NATURE-INSPIRED OPTIMIZATION TECHNIQUES IN WIRELESS BODY AREA NETWORKS: A REVIEW

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Abstract : Wireless Body Area Network (WBAN) is a medical evolutionary application of Wireless Sensor Network (WSN) with distinct challenges in terms of energy efficiency, dynamic network topology, heterogeneous data generation rate and size and low power consumption. It is imperative for WBANs to have a longer network lifetime and greater stability period in order to avoid constant recharging and replacement of nodes attached to a patient. This can be achieved by reducing the energy consumption of the nodes. The literature survey indicates that the optimization techniques play an important role in achieving minimum energy consumption. This paper presents an introduction of WBANs and the various optimization techniques viz. Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Fire Fly Optimization (FFO), Binary Particle Swarm Optimization (BPSO) used for optimizing the performance of the network. The optimization techniques are discussed in context with WBAN indicating their usability or inappropriateness for WBAN applications. A comparative analysis of various techniques is also present.

***Index Terms* - Wireless Body Area Networks, Wireless Sensor Networks, Optimization Techniques.**

I. Introduction

Wireless Sensor Network consists of many distributed autonomous sensors devices where all nodes sense data and send it to base station which is usually called sink [1]. Now a days, Wireless Sensors Network (WSN) have become a very important technology in real life to solve many challenges viz heterogeneous nature of nodes, different quality of services of requirements, different power supply, communication capability, storage and energy consumption. Healthcare monitoring is one of the main key challenge in WSN. Wireless Body Area Networks (WBANs) constitute a key application of WSNs for monitoring the vital sign related data of human body [2].

The term 'WBAN' was first introduced by Van Dan et al. in 2001. In the developed countries, the aging population and the increase cost of healthcare have conferred a lot of important challenges for the healthcare sector. With the rise in elderly populations, the quality of medical service would most likely drop, leading to the increased health care and medical costs. In the world, millions of people suffer from diabetes and die due to heart diseases every year [4]. There is a trend of using growing wireless technologies to support patient monitoring in cost effective manner [5]. WBAN is one such rising technology that permits, monitoring a person's health and providing services to patients at their doorsteps. Traditionally health care and light weight sensors are implanted or worn on the human body with wires to determine its physical parameters viz temperature, heart rate, blood pressure, ECG and these sensors communicate with the sink node [6]. By using radio frequencies the WBANs create a wireless network in the human body to screen vital signs such as body temperature, glucose level, blood pressure, EMG and position. WBANs communicate with old wireless technologies like ZigBee, Bluetooth, WSNs, Wireless Local Area Networks (WLAN), Wireless Personal Area Network (WPAN) and internet [7].

This paper introduced the concept of optimization techniques in Wireless Body Area Networks for minimize energy consumption and solve routing problems. Energy efficiency, task allocation, node deployment and network lifetime are main constraint in Wireless Body Area Networks. Numerous optimization techniques have been introduced for minimizing energy consumption and improving network life time. In this paper describe the various optimization techniques as Fire Fly Optimization (FFO), Genetic Algorithm (GA), and Ant Colony Optimization (ACO) and also presents a compressive analysis for the same.
The rest of the paper is organized as follows. Related work is discussed in section II. Section III discusses various Optimization Techniques. Section IV presents the state-of-art comparison of discussed Optimization Techniques. Section V finally concludes the paper.

II. RELATED WORK

This section describes the work completed by numerous researchers over the previous decade. The majority of the research works have been proposed to achieve energy efficiency and expanding the network lifetime. Some Optimization Techniques in literature are mentioned below:

Bangash et al. [8] discussed numerous challenges and issues of routing protocols for WBANs. The authors also provided a comprehensive review of existing routing protocols specifically designed for WBANs viz. QoS-aware routing protocols, temperature-aware routing protocols, cluster-based routing protocols, postural-movement-based routing protocols and cross-layered routing protocols. The authors presented a state-of-the art comparison among the routing protocols of the specified categories.

Prof N.V.S.N [9] proposed energy efficient optimization technique using Firefly algorithm. It depends on the distance and light intensity between nodes. If distance is minimum between given nodes that means more light intensity, data firstly forward to nearest node thus there's less energy consumption. This technique enhances the performance as compare to LEACH and PSO-C protocols.

