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Particle Swarm Optimization for Wireless Sensor Network Deployment Design by Taking Account of Barrier Position and Attenuation

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***Abstract*—Connectivity in the deployment of sensor nodes is an important part of the Wireless Sensor Network (WSN). The existence of barrier such as wall introduces damping or attenuation to power transmit of WSN, in which can degrades the communication range among nodes. This research studies the deployment system of WSN in indoor environment with barrier based on Particle Swarm Optimization (PSO) algorithm. PSO optimizes the position of WSN by providing global best position solution at each iteration. Different number and position of barrier are used to show the effect of the presence of a barrier on the deployment results. The simulations show that the deployment of sensor networks using PSO algorithm in indoor environment with barrier generates network solutions in which their connections are maintained on transmit power variation, number of barrier and their position.**

Keywords—connectivity, deployment, WSN, PSO, barrier

I. INTRODUCTION

Wireless Sensor Network (WSN) is a computer network that consists of several intercommunicating computers are equipped with one or several sensors [1]. WSN technology has many advantages in its implementation such as small size, low power consumption and use wireless communications so that suitable for any condition of environment. Deployment of nodes is a fundamental problem that must be solved in a WSN. Proper placement of nodes can reduce the complexity of routing problem in WSN such as data fusion, communication between nodes and the other [2]. In addition, the proper placement of sensor nodes can extend the life-time of WSN and thus, maintain a good connectivity among nodes.

Barrier such as wall, building, block house, or unpredicted barrier often exists in sensing area. It significantly affects the connectivity and coverage area of sensor node and therefore it may affect the deployment solution of sensor nodes. The existance of barrier reduces the communication range between sensor nodes. Deploying WSN without considering the barrier is very likely to result holes in coverage area and needs to spend longer time on deploying sensor node. The existance of barrier reduces the communication range between sensor nodes.

Research on the effects of radio wave propagation of mobile radio communications in indoor indicate that the largest attenuation occurs in the rooms are dominated by the concrete wall. This suggests a strong correlation between attenuation and propagation constant of a room [3].

Generally, researchers use the optimization algorithm to solve the WSN deployment problems in indoor environment with or without barrier. Several researcher have tried to offer new algorithms such as robot deployment algorithm to overcome unpredicted obstacles and to optimize the distribution area for the minimal sensor nodes [4]. Additionally, the Obstacle-Resistant Robot Deployment (ORRD) algorithm involves the placement of node design policy, serpentine movement policy, the obstacles handling, and boundary width. The algorithm can quickly deploy minimal number of sensor nodes covering the sensing area and handle regular or irregular obstacles [5].

Other researchers used Particle Swarm Optimization algorithm to control the mobility of nanosensor in WSN with the objective to increase the life-time and improve the network performance of the nanosensor. Simulation results show that the proposed optimization algorithm improves the network coverage by better utilization of neighbour nodes. The results also demonstrate that the algorithm increases nanosensor life-time [6]. The PSO algorithm has been applied in the deployment of sensor nodes to reduce the complexity and improve the quality of service (QoS) of WSN applications. Simulation results show that the proposed algorithm generates superior results in comparison with the traditional deployment on coverage area [7].

Particle Swarm Optimization (PSO) algorithm also has been implemented in developing sensor nodes in free space

area (Line Of Sight). Simulation Results show that the sensor nodes can form a network with well maintained connectivity [8].

Since most papers are not consider the influence of the position and type of barrier in the area of distribution, this paper studies the wireless sensor networks deployment using Particle Swarm Optimization algorithm (PSO) by taking account of barrier position and attenuation. PSO algorithm was used as optimization method because it has several few operational function and parameters thus makes the PSO algorithm faster in execution [9].

II. RADIO WAVES PROPAGATION MODELS

Wireless communication system has been known for two condition: LOS (Line of Sight) and NLOS (Non Line of Sight). In LOS condition, obstacles does not exist between the sender and receiver. If this criterion does not met, then the received signal strength will decrease drastically. NLOS condition, the signals that has arrived at the receiver experiences attenuation, reflection, scattering and refraction. We assumed that the barrier has a certain attenuation value and there are no reflections, signal shadowing or interference wave, then the propagation loss in indoor environment with barrier (L) in decibel can be calculated by Eq. (1) [10].

$$L = 32{,}44 + 20 \log f + 20 \log d + (\sum Br) \qquad (1)$$

with

L : propagation loss
f : frequency in MHz
d : distance between transmitter and receiver (in Km)
Br : attenuation value of barrier.

