Optimizing Node Coverage and Lifespan of Body Area Network using Swarm Intelligence

Abstract

Swarm intelligence (SI) is the group performance of decentralized, self-organized systems, natural or artificial. Swarm intelligence techniques are heuristic stochastic processes.SI approaches can be generalized follows: All approach is a release with a set of a solution called group, and then in the following steps, each applicant of the collection learns together from other candidates and adapt itself in agreement to the resolution space. The approach included and knowledge mechanism of these techniques mostly minimum the essential information and phenomenon. Such nature-inspired mathematical models can be plugged into one framework. The applicability of a discrete version of a popular benchmark swarm intelligence algorithm called and its hybrid version for energy-optimized Body Area Sensor Network (BASN) using node coverage and network lifespan. Mainly successful classes of swarm intelligence (SI) based algorithm for solving energy-based life span optimization problem. The energy model for BASN by considering node coverage simulated in the Network Simulation tool (NS-2) environment.

Keywords: Body Area Sensor Network, Node coverage, lifespan, wireless sensor network, Swarm Intelligence.

• INTRODUCTION

Swarm intelligence is the meta-heuristic method used, and it gives an optimum solution to result in significant improvement in WBAN by optimizing network energy, coverage, and the level of lifespan increments. The entity information is obtained through the sensing device, and transmitted to the relevant service node through the network, thereby realizing human-object, object-object interconnection, and realizing intelligent identification, positioning, tracking, monitoring and management of the physical world [4].

Body area sensor coverage plays a significant role on the WBAN active network and its key aspects may only pass data on the wake-up time slot. Depending on condition or illness, the WBAN sensor nodes work. The maximum sensor is irreplaceable, so have to design the network for WSN needed to optimize the adversary parameters, extend the lifespan, energy consumption, and data delivery [7].

