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ENHANCED WOA FOR MOBILE ENERGY EFFICIENT AND DELAY AWARE CLUSTERING IN WSN

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Abstract: The mobility, energy efficiency and reduction of delay in wireless sensor network (WSN) is most challenges that researchers working on it for more optimizations. The wale optimization algorithm is used in this paper after some modification in some steps to balance between the exploitation and exploration, we enhanced WOA for energy efficient and delay aware with respect to mobility of nodes out of clusters. The performance is evaluated by packet delivery ratio, delay, energy consumption, and throughput with considering the mobility of each node to be selected as cluster head. The proposed mechanism is compared with Hybrid FOA-WOA algorithm, we got good results in term of energy consumption, delay and throughput.

Keywords*:* WOA, WSN, MANET, IOT, Hybrid FOA-WOA.

1. INTRODUCTION

The wireless sensor network (WSN) shows to the nodes set dedicated, dispersed sensors to record and monitor an environment physical situation, as well as organizing collected data at the central location.The nodes transfer data packets between each other through intermediate node. The topology of our infrastructure consider the nodes can move from one cluster to other, and then taking in account the mobility of node when selected as cluster head.

Clustering is good structure of our infrastructure [1]. The groups of nodes formed the clustering process is called clusters, mobile nodes are called cluster head, the nodes which have connection between two clusters is called cluster gateway [2]. The cluster head role is forwarding the packets to the base station or other cluster heads, it gives unique ID to the cluster.

The algorithms of clustering are able to be grouped as the partitioned clustering and hierarchical clustering [3]. The hierarchical clustering classifies data with the partitions sequence either from some singleton clusters to one cluster, which are the whole things/ vice versa. The paper studies the centralized on the partitioned clustering, which share a dataset in the disjoint clusters set. The most popular algorithms of partitioned clustering are the clustering algorithms based on prototype where every cluster is provided by cluster center, also the utilized objective function is distance sum from a thing to center.

K-means is the clustering approach which is popular and based on the center, because of the efficiency and simplicity of it with linear complexity. Although, k-means algorithm solution depends on initially random mode, also it always converges to a local optimum [4]. Currently, investigators for overcoming the issue have provided the algorithms of heuristic clustering. Because of information large amount and problems complexity, the optimization methods which are classic are not able to solve most of the optimization issues; so, investigators have begun to utilize the algorithms of meta-framework. Nowadays, the algorithms of nature-inspired are utilized widely for solving the issues in different fields [5]. Meantime, techniques of clustering, as well as the other steps of data analysis and data mining, made the considerable progress by utilizing collective intelligence algorithms.

Mukhopadhyay and Mualik [6] provided the combined algorithm of clustering. They composed Simulated annealing(SA) with the artificial neural networks in order to improve the quality of solution. Proposed hybrid algorithm was utilized in order to clustering three real-life microarray sets of data and proposed approach results were compared to several commonly utilized algorithms of clustering. Results demonstrated new algorithm superiority. Bundyopadyay and Mualik [7] provided the genetic-algorithm-based approach for solving the problem of clustering. They investigated algorithm on real-life and synthetic sets of data in order to evaluate the performance of it.

Tunchan [8], provided the new approach of PSO in order to cluster the problem which is applicable, efficient and easy-to-tune when clusters number is unknown/ known. Karaboga et al. [9], utilized an algorithm of artificial bee colony in order to solve problem of clustering. Simulations results on 13 problems of tests from the UCI demonstrated proposed algorithm superior performance in comparison to the algorithm of PSO the several other approaches. Therefore, writers were realized that algorithm of ABC is able to be suitable for solving problems of multivariate clustering.

Zhang et al. [10], provided the clustering algorithm of the artificial bee colony (ABC) in order to cluster the rule of Deb which is utilized for the process of selection instead of the greedy selection. They experiment the algorithm on some well-known real sets of data, as well as comparing to the other popular heuristics algorithms in the clustering. Conclusions were so encouraging in terms of clusters quality. Farmani and Armando [11], provided the method which is a k-means and ABC algorithms combination for improving k-means efficiency to find the global optimum solution.

Saminathan [12] proposed Hyperid FOA-WOA algorithm for energy efficient and delay aware clustering, without considering the mobility of nodes when selecting cluster head.

Ahmed Ali Saihood [13], provided the ELFCP-MWSN in which he declies the consumptions of network energy, and lightly less the transmission delay end-to-end data than existing LFCP-MWSN. Also, ELFCP-MWSN includes the simple range free approach for localizing the odes of sensor during the formation of cluster and each time a sensor moves in the other cluster.