Where d (in Eq. 1) is the distance between transmitter and receiver in the network, we get from the Euclidean distance formula and can be expressed in Eq. (2).

$$d = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \qquad (2)$$

x_i,y_i and x_j,y_j is represented the position coordinat of sensor node at the deployment area.

The received signal strength at the receiver can be formulated as as shown in Eq. (3).

$$Pr = Pt + Gt + Gr - ((32{,}44 + 20\log f + 20\log d) + \sum Br) \qquad (3)$$

where
P_t : power transmit
G_t : gain antenna of transmitter
G_R : GAIN ANTENNA OF RECEIVER

III. PARTICLE SWARM OPTIMIZATION ALGORITHM

The PSO algorithm was first introduced by Kennedy and Eberhart in 1995 [11]. PSO is apopulation based optimization algorithm inspired by social behavior of animals such as fish movements (school of fish), herbivore animals (herd), and birds (flock). Each object of animals is simplified into a particle. Three basic concepts of PSO is evaluating, comparing and imitating.

PSO begins with a set of particles (solutions) are generated randomly. Then the quality of each particle is evaluated using the fitness function. Furthermore, the particles will fly in the space by following the optimum particle. At each generation (iteration), the position of each particle is updated based on the two best fitness values. The first is the best achievement by a single particle which is known as *personal best* (p_{best}) and the second is the best achievement by all particles which is called *global best* (g_{best}). After discovering the best values, each particle i at position Xi update its velocity vector and position based on the following Eq. (4).

$$v_i^{k+1} = v_i^k + c_1 r_1^k \left(p_{best_i}{}^k - x_i^k\right) + c_2 r_2^k \left(g_{best_i}{}^k - x_i^k\right)$$
$$x_i^{k+1} = x_i^k + v_i^{k+1} \qquad (4)$$

Fig. 1. Shows the flow chart of optimization with PSO algorithm:

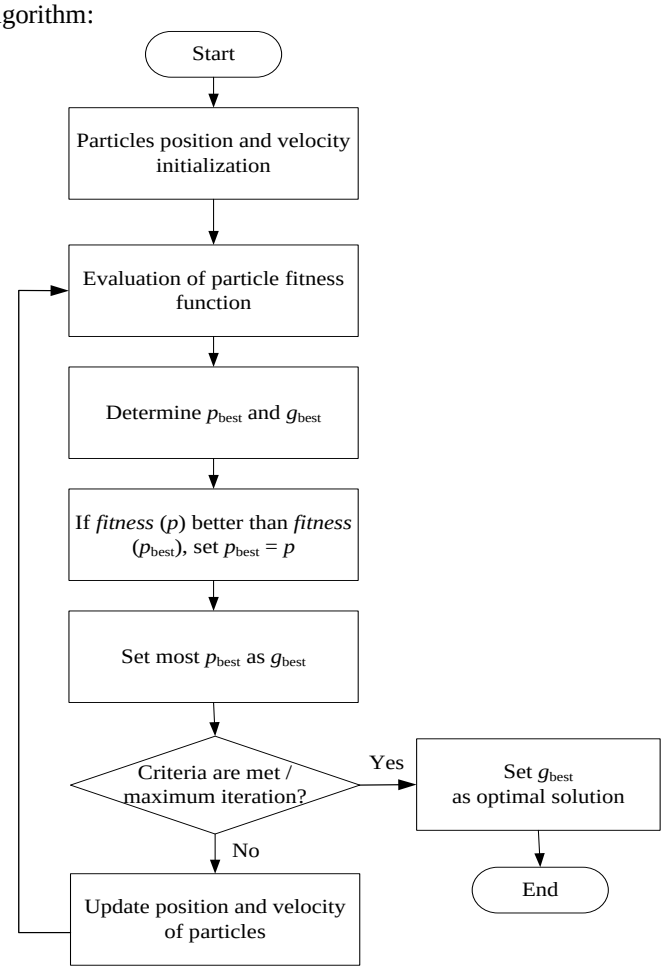

Fig. 1. Flowchart of optimization with PSO.