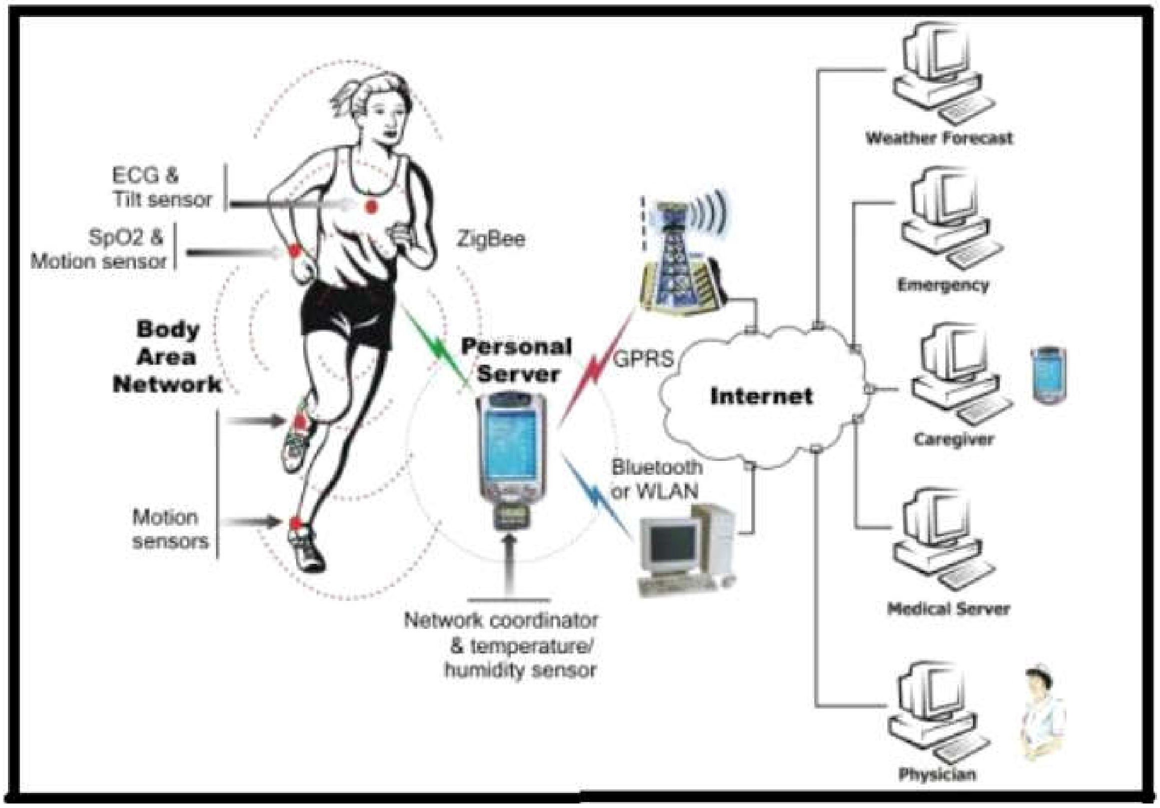

Figure1. Body area network architecture

An important step in the development of a WBAN is the characterization of the physical layer of the network, including an estimation of the delay spread and the path loss between two nodes on the body. This requires a detailed characterization of the electromagnetic wave propagation and antenna behaviour near the human body.

The advantage is that the patient doesn't have to stay in bed, but can move freely across the room and even leave the hospital for a while. This improves the quality of life for the patient and reduces hospital costs. In addition, data collected over a longer period and in the natural environment of the patient, offers more useful information, allowing for a more accurate and sometimes even faster diagnosis [2].

Review literature

WBAN depends on the energy consumption, since sensor nodes are battery powered which raise the issue of network lifetime. Hence, the overall performance can be enhanced by optimizing energy consumption in the network with the help of routing techniques. For any real-time wireless communication system, quality of service is considered as important aspect. There are various challenges present to meet the quality of service requirement for the users. Networking protocols play important role to satisfying the QoS requirement [6].

WBANs are typically constructed from single-hop and multi-hop methods. In certain cases, sensors may send their collected data directly to sink, and they also use Multi-Hop system. Multi-hop protocols are further classified into relay based and cooperative protocols. Mostly these types of protocols use multi-hop topology in WBAN for energy optimization and to prolong the network lifetime [3].

Swarm intelligence (SI) is one of the computational intelligence techniques which are used to solve complex problem. SI involves collective study of the individuals behaviour of population interact with one another locally. Especially for biological systems nature often act as an inspiration. Simple rules are followed by agents and no centralized control structure exists in order to predict the behaviour of individual agents. The random iteration of certain degree between the agents provides an "intelligent" behaviour which is then unknown to individual agents [1].

Proposed work

This section describes the required methods and materials for the proposed PSO and its hybridization for optimizing the node coverage and network lifespan. Combination of algorithm used to optimize the parameters for various problems.

Genetic algorithm:

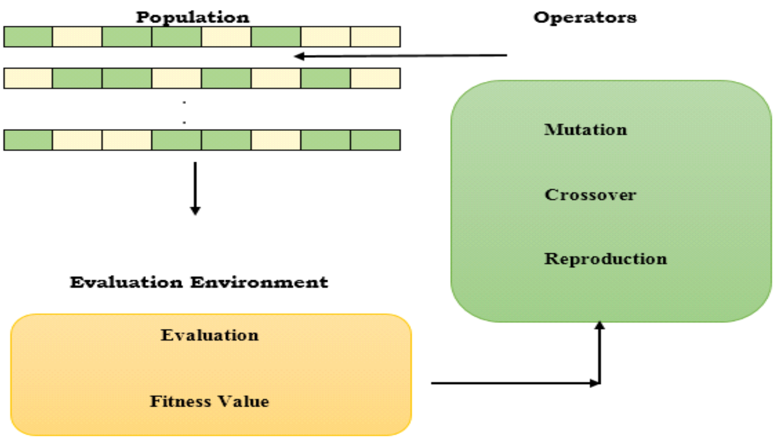

Figure 2. Genetic algorithm

PSO Algorithm:

The proposed work is the PSO based energy efficiency model for WBAN. It comes from PSO that is a population-based optimization method. It falls under the Meta-Heuristic Algorithm categories, which means that it could be used to solve numerous problems. They designed to identify the optimal global subset of active nodes for communication success and extended network life. This optimal global particle holds global optimal active nodes. It starts with a randomized population of initial solutions and searches for an optimal solution in the problem region. The potential solutions are called particles, which travel by their strongest particles in the problem space.

