Energy Efficient PSO Optimized Reliable Routing Scheme for WBAN

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Abstract- Wireless Body Area Network WBAN) is an emerging technology for delivering quality health care to users. Low power devices attached to the body have very limited battery life. So, it is desirable to have energy efficient routing protocols that maintain the required minimum reliability value for sending the data from a given node or source to the sink. This paper proposes comparison between two optimization techniques, GA and PSO. Genetic Algorithm (GA) is applied to the multi-objective cost function with residual energy and path loss as its parameters for selecting the most optimal route from a assigned body coordinator to the sink. Distance between any two sensor nodes is reduced by applying multi-hop approach. Performance of GA is compared with Particle Swarm Optimization (PSO) technique for energy aware routing by considering two parameters residual energy and path loss.

Keywords- WBAN, PSO, GA

I. INTRODUCTION

Wireless Body Area Network (WBAN) is fast emerging field in medical science with the association of sensor technology. In past many authors surveyed possibilities of various aspect of WBAN structures and methodologies [1-11].The WBAN has emerged as a new technology for patient monitoring and e-healthcare that produces it possible for the information of a patient's important body parameters and movements to be collected and analyzed via small wearable or implantable biosensors and communicated utilizing brief-variety wireless communication systems. A WBAN contains of on-physique and in-physique sensors (nodes) that systematically displays the consumer's important experience for analysis and prescription [6].Wireless Body Area Network (WBAN) guarantees progressive answers for E-Health. It consists of some of tiny devises referred to as "sensors" connected to the human body. These sensors constantly monitor the patient health country, even as he's doing his daily interest, to be communicated to the specialized medical server or entity (physician, emergency, and laboratory). Some patients need a long time and real time supervision of their vital symptoms like ECG (electrocardiography) and glucose level. WBAN, then, permits the early detection and intervention to keep the affected person existence.

In this paper energy efficient optimization is implemented for reliable routing scheme using swarm optimization algorithm known as particle swarm optimization (PSO). Further we compared performance of WBAN for longest lifespan of network and energy efficiency using Genetic Algorithm (GA). Parameters considered for comparison are taken standard parameters such as path loss, residual energy and cost function of both optimization algorithm. It was found that results of PSO based routing algorithm were better than results of GA for same network parameters and configuration.

II. PARTICLE SWARM OPTIMIZATION

Particle swarm optimization (PSO) is a population based stochastic optimization technique developed by Dr. Eberhart and Dr. Kennedy in 1995, inspired by social behavior of bird flocking or fish schooling.Particle Swarm Optimization (PSO) algorithm is implemented to optimize the weights of cost function to increase the network lifetime. The PSO defines all the particles in the D-dimensional space as $X_i = (x_{i1}, x_{i2}, ..., x_{iD})$, where the subscript 'i' represents the particle number. The memory of the previous best position is represented as $P_i = (p_{i1}, p_{i2}, ..., p_{iD})$, and a velocity for each dimension is independently established as $V_i = (v_{i1}, v_{i2}, ..., v_{iD})$. After each iteration, the velocity term is updated, and the particles moved with some randomness in the direction of their own best positions, *pbest*, and the global best position, *gbest*. This is apparent in the velocity update equation, given by

$$V_{id}^{(t+1)} = \omega \times V_{id}^{(t)} + U[0,1] \times \psi_1 \times (p_{id}^{(t)} - x_{id}^{(t)}) + U[0,1] \times \psi_2 \times (p_{gd}^{(t)} - x_{id}^{(t)}) \quad (1)$$

The position is updated using this velocity and

$$X_{id}^{(t+1)} = X_{id}^{(t)} + V_{id}^{(t+1)} \quad (2)$$

where U [0,1] samples a uniform random distribution, t is a relative time index, ψ_1 and ψ_2 are weights trading off the impact of the local best and global best solutions' on the particle's total velocity.

III. PROPOSED WORK

We implemented Genetic Algorithm (GA) algorithm in a WBAN having 9 sensors at all important locations of body.GA is used for increasing lifetime of network. We compared performance of GA with Particle Swarm Optimization (PSO) with the help of multi-objective cost function having two parameters, first is residual energy of node and second is pathloss.

The residual energy (RE) is the most important variable which can affect the network lifetime. If a node with low RE exist, it may soon become powerless an inoperable. RE also depends upon the distance between a node and the sink that determines the energy consumption of the node. These input variables are considered to avoid selecting low energy nodes (RE) to minimize the total energy consumption of nodes. Second is pathloss which is determined by friis transmission formula.