In this study, PSO parameters are:

A. Swarm

Swarm is a collection of particles that make up the population. The recommended range of swarm size is 20-60. The small size of swarm can lead to trapped at local optimum even if the process is very fast. In contrast, the large sizes of

swarm rarely get stuck in local optimum, but the process is much longer. In this study we used 30 with consideration of time efficiency and the achievement of solutions to approach the global optimum.

B. Particle

Particle (denoted by *Xi*) is asolution which is randomly generated and optimized to produce a good solution. This study concern to the optimization of the sensor nodes position when they are deployed in the area by taking account of barrier position and attenuation. The particles that are implemented represent the position of the sensor nodes in two dimension (2D) space with square deployment area. The distribution area is a square with maximum room size of 500 x 500 m^2. Representation of the particle can be seen in Fig. 2.

$X_{1,1}$	$X_{1,2}$	$X_{1,3}$	. . .	$X_{1,j}$
$X_{2,1}$	$X_{2,2}$	$X_{2,3}$	. . .	$X_{2,j}$
. . .	. . .	. . .	. . .	. . .
$X_{i,1}$	$X_{i,2}$	$X_{i,3}$	. . .	$X_{i,j}$

Fig.2 Particle representation

$X_{i,j}$: position of particle *i* and node *j* in 2D space
i : the size of swarm
j : the number of sensor node

The $X_{i,j}$ are retricted to the lower limit (Xa = 0.0 and the upper limit of (Xb = size of deployment area).

C. Fitness Function

The fitness function of this study is determined based on the power received and the number of connections with the following provisions:

1) Required power receive for a successful connection is -110 dB. If the power received is less than -110 dB, the node is not connected. Retrictions minimum power received by a node greater than -110 dBm because the radio frequency range of the TR 52B can reach 700 m (1.2 kb/s) and 500 m (19.2 kb/s), but actually the distribution area specified in the test is not more wide than TR 52B specification.
2) The deployment is designed to connect all sensor nodes in the network in full mesh form (each node connected to all nodes with direct connection). However, partial mesh form (each node connected to all nodes but does not direct connection, connection can by pass through the other node) are also allowed. Because of those influences, the number of connections have also been calculated in the fitness function.

Based on these scenarios, the proposed fitness function is defined by Eq. (5)

$$F(Xi) = \sum_0^{j-1} Pr_k(Xij) - \sum 2^{n_{ij}-1}.C \qquad (5)$$

where

$F(X_i)$ = fitness function of particle *i*.
$Pr_k(Xij)$ = the best power received by particle *i* sensor node *j*.
n_{ij} = number of detected nodes in particle *i* sensor node *j* (the number of connections).
C = constant value (30).

$Pr_b(X_{ij}) = \min[Pr(X_{ij})] \geq (-110\text{ dB})$
$Pr_b(X_{ij})$ is the best signal received by a sensor node *i* particle *j*. The goal of determine $2^{n_{ij}-1}$ and choosen value of C = 30 are to make balance value between sum of power receive and sum of the number connection, so no one value is dominant to the other.

D. Learning Rate

Learning rate used in this study is $c_1 = 1.3$ and $c_2 = 2.8$ with consideration for balancing between cognitive part and social part in PSO.

E. Constriction Factor

Another parameter that is known in PSO algorithm is the constriction factor. This parameter was introduced by Clerc with the aim to ensure the faster convergence in PSO algorithm [12]. Value of constriction factor (K) is given by Eq. (6).

$$K = \frac{2}{|2-\varphi-\sqrt{\varphi^2-4\varphi}|},\ \varphi = \varphi_1 + \varphi_2,\ \varphi > 4. \qquad (6)$$

with $\varphi_1 = c_1 = 1.3$ and $\varphi_2 = c_2 = 2.8$

The equation to update the velocity and the new position of particle by entering the constriction factor value is defined by Eq. (7).