Algorithm 1: PSO Based Energy Model for Extended WBAN Lifespan

Input: Set of initial active nodes, Energy status of the nodes in WBAN

Output: best, the globally optimal set of active nodes

- Set initial particles // Initialization
- Initial the parameters (*v* and *p)* of each particle
- Set p*best* and g*best*
- Repeat

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        for each candidate
            update f and evaluation = f
        if update f > f (best(particle))
                Update best with the position        end if
        End for
    Update best
    Update v
    Update p
    until facing the stopping criteria
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- Return best as optimal global particle

Various optimization problems have been addressed using these algorithms and these have turned out to be an important tool in analyzing physical systems, in solving the complex problems and in searching for the best solution from a set of all possible feasible solutions. Particularly, global optimization (GO) has become very challenging in the development of computational fields. Search for the globally optimal solution is more crucial than that for local optima as the former corresponds to the correct and desirable solution.

Fitness function of every particle is executed and the fitness value (best solution) is calculated and stored. The fitness value of the current optimum particle is called “pbest.” PSO optimizes the best population value that is obtained so far by any particle in the neighbors and its location is called lbest.

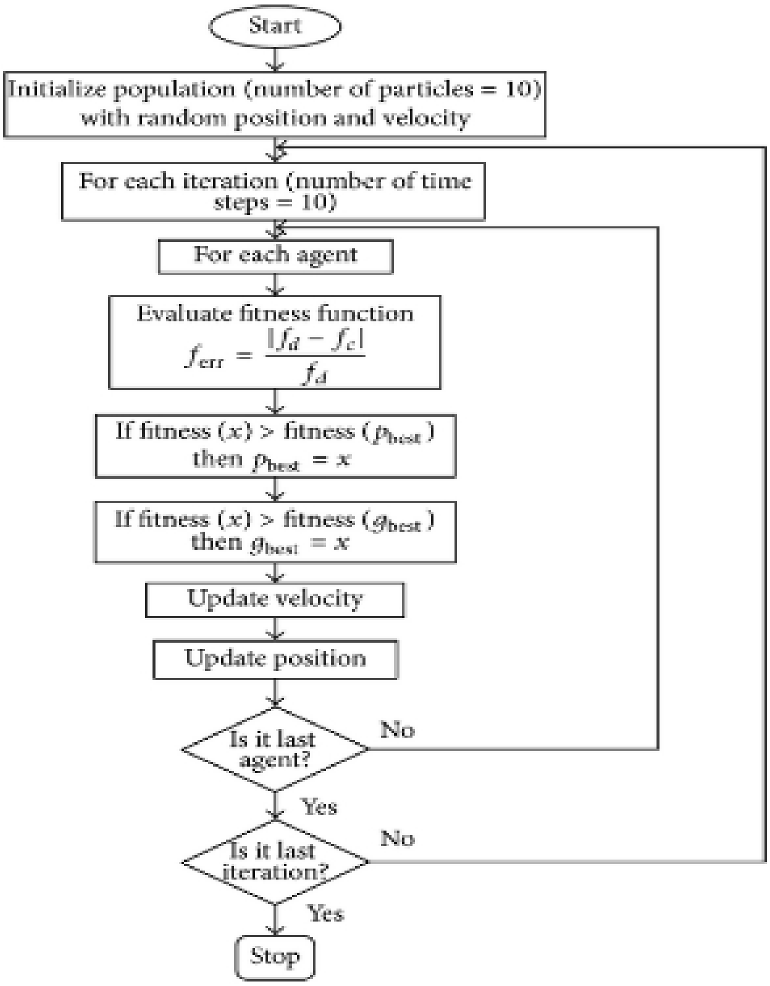


Figure3. Flowchart of PSO algorithm.

Ant Colony Optimization:

Ant colony optimization algorithm (ACO) is a probabilistic technique for solving computational problems which can be reduced to finding good paths through graphs. Artificial ants stand for multi-agent methods inspired by the behaviour of real ants. ACO is a method which is inspired from the foraging behaviour of some ant species. These ants deposit pheromone on the ground in order to mark their paths from the nest to food that should be followed by other members of the colony. This algorithm has a mechanism for solving discrete optimization problems in various engineering domains.

ACO-based routing protocol and aims to reduce the path distance and achieve load balance to some extent. During the process of path creation, both the energy levels of nodes and the path lengths to be constructed are taken into account to update the pheromone trail. The paths are created by forward ants and backward ants.

