Optimization of energy consumption of wireless sensor networks in pursuit of moving targets using LEACH-C algorithm optimized by Cuckoo algorithm and Radial Basis Functions networks

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Abstract: The problem of tracking moving targets in wireless sensor networks is one of the most challenging issues of this type of network due to its high-powered consumption, limited energy and network lifetime.In this paper, the sensors of a wireless sensor network is clustered by using the LEACH-C clustering algorithm and its performance is improved by using the Cuckoo optimization algorithm (COA) and Levy flight. Then, with the help of the Radial Basis Functions network (RBF), the data received from a moving target is transmitted to the central base station (BS) in a multi-step connection through the best path from the Cluster Heads (CH), which reduces the energy consumption of the Cluster Heads (CH) compared to using the LEACH - R algorithm. Using MATLAB simulator, a wireless sensor network is simulated with specifications of 100 *100 meters, 100 wireless sensors with an initial energy of 0.5 volts, a fixed central base station (BS) and 1000 rounds of testing. The results shows that the location of the target is determined with the least time and energy, and the tracking is done with an appropriate accuracy and quality. Therefore, by comparison to the LEACH - R algorithm method a significant reduction in the energy consumption of sensors is observed. As a result, the use of Cuckoo optimization algorithm (COA) and Levy Flight algorithm in improving the LEACH-C clustering algorithm and the use of Radial Basis Functions network (RBF) in selecting the best path in tracking reduces the energy consumption of sensors and increases the network lifetime.
Keywords: Wireless sensor networks, moving target tracking, LEACH-C clustering algorithm, Cuckoo optimization algorithm, Levy flight, radial basis functions network.

1. Introduction

A WSN[1] consists of a large number of wireless receiver nodes (sensors) in its surroundings which are widelydistributed, and by collecting, processing and storing information from that environment, the entire network area is covered. **[1]**

The most prominent features of this type of network are as follows:

- Algorithms and protocols used in this type of network have self-organizing and self-management features, so there is no need for a precise and predetermined arrangement of sensor nodes at the network level. **[2]**
- Sensor nodes using a processor installed on their mainboard can perform initial surface calculations on data and raw information received from their surroundings at the network level and then this semi-processed data to complete the computational process, and the final decision is sent to the central BS[2]. This feature makes it possible to participate and cooperate in the task between the sensor nodes. **[2]**
- There is no need to use thousands of meters of wires and various network equipment, and their installation, commissioning and configuration costs are negligible. **[2]**

But a number of these unique features of wireless sensor networks have led to rising some specific issues and reviews of itssolutions in tracking. Some of these features include:

- Excessive use of wireless sensors in the network due to its low price. **[3]**
- No manual adjustment of wireless sensors in extensive networks. **[3]**

[1] Wireless Sensor Networks (WSN)
[2] Base Station (BS)

- Creating an overhead in the information sent to the central BS due to simultaneous detection of a target by several sensors. **[3]**
- The possibility of not covering part of the network due to the lack of uniform density of sensors at the network level in random deployment. **[3]**
- Sensors use little radio bandwidth to conserve energy. **[3]**
- Noise and interference from waves interfere with the signals received from the sensor nodes. **[3]**

2. Significance Of The Study

One of the most crucial challenges ofWSN is the energy limitation of sensor nodes. Because by reducing or depleting the energy of the sensor nodes, we cause the loss of a part or part of the network, which ultimately reduces the life of the network. As a result, the use of energy efficiency optimization algorithms is essential when designing sensor networks.**[4]**

Detection methods in the structure of wireless sensor networks are divided into five general categories: **[1]**

- Tree-based[3] methods **[1]**
- Clustering-based[4] methods **[1]**
- Prediction-based[5] methods **[1]**
- Mobicast message-based[6] methods **[1]**
- Hybrid-based[7] methods**[1]**

Tracing in the clustering method in this paper consists of the following two phases:

- Tracking moving targets
- Transfer of information to the central BS

In the first phase, tracking methods based on clustering of all sensor nodes in the network are divided into several groups, eachof which has a central node (CH[8]) that often has more energy than other sensor nodes **[5][6]**.Then, if the nodes of that cluster detect a target, it sends its information to the node at the CH. The CH, after aggregating the received information and the spatial target preliminary calculations, sends the necessary information to the central BS for the final decision.Thus, due to the reduction of communication bandwidth between the source and destination, theenergy consumption in the network is reduced and ultimately the network lifetime increases. **[2]**

In this phase, the LEACH-C algorithm is used in clustering sensors in the network in order to reduce their energy consumption. then, the efficiency of this algorithm is improved with the COA[9] and Levy Flight.

The radio sensors used in this simulation have the power to detect the target up to a radius of 5 meters; and using the RSSI[10]method, the distance between the target and the two nearby sensors is estimated by measuring the signal strength transmitted from the transmitter to the receiver. In the next step, the exact coordination of the target location is calculated using the Trilateration algorithm. Thus, its purpose and coordinatesare identified. To track the target and predict the following area of the moving target, we used the linear prediction method. This practice can calculate and predict the coordinates of the next location of the target by comparing the current time, place, speed and direction of the target with the previous time, place, speed and direction of the target.