$$v_i^{k+1} = K.v_i^k + c_1 r_1^k\left({p_{best}}_i^k - x_i^k\right) + c_2 r_2^k\left({g_{best}}_i^k - x_i^k\right)$$
$$x_i^{k+1} = x_i^k + v_i^{k+1} \qquad (7)$$

with provisions :

$$v_i^{k+1} = 0,\ \text{if } x_i^k < X_{\min} \text{ or } x_i^k > X_{\max}$$

$$x_i^{k+1} = \begin{cases} x_i^k + v_i^{k+1} \text{if } X_{\min} < x_i^k + v_i^{k+1} < X_{\max} \\ X_{\max} \text{ if } x_i^k + v_i^{k+1} > X_{\max} \\ X_{\min} \text{ if } x_i^k + v_i^{k+1} < X_{\min} \end{cases}$$

$X_{\min}$= lower limit

$X_{\max}$ = upper limit

v_i^{k+1} = velocity of particle *i* at iteration *k* + 1

x_i^{k+1} = position of particle *i* at iteration *k* + 1

IV. DISCUSSION AND RESULT

The proposed scheme is simulated using two simulation models: single barrier simulation model and two barriers simulation models.

A. Testing Scenario

The testing process of this study following restriction:

1) Using various level of power transmit of IQRF TR 52B (according to the datasheet) that is -25 dB, -28 dB, -31 dB, -34 dB. The number of sensor nodes is 10. The frequency is 868 MHz and the maximum iteration is 50.
2) The distribution area is divided by a barrier into 1, 2 and 3 space with barrier location can be changes.
3) The barrier that is assumed is a brick wall with 6 dB attenuation values, the glass with 2 dB and wood with 2.85 dB [13].

B. Testing Result

In this study, experimets are conducted by combining the value of c_1 and c_2 according to the range suggested in Zhang's study [14]. Considering the number of possible combinations, the value of c_2 is fixed to 1.3 and value of c_1 can be changed. The combination values of c_1 is 2.75, 2.8, 2.9, 3.0 and the latest by exchanging the value of c_1 and c_2 by c_1 = 1.3 and c_2 = 2.8. The experiments were performed with the same initial position and power transmit (-25 dB) in a room without barrier. The result is shown as in Fig. 3.

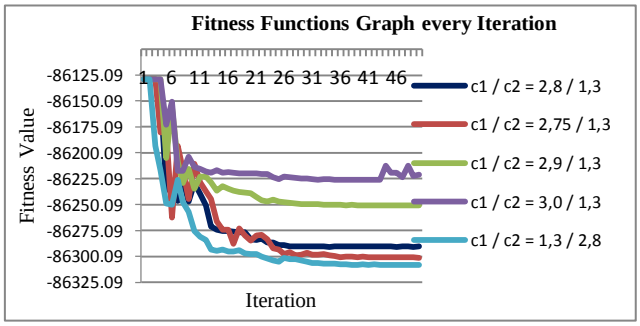

Fig. 3. Comparison the rate of convergence with different values of learning rate in the room without barrier.

As shown in Fig. 3, the combination of the value of c_1 = 2.8 and c_2 = 1.3 produces faster convergence rate. Thus, the value for the learning rate in this study is set to c_1 = 2.8 and c_2 = 1.3 for all simulation models.

1) Single Barrier Simulation Model

Deployment of sensor nodes is tested in the area with a single barrier, in which the barrier location coordinates is on the x axis and shifted by a certain values. Fig. 4 shows the results of the deployment in the room by different type and locations of barrier at power transmit -25 dB.

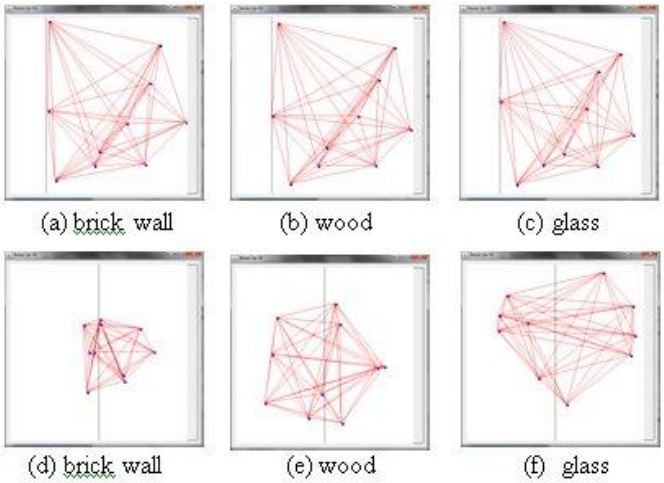

Fig. 4. Results of the deployment in the room with single barrier by different type and locations of barrier at transmit power of -25 dB.