When the ant arrives at the destination node, it travels backwards through the visited path and updates the pheromone trail based on the energy quality and the number of nodes of the path. When the forward ant reaches the destination node, it is transformed into a backward ant, whose mission is to update the pheromone trail of its visited path that is stored in its memory. It is noted that, the memory of each ant is reduced to just two records, i.e. the last two visited nodes.

The ACO heuristic algorithm was later introduced by Dorigo and his collaborators for solving some combinatorial optimization problems. The general foraging behavior of ants is described below:

- The first ant finds the food source, via any way, and then returns to the nest, leaving behind a pheromone trail.
- Ants indiscriminately follow possible ways, but the strengthening of the runway makes it more attractive as the shortest route.
- Ants take the shortest route; long portions of other ways lose their trail pheromones.

Table 1. Parameters of ACO algorithm.

Parameter	Meaning
β	Relative importance of the heuristic factor
Jk (i)	Collection of cities that ant k allows selecting in the next step
t	times

τij(t)	Pheromone on the edge (I,j)
ηij	Visibility of pheromone on edge (I,j)
dij	Distance between cities (i,j)
m	Number of ants
k	Ant number
n	Number of cities
Δτij	Pheromone increment on edge (i,j) of this iteration
Δτ k ij	Pheromone quantity on edge (I,j) left by the ant k in this iteration pheromone evaporation (volatilization) coefficient.
ρ	1-p is the persistence (residual) coefficient where 0< p< 1
P k ij(t)	Probability of ant k moving from city i to city j at time t (transition probability)
$Tabu_k$	Tabu list for ant k

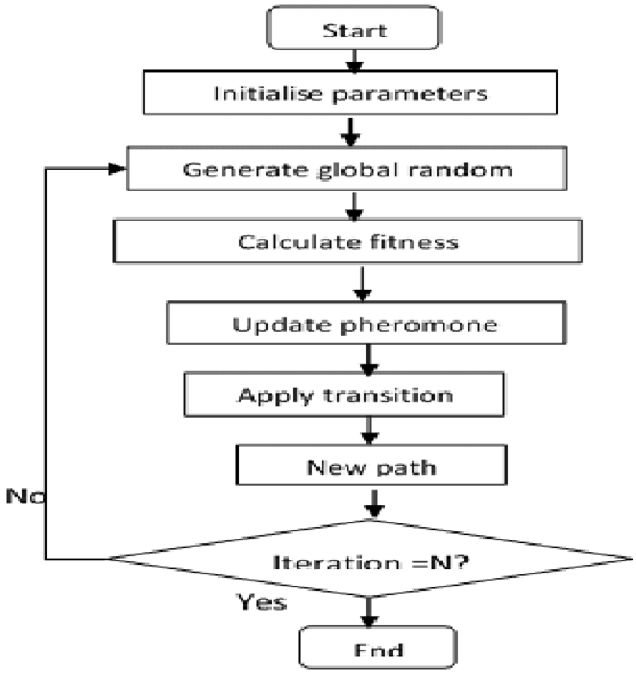


Figure4. Flow chart of ant colony optimization.

Simulation parameters:

Parameters	Value
Area	500 X 500

No. of Relay nodes	8
No. of sensor nodes	100
Transmission of relay nodes	50m
Propagation	Two Ray Ground
Network interface type	Wireless Phy
Traffic type	CBR, FTP
IEEE 802.15.4 Standard	Default values
Simulation time	1000 seconds
Initial energy	50 J
Energy threshold	20% of the initial energy
Sensors	EEG, ECG, Pulse, Motion, Blood Pressure, Blood Glucose

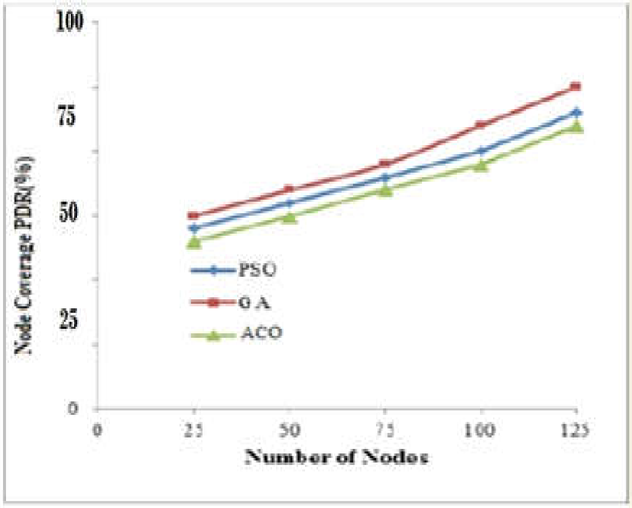
Result and discussion

The purpose of study is to evaluate the performance of ACO, GA and PSO for node coverage optimization in wireless body area network.

