PSO Optimized Energy Efficient WBAN

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Abstract- It is quite evident that average lifespan is increasing and for the healthcare managements the investments provide by the health treatments gives cost effective solutions. The quality of healthcare provided to the user by using the Wireless Body Area Network (WBAN) technology. The devices which are attached to the body having low battery life due to low power range. Some protocols are used which are energy efficient maintain the reliability for the overall process i.e. sending the data from source to sink. For this purpose we use two optimization techniques genetic algorithm and particle swarm optimization. These two methods are applied to the coat functions which are multi objective in nature with path loss and residual energy and find the optimal solution from a body coordinator to the sink. An approach is used which reduced the distance between any two sensor nodes called multi-hop approach. The comparison between PSO and GA is done on the basis of two parameters residual energy and path loss for energy aware. It also provides a comprehensive energy model to calculate the residual energy of the network and throughput of the network. After comparison of both optimization techniques on WBAN networks having sensor at all important locations of body, the results shows an improved performance in terms of energy efficiency.

I. INTRODUCTION

a. Wireless Body Area Networks (WBANs)

A WBAN topology often includes of many low value and extremely energy skillful bio-sensor nodes, some nodes with high capability showing as grasp nodes having excessive computational capabilities and facilitate for larger data rates as a router. A WBAN contains of on-physique and in-physique sensors (nodes) that systematically display 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 short devices referred to as "sensors" connected to the human body. The function of these sensors to monitor the human health country even when he/she did his/her daily interest connects to the medical server (physician, emergency, and laboratory). Like ECG and glucose level patients required long time and real time supervision. The main advantage of the Wireless Body Area Network (WBAN) grows extensively regarding its adjustments, accuracy, expenses performance and mobility. It helps a large range of revolutionary packages that advance the first-rate of lifestyles and decorate services.

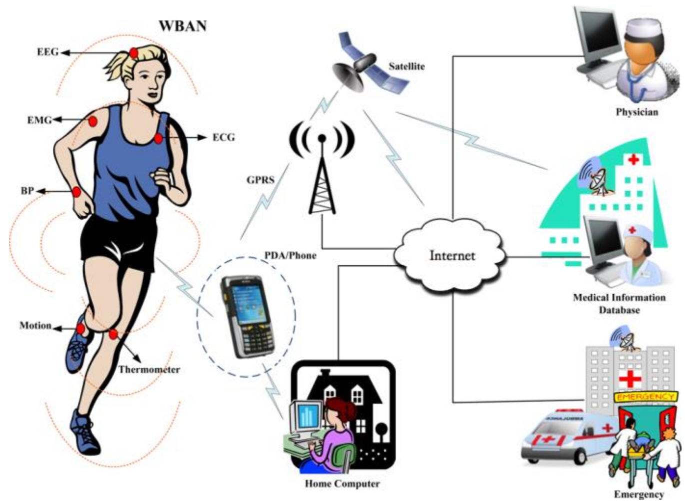

Fig.1: common structure of a WBAN-situated wellbeing monitoring method [2]

The structure of WBANs is classified into three foremost classes established on the basis of nodes achievements as shown in the Fig. 2 [2]:

- Intra-BAN communications
- Inter-BAN communications
- Past-BAN communications

These categories quilt quite a lot of features that variety from simple to problematic design problems, and simplifies the formation of a element-founded, effective BAN process for a extensive variety of functions. Explicit specifications may also be finished in line with certain purposes by means of customizing design components.

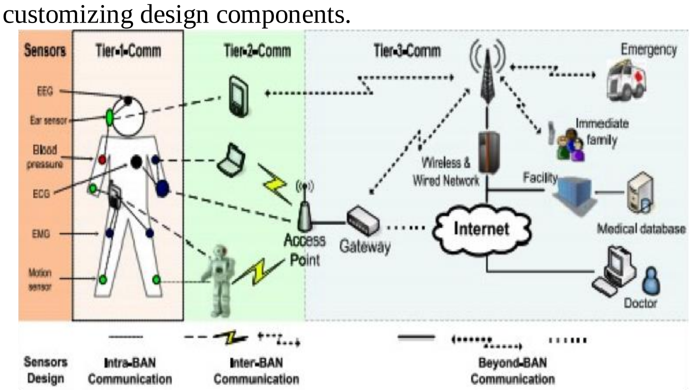

Fig.2: 3 Tier Architecture of WBAN [2]

a. Characteristics of WBANs

Following are the considerable amount of principal attributes of WBANs:

