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Analysis of The Power Dissipation of The Wireless Sensor with Heuristic and Metaheuristic Methods for Solving

***Abstract**. A wireless sensor network (WSN) consists of nodes and base stations, with nodes being environment sensors or controllable sensors. WSN has been continuously developed in several industries, especially in agriculture, where it is used to perceive the ambiance of plots through mobile applications, operating these sensors interconnected through various protocols. However, these node sensors have limited lifespan, due to the battery depletion or reliability of other power sources such as solar cells. Computation of energy consumption, therefore, is essential important to the WSN. In this study,the base stations are placed within an area of 35×35 m^2 in an order determined by different methods: ABC, ACO, FA, GA, and PSO. Additionally, PEGASIS is introduced for efficient power gathering as a chain protocol for increasing the WSN's lifetime. The simulation results yield an overall energy of 6453, with ABC being the optimal routing for the PEGASIS energy efficiency determination*

***Streszczenie.** Bezprzewodowa sieć czujników (WSN) składa się z węzłów i stacji bazowych, przy czym węzły są czujnikami środowiskowymi lub czujnikami kontrolowanymi. WSN jest stale rozwijany w kilku branżach, zwłaszcza w rolnictwie, gdzie jest używany do postrzegania atmosfery działek za pomocą aplikacji mobilnych, obsługujących te czujniki połączone ze sobą za pomocą różnych protokołów. Jednak te czujniki węzłowe mają ograniczoną żywotność ze względu na wyczerpanie baterii lub niezawodność innych źródeł zasilania, takich jak ogniwa słoneczne. Dlatego też obliczanie zużycia energii jest bardzo ważne dla WSN.W niniejszym opracowaniu stacje bazowe rozmieszczono na powierzchni 35×35 m2 w kolejności ustalonej różnymi metodami: ABC, ACO, FA, GA, PSO. Dodatkowo wprowadzono PEGASIS w celu wydajnego gromadzenia energii jako protokół łańcuchowy zwiększający żywotność sieci WSN. Wyniki symulacji dają całkowitą energię 6453, przy czym ABC jest optymalnym routingiem dla określenia efektywności energetycznej PEGASIS (**Analiza rozpraszania mocy czujnika bezprzewodowego za pomocą heurystycznych i metaheurystycznych metod rozwiązywania**)*

Keywords: wireless sensor network (WSN), environmental sensors, protocols, PEGASUS
Słowa kluczowe: *bezprzewodowa sieć czujników (WSN), czujniki środowiskowe, protokoły, PEGASUS*

Introduction

Sensors are a type of device which can transmit and receive data via a microcontroller. Sensors have been employed in numerous applications, along with their price continually lowering. Development of sensors has placed IoT and WSN in several industries such as biomedicine, manufacturing, and agriculture. Wireless environment sensors are incorporated into "smart farms", where they are used to monitor large plots via the Internet. The base stations must be suitably designed and arranged to save energy consumption and consequently increase lifespan of the sensors.

One of the most common problems is the energy consumed by each node. The sensors spend energy on transmitting data for synchronization and an efficient energy consumption leads to an expanded lifetime. In planning and modeling, base stations must be arranged such that the energy consumption is optimized for the hardware's resource management.

In this study, a two-dimensional arrangement of base stations in an area of 35×35 m^2 has been designed. The optimal number of base stations is obtained by varying from 30 to 100 and their positions are determined by five metaheuristic routing methods: ABC, ACO, FA, GA, and PSO. The gathering energy efficiency for wireless sensors is computed by PEGASIS. The results conclude that the optimality is yielded at 60 nodes via the ABC approach, when the overall energy is 6453.