The second phase of tracking involves transferring the target information to the central BS from the best path using multi-step communication instead of single-stepcommunication. One of the most critical issues in reducing energy consumption in this phase is how to choose the best possible path and transfer information from the target identification nodes to the central BS. Choosing the best route can be based on various factors such as energy consumption, the shortest route, response speed, latency and accuracy in data transmission. In this paper, we used

[3]Tree-based target tracking protocols
[4]Cluster-based architecture
[5]Prediction-based tracking protocols
[6]Mobicast message-based tracking protocols
[7]Hybrid protocols
[8] Cluster Head
[9] Cuckoo optimization algorithm
[10]Received Signal Strength Indicator (RSSI)

RBF[11] to find the closest path with the most powerful sensor in terms of energy level to transmit target information to the central BS.

3. Review Of Related Studies

Several previous works related to this proposed method are reviewed in this paper in two phases of clustering based on reducing energy consumption and tracking moving targets that increase network lifetime.

The method proposed by **J. Rejina Parvin,&C. Vasanthanayaki** in energy efficiency optimization in tracking moving targets in wireless sensor networks was the use of GA[12] and P-EETT[13]algorithms. This method includes two phases, clustering, and network coverage and target tracking. In the first phase, GA algorithm was used for clustering. In the second phase, P-EETT algorithm was used for network coverage and the target was tracked with the help of the position of each target's node, speed, acceleration and angle. The results showed that the proposed method in this article performed better than some of its previously compared methods. **[7]**

The method proposed by **H. Ahmadi, &F. Viani, &A. Polo, &R. Bouallegue** in locating a moving target uses several regression trees to perform better in the ensemble learning method,and the RSSI for static localization and monitoring of the moving target. The performance results have been analyzed by comparison with SVR[14] algorithm, NB[15] method and regression tree, which shows that the solution adapted to the computational conditions is accurate and robust to environmental changes. **[8]**

The method proposed by **S.K Gharghan, & R. Nordin, & M. Ismail** was to determine the location of cyclists and their distance from each other. In this method, they used two techniques of ANFIS[16] and ANN[17] that focused on a range-based localization method using the RSSI, measured by three ZigBee[18] sensors, distributed across the track.In the first phase, ANFIS was used to localize and estimate the distance between cyclists, and in the second phase, ANN separately with three PSO, GSA and BSA algorithms were combined. The results showed that the combined GSA-ANN performed better than other accepted methods in terms of localization, the accuracy of distance estimation with adistance estimation error of 0.02 m. **[9]**

The method proposed by **K. Munasinghe,& M. Aseeri, &S. Almorqi, &Md.F. Hossain, &M. Binte Wali, &Abbas Jamalipour,**in monitoring and tracking targets underwater is the use of EM[19] based communication systems, which is the first of its kind in the field of underwater communication where underwater monitoring techniques for High-speed UWSNs[20] based on EM have been investigated. **[10]**

The method proposed by **A. K. M. Shamiul Islam, & Farhana Nasrin Bristy, & Samira Alam, & Anisur** in pursuing a moving target using modifiedLEACH-R[21] protocol in wireless sensor networks. In this paper which is our reference article, the LEACH-R algorithm was used for clustering. Then, to identify the target and estimate the distance, the RSSI method was used. Next, the Trilateration positioning algorithm was used to determine the coordinates of the current target location. At the end, the linear prediction method was used to determine the following area of the target. The method proposed in this paper has increased the time of the first dead node and also increased the operating time of the last node in comparison with the method suggested in its base article, which used theLEACH[22]algorithm and the overall life of the network hasincreased. **[11]**

The details of the method used in this paper [8] are as follows:

3.1. Clustering based on reducing energy consumption

One of the most popularclustering algorithms based on reducing energy consumption is the LEACH algorithm. In different years, this algorithm was repeatedly modified to improve work efficiency, and several versions of it were produced with unique features. The most widely-used modified algorithms are LEACH-R and LEACH-C algorithms.

[11]Radial Basis Functions network (RBF)
[12] Genetic Algorithm (GA)
[13]Particle Swarm Optimization (PSO) based Energy Efficient Tar-get Tracking (P-EETT)
[14] Support Vector Regression Algorithm regression (SVR)
[15] Naive Bayes method
[16] Neural Fuzzy Inference System (ANFIS)
[17] Artificial Neural Network (ANN)
[18] ZigBee anchor nodes
[19] Electromagnetic (EM) wave-based
[20]Underwater Wireless Sensor Network (UWSN)
[21] LEACH- Reward
[22] Low Energy Adaptive Clustering Hierarchy (LEACH)

3.1.1. LEACH clustering algorithm

The most well-known clustering protocol in wireless sensor networks in which cluster formation is distributed is the Low Energy Adaptive Clustering Hierarchy Protocol (LEACH). **[12] [13]**