Fateh boutekkouk et.al [10] proposes a hybrid approach for increase the network lifetime on heterogeneous network. This paper proposed firefly technique and chain based routing. By using firefly algorithm find the optimal clustering. Chain based routing is used to find the best chain inside each cluster for sending the data to sink node. Both techniques are consumes less energy.

Rajeev Kumar [11] to increase the lifetime of networks, the authors proposed two optimization technique, Ant bee colony optimization and Ant colony optimization (ABCACO) for WSNs. Ant bee colony optimization is used to decrease the distance between cluster head and base station. It gives better performance as compare to existing algorithms in term of lifetime of networks and scalability.

Varsha Gupta et. al [12] proposed a modified Ant Colony optimization technique on LEACH protocol for head selection of cluster. Clustering head selection is based on two parameter such as distance and energy in LEACH-MA method.

Rejina Parvin [13] proposes Enhanced optimized energy efficient routing protocol (E-OEERP) using Particle swarm optimization (PSO) and gravitational search algorithm (GSA) for prevention of formation of residual nodes. During cluster origination number of the nodes is not a member of any cluster, these nodes are referred to as residual nodes. Residual nodes need a high energy for data transmission from given node to sink. PSO algorithm creates a cluster on basis of residual energy and plays important role for prevention of residual nodes. GSA algorithm finds the next hop distance.

P.Leela et.al [14] proposes a hybrid clustering approach for expanding network lifetime. This approach is based on firefly algorithm and artificial bee colony for less energy consumption. [8]

Snehal Sarangi [15] proposed PSO based routing protocol for less energy consumption. This protocol is used to find the best path for routing. The path chooses on basis of minimum energy consumption. [9]

Banimelhem et.al [16] proposed genetic-based approach for reducing the communication distances between the base station and cluster heads and enhanced the performance of the LEACH protocol. New location is finding for each round using Genetic algorithm. This algorithm is providing better network lifetime as compared to LEACH [10]

III. VARIOUS OPTIMIZATION TECHNIQUES

Numerous optimization techniques are used for increase the network lifetime and minimum energy consumption in WBANs. These techniques are shown in fig 1.1

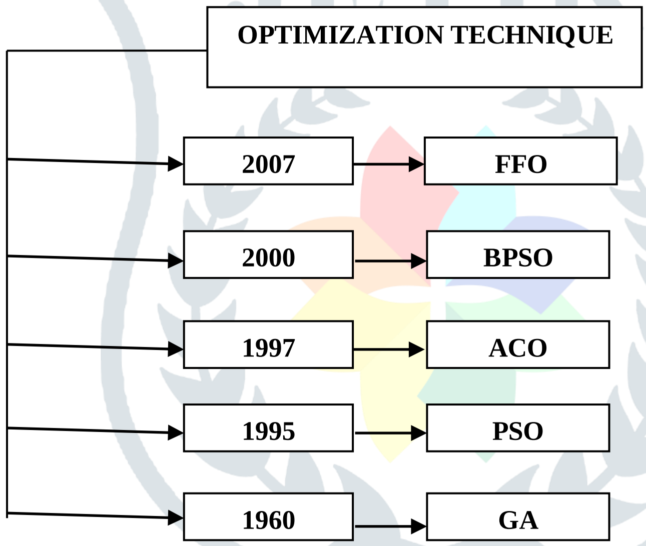

Figure 1.1 Optimization Techniques

Some of the techniques discussed as below:

3.1Firefly Algorithm (FFO):

Firefly Algorithm is proposed by Dr. Xin She yang at Cambridge University in 2007[9]. Fireflies set of rules is work on the essential phenomenon of bioluminescence. Bioluminescence is the system wherein Firefly insect yields flashes of short duration. Hence it is able to be said that for all firefly bugs, intensity of flash is a important parameter. It is one sort of colony looking generation. For a maximization problem, the brightness can definitely be proportional to the value of the goal characteristic. Based on those 3 policies, three definitions are given as following in Firefly set of rules.