A cost function or fitness function with two inputs RE and PL and one output C_k can be shown as w_1

$$C_k = w1 \times RE + w2 \times PL \quad (3)$$

Where w1, w2 are weights of two variables, RE and PL. Range of w1 and w2 are taken as

0.5<w1<1 (4)

0<w2<1-w1 (5)

w1+w2=1 (6)

Normalization function used to normalize input variable with in required range is given below.

$$\text{Normalized } x_i = \frac{x_i - \min(x)}{\max(x) - \min(x)} \quad (7)$$

Table 1 Location of bio-sensors on patient's body

Node no	X coordinates cm	Y coordinates cm
1	364.25	352.25
2	212.75	550.25
3	95.74	553.25
4	487.25	539.75
5	202.25	655.25
6	409.25	644.75
7	392.75	830.75
8	214.25	1093.25
BC	395.75	541.25

Eight bio-sensors and a Body Coordinator (BC) is used to create WBAN environment in a standard human body of 175 cm height. Location of bio-sensors are given in table 1 using X-Y coordinates on body and shown in figure 1.

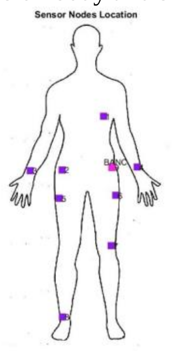

Fig 1: Locations of Bio-sensors on human body

Residual energy of each node is calculated by using equation (8) and (9).A radio dissipates $E_{elec} \times l$ to run either the transmitter or the receiver circuitry. The energy consumption for transmitter an l bit data packet with distance d.

$$E_{TD}(l \times d) = \begin{cases} l \times E_{elec} + l \times \varepsilon_{fs} \times d^2 & if\ d \leq d_0 \\ l \times E_{elec} + l \times \varepsilon_{amp} \times d^4 & if\ d > d_0 \end{cases} (6) \quad (8)$$

$$E_{RX}(l) = l \times E_{elec} \quad (9)$$

Where E_{elec} is the dissipated energy (per bit) in every transmitter and receiver circuit, and depends on such electronics factors as digital coding, modulation, filtering and spreading of the signal. The amplifier parameter used for free space and multipath environment ε_{fs} and ε_{amp}respectively. The distance threshold d_0 is defined as $d_0 = \sqrt{\varepsilon_{fs}/\varepsilon_{amp}}$.

PL can be calculated by using Friss transmission formula in free space.

$$PL(d) = PL(d_0) + 10n\log(\frac{d}{d_0}) \quad (10)$$

Where PL(d_0) is the path loss in dB at a reference distance d_0 and is calculated using equation (9) and n is path loss exponent taken 3 for inside body scenario.

$$PL_{d0} = 20\log(\frac{4\pi d_0 f}{c}) \quad (11)$$

Here

f- Frequency of operation for WBAN (2360-2390 MHz) IEEE 802.15.6

c- velocity of light

The body movement and moving parts can cause variation in the path loss value due to change in distance between sensor nodes. So, the PL can deviate from its mean value and phenomena is called shadowing. It is assumed that path loss and shadowing affect the link between two nodes. So considering effect of shadowing PL become:

$$PL = PL(d) + X_\sigma \quad (12)$$

Here X_σ is a shadowing factor in db, which is a Gaussian-distributed random variable with zero mean and a standard deviation σ.

Distance between k and d nodes is calculated using equation (13)

$$dist_{k,d} = \sqrt{(x_k - x_d)^2 + (y_k - y_d)^2} \quad (13)$$

IV. RESULTS

In this work comparison of standard genetic algorithm with PSO algorithm carried out for WBAN architecture having nine nodes placed at different location on body.

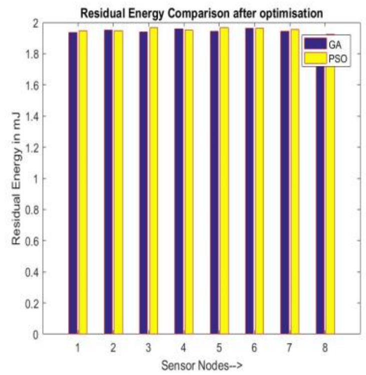

Fig 2: Residual Energy comparison between PSO and GA

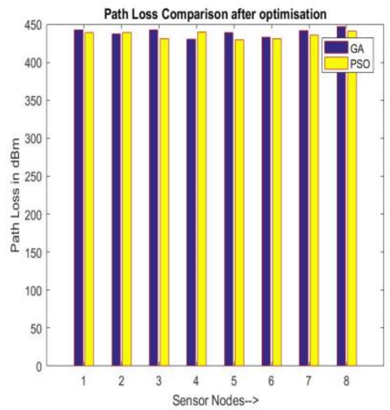

Fig 3: Path loss comparison between PSO and GA

Figure 2-3 shows comparison between residual energy and path loss between PSO and GA based routing algorithm. It is clearly evident from figure 2 that residual energy is higher for PSO based optimization in comparison to GA based optimization. Similarly pathloss which is calculated using friss transmission formula is less for our PSO based optimization than standard GA based optimization. We have chosen these two parameters because they are standard and solely responsible for network stability and lifetime.