As shown in Fig. 4, it can be inferred that the type and positions of barrier affect the deployment solution. For the simulation with the barrier position at x = 100 (Fig. 4 (a) to (c)), the room with brick wall has the average of communication range at 269.0681 meters, wood barrier at 269.0831 meters and glass barrier at 268.2368 meters. The simulation models with barrier position at x = 250 ((Fig. 4 (d) to (f)), the average of communication range is shorter than the barrier position at coordinates x = 100. The average of communication range in the room with brick wall at 142.5302 meters, wood barrier at 223.6971 meters and glass barrier at 254.9477 meters. Based on Table I, we can saw that on transmit power -25 dB, barrier position at middle (x = 250) has better communication range average than barrier position at the edge (x = 400) (wood and glass barrier). It caused the large transmit power and small attenuation make the nodes have long distance but still connected each other. Table II show that decrease of transmit power (-28 dB), just glass barrier by middle position (x = 250) has better communication range average than edge position (x = 400). For the transmit power -31 dB and -34 dB (show in Table III and IV), all the barrier types in the middle position has a shorter average of communication range than barrier position on the edge (x = 100 and x = 400).

Table I shows the network form and average of communication range with different types and location of barrier and transmit power is -25 dB, while Table II shows the network form and average of communication range with different types and location of barrier as Table I but using -28 dB transmit power.

Table I. Network form and average of communication range of single barrier simulation model on -25 dB transmit power.

Type of barrier	Barrier position	Form of network	Average of communication range (m)	Standar deviation (m)
Without barrier	x = 0	Full mesh	331,9966	136,2241
Brick wall	x = 100	Full mesh	269.0681	116,2596
	x = 250	Full mesh	142.5302	59.6028
	x = 400	Full mesh	278.8911	117.3982

Wood	x = 100	Full mesh	269.0831	115.3094
	x = 250	Full mesh	223.6971	85.0946
	x = 400	Full mesh	219.4241	94.6968
Glass	x = 100	Full mesh	268.2368	114.1623
	x = 250	Full mesh	254.9477	111.1347
	x = 400	Full mesh	227.4202	114.1347

Table II. Network form and average of communication range of single barrier simulation model on -28 dB transmit power.

Type of barrier	Barrier position	Form of network	Average of communication range (m)	Standar deviation (m)
Without barrier	x = 0	Full mesh	220.4852	85.5224
Brick wall	x = 100	Full mesh	218.2637	87.8383
	x = 250	Full mesh	97.1036	48.5407
	x = 400	Full mesh	202.6215	92.3733
Wood	x = 100	Full mesh	218.2637	87.8384
	x = 250	Full mesh	165.5994	80.3555
	x = 400	Full mesh	204.7691	84.1624
Glass	x = 100	Full mesh	218.2637	87.6364
	x = 250	Full mesh	201.1755	78.0586
	x = 400	Full mesh	192.5653	78.6488

TABLE III. NETWORK FORM AND AVERAGE OF COMMUNICATION RANGE OF SINGLE BARRIER SIMULATION MODEL ON -31 DB TRANSMIT POWER.

Type of barrier	Barrier position	Form of network	Average of communication range (m)	Standar deviation (m)
Without barrier	x = 0	Full mesh	142.5265	60.4873
Brick wall	x = 100	Full mesh	146.8617	57.5128
	x = 250	Full mesh	127.5731	58.9135
	x = 400	Full mesh	148.1423	62.5463
Wood	x = 100	Full mesh	143.8315	60.2588
	x = 250	Full mesh	129.4584	49.6890
	x = 400	Full mesh	148.1423	62.5464
Glass	x = 100	Full mesh	143.8315	60.2588
	x = 250	Full mesh	120.5877	48.1129
	x = 400	Full mesh	148.1423	62.5463

TABLE IV. NETWORK FORM AND AVERAGE OF COMMUNICATION RANGE OF SINGLE BARRIER SIMULATION MODEL ON -34 DB TRANSMIT POWER.