The LEACH algorithm has the following objectives: **[12]**

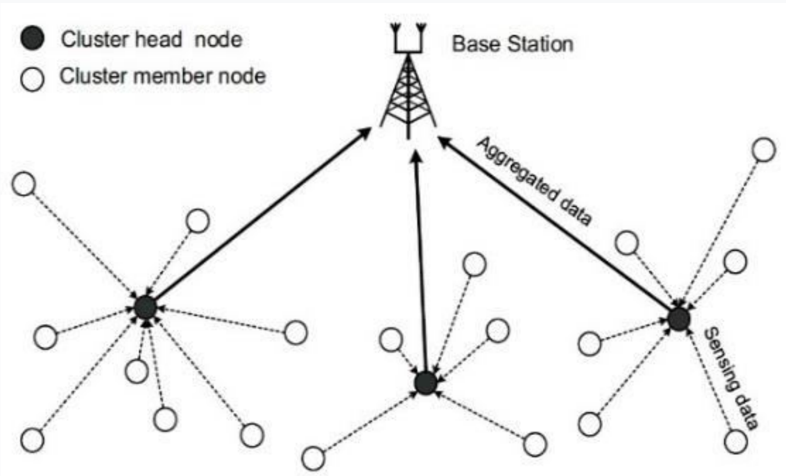
- By reducing the energy consumption of the sensor nodes, it increases the life of the network. **[12]**
- Using the aggregation of information sent from sensor nodes reduces the number of messages sent between the source and destination, which ultimately reduces the information overload. **[12]**

The method of execution of the LEACH algorithm includes several iterations that the beginning of each period is in the following order: **[14]**

- Setup Phase
  - ✓ A limited number of sensor nodes are randomly selected for the CH by the central BS. **[14]**
  - ✓ Nodes around the CH of random are classified as members of that CH based on the Euclidean distance (proximity of distance). **[14]**
- Data Transmission phase
  - ✓ Cluster member nodes collect data from their surroundings and send them to their CH. **[14]**
  - ✓ The CH send the integrated packets to the central BS after aggregating and combining the data. **[14]**

Figure (1) is an example of a wireless sensor network clustered with the LEACH algorithm.

Figure.1LEACH network model **[15]**



LEACH algorithm has superior features over other similar algorithms, which include:

- Using clustering techniques and assistance from local BSs (Cluster Heads) reduces energy consumption due to sending information to a central BS with a long distance. **[15]**
- Information overhead is only in nodes of CH’s and only for communication within clusters. **[15]**
- Using data aggregation and combination techniques in CH’s reduces the amount of information sent to the central BS, which ultimately reduces energy consumption in WSN. **[15]**
- The nodes of each cluster, except for the time opportunities it receives from the CH, put their energy into sleep, which significantly reduces the energy consumption of the sensors. **[15]**

The LEACH algorithm also has disadvantages which are:

- The LEACH algorithm assumes that all network nodes have sufficient power to send information to the central BS aw well as adequate computing power to support different MAC protocols. Therefore, it is not applicable in large-scale networks. **[16]**

- This algorithm assumes that all nodes in each selection cycle start with an equal amount of energy capacity, assuming that the CH consumes as much energy as the other nodes. **[16]**
- The most important drawback of LEACH is that it is not clear how a predetermined number of CHs will be evenly distributed across the network. Therefore, it is possible that the selected CHs are concentrated in a part of the network. **[16]**

The solution to this problem could be to use a centralized or modified clustering algorithm (LEACH-R).

3.1.2. LEACH-R clustering algorithm

The modified LEACH-R algorithm introduces an energy-efficient clustering scheme for the WSN, which depends on the hierarchical structure of the low-power adaptive cluster and overcomes many of the limitations of the traditional LEACH protocol. In the LEACH-R protocol, after clustering the entire network in the center of the CHs, when a target enters the wireless sensor network, the CH that detects the target is activated. The active CH, then selects three sensor nodes from its members to track the target, in which one node is selected as the Leader node. The selected nodes calculate the target and the current location of the target using Trilateration algorithm and sends the data to the leader node. In the previous methods, the localization of the moving goal is done by the CH. But in the LEACH-R algorithm, the localization is done by the leader node. Using this method, the energy consumed in the network is reduced, because the transmission power of the nodes is directly proportional to the distances. Therefore, the energy consumed to send data between nodes is less than sending data from one of the selected nodes to its CH. **[11][16]**

This modified algorithm increases the time of the first dead node and also increases the operating time of the last node, thus increasing the overall network lifetime.

In the base paper **[11]**which we intend to improve, the LEACH-R algorithm for clustering has been used.

3.2. Tracking moving targets

The target tracking system in WSN usually consists of the following three steps: **[17], [12]**

- Target identification
- Find the target coordinates
- Prediction

The implementation of the items mentioned in the base article **[11]** that we are going to improve is as follows:

3.2.1. Target detection

One of the most common and least expensive ways to identify a target is to use the RSSI method. Estimates the distance between two sensors by measuring the strength of the signal transmitted from transmitter to receiver. The signal strength is usually inversely proportional to the square footage, and a well-known radio propagation model can be used to convert signal strength to distance. **[11]**

3.2.2. Find the target coordinates

After receiving the message, the CH node calculates the distance value from the two nodes closer to the target, estimates the coordinates of the current target location using the Trilateration algorithm. **[11]**

3.2.3. Prediction

A prediction-based algorithm typically uses a linear prediction method to determine the next location of a moving target. This mechanism can calculate and predict the coordinates of the following area of the target by comparing the current time, place, speed and direction of the target with the previous time, place, speed and direction of the target. If the predicted location is in the current cluster, the CH selects three nodes close to that location. If the expected site is not from the existing cluster, the active CH sets the nearest CH to that location as the next active CH and assigns the tracking task to the new active CH. **[11]**

4. Objectives Of The Study

- To find out how to reduce the energy consumption of network sensors and increase its lifespan by reducing the communication bandwidth between the source and the receiver.
- To find out how to find the shortest route using multi-step communication by the most energetic cluster heads to transfer information in the shortest time and with the least energy to the central BS for the final decision.