Sensor network model

A. Quadratic assignment problem (QAP)

QAP is a classical combinatorial method of optimization widely known in research. QAP is NP-hard, so in practice solving a QAP requires a heuristic algorithm, found in very high-quality solution in a short computational time. In the context of facilitie location, *n* faclilties are placed within an *N*×*M* space, with all flows between each other set to zero. In the case of locations below *n*, the problem is considered impossible. The equation of QAP is formulated as the following parametes n the total number of bases stations

f_{ik} position of base station

d_{jl} distance between positions j and l

$$x_{ij} \begin{cases} 1 & \textit{If facility 1 is assigned to location} \\ 0 & \textit{Otherwise} \end{cases}$$

B. Artificial Bee Colony (ABC)

(1)
$$min = \sum_{i}^{n}\sum_{j}^{n}\sum_{k}^{n}\sum_{l}^{n} f_{ik} d_{jl} x_{ij} x_{kl}$$

(2)
$$\sum_{j}^{n} x_{ij} = 1 \quad \forall i$$

(3)
$$\sum_{i}^{n} x_{ij} = 1 \quad \forall i$$

(4) x_{ij} *is binary*

This algorithm imitates the nature of bees seeking food, where a colony classifies bees into 3 categories: employed bees, onlooker bees, and scout bees. Employed bees are responsible for seeking local food sources and reporting the amount of food found to onlooker bees. Onlooker bees then select food sources from the list. The higher amount of food gives a higher probability of that food source being selected, while the amount of food from nearby sources is considered as well. Unselected food sources are discarded, and the employed bees are turned into scout bees to seek new food sources. Positions of food sources are statistically possible answers, and the total number of employed bees and scout bees equals the total number of possible answers. The process can be described as the following equations:

(5) $\vec{x}_{ij} = \vec{x}_{min\ j} + rand[0,1](\vec{x}_{max\ j} \quad \vec{x}_{max\ j})$

(6)
$$fit_{ij}(\vec{x}) = \begin{cases} \dfrac{1}{1+f_i(\vec{x}_i)} \\ 1+\left|f_i(\vec{x})\right| \end{cases}$$

where

$\vec{x}$ is a vector of answers from randomization; i is the population size; j is the total number of parameters (dimensions); $fi(\vec{x})$ is the objective function of x; $fit_{ij}(\vec{x})$ is the number of food sources

(7) $\vec{v}_{ij} = \vec{x}_{ij}\varphi \times x_{ij} \quad x_{rj}$

Where: $\vec{v}_{ij}$ is position of the new food source; φ is random arbitrary value in the range 0-1

(8)
$$P_i = \frac{fit_i(x_i)}{\sum_{i=1}^{S_n} fit_i(x_i)}$$

C. *Power-Efficient Gathering for Sensor Information Systems (PEGASIS)*

PEGASIS is a protocol for designing information gathering and transmission to base stations with the assumption that each sensor knows its position (distance from the base station). The objective of PEGASIS is to minimize the distance during data transmission of each sensor. A leader is selected with a distance of 1 hop, then the information is serially transmitted from the nearest sensor in the network to the leader as a chain. The entire information is then sent to the base station as the following equations. Distance between nodes.

(9)
$$D = \sqrt{(A.xd \quad B.xd)^2 + (A.yd \quad B.yd)^2}$$

where *A* and *B* are node sensors,numbers on the and x- and y-axes are respective co-ordinates, and *xd* and *yd* are x and y in correspondence.

Finding the nearest unconnected node

(10)
$$DN = \sqrt{(A(i \quad 1).xd \quad B(j).xd)^2 + (A(i \quad 1).yd \quad B(j).yd)^2}$$