1) The light intensity I(r) can be expressed as

$$I(r) = I_0 \ e^{-\gamma r^2} \quad (1)$$

Where I_0 =uniquel Light Intensity

ɣ = constant light absorption coefficient

r = distance

2) As the attractiveness is proportional to the light intensity, so we get attractiveness β

3) When a firefly i is attracted through a firefly j, the firefly i movements to the firefly j and the position of firefly i may be described as

$$x_i = x_i \ + \beta_0 e^{-\gamma r_{ij}^2} \ (\ x_j \ - x_i) + \alpha\varepsilon_i \quad (2)$$

Where x_i, x_j is the state of firefly I and j respectively, the third term is randomization with α being the randomization parameter and ε_i is a vector of random numbers drawn from a Gaussian distribution or uniform distribution .

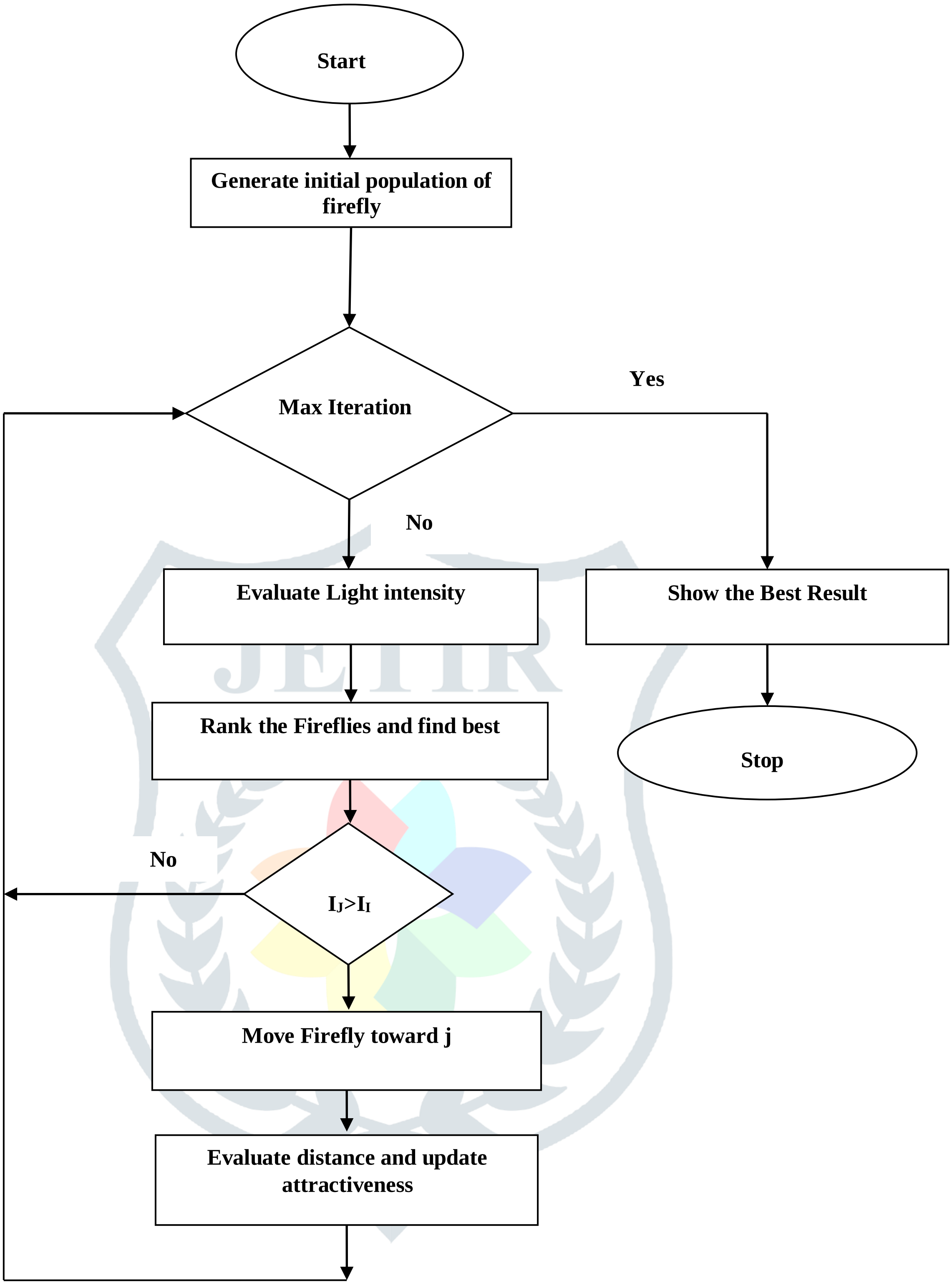

Figure. 3.1 Flow Chart of FFO

3.2 Binary Particle Swarm Optimization (BPSO):

Binary Particle Swarm Optimization approach is released by Eberhart and Kennedy. BPSO is motivated from the habits of the birds, bee and school of fishes. Hence BPSO adheres to the behavior of the organic bird folk. The key idea to develop the BPSO is that the data can be distributed to individuals in the population. It uses the search requirements which can be depending on the particle population[15]. BPSO usually split into two sections of a search such as global neighborhood and local neighborhood .Best position of particle in swarm can help an individual to determine its encounter which is often intended in local search as well as in global search. In Global best, every particle moves towards the best particle in swarm generally known as gbest model. However, if a particle moves towards its ideal particle in confined area known as best model in the swarm.

Every particle has their own position ,velocity and fitness value. BPSO algorithm has usually two updating formulas: velocity weight and position updating formula. They are as follow, respectively.

