An overview of Swarm Intelligence based Algorithm for Optimization Problem in Wireless Sensor Networks

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ABSTRACT- Wireless sensor network consist of many sensor nodes in which each sensor node collects the data from sensing environment and transmit it to the Ebase station. The most important key in WSN‘s is to find the optimal path to transmit the data. Nature is the best coach and its designs and strengths are enormously massive and eccentric that it gives inspiration to researchers to emulate nature to solve hard and complex problems in networks. Computation using Bio inspired algorithm has come up as a new epoch in computing, casing wide range of application. This paper gives overview of most successful classes of swarm intelligence (SI) based algorithm for solving optimization problem.

Keywords: wireless sensor networks, optimization problem, swarm intelligent based algorithm.

I. INTRODUCTION

Wireless sensor network is a group of large number of sensor nodes that are deployed in a region which manage themselves to form a network and work collaboratively to perform network functionality. WSN‘s can be used in many applications like healthcare, military, battle field and tracking and monitoring systems. For example sensor networks can be deployed in the atmosphere for monitoring and controlling of plant and animal behavior or in ocean for controlling temperature.

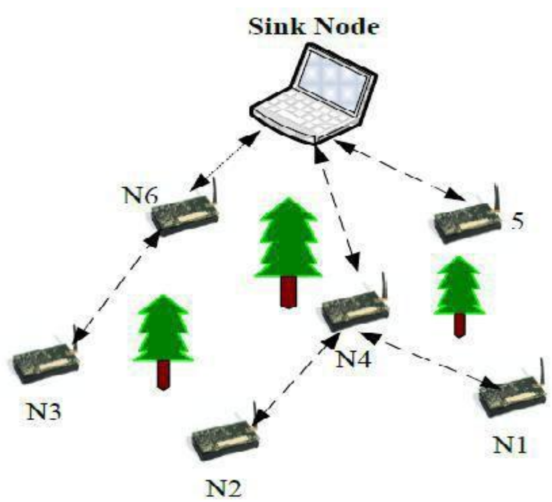

Fig 1: Simple Architecture of Wireless Sensor Network.

There are some explicit characteristics of WSNs where routing protocols must have in order to make use in real-world applications.
1) Memory requirements and minimal computation.
2) Self-organization.
3) Energy efficiency.
4) Scalability.
5) Support for in-network data aggregation.

Swarm intelligent algorithm are the problem solving methodology which is derived from the natural behavior and operation of natural system. These algorithms can solve problems in almost all application areas like wireless sensor networks, computer networks, image processing, mining data, signal processing, control systems and more. Bio inspired algorithm have the ability to resolve the complex relationship from inherently very simple initial conditions and rule. The architecture of wireless Sensor Networks is a s shown in the Fig 1.

The organization of paper as: section II provides the need for optimization in WSN‘s. Section III provides motivation behind swarm intelligent family. Section IV provides overview of various swarm intelligence family. Conclusion is drawn in section V.

II. NEED FOR THE OPTIMIZATION IN WSN'S

Optimization is the process or method for obtaining the most excellent results under a given condition. Network optimization is a very significant task and a number of optimization techniques are used to attain desire goals in network. The optimization of both hardware and software is required for designing of WSN‘s for achieving energy efficiency, reduced cost and application requirement optimization. For different problems several optimization algorithm are present, the challenge is that selecting a best algorithm for a requirement. More important requirements for a WSN are, achieve high quality QoS, energy efficiency low bandwidth, limited processing and storage in sensor node [6]. These are the some of the issues of WSN which are directly related to the problem of optimization.

Sensor networks and biological systems require to adapt themselves according to the changeable environmental conditions including the ability to selforganize, scalability and to provide robust operation for the long life of the sensor network. [7]. The simple optimization process is as shown in the Fig 2.

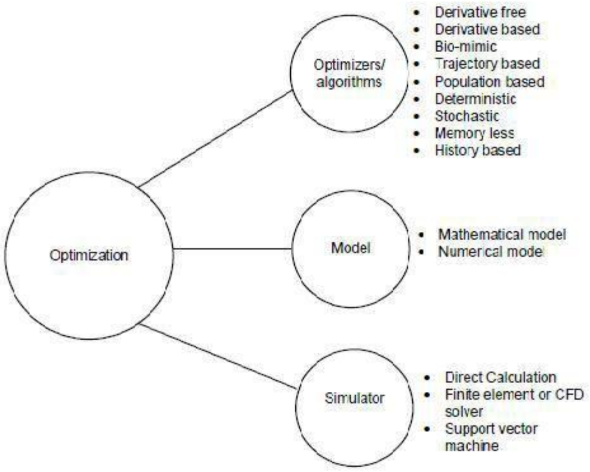

Fig 2 A simple optimization process.