where *i* and *j* are the remaining node sensors to be selected as leader

(11) $Q = S(i).E_o / D$

$S(i)$ is representative node sensor of the network field

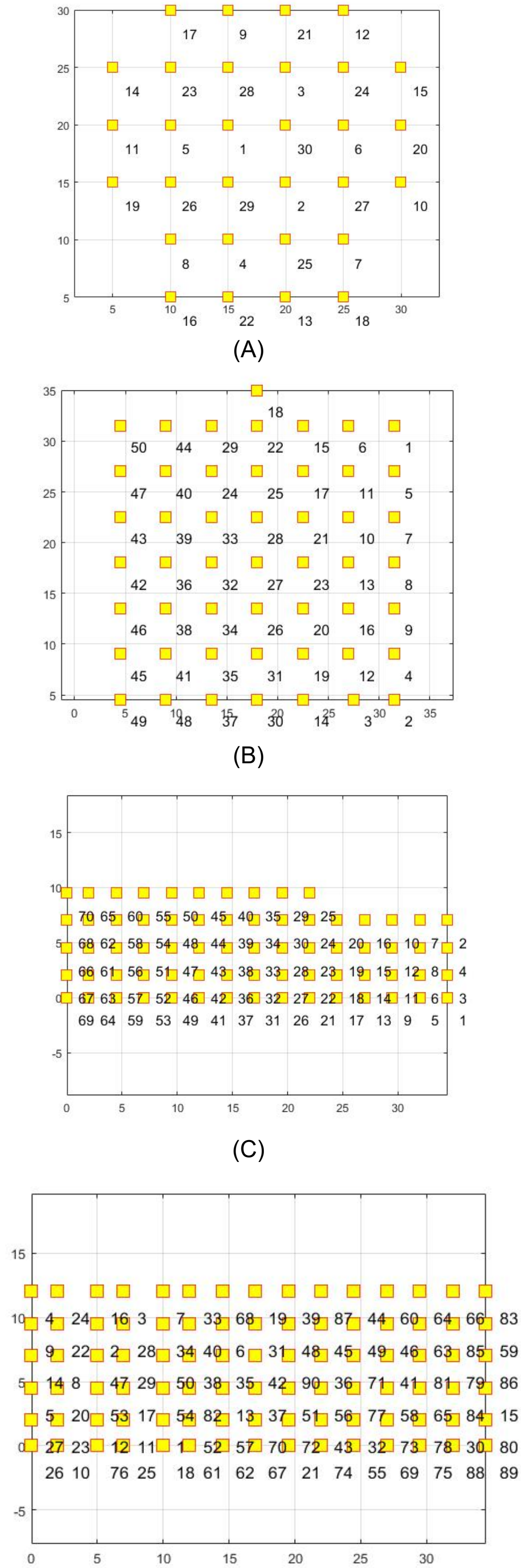
E_o is the node's initial energy

Energy of the nodes are calculated as

(12)	$S.E = S.E \quad (ET_x \times datanum) + datanum \times Emp \times (D)^4 \quad if \quad D > d_0$
	$S.E = S.E \quad (ET_x \times datanum) + (datanum \times Efs) \times (D)^2$

In this experiment can be simulated as a network of node sensors with the number of nodes ranging from 30 to 100 in steps of 10, to find an optimal number within the area of 35×35 m^2.

Methods



(A) (B) (C) (D)

Fig 1.Number of nodes

Parameters for metaheuristics ABC, ACO, FA, GA, and PSO used in QAP for finding the Convergence Curve Svg are set as following.

Table 1 Parameters for ABC

Parameter	Value
Maximum Number of Iterations	500
Population Size (Colony Size)	50
Number of Onlooker Bees	50
Acceleration Coefficient Upper Bound	1

Table 2 Parameters for ACO

Parameter	Value
Maximum Number of Iterations	500
Number of Ants (Population Size)	50
Initial Phromone	10
Phromone Exponential Weight	0.3
Evaporation Rate	0.1

Table 3 Parameters for FA

Parameter	Value
Maximum Number of Iterations	500
Number of Fireflies (Swarm Size)	50
Light Absorption Coefficient	1
Attraction Coefficient Base Value	2
Mutation Coefficient	0.2
Mutation Coefficient Damping Ratio	0.98
Uniform Mutation Range	0.05 (max – min)
Number of Additional Mutation Operations	2

Table 4 Parameters for GA

Parameter	Value
Maximum Number of Iterations	500
Population Size	50
Crossover Percentage	0.4
Mutation Percentage	0.8
Selection Pressure	5

Table 5 Parameters for PSO

Parameter	Value
Maximum Number of Iterations	500
Population Size (Swarm Size)	50
Inertia Weight	1
Inertia Weight Damping Ratio	0.99
Personal Learning Coefficient	1.5
Global Learning Coefficient	2.0
Number of Mutations Performed on Each Particle	1
Number of Mutations Performed on Global Best	3

After setting the parameters, each method is implemented for 50 iterations for finding their optima and the minimum Convergence Curve Svg is obtained as the following figure.