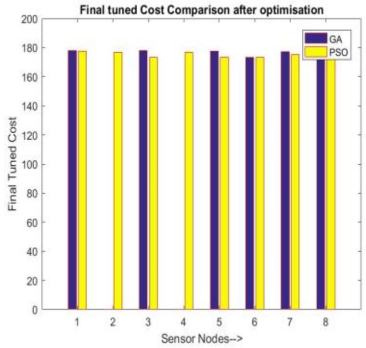

Fig 4: Final tuned cost comparison between PSO and GA

Figure 4 shows comparison between tuned cost function by using PSO and GA for WBAN routing optimization. Cost function is a function using residual energy and path loss of each node which is to be minimized by optimization algorithm. It is seen from figure 4 that cost function is less for PSO based optimization than GA based optimization.

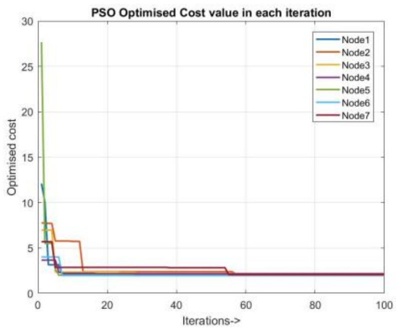

Fig 5: PSO optimized cost value in each iteration

Figure 5 shows iteration wise cost value for each node in the case of PSO based optimization.it is seen from figure 5 that cost value optimize for less number of iteration for each node , hence taking less time.

Table.2: Comparison between tuned multi-hop Path from source to sink node for PSO and GA based optimization

Source node	Neighbour node by PSO	Neighbour node by GA	Destination node / BC
1	2	4	9
2	4	4	9
3	2	2	9
4	2	2	9
5	1	2	9
6	2	4	9
7	3	2	9
8	7	7	9

V. CONCLUSIONS

It is found that residual energy and path loss results are much better in case of PSO tuned weights of sensor nodes of WBAN, in comparison to GA tuned weights. It is also observed that process time taken by using PSO is less than GA based optimization. Hence, we can conclude that our comparison of PSO and GA for efficient energy model of WBAN is successful and PSO performs better than GA in small WBAN environment having nine sensor nodes positioned at specific locations of body. In future we can use energy harvesting technique also for energy retaining in sensor nodes.

VI. REFERENCES

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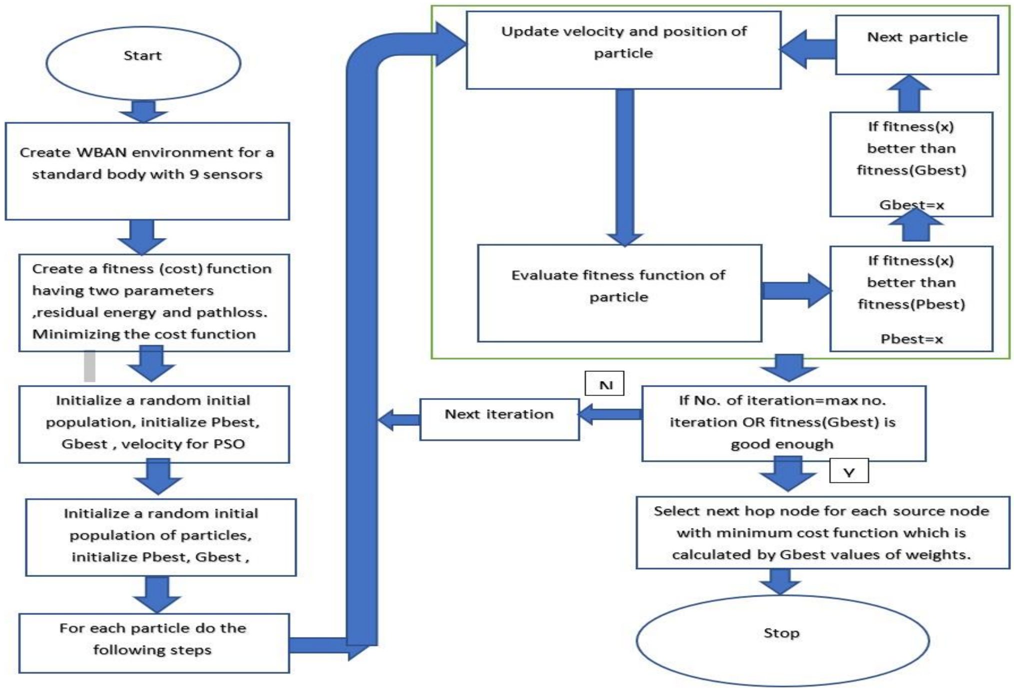

Fig 6: Complete work flow diagram using PSO