- WBAN is a multi-bounce remote system.
- It helps advert hoc systems administration and good of self-framing, self-organization and self-fixes
- Mobility reliance on the sort of work hubs
- It has various kind of network get to
- Vigor-utilization requirements are depending on the type of work hubs
- It is appropriate and interoperable with current Wi-Fi systems.

Multi-Hop Wi-Fi networks increases the insurance plan area of gift wireless networks without affecting the channel ability and furnish non-line-of-sight (NLOS) connectivity among the customers where direct line of sight (LOS) links usually are not to be had. This is realized via shorter hyperlink distances, extra effective frequency reuse, and not more interference between the nodes. Aid for ad hoc networking and compatibility of self-forming and self-organizing function enable WBANs with low upfront funding requirement and steadily the community can be improved when wanted. More than one variety of networks entry and offerings will also be furnished to the end users by integrating WBANs with other wireless networks.

Wireless physique area community (WBAN) is a body-centric wearable or implantable Wi-Fi sensor network ready to participate in actual time physiological knowledge assortment and transmission. It plays a large role in subsequent generation wireless networks and distant scientific techniques. There has been developing concentration from research corporations on WBAN not too long ago [1-5]. For effective deployment of physique field networks that may perform long-lasting and continuous monitoring of scientific parameters, it's main that the wearable and implantable devices ought to be small, light-weight and knowledgeable in vigor usage. Kinds of viable purpose of WBAN are strictly confined due to the fact of battery lifetime. The sensors employed in WBANs usually use batteries which might be seldom replaced or recharged, which makes energy efficiency some of the enormous obstacle to be viewed. It is cantered that wireless communication part is the highest power ingesting section on the sensor node. As a result, energy effectively optimization is pretty much required in WBANs [3-4].

b. Objectives

To study various existing approaches of interaction or communication in WBANs also propose a model for cost evaluation of links between the objects, to design a soft computing based approach for WBANs and record the performance of proposed algorithm for various scenarios.

II. PARTICLE SWARM OPTIMIZATION

Particle swarm optimization (PSO) is a populace based stochastic advancement procedure created by Dr. Eberhart and Dr. Kennedy in 1995, roused by social conduct of feathered creature running or fish tutoring.

PSO imparts numerous similitude’s to developmental calculation systems, for example, Hereditary Calculations (GA). The framework is instated with a populace of arbitrary arrangements and scans for optima by refreshing ages. Be that as it may, not at all like GA, PSO has no advancement administrators, for example, hybrid and change. In PSO, the potential arrangements, called particles, fly through the issue space by following the present ideal particles. Contrasted with GA, the upsides of PSO are that PSO is anything but difficult to execute and there are couple of parameters to change. PSO has been effectively connected in numerous regions: work enhancement, fake neural system preparing, fluffy framework control, and different zones.

The pseudo code of the methodology is as per the following

```
For every molecule
Introduce molecule
END
Do
For every molecule
Figure wellness esteem
On the off chance that the wellness esteem is superior to
anything the best wellness esteem (pBest) in history
set current incentive as the new pBest
End
Pick the molecule with the best wellness estimation of
the considerable number of particles as the gBest
For every molecule
Compute molecule speed agreeing condition (a)
Refresh molecule position concurring condition (b)
End
```

While most extreme emphases or least mistake criteria isn't accomplishedParticles' velocities on each dimension are clamped to a maximum velocity Vmax. If the sum of accelerations would cause the velocity on that dimension to exceed Vmax, which is a parameter specified by the user, then the velocity on that dimension is limited to Vmax

