Algorithm	Proposed by	Advantages	Disadvantages	Applications
Evolutionary Algorithms				
1. Genetic Algorithm	Holland in 1975	GA is useful and efficient when: 1. The search space is large complex or poorly known. 2. No mathematical analysis is available. 3. Domain knowledge is limited to encode to narrow the search space. 4. For complex or loosely defined problems since it works by its own internal rules. 5. Traditional search method fails.	1. Have a tendency to converge towards local optima. 2. Operating on dynamic data sets is difficult. 3. Simpler optimization algorithms may find better solutions than GAs. 4. Not suitable for solving constraint optimization problems.	Optimization problems in data mining and rule extraction, dynamic and multiple criteria web-site optimizations, decision thresholds for distributed detection in wireless sensor networks and many more.
2. Genetic Programming	Koza in 1992	Generates diversity not only in the values of the genes but also in the structure of the individuals.	Solution can be always computer programme.	Portfolio optimization, design of image exploring agent, epileptic pattern recognition, automated synthesis of analogue electrical circuits symbolic regression, robotics, data mining (automatic feature extraction, classification etc.), cancer diagnosis.
3. Evolution Strategies	Bienert, Rechenberg, Schwefel) at the Technical University in Berlin in 1964	--------	This does not incorporate selectiveness.	Parameter estimation, image processing, computer vision system, Task scheduling and car automation, structural optimization, evolution strategy for gas-turbine fault-diagnoses, vehicle routing problems, clustering.
4. Differential Evolution	Storn and Price in 1995	1.DE is easy to implement, requires little parameter tuning. 2. Exhibits fast convergence. 3. It is generally considered as a reliable, accurate, robust and fast optimization technique.	1. Noise may adversely affect the performance of DE due to its greedy nature. 2.The user has to find the best values for the problem-dependent control parameters used in DE and this is a time consuming task	Unsupervised image classification, clustering, digital filter design, optimization of non-linear functions, global optimization of non-linear chemical engineering processes and multi-objective optimization.
SWARM INTELLIGENCE ALGORITHMS				
Algorithm	**Proposed by**	**Advantages**	**Disadvantages**	**Applications**
1. Particle Swarm Optimization	Kennedy and Eberhart in 1995	1. Unique searching mechanism. 2. Simple concept. 3. Computational efficiency. 4. Easy implementation. 5. More efficient in maintaining the diversity of the swarm.	The limitation of the method is appearing in problems with extremely small feasible spaces.	Multimodal biomedical image registration, classification of instances in multiclass databases, feature selection, power system optimization problems, edge detection in noisy images, finding optimal machining parameter assembly line balancing problem in production and operations management.
2. Ant Colony Optimization	Dorigo & Di Caro in 1999	1. Locality of interactions. 2. Availability of multiple paths. 3. Self organizing behaviors. Failure backups. 5. Ability to adapt in a quick and robust way to topological and traffic changes and component failures. 6. Scalable performance. Robustness to failures. 8. Easiness of design and tuning.	---------	TSP Problem, Quadratic Assignment problem (QAP) Job-Shop Scheduling problem, dynamic problem of data network routing, a shortest path problem where properties of the system such as node availability vary over time, continuous optimization and parallel processing implementations, vehicle routing problem.

3. Artificial bee colony algorithm	Teodorovic and Dell'Orco	1. Easily hybridized with different metaheuristic algorithms. 2. Its components makes it robustly viable for continued utilization for more. exploration and enhancement possibilities 3. Uses uniform distribution to generate a new solution. 4. Uses neural networks for the classification.	---------	Scheduling problems, image segmentation, capacitated vehicle routing problem, WSNs, assembly line balancing problem, Solving reliability redundancy allocation problem, training neural networks, XOR; Decoder–Encoder and 3-Bit Parity benchmark problems, pattern classification.
4. Firefly algorithm	Li et al. in 2002	1. Explore cost function space more effectively. 2. The algorithm could be hybridized together with other heuristic local search based technique like Adaptive Simulated Annealing. Mainly uses real random numbers and is based on the global communication among the swarm particles (i.e. the firefly), hence more effective in multi objective optimization.	Less stable in terms of standard deviation.	Function optimization, parameter estimation, combinatorial optimization, least squares support vector machine and geo technical engineering problems.

4. Artificial Bee Colony (ABC) Algorithm Implementation

Generally a given problem is modeled in such a way that a classical algorithm like simplex algorithm can handle it. This generally requires making several assumptions which might not be easy to validate in many situations. In order to overcome these limitations more flexible and adaptable general purpose algorithms are needed. It should be easy to tailor these algorithms to model a given problem as close as to reality. Based on this motivation many nature inspired algorithms were developed in the literature like genetic algorithms, simulated annealing and taboo search. It has also been shown that these algorithms can provide far better solutions in comparison to classical algorithms. A branch of nature inspired algorithms which are known as swarm intelligence is focused on insect behavior in order to develop some meta-heuristics which can mimic insect's problem solution abilities. Ant colony optimization, particle swarm optimization, swap nets etc. are some of the well known algorithms that mimic insect behavior in problem modeling and solution.

Artificial Bee Colony (ABC) is a relatively new member of swarm intelligence. ABC tries to model natural behavior of real honey bees in food foraging. Honey bees use several mechanisms like waggle dance to optimally locate food sources and to search new ones. It has been found that Artificial Bee Colony Optimization (ABCO) is a special kind of optimization technique having characterization of Swarm Intelligence (SI) which is highly suitable for finding the adaptive routing for such type of networks. ABCO is a probabilistic technique for solving computational problems which can be reduced to finding good paths through graphs. ABCO is used because they are more robust, reliable, and scalable than other conventional routing algorithms.