$$v(t+1)=w*v(t)+c1r1+c2r2[pBest(t)-x(t)]+c2r2[gBest-x(t)] \tag{3}$$

$$x(t+1)=x(t)+v(t+1) \tag{4}$$

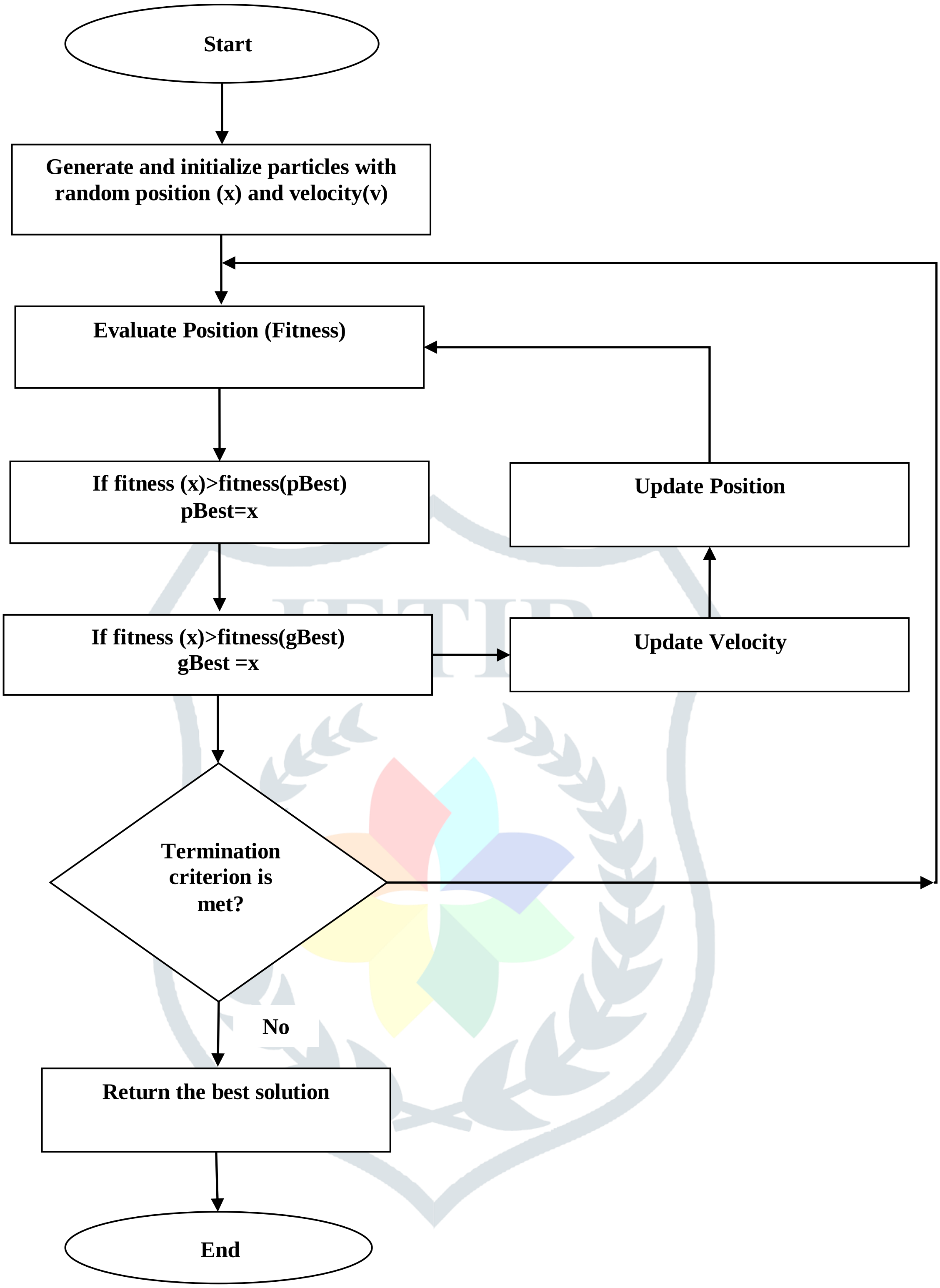

Figure 3.2 Flow Chart of BPSO

3.3 Ant Colony Optimization (ACO):

Ant Colony Optimization (ACO) is considered to be the derivation form of Swarm intelligence (SI). The ant colony optimization algorithm was presented by Marco Dorigo in 1997 and it has been a worldview for structuring meta heuristic calculations for enhancement issues and is motivated by the scavenging conduct of insect[12]. ACO aims optimization issues that are discrete in nature and could be reached out to persistent optimization issues that can be helpful to discover surmised approximately an answer. ACO calculation is the best and generally perceived algorithmic dependent on the subterranean insect conduct dependent on the ant behavior.

An ACO has been basically a framework dependent on operators which mimic the regular conduct of ants, including systems of collaboration and adjustment. Ants are visually impaired, tragically challenged. Ants live in provinces and they store pheromones in the ground that structure a trail. The trail draws in different ants and pheromones vanish quicker on longer ways. So shorter ways fill in as the best approach to nourishment for a large portion of different ants. ACO calculations depend on the accompanying thoughts. Each way pursued by an ant is related with a hopeful answer for a given issue. At the point when an ant pursues a way, the measure of pheromone kept on that way is relative to the nature of the comparing hopeful answer for the objective issue. At the point when an insect needs to pick between at least two ways, the path(s) with a bigger measure of pheromone have a more prominent likelihood of being picked by the subterranean insect. Accordingly, the ants in the end combine to a short way, ideally the ideal or a close ideal answer for the objective issue, as clarified before for the instance of common ants.