5. Hypotheses Of The Study

The hypotheses considered in this article are outlined in the Table (1).

Table.1. Simulation parameters used

Parameters	Value
Number of Nodes (Wireless Sensor)	100nodes
Ambient Size	100 × 100meters
Central BS Location	(x=40, y=50)
Number of Rounds	1000
Size of Packets sent from CH to BS	200
Size of Packets sent from nodes to the CH	6400
Primary Energy	10
Energy Required to Transfer each Package	50 * 0.000000001
Energy Required to Receive each Package	50 * 0.000000001
Energy Required to Collect Data	50 * 0.000000001
The energy required to transmit the sensor node for one step	0.001
Number of initial populations in COA	5
Minimum number of eggs	2
Maximum number of eggs	4
Number of COA rounds	100
The direction of movement of the target	Selectable (North, South, East, West, Northeast, Northwest, Southeast, Southwest)
Sensing Radius	5 meters

6. The Proposed Method

Our proposed method for optimizing the energy consumption of sensors in pursuit of moving targets focuses on two phases, which include:

- Tracking moving targets.
- Transfer of information to the central base station.

6.1. Tracking moving targets

First, the sensors are clustered to break down the ample problem space into smaller sub-spaces in sensor networks. In our proposed method, we used clustering operations using the LEACH-C algorithm. Then, to improve the performance of this algorithm in finding the best sensor in terms of high energy level for the head of the cluster (CH), we used the COA and Levy flight. Finally, after complete clustering of the network, radio sensors with a receiving radius of 5 meters were used to detect and track targets in each cluster. After the first target is identified by the first CH, three sensors which are closer to the target are activated by its CH. Then by the RSSI method, the target distance from the sensors is estimated. Next, the exact coordinates of the target are calculated using the Trilateration positioning algorithm. Finally, using the linear prediction method, the coordinates of the next location of the moving target is predicted.

6.1.1. LEACH-C algorithm

To eliminate the weaknesses of the LEACH algorithm, the LEACH-C algorithm was designed. LEACH-C is a centralized clustering algorithm, and its installation phase is as follows:

- Each node transmits its location information (GPS[23]) and residual energy to the central BS. **[18]**
- The central BS selects and announces the optimal CH by performing the necessary calculations. **[18]**
- Nodes around the optimal CHs are classified as members of that CH based on the Euclidean distance (proximity of distance). **[18]**

Clustering at the central BS by the LEACH-C algorithm is as follows:

[23] Global Positioning System

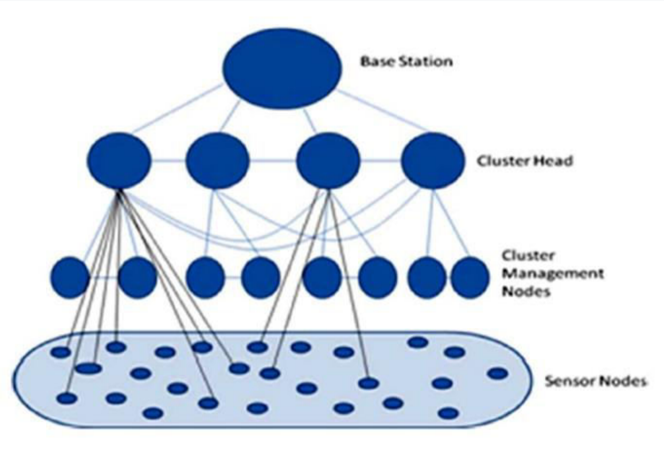
- The central BS, using the location and energy information of each node that has received from the whole network level, calculates and determines the CHs in the entire network level so that the entire network has the same coverage. **[18]**
- The nodes specifications of the CHs are sent to all nodes at the network level. **[18]**
- Clustering of nodes is done to reduce energy consumption by using the shortest Euclidean distance of each node with the nearest CHs. **[18]**

There are the following problems in LEACH-C clustering:

- At the beginning of each clustering period, the remaining energy of each node should be sent to the central BS, which will quickly deplete the nodes and reduce the network lifetime. **[18]**
- The low energy level of all nodes of a cluster causes the destruction of that cluster, which leads to loss of coverage of part of the network. **[18]**

One of the superior features of the LEACH-C protocol compared to the LEACH protocol is the determination of good clusters in terms of high energy as well as better clusters throughout the network. The central BS with equal distribution of sensor network energy load among all nodes by average Taking the remaining power in all network sensors does this. **[18]**

Figure.2. Wireless sensor network equipped with LEACH-C protocol **[19]**



To eliminate these problems and optimize and find the best CH in terms of residual energy capacity, we use the COA so that CH is selected periodically or when the energy of all nodes is less than the average of the whole network.

6.1.1.1. Cuckoo optimization algorithm (COA)

The mechanism of optimization algorithms is that they first start with an initial population of variables and work until the absolute minimum or maximum condition of the objective function is reached. **[20]**

The most essential advantages of optimization algorithms are:

- Resistant to changing conditions. **[20]**
- wide usage. **[20]**
- Connectable to other methods. **[20]**
- Ability to solve complex problems or no solutions. **[20]**

One of the most popular optimization algorithms is the Cuckoo search algorithm. This new meta-innovative algorithm is inspired by the method of laying and reproducing a bird called a Cuckoo.