Type of barrier	Barrier position	Form of network	Average of communication range (m)	Standar deviation (m)
Without barrier	x = 0	Full mesh	111.0409	46.9630
Brick wall	x = 100	Full mesh	106.8776	41.4769
	x = 250	Full mesh	72.3909	33.7546
	x = 400	Full mesh	110.9631	46.9000
Wood	x = 100	Full mesh	106.8776	41.4769
	x = 250	Full mesh	91.2346	40.3804
	x = 400	Full mesh	111.0409	46.9630
Glass	x = 100	Full mesh	106.8776	41.4769
	x = 250	Full mesh	92.3332	38.8686
	x = 400	Full mesh	111.0409	46.9630

Based on the results as shown in Table I to IV, we can conclude that the position and type of barriers affect the distribution results. All of the simulation models with different types of barrier, generally, barrier positions on the edge (barrier position coordinates are x = 100 or x = 400) have a longer average of communication range compare with the simulation models by the barrier in the middle position (coordinates x = 250). It is because the large power with small attenuation make the nodes have long distance but still connected each other, the position of the barrier in the middle may affect the nodes position are balanced, and the position of the nodes are spread evenly. In the general, a brick wall barrier in the middle (coordinate x = 250) produces a shortest average of communication range than the other types like wood and glass barrier because the brick wall has the greatest attenuation (6 dB). Wall of glass has average a longer communication range for most small attenuation (2 dB) compared to the brick wall (6 dB) and wall of wood (2.85 dB).

2) Two Barrier Simulation Models

In this simulation models, space is divided in three sections by two barrier. The barrier placed sequentially at x_1 = 100 and x_2 = 400, x_1 = 225 and x_2 = 275, and the last is the coordinates at x_1 = 167 and x_2 = 333.

Fig. 5 shows the results of the deployment space of two barriers with the same location that is x_1 = 225 and x_2 = 275, but with different transmit power.

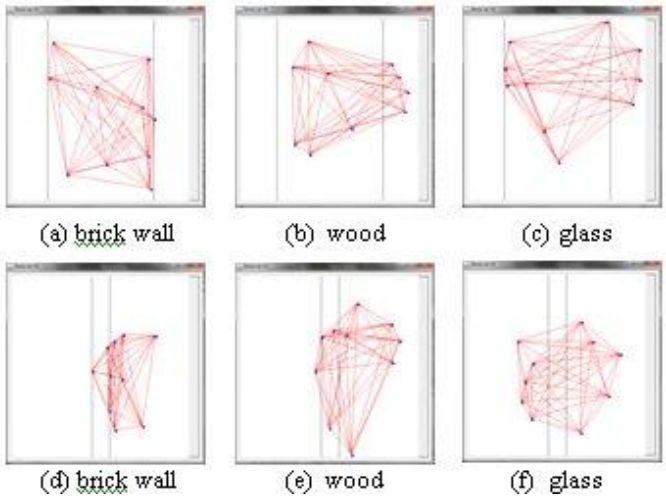

Fig. 5. Results of the deployment in the room with two barrier by different type and locations of barrier at transmit power -25 dB.

As shown in Fig. 5, it can be inferred that the number, type and position of barrier affect the deployment solution. For the simulation with the barrier position at x_1 = 100 and x_2 = 400 (Fig. 5 (a) to (c)), the room with brick wall has the average of communication range at 243.4523 meters, wood barrier at 221.7073 meters and glass barrier at 257.8703 meters. The simulation models with the barrier position at x_1 = 225 and x_2 = 275 ((Fig. 5 (d) to (f)), the room with brick wall has the average of communication range at 143.9456 meters, wood barrier at 200.7037 meters and glass barrier at 198.0752 meters. From this results, it can be inferred that addition of barrier affect the deployment result. The average of communication range with two barrier is shorter than single barrier. Its caused addition of barrier give addition attenuation or damping, so the power receive at the receiver is weaker and communication range would be short. As same as single barrier, two barrier simulation model with barrier position at

the middle (x_1 = 225, x_2 = 275 and x_1 = 163, x_2 = 333) give simulation result with shorter range communication average than barrier position at the edge (x_1 = 100, x_2 = 400).