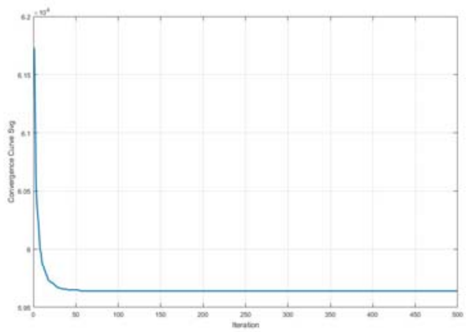


Fig 2. Convergence Curve Svg

For each number of nodes, all the 50 resultant values are stored and the optimal energy efficiency is calculated by PEGASIS.

Parameters	Value
Eo (Initial Energy of Nodes)	0.2 j
Number of Data/ Data Packet	4000 Bit
Eelec (Energy consumption for ETx and ERx of the signal)	50 nj/bit
Eelec (Energy consumption for ETx and ERx of the signal)	5 pj/bit
Emp (Multi path space routing energy displace)	0.0010 pj/bit/m
Eda	5 nj/bit/signale

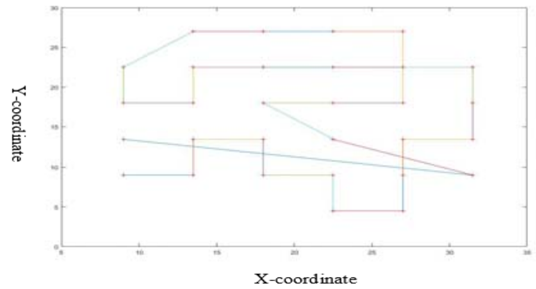


Fig 3. Distribution of node sensors as a PEGASIS network

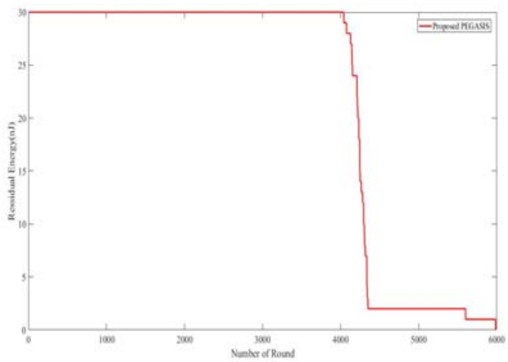


Fig 4. Energy Consumption per round

Results

Table 6 Energy efficiency determined by PEGASIS

	Metaheuristic				
Number of nodes	ABC	ACO	FA	GA	PSO
30	5987	5098	5622	5777	5622
40	5905	5584	5549	5879	5291
50	5254	5902	5254	5822	5254
60	**6453**	5102	5107	5090	5107
70	5711	5843	5709	5892	5709
80	5825	5813	5917	5673	6046
90	6069	5970	5976	6046	5887
100	5798	6120	6072	6072	6072

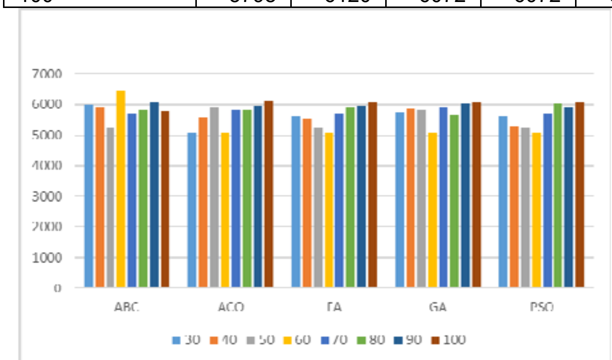


Fig 5. Energy efficiency determined by PEGASIS

Conclusion

In the experiment of efficiency determination of PEGASIS with five metaheuristic methods (namely, ABC, ACO, FA, GA, and PSO) and eight numbers of nodes (30, 40, 50, 60, 70, 80, 90, and 100) within an area of 35×35 m^2, it is found that the optimum is obtained by Artificial Bee Colony (ABC) at 60 nodes. When compared with [8] Energy Efficient PEGASIS Routing Protocol for Wireless Sensor Networks, the value shows an improvement of 19.56%.

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