A bee colony can be thought of as a swarm whose individual agents are bees. Each bee at the low-level component works through a swarm at the global level of component to form a system. Thus, the system global behaviour is determined from it is individual's local behaviour where the different interactions and coordination among individuals lead to an organized teamwork system. This system is characterized by the interacting collective behaviour through labour division, distributed simultaneous task performance, specialized individuals, and self- organization.

The exchange of information among bees leads to the formation of a tuned collective knowledge. A colony of honey bees consists of a queen, many drones (males) and thousands of workers (non- reproductive females). The queen's job is to lay eggs and to start new colonies. The sole function of the drones is to mate with the queen and during the fall they are ejected from the colony. The worker bees build honeycomb, and the young, clean the colony, feed the queen and drones, guard the colony, and collect food.

As nectar is the bees' energy source, two kinds of worker bees are responsible for food. These are scout bees and forager bees. A bee does many things in its life history, and does not become a scout/work bee until late in its life [3]. While scout bees carry out the exploration process of the search space, forager bees control the exploitation process. However, exploration and exploitation processes must be carried out together by the colony's explorers and colony's exploiters. As the increase in the number of scouts encourages the exploration process, the increase of foragers encourages the exploitation process.

Studying the foraging behaviour leads to optimal foraging theory that directs activities towards achieving goals [4]. This theory states that organisms forage in such a way as to maximize their intake energy per unit time [4]. In other words, the swarm of bees behaves in such a way as to find and capture the food that containing the most energy while expending the least possible amount of time in real variables. There are two forms of scenarios for any bee in forging process which are either scout or forager.

4.1 The Behaviour of Scout Scenario

Scouts fly around and search for food. When they find a source of nectar or pollen fly back to the colony and start dancing to communicate with other bees on a particular region in the comb [3]. Hence the behaviour of the scout scenario is summarized according to the following activities:

The scout flies from its colony searching for food sources in a random way. Once it finishes a full trip, it returns back to its colony. When a scout arrives at the colony, it goes inside and announces its presence by the wing vibrations. This means that it has a message to communicate. If it has found a nearby source of nectar or pollen, it undergoes a circular dance. The nearby bees follow it through this circular dance and smell it for the identity of the flowers. They listen to the intensity of the wing vibrations to indicate the value of the food source. If the source is so close, no directions are given. Alternatively, if the flower source is a long ways off, careful directions must be given.

The abstract convention that the scout makes is that the up position on the comb is the position of the sun. Because bees can see polarized light, they can tell sun position without actually seeing the sun. The scout dances in a precise angle from the vertical. This equals to the horizontal angle of the sun with reference to the colony exit with the location of the food source. Next the scout bee must tell the other bees how far away the flower source is. This is done by waggling the abdomen from side to side. The slower the waggling, the further away is the distance of the food flower.

Movement of the Scouts

- The movement of the scout bees follows equation.

$$\theta_{ij} = \theta_{j\min} + r \cdot (\theta_{j\max} - \theta_{j\min})$$

r : A random number and $r \in [0,1]$

4.2 The Behaviour of Forger Scenario

The bees in the colony closely follow the scout to learn these directions, and also learn the odour of the flower on scout bee, so they can find the flower when they arrive at the source location. Because the sun is moving in the sky, the bees should use an accurate clock sense to adjust for the changing sun position with reference to the food source and the colony exit. Even more remarkable, if a trained bee is removed from the colony to another location where the flower is not visible, but the colony is, the bee does not return to the colony to get its bearing, but reads sun position, and triangulates, and flies directly to the flower [3]. Subsequently, the forager bees take a load of nectar from the source and return to the colony and unload the nectar to the store of food.

Foraging requires energy and the honeybee's evaluation as to where, what, and how long to forage are all related to the economics of energy consumption and the net gain of food to the colony. Generally bees fly only as far as necessary to secure an acceptable food source from which there is a net-gain. Therefore, these are the factors that influence foraging behavior and determine profitability. The net rate of energy intake is defined as the energy gained while foraging minus the energy spent on foraging, divided by time spent foraging [5].

4.3 Movement of the Onlookers

- Probability of Selecting a nectar source:

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

P_i : The probability of selecting the i^{th} employed bee
S : The number of employed bees
θ_i : The position of the i^{th} employed bee
$F(\theta_i)$: The fitness value

4.4 Movement of the Forgers

- Calculation of the new position:

$$x_{ij}(t+1) = \theta_{ij}(t) + \phi(\theta_{ij}(t) - \theta_{kj}(t))$$

x_i : The position of the onlooker bee
t : The iteration number
θ_k : The randomly chosen employed bee.
j : The dimension of the solution
$\phi(\bullet)$: A series of random variable in the range [-1,1]

5. Conclusion

This paper proposes an algorithm for the Artificial Bee Colony system according to the two scenarios of scouting and forging processes. Artificial Bee Colony (ABC) algorithm has opened up a vast stage for WSN protocol suite design. Like any swarm intelligent scheme, they are compatible to any stage of a WSN design and implementation, which makes them an attractive choice as the base. A random selection process carried out by scouts. The algorithm outperformed other techniques in terms of speed of optimisation and accuracy of the obtained results. The proposed algorithm can be applied to many combinatorial optimization problems, dynamic problems in real variables, stochastic problems, multi-targets; data mining search engine crawling, parallel implementations.

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