III. MOTIVATION BEHIND SWARM INTELLIGENCE (SI) FAMILY

An intensive literature survey on nature inspired algorithm has been carried out to know the cause for intrinsic weakness of evolutionary optimization algorithm. The survey concealed that the performance of existing algorithm are dependent on time taken by biological counterpart. For example in genetic algorithm performance is slow in retrieving optimal solution as it implementation of simple Darwin theory which takes number of years to reveal changes in fitness of species. In Differential evolution according to krink et al. noise adversely affect the performance of Differential evolution because of its greedy nature. The best values for problem dependent parameters have to be found out by user, which is a time consuming task.

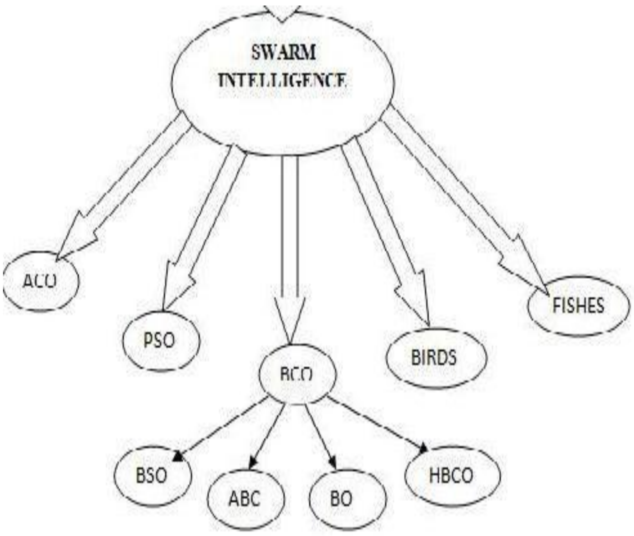

Fig 3: hierarchical representation of Swarm intelligence family.

IV. OVERVIEW OF SWARM INTELLIGENCE FAMILY

A Swarm can be defined as a set of mobile agents which are likely direct or indirectly communicate among each other and collaboratively solve a distributed problem. Swarm intelligence is the area which deals with nature and system collected individuals that synchronize using self organization and decentralization.

A very simple rules are followed by agents even though there is decentralized control structure which dictates agents how to behave, interaction between agents. Natural examples of SI consist of ant colonies, fish schooling and bee colony etc.

There are five fundamental principles to describe swarm intelligence.

1)principle of proximity: to carry out simple space and time computation.

2) principle of quality: responding to quality factors in the environment.

3)principle of diverse response: should not commit activity along excessively narrow channels.

4)principle of stability: with environment changes should not change its mode of behavior.

5)principle of adaptability: change behavior mode when worth of computational price.

The classification of swarm intelligence algorithm is on the basis of social behavior of animals, human immune system, among which algorithm based on behavior of animals can be explored as:

A Particle swarm optimization (PSO)

PSO algorithm is based on population based optimization technique proposed by Kennedy and Eberhart [9]. Due to its simple concept, efficient computation, easy implementation and unique searching mechanism PSO has been used in many engineering problem. The steps of PSO are as below:

1. Swarm has to be initialized by assigning a random position.
2. Fitness function has to be estimated for each particle.
3. Compare particle‘s fitness value with pbest for each individual particle. If the current value is better than the pbest value, then set this as pbest for current paticle‘s position.
4. Particle is identified which has best fitness value and is identified as gbest.
5. Velocities and positions of all the particles are revised using step 1 and 2.
6. Until sufficiently good fitness value is achieved repeat steps 2-5.

Advantages of PSO:

1. It is easy to implement and there are few parameters to adjust.
2. It has more effective memory capability.
3. In order to improve themselves PSO maintains diversity as all the particles use the information related to most successful particle.

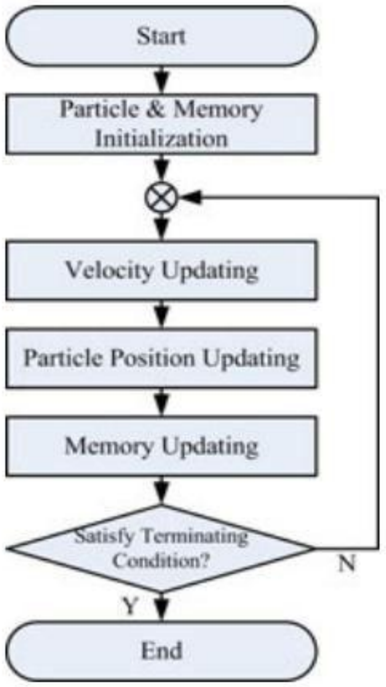

Fig 4: Steps for Particle swarm optimization.