III. PROPOSED WORK

Wireless BodyArea Network (WBAN)is a rising innovation for conveying quality wellbeing care to clients. Low power gadgets appended to the body have exceptionally restricted battery life. In this way, it is alluring to have vitality proficient steering conventions that keep up the required least unwavering quality incentive for sending the information from a given hub or source to the sink. This postulation proposes correlation between two enhancement procedures, GA and PSO. Genetic Algorithm (GA) is connected to the multi target cost work with leftover vitality and way misfortune as its parameters for choosing the most ideal course from a relegated body facilitator to the sink. Separation between any two sensor hubs is diminished by applying multi-bounce approach. Execution of GA is contrasted and Molecule Swarm Streamlining (PSO) method for vitality mindful steering by thinking about two parameter residual energy and path loss. In our work, we implemented Genetic Algorithm (GA) algorithm in a BAN 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 path loss. The main steps of our work can be summarized as follows:

• WBAN environment is created using a standard body height of 175 cm and 9 sensors at all important locations. One centre is assigned as body coordinator or sink node which will collect data from all other sensors.

• A cost function is made to calculate two parameters, first is residual energy (RE) which depends upon distance of node from body coordinator. Second is path loss which depends on Friis transmission formula and path loss.

• Genetic Algorithm (GA) algorithm is implemented to optimize the weights of cost function to prolong the network lifetime, based on the different application specifications.

• Particle Swarm Optimization (PSO) algorithm is implemented to optimize the weights of cost function to increase the network lifetime. Performance of both techniques is compared on the basis of residual energy and Flow chart of our work is given below for easy understanding.

An efficient WBAN system should have high residual energy of each nodes and minimum path loss between sources and sink nodes. To make longer network lifetime, we created a cost function which is dependent upon two parameters. These are:

1. Residual energy of node (RE)
2. Path loss (PL)

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 path loss 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

$$C_k = w1 \times RE + w2 \times PL \quad (1)$$

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

$$0.5<w1<1 \quad (2)$$

$$0<w2<1-w1 \quad (3)$$

$$w1+w2=1 \quad (4)$$

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

$$Normalized x_i = \frac{x_i - \min(x)}{\max(x) - \min(x)} \quad (5)$$

a. Calculation of Residual energy

In each round, the hubs sense the WBAN condition and send the acquired data to the sink. The sink is in charge of accepting the information from hubs, and sending this data to the client end. All hubs have similar abilities of detecting, handling and conveying. Every hub can discuss straightforwardly with the sink and with different hubs. The primary request radio correspondence is utilized to display the disseminated vitality. In this model, a radio disseminates $E_{elec} \times l$ to run either the transmitter or the beneficiary hardware.

$$E_{TD}(l \times d) = \begin{Bmatrix} l \times E_{elec} + l \times \varepsilon_{fs} \times d^2 if d \le d_0 \\ l \times E_{elec} + l \times \varepsilon_{amp} \times d^4 if d > d_0 \end{Bmatrix} (6)$$

$$E_{RX}(l) = l \times E_{elec} (7)$$

Where E_{elec} is the disseminated vitality (per bit) in each transmitter and recipient circuit, and relies upon such hardware factors as computerized coding, tweak, separating and spreading of the flag. The speaker parameter utilized with the expectation of complimentary space and multipath conditionε_{fs} and ε_{amp}respectively. The distance threshold d_0 is defined as $d_0 = \sqrt{\varepsilon_{fs}/\varepsilon_{amp}}$

b. Calculation of Path Loss

Path loss may be characterized as a decrease in control thickness of electromagnetic waves. In the on body proliferation display, between sensor correspondences can happen when the transmitted signs spread through the body. Flag ought to diffract around body the body or reflected off by close-by diversions and after that back to body. Distance and frequency predominantly affect value of path loss. PL can be calculated by using Friss transmission formula in free space.

$$PL(d) = PL(d_0) + 10n\log(\frac{d}{d_0}) \qquad (8)$$

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.