Packet delivery ratio:

Packet delivery ratio is the ratio of packets that are successfully delivered to a destination compared to the number of packets that have been sent by sender. In order to calculate packet delivery ratio we need total number of packets sent and number of received packets.

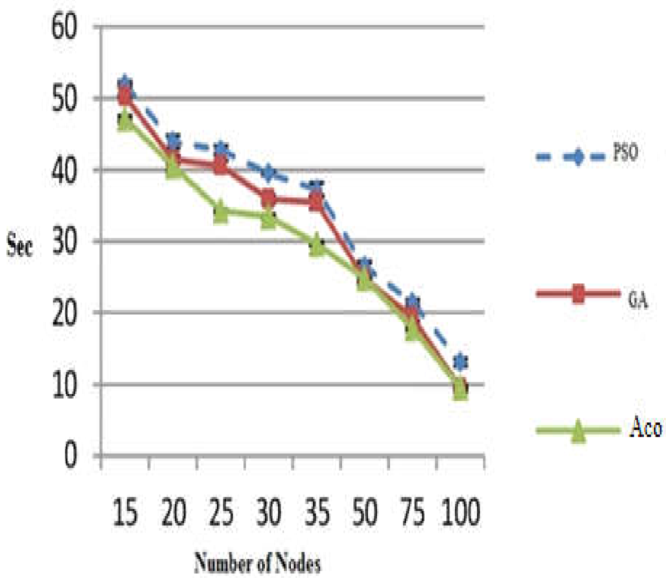
$$\text{Packet delivery ratio} = \frac{\sum \text{Number of packet received}}{\sum \text{Number of packet sent}}$$



End-to-end delay:

End-to-end delay or one-way delay (OWD) refers to the time taken for a packet to be transmitted across a network from source to destination. It is a common term in IP network monitoring, and differs from round-trip time (RTT) in that only path in the one direction from source to destination is measured.

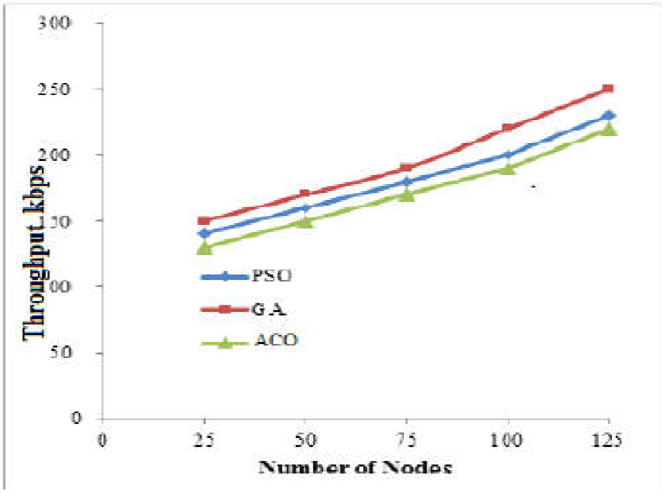
End to end delay = Received time – Send time



Throughput:

Throughput is an actual measure of how much data is successfully transferred from source to destination, and bandwidth is a theoretical measure of how much data could be transferred from source to destination.This used to express the numerical formula for throughput. Number of successful packet sent ratio.

Throughput = number of information packets (bits) / time period (sec).



Conclusion

In this work, QoS parameters such as packet transfer rate, end-to-end delay, and efficiency are accessed for coverage optimization of nodes in the WBAN. The PSO algorithm has removed the effect of ACO and GA algorithms on local convergence and improves consistency between knowledge sharing and filtering to find the best solution in the search area. Optimization algorithms revision in WBAN to improve several key issues such as energy efficient, power consumption, throughput, reliability, and duty cycle. These algorithms of optimization are offered a wide range of benefits to patients, healthcare monitoring, and staff in hospital to detect abnormal condition early. The future work is to optimize QoS using competition hypothesis in modelling mathematic with supportive communication.

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