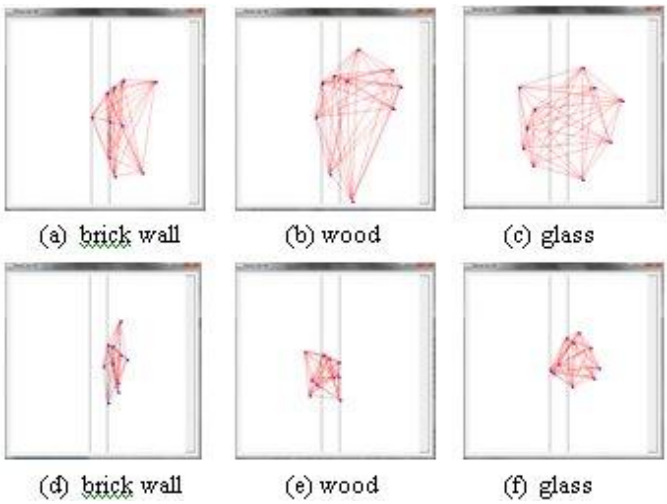

Fig. 6. The deployment result in the room with two barrier and the same position of barrier at transmit power of -25 dB and -34 dB.

Fig. 6 (a) to (c) uses the transmit power of -25 dB with barrier position at x_1 = 100 and x_2 = 400, while Fig. 6 (d) through (f) uses same types and position of barrier but different level of transmit power (*Pt* = -34 dB). As shown in Fig. 4, the deployment results in six form of networks with different qualities. Greatest transmit power (-25 dB) would result in longest average of communication range (Fig. 6 (a) to (c)). In contrast, smallest transmit power (-34 dB) will produces a smallest or average shortest communication range (Fig. 6 (d) to (f)). All deployment as shown in Fig. 6, the connections are maintained well, although two deployment results like Fig. 6 (d) and (e) form a partial mesh network, but it still connected because IQRF sensor nodes are multi hop. These results can satisfy the required conditions in the evaluation of the fitness function.

Table V. Network form and average of communication range of two barrier simulation model on -25 dB transmit power.

Type of barrier	Barrier position	Form of network	Average of communication range (m)	Standar deviation (m)
Without barrier	x = 0	Full mesh	331.9966.	136.1224
Brick wall	x_1 = 100 x_2 = 400	Full mesh	243.4523	102.1281
	x_1 = 225 x_2 = 275	Full mesh	143.9456	70.5699
	x_1 = 167 x_2 = 333	Full mesh	157.5310	68.5041
Wood	x_1 = 100 x_2 = 400	Full mesh	221.7037	95.5415
	x_1 = 225 x_2 = 275	Full mesh	200.9286	98.9501
	x_1 = 167 x_2 = 333	Full mesh	210.4026	82.9512
Glass	x_1 = 100 x_2 = 400	Full mesh	257.8703	102.1283
	x_1 = 225 x_2 = 275	Full mesh	198.0752	102.1271
	x_1 = 167 x_2 = 333	Full mesh	199.9742	102.1281

Table VI. Network form and average communication range of two barrier simulation model on -34 dB transmit power.

Type of barrier	Barrier position	Form of network	Average of communication range (m)	Standar deviation (m)
Without barrier	x = 0	Full mesh	111.0409	46.9630
Brick wall	x_1 = 100 x_2 = 400	Full mesh	106.8787	41.4809
	x_1 = 225 x_2 = 275	Partial mesh	76.4955	41.2702
	x_1 = 167 x_2 = 333	Full mesh	99.7524	39.4909
Wood	x_1 = 100 x_2 = 400	Full mesh	106.8787	41.4808
	x_1 = 225 x_2 = 275	Partial mesh	81.4545	34.1273
	x_1 = 167 x_2 = 333	Full mesh	98.2872	38.7986
Glass	x_1 = 100 x_2 = 400	Full mesh	106.8787	41.4809
	x_1 = 225 x_2 = 275	Full mesh	83.5506	34.7054
	x_1 = 167 x_2 = 333	Full mesh	97.9347	39.0145

Table V shows the network form and the average of communication range with different types and location of barrier and transmit power is -25 dB, while Table VI shows the network form and the average of communication range with different types and location ofbarrier as Table V but using -34 dB transmit power.