$$PL_{d0} = 20\log(\frac{4\pi d_0 f}{c}) \qquad (9)$$

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

C=velocity of light

The body development and moving parts can cause variety in the way misfortune esteem because of progress in separate between sensor hubs. Along these lines, the PL can go astray from its mean esteem and marvels are called shadowing. It is accepted that way misfortune and shadowing influence the connection between two hubs. SO considering impact of shadowing PL progress toward becoming:

$$PL = PL(d) + X_\sigma \qquad (10)$$

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

Distance between k and d nodes is calculated using

$$dist_{k,d} = \sqrt{(x_k - x_d)^2 + (y_k - y_d)^2} \qquad (11)$$

c. Performance Evaluation

With a specific end goal to show the viability of the proposed, the greatest and standard deviation of cost work is utilized to think about GA and PSO algorithms. The standard deviation of least cost capacity can be communicated as

$$STD = \sqrt{\frac{1}{N}\sum_{J=1}^{M}\sum_{i=1}^{N}(x_i\, a_{ij} - c_j)^2} \qquad (12)$$

With a specific end goal to exhibit the viability of the PSO, recreation after effects of the both calculation are analyzed for 50mx50m, 100mx100m and 200x200m geographical area.The base station situated at the focal point of the system. All sensors have a similar beginning vitality.

A step by step algorithm for the proposed work is given as:

STEP1. Initialize the WBAN sensor nodes population in physical body at all important locations.

STEP2. Create a cost or fitness function which depends upon two parameters Residual Energy of sensor nodes (RE) and path loss (PL). RE depends upon distance between sensor node, neighbor node and destination node, as it is multi-hop communication approach.

STEP3. Initialize random positions and directions of particles of PSO

STEP4. Update velocity and positions of particle using cost function for every particle.

STEP5. Do iterations until best value of cost function is achieved.

STEP6. Do iteration for multi-hop approach when each node is source node and destination node is fixed. Determine neighbor table (NT). Update value of cost function for each node as source in NT table.

STEP7. Find out the value and position of neighbor node with minimum cost function.

STEP8. Result will be positions and weight of particle of PSO with minimum cost or fitness function output.

IV. RESULTS AND DISCUSSION

We used PSO optimiztion to reduce the enregy consumption in the WBAN network and PSO chose the path with maximum residual energy and at least distance to main head node. We compared the results with genetic algorithm which did the same work but got less consumed path than PSO optimzed results. The comparison of optimization curve is shown in figure 3 and 4 for PSO and GA convergence respectivelt. Both tune for common objective function given in equation 12 . For a good optimizaiton the convergence curve must be decreasing and after few iterations, it should reach at a saturation value which don't changes further.

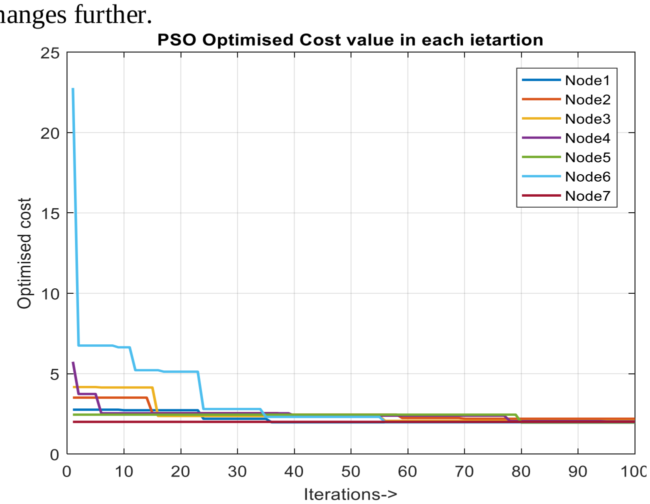

Fig.3: PSO optimized convergence curve

The optimal path selected by PSO algorithm for each source nodes to sensor is shown in table 1. The distance travelled in that path is also shown. The path followed by GA tuned method for all souce nodes is shown in table 2 along with total travelled distance.