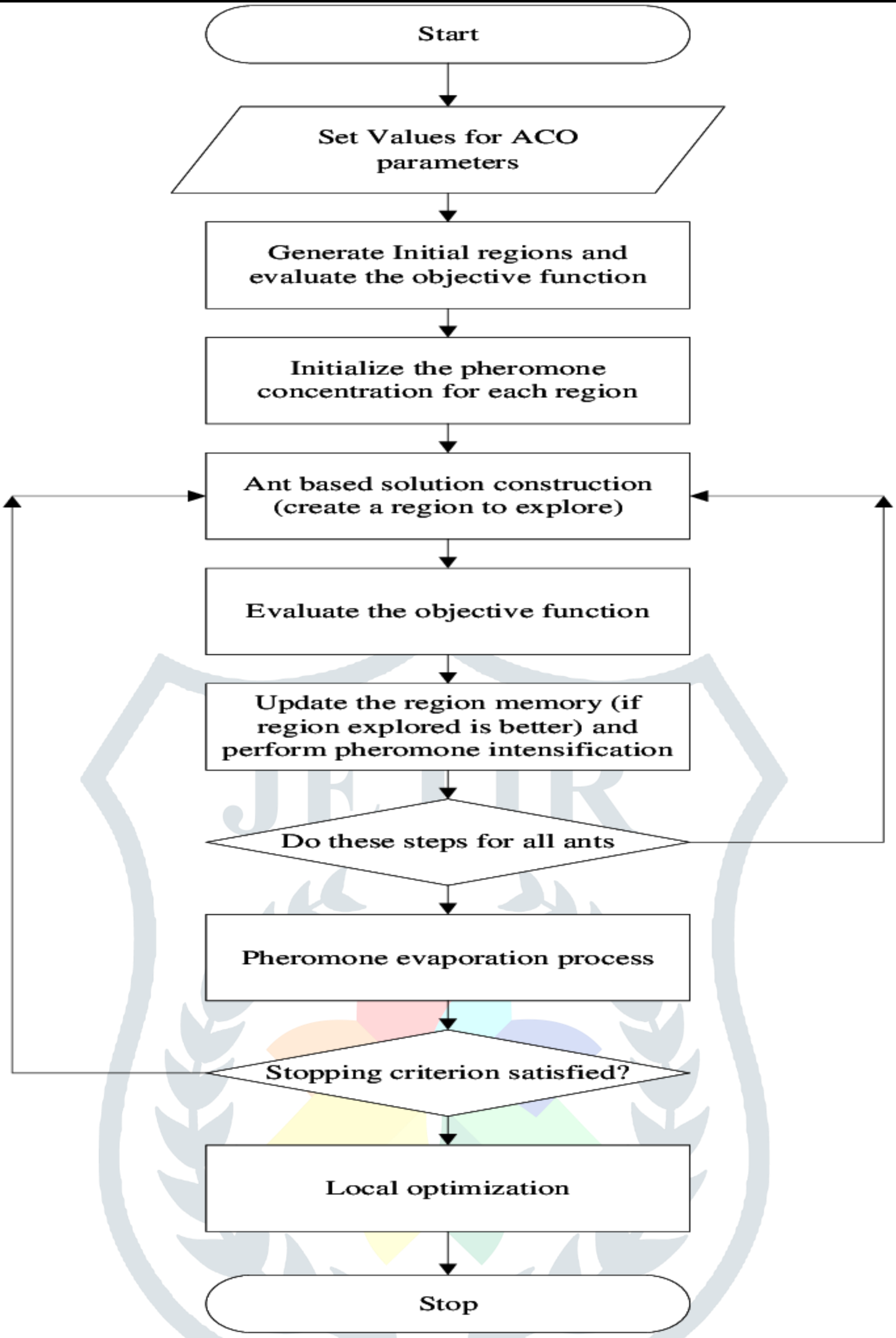

Figure 3.3 Flow chart for ACO

3.4 Particle Swarm Optimization (PSO):

The basic crux of PSO lies in particle, swarm and optimization. A particle is a localized object to which can be ascribed several physical and chemical properties such as volume or mass. Swarm is the collection of something that move somewhere in large number, for eg. Flock, herd etc. PSO technique is a population based stochastic optimization technique developed by Dr. Eberhart and Dr. Kennedy in 1995[13]. They inspired from social behaviours like bird flocking or fish schooling. PSO is multiobjective and dynamic optimization.The food which is nearest to the position is found randomly by the flock of animals. Animals advise to one another about position of food. It will happen over and over until food source is found. Particle swarm optimization comprises of a swarm of particles, where particle constitute a potential solution. Each particle is spoken to by its best position. It determined on premise of local best position as lbest and global best position gbest. PSO determined on premise of following:

1. Current position of particle
2. Current velocity of particle

Suppose a fish has a position and a velocity whenever. Looking for food, the fish changes its position by altering the velocity. The velocity changes dependent on its past experience and also the feedbacks received from its neighbour. This process of searching can be artificially simulated for solving non-linear optimization problem. So this is a population based stochastic optimization technique inspired by social behaviour of bird flocking or fish schooling. Each solution is considered as fish, called particle. All particles have a fitness value. The fitness values can be measured using objective function. The velocity and position of each particle i.e. fish is calculated according to the following equations.

$$Vid(new)=w*Vid(old)+c1r1(lbestid-Xid)+c2r2(gbestid- Xid)................. \quad (5)$$

$$Xid(new) = Xid(old)+Vid(old)............. \quad (6)$$

Where d = 1, 2... D, i = 1, 2, ..., N and N indicates the swarm size and n = 1, 2, ... gives denotes the iteration number. r1, r2 are two random numbers. These variables are uniformly distributed in [0, 1] for Ensuring complete coverage.