The COA is based on three rules, which are: **[20]**

- Each bird lays only one egg at a time, and this egg is laid in a randomly selected nest. (Each nest holds a solution) **[20]**
- Nests with higher quality eggs (solutions) are passed on to the next generation. **[20]**

- During the implementation of this algorithm, the nests used remain constant, and the host bird with the probability of “pa” may find a Cuckoo egg. In this case, the host bird has no more than two choices: first, to throw away the guest egg and second, to leave the nest entirely and move to another new location. In this algorithm, if there are “N” nests present, the “pa” percent of those nests are replaced with new nests for ease of operation. (Rejected solutions are replaced with new random solutions in new locations). **[20]**

In Figure (3) and (4), the radius (ELR) travelled by the Cuckoo for spawning from its habitat and the adult Cuckoos migrating for spawning in better areas are shown respectively. **[20]**

Figure.3. Spawning radius of Cuckoos **[20]**

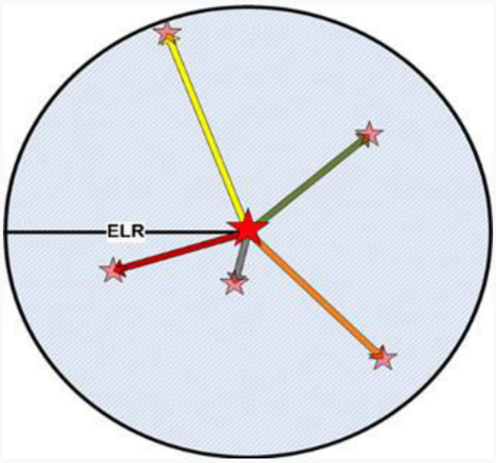
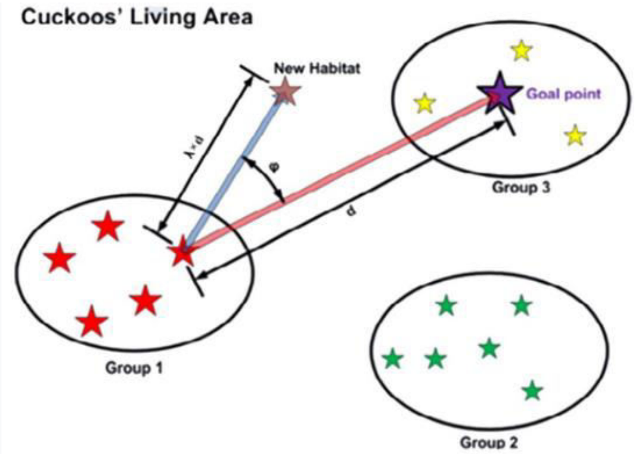


Figure.4. Migration of Cuckoos to the target habitat**[20]**



In the COA to form a cluster with the axis of the strongest CH in terms of energy level, two parameters of energy and location of the node (including two components x and y) are used as follows: **[20]**

- Several nodes in constant numbers are selected as the best CH (creating the initial habitat of the Cuckoo and laying eggs). Equation (1) shows the nests available for spawning, and Equation (2) shows the spawning radius. **[20]**

Equation.1. The nests available for spawning **[20]**

$$Habitat = [X_1.X_2.\dots.X_{N\,Var}]$$

Equation.2. The spawning radius **[20]**

$$ELR = \alpha \times \frac{Number\ of\ current\ cuckoo\ seggs}{Total\ number\ of\ eggs} \times (Var_{hi} - Var_{low})$$

Where Var_{hi}upper limit and Var_{low}lower limit indicate the Cuckoo spawning limits, which usually have a direct and close relationship between the spawning range and the current eggs. **[20]**

- According to the Euclidean distance of the nodes in the network surface with the selected nodes and their residual energy, the amount of fitness of the nodes chosen as the best CH is calculated (fitness is the highest energy of the node compared to two nodes). See Equation (3): **[20]**

Equation.3. Calculate the fitness of CH **[20]**

$$Profit = fp(habitat) = f_p(X_1.X_2.\dots.X_{N\,Var})$$

Where f_p(Profit function), is used to obtain the amount of profit and evaluate the suitability of the current residence of the Cuckoo. **[20]**

- The location and energy of several nodes are calculated randomly using the Levy flight within the network and evaluated using the fitness function. **[20]**
- The fitness of the Levy Flying's CHs is compared to the fitness of the best CH. If the Levy's CHs is better, they are selected as the best CH, and the cluster is arranged relative to the new cluster. (Migration of Cuckoos to a better location). See Equation (4): **[21]**

Equation.4. Finding the best CH by Levy Flight CH **[21]**

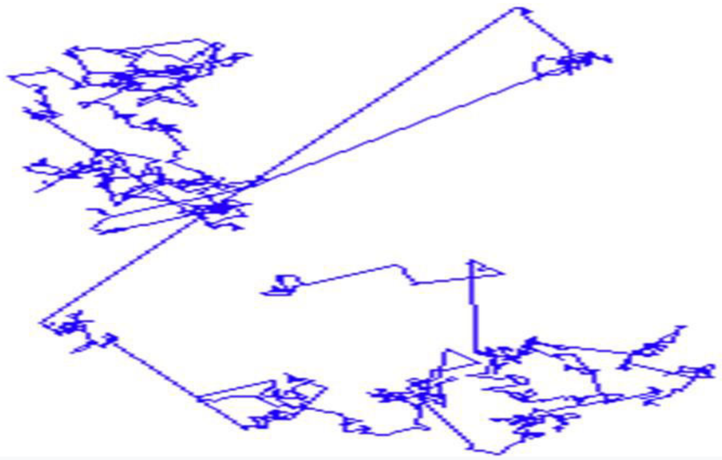
$$X_{NextHabitat} = X_{CurrentHabitat} + F(X_{GoalPoint} - X_{CurrentHabitat})$$