B. Ant Colony Optimization (ACO)

in the nineties Dorigo et al. (1996) named Ant System‖ (AS), The first ant algorithm, tested successfully on the Travelling Salesman Problem. To generalize, the overall method of solving combinatorial problems by estimated solutions based on the generic behavior of natural ants, The ACO meta heuristic was developed (Dorigo & Di Caro, 1999;).the three main functions of ACO is as follows.

AntSolutionsConstruct: this performs the construction process of solution where according to a transition rule the artificial ants move through adjacent states of a problem, iteratively building solutions.

Pheromone Update: This performs updating of pheromone trail. updating the pheromone trails is done, once complete solutions have been built, or updating after each iteration. In addition to pheromone trail reinforcement, ACO also includes pheromone trail evaporation. Evaporation of the pheromone trials helps ants to forget‗ bad solutions that were learned early in the algorithm.

DeamonActions: is the optional step in the algorithm that involves applying extra updates from a global perspective. This may include applying supplementary pheromone reinforcement to the best solution generated. To improve the performance of ant system, Dorigo and Gambardella (1997) proposed an alternative approach, ant colony system (ACS), which is based on four modifications for ant system: a different transition rule, a different pheromone trail update rule, the use of local updates of pheromone trail to favor exploration, and the use of candidate list to restrict the choice.

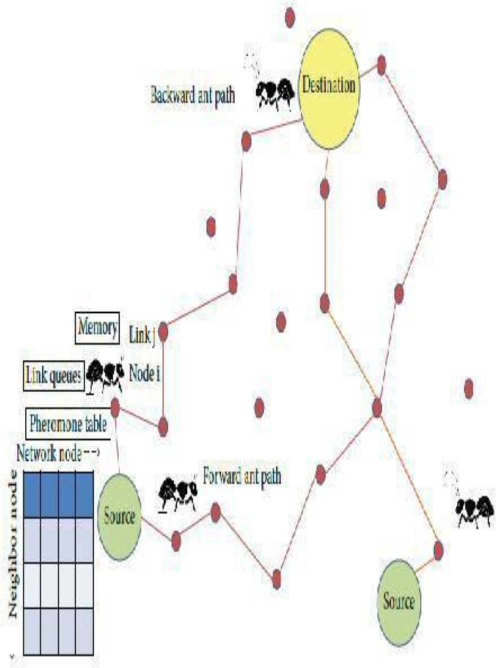

Fig.5. Representation of ACO Algorithm With Respect to Ants Foraging Behavior

C Bee Colony Optimization (BCO)

It is another Swarm Intelligence (SI) algorithm where the agents of the group are honey bees. Bees communicate with each other by a mechanism called ―Waggle Dance‖. They exchange information among themselves regarding the rich food source location. Because of their collective food foraging behavior, the name (BCO) is given to the honey Bees. The bee system is a standard example of organized team work, labor division, simultaneous task performance, specialized individuals. there are different types of honey bees In a honey bee colony. There is a queen bee, male drone bees and thousands of worker bees.

Types of bees: Queen: The responsibility of the Queen‗s is to lay eggs to form new colonies . The responsibility of Drones which are the male of the hive is to mate with the Queen Bee .it will be discarded from the colony during their down fall. The worker bees are the females of the hive [19]. They are the important building blocks of the hive. They are responsible for building the honey bee comb, cleaning it, maintain it, guard it, and feed the queen and drones. Apart from these , the main job of the worker bee is to search and collect the food. Two types of worker bees are there namely scout bees and forager bees. Both of them are equally responsible for the collection of food but with different roles. The role of Scout Bee‗s is to fly randomly all around and search for food. They come back to their hive after their exhaustion of energy and distance limits. Upon arrival to their hive the scout bee shares their experience and a lot of important information with the forager bees.

D. Artificial Bee Colony Algorithm (ABC)

Various swarm intelligence algorithms are available Based on the behavior of the bees in nature, that are classified into two methods; foraging behavior and mating behavior. Algorithms simulating the foraging behavior of the bees include the Artificial Bee Colony (ABC) ,the Virtual Bee algorithm , the Bee Colony Optimization algorithm , the Bee Hive algorithm, the Bee Swarm Optimization algorithm. and the Bees algorithm. An individual entity demonstrate a simple set of behavior policies , but a group of entities shows complex emergent behavior with useful properties such as scalability and adaptability. 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 three groups of bees: *employed bees, onlookers and scouts.*

An employed bee produces a modification on the position in the memory depending on the loca linformation and tests the nectar amount of the new source. Using the nectar amount of the new one is higher than the previous one, the bees remember the new one and forget the old one. After every working bees complete the search process. They share the nectar information of the food sources and their position information with the onlooker bees on the dance area. The algorithm global search performance depends on random search process performed by scouts and solution production mechanism performed by employee and onlooker bees.