As shown in Table V and VI we can conclud that the distribution results not only affect by position and type of barriers but also by level of transmit power and the number of barrier. If we compare Table V with Table VI, we find that increasing the number of barrier and decreasing the level of transmit power produces different solution. Lower transmit power (-34 dB) with two barrier simulation model produces worse solution than the single barrier. On the position of the barrier in the middle, barriers from wall and wood produce a partial mesh network forms. All of the simulation models with different types of barrier, barrier positions on the edge (barrier position coordinates are x_1 = 100 and x_2 = 400) have a longer average of communication range than with the simulation models by the barrier in middle position (coordinates x_1 = 225 and x_2 = 275). From three simulation models, the position of the barrier x_1 = 225 and x_2 = 275 with brick wall barrier type generates the shortest range communication and barrier positions x_1 = 100 and x_2 = 400 and glass wall barrier type produces longest communication range.

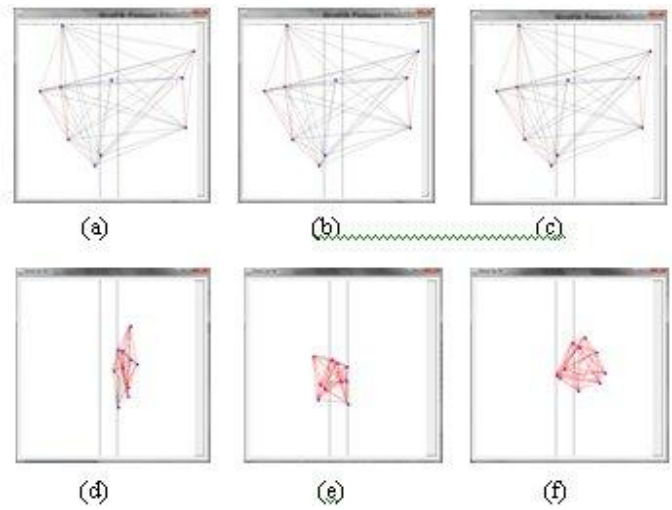

Fig. 7. Comparison deployment result with and without optimization using PSO algorithm: (a) brick wall, (b) wall of wood, (c) wall of glass ((a) to (c) without optimization), (d) brick wall, (e) wall of wood, (f) wall of glass ((d) to (f) with optimization).

Fig. 7 (a) to (c) shows the deployment result on power transmit of -34 dB in the room with different barriers without optimization. The result is worse for all simulation models (the room with brick wall, wall of wood and wall of glass barrier). All of solutions form partial network. However, in fact there is only few connection occured, which is shown with grey line to indicate that the received power of sensor node is less than -110 dB and therefore, it does not fullfil the connection. In WSN, partial network is not allowed.

Fig. 7 (d) to (f) shows the deployment result in the room with different barrier like Fig. 7 (a) to (c) but using optimization with PSO algorithm. All of deployment results successfully establish connection with the network. The room with brick and wood walls forms partial mesh, but it is still allowed in accordance to the limits of testing scenario.

Based on the comparison results of the deployment as shown in Fig. 7, the deployment with PSO algorithm successfully forms a network with good connectivity. The fitness function that is applied using PSO algorithm successfully makes the well maintained network connection. Optimization with PSO algorithm shows better performance when compared to that of the traditional random deployment. Traditional random deployment (without optimization) gives a poor solution with partial network form. After optimization with PSO algorithm is done, the solution can form a network with well maintained connections for all transmit power levels (-25 dB, -28 dB, -31 dB and -34 dB).

Based on all the deployment results can be concluded that the deployment results are affected by the distance between nodes, the position and type of barrier, and level of the transmit power. In this study, optimization of PSO algorithm using the proposed fitness function shows good performance and results compared to the traditional deployment without PSO algorithm.

V. CONCLUSSION

In this research, we have proposed wireless sensor networks deployment using Particle Swarm Optimization (PSO) algorithm by taking into account barrier position and attenuation. The room with a number of barriers and greater attenuation values (two barrier and brick wall) provides greater attenuation to the transmit power and result in shorter average of the communication range. Largest transmit power (-25 dB) produces a network with longest average communications range and better network connection than that using smallest transmit power (-34 dB). PSO algorithm also shows good performance to produces a solution where connections are maintained compared to that of the traditional deployment (without optimization).

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