Where "F" is a parameter that causes the Cuckoos to deviate from the main path to a better location, which leads to finding other suitable locations along the way. Using Levy Flight can help you find these suitable places in the middle of the road much better and faster. **[21]**

6.1.1.2. Levy Flight

Levy Flight or Levy Walk is a random walk with random steps that follows the Levy distribution along with these steps. The results of many studies on the flight of birds and insects have shown that the flight patterns of many of them follow the Levy Flight or Levy Walk. Figure (5) shows an example of a Levy flight. **[21]**

Figure.5. Levy Flight show**[21]**



Levy Flight can improve performance as follows:

- Using Levy, other more suitable locations on the main route to a better location are selected again. These locations are dependent on previous locations previously obtained by Levy Flight. The distance between the locations chosen by Levy Flight is the difference between the current Levy Flight location and the better location.
- After the optimal locations are obtained by the COA, through the Euclidean distance, the nodes that have the closest distance and the highest energy are known as CH, and the rest of the nodes choose their CH according to the amount of energy and distance from those centers.

In this paper, the process of selecting a location by Levy Flight, comparing its fitness with a better place, and selecting the best fitness until the algorithm reaches the optimal answer is considered 200 times. A number of locations selected by the COA may not be suitable, with a probability of 25%, if any, these locations are not considered. Another new site will be selected by Levy Flight again.

The density function of the Levy Flight is calculated from Equation (5): **[22]**

Equation.5. The density function of the Levy Flight**[22]**

$$L(s.\gamma.\mu) = \sqrt{\frac{\gamma}{2\pi}} \frac{1}{(s-\mu)^{\frac{3}{2}}} exp\left(-\frac{\gamma}{2(s-\mu)}\right)$$

$$if \quad 0 < \mu < s < \infty$$

Where "μ" are the minimum steps and "γ" are the size parameter, and "s" are the random steps. **[22]**

New solutions in the COA are generated by Levy Flight from Equation (6): **[22]**

Equation.6. Optimized Cuckoo optimization algorithm by Levy Flight**[22]**

$$x_i^{(t+1)} = x_i^{(t)} + \alpha \otimes Levy(\lambda)$$

"α" is the positive step size scaling factor and "⊗" is the entry-wise product of two vectors. In the real world, the more similar the Cuckoo eggs are to the eggs of the host bird, the better the chances of not recognizing the eggs and the higher the probability of survival. Therefore, it is wise that the size of α should be a coefficient of difference between the available solution and the best solution. See Equation (7):

Equation.7. Optimized positive step size scaling factor

$$\alpha = \alpha \left| x_i^{(t)} - x_{best}^{(t)} \right|$$

6.1.2. Track moving targets in each cluster

In this paper, target detection is performed using sensors with target detection power up to a radius of 5 meters and the RSSI method. The first CH that detects the target commands all sensors in its cluster to be activated to detect and track the target's location.

The target distance is then estimated by two sensors closer to the target and using the signal strength received from the target in the RSSI method. Signal strength is usually inversely proportional to distance, and a known radio emission model can convert signal strength to distance. Then, using the Trilateration algorithm in CH, the coordinates of the goal (x, y) are obtained. In this way, its purpose and coordinates are identified.

Then, to track the target, the information must be sent from one node to the surrounding nodes in the cluster from the most appropriate path, taking into account the reduction of sensor energy consumption and the shortest time to receive a response from the CH so that the target can be tracked in the best possible way. Routing for transferring information in LEACH-C clustering algorithm uses one-step communication. The information received from the target is first delivered from the sensors to the CH, and then the information is aggregated and sent to the central BS.

To predict the next target location in this article, similar to the base article, the linear prediction method is used. This mechanism can calculate and predict the coordinates of the next area of the target by comparing the current time, place, speed and direction of the target with the previous time, place, speed and direction of the target. Using (y_i, x_i) and (y_{i-1}, x_{i-1})as well as coordinates of nodes "i" and "$i-1$" at time "t_i"and "t_{i-1}" can be calculated the target's speed "v" and the direction. The predicted location (y_{i+1}, x_{i+1}) of the target after the given time "t" is calculated using the velocity and direction of the target. If the expected area is in the current cluster, the active CH selects two nodes close to that location. Otherwise, if the expected area is not from the current cluster, the active CH sets the nearest CH to that location as the next active CH and assigns the tracking task to the newly active CH. **[11]**

6.2. Transfer of information to the central BS

Routing in our proposed method from CH node to central BS uses intelligent multi-step communication. In each step of information transfer, first, the data is transferred between a sensor node of a target and the node of the CH as a single-step and then this transfer is Intelligently passed between two nodes of the CH based on the CHs and finally, the transfer from the CH node of the final cluster to the node of the central BS changes.