E. Fish Swarm Algorithm (FSA)

The fish swarm algorithm (FSA) is a population-based/swarm intelligent technique that is inspired by the natural schooling behavior of fish.FSA exibits a strapping ability to avoid local minimums in order to achieve global optimization. In this algorithm fish is represented by its D-dimensional position Xi = (x1, x2, . . ., xk, . . ., xD), and FSi to represent the food satisfaction for the fish. Euclidean distance dij = ||Xi −Xj|| denotes the relationship between two fish. FSA typically imitates three behaviors, which is defined as ―searching food, ―swarming in response to a threat, and ―following to boost the chance of achieving a flourishing result.

Searching can be said as as a random search adopted by fish for searching of food, with a tendency towards food concentration. The main objective is to minimize FS (food satisfaction).

Swarming: this aims in satisfying food ingestion needs, entertaining and attracting new swarm members. A fish which is located at Xi and has its neighbors within its visual . where Xc identifies the center position of those neighbors and it is used to describe the attributes of the entire neighboring swarm. If the swarm center has greater attentiveness of food than is available at the fish_s current position Xi (i.e., FSc < FSi), and if the swarm (Xc) is not very crowded (ns/n < δ), the fish will move from Xi to next Xi+1, toward Xc .

Following behavior is one, when a fish locates food, all neighboring individuals follow it. Within a fish_s visual, few fish will be apparent as finding a greater amount of food than others, and this fish will obviously try to follow the best one(Xmin) in order to increase satisfaction(i.e., gain relatively more food[FSmin < FSi] and less crowding[nf/n < δ]). nf represents number of fish within the visual of Xmin. Three important **parameters** involved in FSA include visual distance (visual), maximum step length (step), and a crowd factor. These two factors influence the effectiveness of FSA.

F. Bat algorithm (BA)

In 2010 yang proposed Bat Algorithm which is also a swarm based metaheuristic algorithm inspired by a property called as echolocation. This echolocation is a type of sonar which guides bats during flying and hunting behavior. two components which affect the search characteristics of an algorithm are exploration and exploitation.

Exploration is nothing but a capability of an algorithm to find solution which is promising by seeking strange region,

Whereas the exploitation improves the solution obtained by exploration. In survey many studies indicates that exploration capability of an algorithm must be employed first, and from which algorithm scans the whole search space and to improve the solution obtained by exploration should be employed in the optimization process.

G. Cuckoo search (CS)

CS is an optimization algorithm which was developedby Xin-She Yang and Suash Deb in the year 2009. This CS algorithm was inspired by the obligate brood parasitation of cuckoo species which lays their eggs in the nests of other host birds.

Some host birds engages direct conflict with the intruding cuckoos. For example, if the host birds discovers that the eggs in their nests are not their own eggs,then they will either throw the alien eggs away or abandon their nets and just build another one. The female parasitic cuckoos of New World brood-parasitic Tapera are very specialized in the mimicry in colors and pattern of eggs which resembles the eggs of the chosen host species.

Cuckoo search idealized such breeding behavior andthought of using this idea for various optimization problems. This idea can outperform other metaheuristic algorithm which are in applications.

Cuckoo search uses the following representation

1. Each egg in a nest is solution, and a cuckoo egg is a new solution .the aim of CS is to replace the not so good solutions in the nests with the new solutions(cuckoo). Now, this algorithm is like each nest has one egg.but this algorithm can be extended such that each nest has multiple eggs which means multiplication.
2. The idealization rule of CS is based on,

Each cuckoo lays one egg at a time, and dumps in random nests.

3.The best nests with high quality egg will be carried to next generation

The egg laid by a cuckoo is discovered by the host bird with a probability of a p_a\in(0,1). Discovering operate on some set of worst nests,and discovered solutions is dumped from farther calculations

CONCLUSION

All SI-based algorithms make use of multi-agents, which is inspired by the collective behaviour of social insects, like ants, bees, as well as from extra animal societies like flocks of birds or fish. The particle swarm optimization (PSO) uses the swarming behaviour of fish and birds, Ant colony optimization (ACO) uses the communication of social insects (e.g., ants), while the ABC Bee algorithms are all based on the foraging behavior of honey bees. Cuckoo search (CS) is based on the way of some cuckoo species brooding parasitism. Bat algorithm makes use of echolocation of few foraging bats. SI-based algorithms are the most popular and widely used algorithm for solving optimization problem in wireless sensor networks. There are many reasons for this, first reasons is that SI-based algorithms will share information among multiple agents, so that self-organization, co-evolution and learning through iterations will help to provide the high efficiency of most SI-based algorithms. Second reason is that multiple agent can be parallelized effortlessly so that significant optimization becomes more practical from the implementation point of view.

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