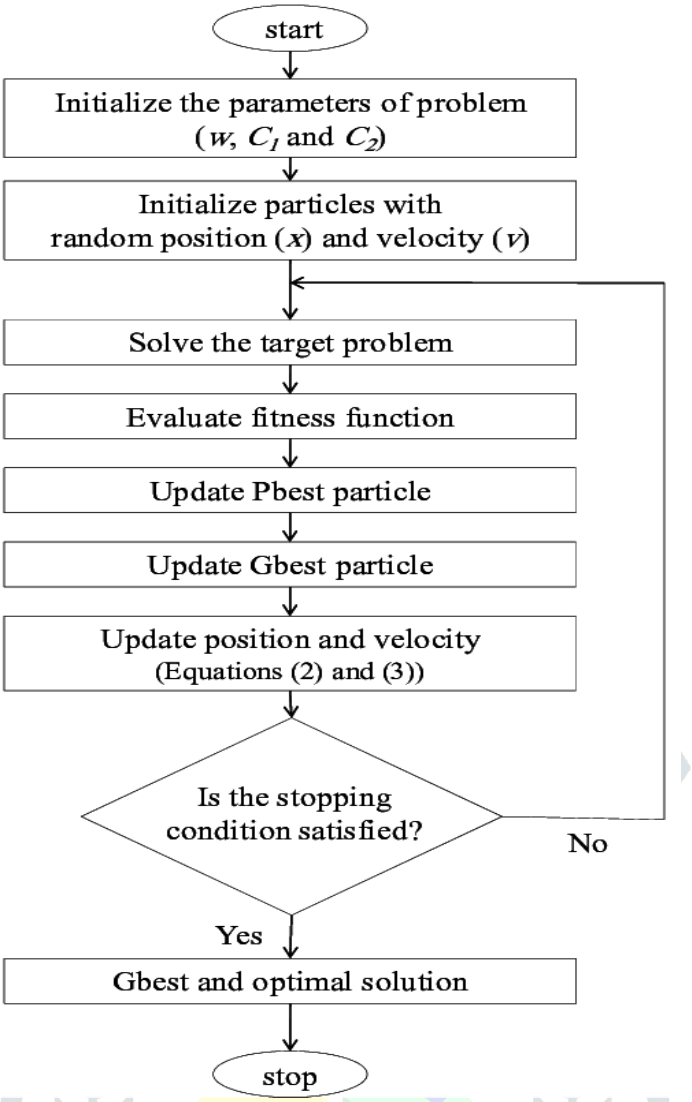

Figure 3.4 Flow Chart of PSO

3.5 Genetic Algorithm(GA):

Genetic Algorithms (GAs) are adaptive heuristic search algorithms. GA depends on Darwinian principles of biological evolution, reproduction and "the survival of the fittest". It is created by Holland and his partners during the 1970s. GA algorithm identified with genetic process of biological organisms. GA for the most part used to solve search and optimization problems. GA comprises of an accumulation of strings which are known as chromosomes. Chromosome portrays search space on various points. Chromosomes represent in the form of binary strings as 0's and 1's or real numbers.

GA depends on a similarity with genetic structure and conduct of chromosome of the population. Following is the establishment of GAs dependent on this similarity–:

1) Individual in population go after resources and mate.
2) Those individuals who are effective (fittest) at that point mate to make more offspring than others
3) Genes from "fittest" parent engender all through the generation, that is sometimes parents create offspring which is superior to either parent.
4) Thus each successive generation is increasingly appropriate for their environment.

GA in wireless sensor systems discover number of groups and their heads in conveyed condition. There isn't correspondence with global optimization process.