At each stage of data transfer between CH node that sending the target's location to the central BS, there are likely to be several paths, and based on the distance and residual energy of these CHs, one CH node is nominated by the Radial Basis Functions (RBF) and the shortest path is selected. In fact, in this paper, the RBF is used as an evaluator function.

We use equations (8) and (9) to find the best path to reduce network energy consumption in data transmission.

Equation.8.

$$C(n) = \begin{cases} 1 & Most\ energy\ left \\ 0 & otherwise \end{cases}$$

Equation.9.

$$D(n) = \begin{cases} 1 & The\ shortest\ distance \\ 0 & otherwise \end{cases}$$

Where "C" represents the residual energy of the destination node n, and"D" represents the distance of the present node to the destination node. In other words, the RBF, tries to examine the surrounding nodes and select the most suitable node to transmit information to them. Here, the node with the most energy and the shortest distance receives data from the previous node and is selected as the best path.

6.3. Simulation

MATLAB software version R2018b 64-bit was used to simulate this paper. And to implement this sensor network, we used the parameters of Table (1).

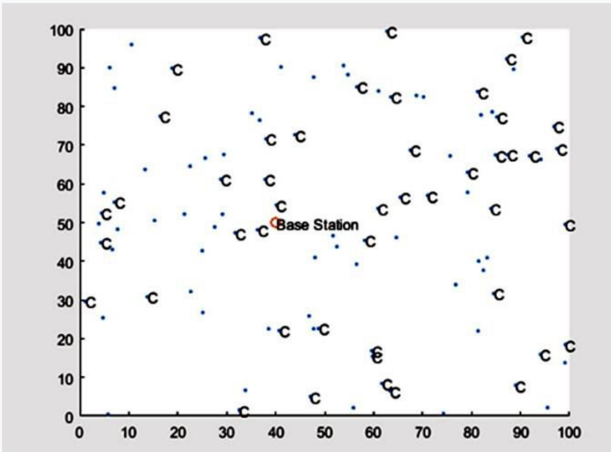
In the first phase of the simulator implementation, according to Table (2), we quantify the desired unknowns to build a wireless sensor network equipped with the proposed clustering protocol.

Table.2. Initializing value in the first phase of the simulation

Parameters	Value
Number of Nodes (Wireless Sensor)	100nodes
Ambient Width Size	100 meters
Ambient Length Size	100 meters
Central BS Coordinate Length	x=40
Central BS Coordinate Width	y=50
Number of Rounds	1000
Primary Energy	10

After specifying the parameters, a network of sensors is created, as shown in Figure (6).

Figure.6. A network of wireless sensors equipped with the proposed protocol



In the second phase of the simulator, according to Table (3) and Table (4), we quantify the desired unknowns to determine the sensitivity radius of the sensor and the direction of movement of the moving target.

Table.3. Determining the sensing radius of sensor in the second phase of the simulation

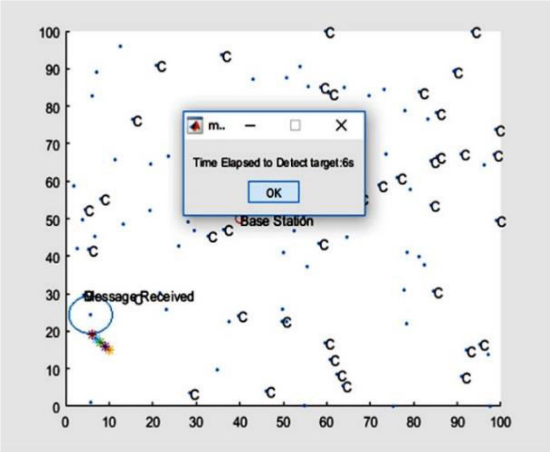
Parameters	Value
Sensing Radius of Sensor	100nodes
Is there a goal to start tracking?	yes

Table.4. Determining the direction of movement of the target in the second phase of the simulation(one choose)

Parameters	Value
North	Selection
South	Selection
East	Selection
West	Selection
Northeast	Selection
Northwest	Selection
Southeast	Selection
Southwest	Selection

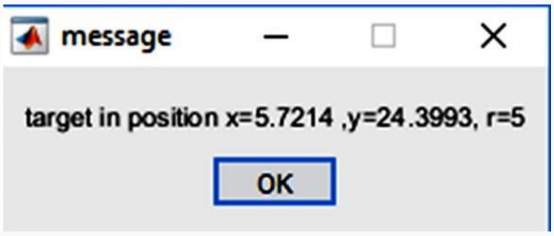
In the third phase of the simulator run, after specifying the value of the parameters according to Tables (2) and (3) and selecting the northwest option from Table (4), the output was obtained as Figure (7).

Figure.7. Simulation output when finding a target in the proposed method



It can be seen that the target node has moved in the network for 5-time intervals without being traced, and in the sixth interval, it has been identified by a node and, its range has been determined. Then the information obtained by the target sensing node is first transmitted to its CH, and then a message from the CH node is sent to the central BS, as shown in Figure (8).