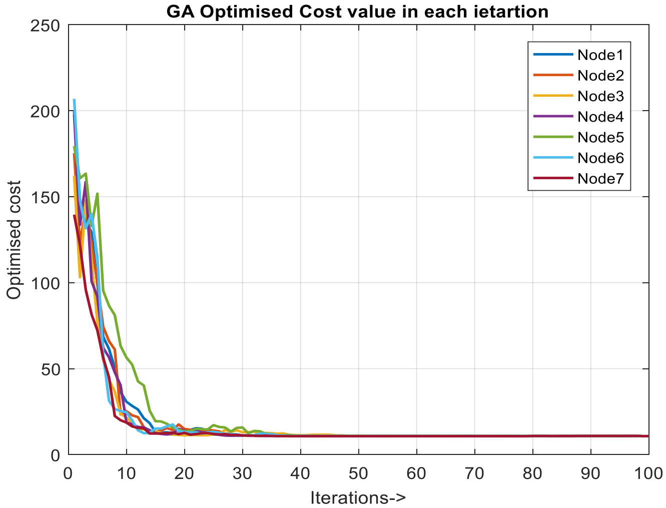

Fig.4: GA optimized convergence curve

Table 1 PSO tuned multi-hop Path from source to sink node

Source node	Neighbour node	Destination node / BC	Total Distance (in cm)
1	2	9	44.4905
2	4	9	44.8420
3	1	9	58.2082
4	2	9	41.0049
5	6	9	39.5769
6	2	9	35.3391
7	4	9	47.9678
8	6	9	67.7560

Table 2 GA tuned multi-hop Path from source to sink node

Source node	Neighbour node	Destination node / BC	Total Distance (in cm)
1	4	9	46.0848
2	4	9	44.8420
3	2	9	25.2387
4	2	9	41.0049
5	2	9	24.0872
6	4	9	30.4520
7	6	9	37.5233
8	7	9	67.8708

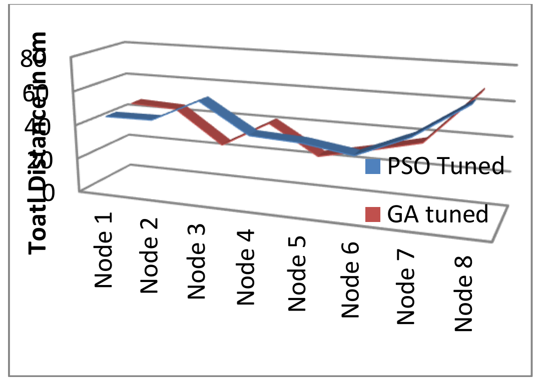

Fig.5: Total distance comparison of each WBAN source node to sink node in cm

A comparative bar plot for distance travelled fopr each path is shown in figure 5. The less is path travelled, more is the residual energy. The corresponding residual energy curve is shown in figure 6. It is also a comparative bar graph which shows that PSO tuned path has more residual energy in their nodes. It shows that node 8 has maximum residual energy and PSO tuned path uses least of them. A distribution of residual energy of each node with the distance of each node to sensor is shwon in figure 7. Since the RE is proportional to distance, so the node which is nearer to sink node consumes less energy, so node 8 has the minimum RE as it is farthest from sink node.

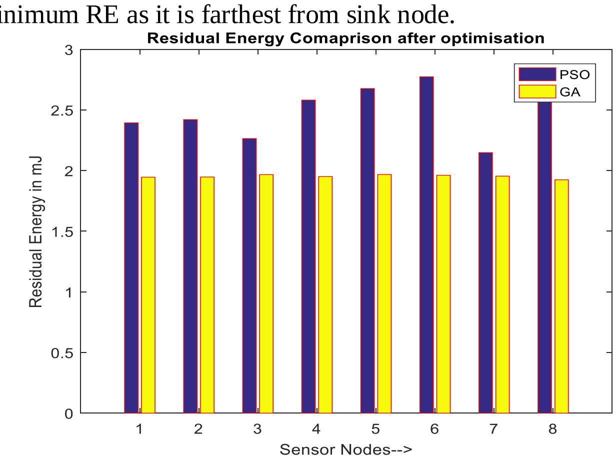

Fig.6: Residual energy comparison between PSO and GA

The residual energy comparative table is shown in table 3.

Table 3 RE Table

GA	1.94	1.94	1.96	1.95	1.96	1.96	1.94	1.92
PSO	2.1	2.6	2.67	2.20	2.01	2.48	2.32	2.55

The path loss component is also calculated for packet transfer in WBAN. The tabel 4 shows the path loss component and figure 8 shows the bar graph for compariosn in PSO and GA.