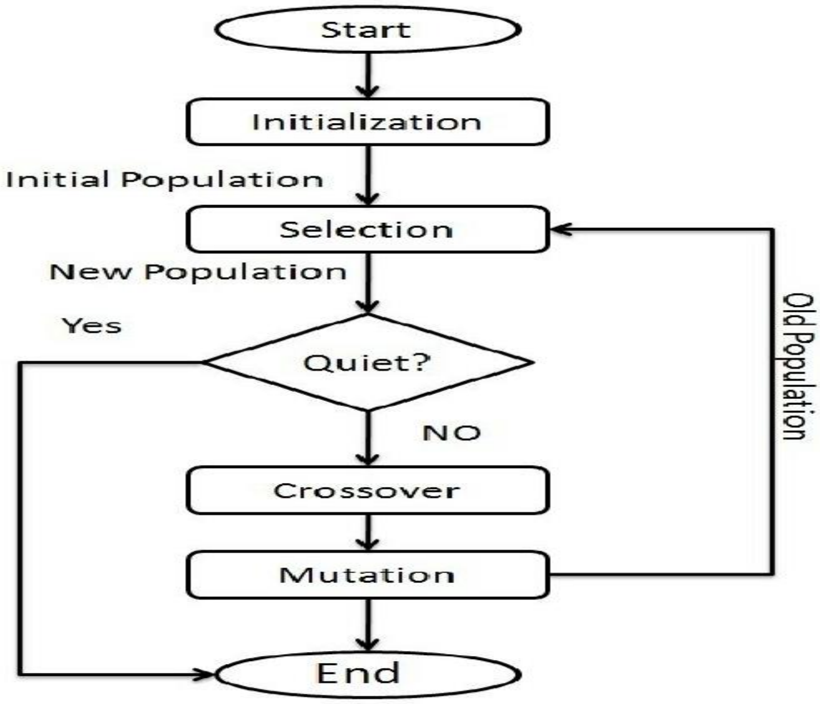

Figure 3.5 Flow Chart of GA

IV. COMPARISON OF OPTIMIZATION TECHNIQUES

Table 4.1: Review of different Optimization Techniques

Parameters	**GA**	**PSO**	**ACO**	**BPSO**	**FFO**
Developed	1960	1995	1997	2000	2007
Representation	In binary form as 0's and 1's, random variables	Dimensions for vector position and speed	Undirected Graph	Hyper cube	Attraction on foundation of distance r
Operators	Selection,crossover, Mutation	Initial values updates and evaluation.	Pherom one updates Evaporation and trial	Particle's local best and global best updated continuous	Light Intensity, attraction
Control Parameters	Population length,choice technique,crossover and mutation probabilit y, chromosomes,	Particles position,wide variety of particles,Range, weight, range of iterations	variety of ants, iterations,pherom one evaporation fee	Particles velocity, intertia weight	Attraction of fireflies,light intensity
Node Deployment	Random in addition to deterministic node deployment	Centralized nodes deploy - ment used to decide local best and global best position.	Nodes deployed in disbursed nature, utilized in dynamic packages	Nodes are organized into clusters based and distance	Nodes deployed in random manner
Clustering and routing	Reduce verbal exchange distance with formation of range of predefined clusters	Select higher power nodes as CHs in every round and find premier route	Find shortest route from supply to vacation spot and data transmission better	Node are organized into Clusters based on distance	Select nodes in Cluster on foundation of distance
Pros	1.Handle complicated problems and parallelism 2.Discret	1. It determines lbest and gbest position. 2. Inherently non-stop, no	1.Can be used in dynamic packages 2.Better for travelling	1.Overall system very fault tolerant and hard to bring down.	1.Effective in multi goal optimization

		overlapping and mutation calculation	salesman problem	2.Better for Travelling salesman Problem and scheduling	
Cons	1. It works simplest for randomly deployed nodes.	1.It can not paintings properly for scattering and optimizing 2. Not work well for non coordinate system	1. Local search is not sufficient 2.Consume big amount of energy if more quantity of paths.	1.A big value of the velocity shows that the current position of the particle is not proper. 2. very expensive	1. It works simplest for randomly deployed nodes.

V. CONCLUSION

There are a number of challenges in Wireless Body Area Networks viz. limited node energy, dynamic network topology, heterogeneous data generation rate, path loss, QoS etc that need to be addressed. For prevention of these limitations there is required an optimal energy resources that consume less energy. Numerous Optimization techniques like ACO, FFO, PSO, BPSO and GA used for optimization in wireless Body Area Network. This paper is an attempt to review the existing optimization techniques and presents a compressive analysis for the same on the basis of various parameters.

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