Figure.8. Information received at the central BS after tracking a moving target in the proposed method



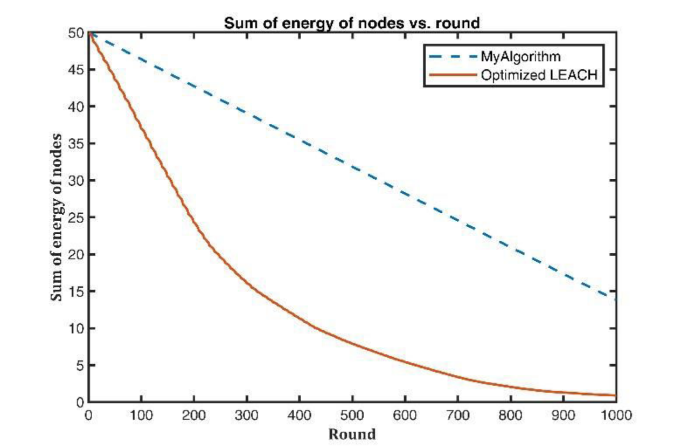
7. Comparison and Analyse

In this section, we compare and evaluate the method proposed in this paper with the method proposed in the base article in three phases:

- Number of dead nodes
- Total number of packets sent
- Total energy consumption in each implementation period

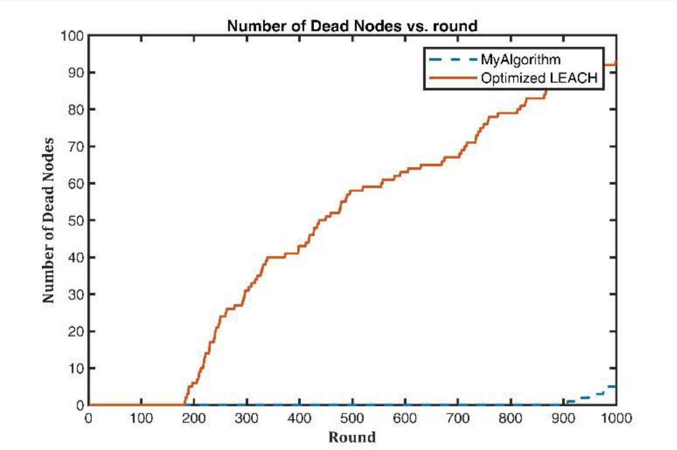
Total residual energy means the sum of all energies of the network nodes in each execution period. Figure (9) shows the total energy of the 100 nodes in 1000 execution cycles in our proposed way and the proposed way of the base paper. In this diagram, the x-axis represents the execution periods, and the y-axis represents the total residual energy of the nodes in different periods.

Figure.9. The total residual energy for the nodes in our proposed method and the proposed method of the base paper in 1000 execution periods



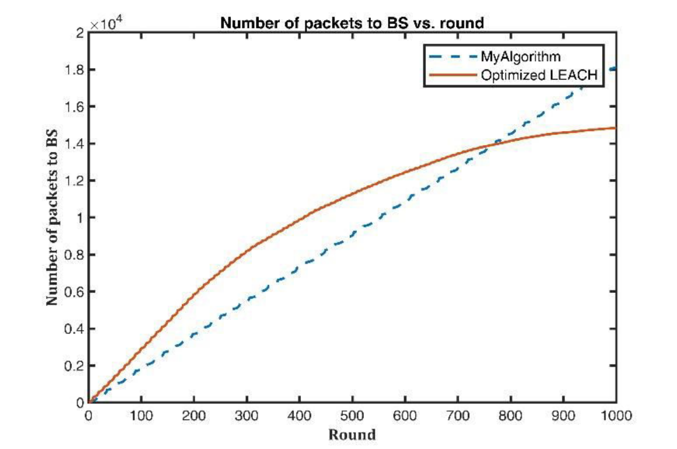
The number of nodes that lose their energy during the periods and their energy level reaches more diminutive than the stability threshold, are called dead nodes. Figure (10) shows the total number of dead nodes out of 100 nodes in 1000 execution periods in our proposed method and the proposed way of the base paper. In this diagram, the x-axis represents periods, and the y-axis represents the number of dead nodes in different periods.

Figure.10. The total residual energy for the nodes in our proposed method and the proposed method of the base paper in 1000 execution periods



The number of packets sent to the central BS means the number of packets sent to the CH through the sensor nodes and to the central BS through the CH. Of course, here, we only mean the number of packages sent from the CH to the central BS. Figure (11) shows the number of packets sent from the CH nodes to the central BS in 1000 execution cycles in our proposed method and the proposed method of the base paper. In this diagram, the x-axis, periods, and y-axis, represent the number of packets sent from the CH to the central BS.

Figure.11. The total number of packages sent in our proposed method and the proposed method of the base paper in 1000 execution periods



8. Conclusion

In this paper, the Cuckoo optimization algorithm (COA) and Leavy Flight was used to optimize the LEACH-C algorithm in finding the strongest CHs in terms of energy levels. In addition, the Radial Basis Functions network (RBF) was used to find the best path to send information from CH to central BS. Based on the simulation results, it was found that our proposed design with the least amount of energy consumption in the shortest time, was able to identify the position of a moving target with very high accuracy. As a result, the network's life and accuracy was higher than the method proposed in the base paper **[11].**

In the proposed way, the number of packets sent was greatly reduced, and by dividing the energy consumption load, we faced a dead node in a longer time than in the base paper method, and finally the residual energy of our network at the end of the test from the network tested in base paper was higher, which proved the superiority of our proposed method

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