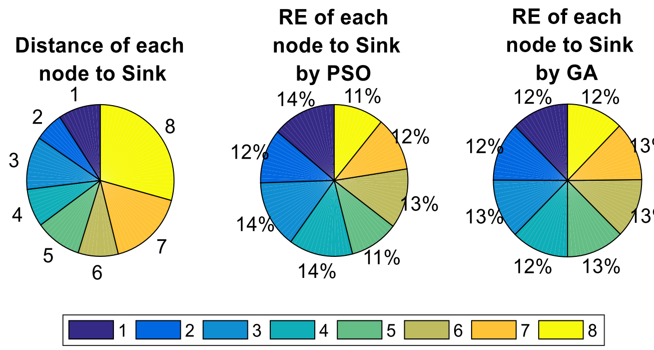

Fig.7: Distibution of RE energy by PSO and GA tuned path w.r.t. distance of each node to sink

Table 4 Path Loss table

GA	440	440	430	437	431	432	443	440
PSO	438	439	430	439	442	436	444	441

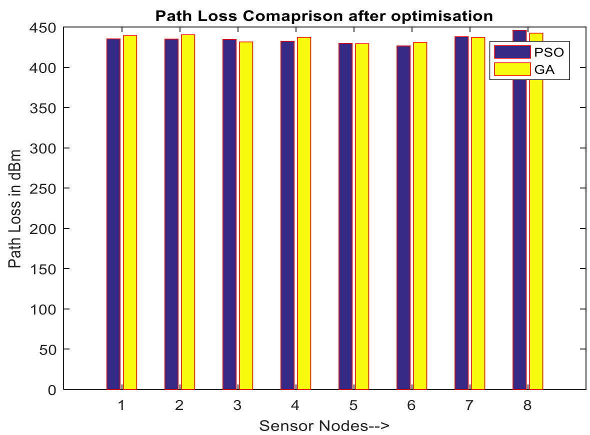

Fig.8: Path loss comparison between PSO and GA

The objective function is the cost function which takes the RE and path loss component into consideration. The final tuned objective function value by PSO and GA for each source node is shown in table 5 and a bar plot is shown in figure 9.

Table 5 Cost function Table

GA	177	176	173	177	172	174	28	177
PSO	2.03	2.76	7.31	23.5	12.1	2.62	2.1	7.57

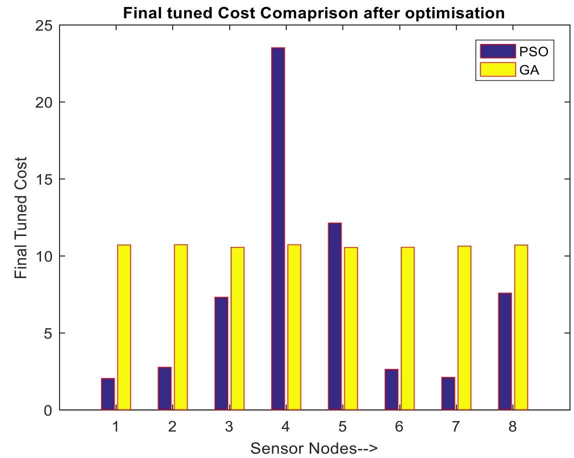

Fig.9: Final tuned cost comparison between PSO and GA

V. CONCLUSION

This proposition presents correlation among GA and PSO - the vitality productive improved dependable directing plans for WBAN considering its consistent system operation so that WBAN supports its usefulness for the longest life time. The proposed cost work is an element of hub's lingering vitality and path loss. Hub with least estimation of the cost work is chosen as the forwarder node or next bounce hub. Other than the vitality utilization, path loss demonstrates utilizing Genetic Algorithm (GA) based advancement for vitality productive directing is provided in this work. The execution of GA is compared with Particle Swarm Optimization (PSO) as far as vitality utilization, throughput and path loss. The numerical outcomes outline that PSO could accomplish more vitality investment funds when contrasted with GA. Hence the expanded lifetime makes PSO significant for expanding the effectiveness of WBAN as an instrument for quiet consideration. The execution of PSO is compared with GA which demonstrates lesser vitality utilization of PSO as compared to GA due to multi-jump correspondence approach.

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