In this paper we did two steps, first, we enhanced the wale optimization algorithm (WOA) by adding way to switch between shrinking encircling and spiral model by parameter (p) which was selected randomly between [0.1] in origin WOA, this may lead to premature convergence in some cases, if the whale is far from the prey in rational value we use spiral model for searching, and according to this rational value we may switch to shrinking encircling.

Second, we used enhanced WOA for energy efficient and delay aware cluster head with considering the mobility of node selected.

2. ENHANCED WOA

Whale optimization algorithm taking the idea of hunting of humpback, which use two type of movements to attack the preys. Figure 1 shown the way used by humpback, by which the initial position is chosen then the humpback start moves encircling the preys toward the target which is the optimal position, then using the bubble-net attacking for exploitation.

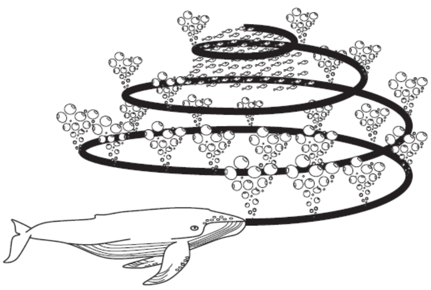

Figure 1 humpback hunting way

2.1. Encircling prey

The current best solution is target prey; the search will update the position toward the optimum solution which is target prey.

$$\overrightarrow{D} = |\overrightarrow{C}.\overrightarrow{X} * (t) - \overrightarrow{X}(t)| \qquad (1)$$

$$\overrightarrow{X}(t+1) = \overrightarrow{X} * (t) - \overrightarrow{A}.\overrightarrow{D} \qquad (2)$$

Where

$\overrightarrow{A}$ & $\overrightarrow{C}$: Coefficient vectors.

t: is current iteration.

$\vec{X}$: is position vector.

$\vec{X}^*$: is position vector of best solution.

In equation (1) & (2) $\vec{A}$ is changing probably depending on the value of (a) as in equation (3)

$$\vec{A} = 2\vec{a}\,.\vec{r} - \vec{a} \qquad (3)$$

$$\vec{C} = 2\,.\vec{r} \qquad (4)$$

Where

$\vec{a}$ is linearly decreased from 2 to 0 during iterations in exploration and exploitation phases.

$\vec{r}$ is random vector between [0,1].

2.2 Bubble-net attacking (exploitation)

There are two way of attacking used by humpback, shrinking encircling mechanism which achieved by decreasing the value of $\vec{a}$ in equation (3), then $\vec{A}$(random number between [- $\vec{a}$, $\vec{a}$])is decreased. Figure 2 shows the possible position of humpback toward optimum position when 0<A<1.

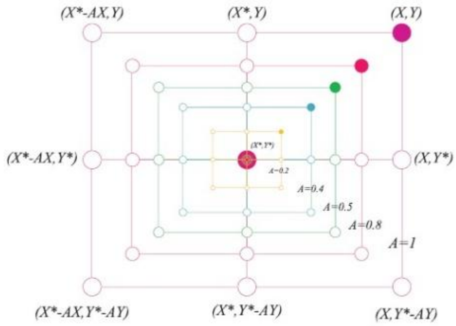

Figure 2position of humpback toward optimum position when 0<A<1

Second is spiral updating position, by which the distance between the current location of the whale and prey is calculated, then spiral shape is created between whale and prey.

$$X(t+1) = \vec{D}'.e^{bl}.\cos(2\pi l) + \vec{X} * (t) \qquad (5)$$

$$\vec{D}' = |\vec{X} * (t) - \vec{X}(t)| \qquad (6)$$

Where

$\vec{D}'$ is distance between the current position of the whale and target prey.

b: is constant to define the shape of logarithmic spiral.

l: is random from [-1,1].

Figure 3 shows the spiral updating position.

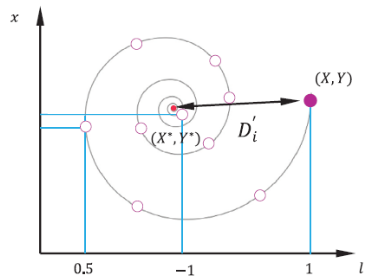

Figure 3spiral updating position of humpback

The origin WOA consider random value of (p) to switch between shrinking encircling mechanism and spiral model, the proposed way for switching is depending on the distance between whale and prey at eachiteration and the value of $\vec{A}$ as shown in equation (7).

$$p = \left|\frac{\vec{D}'}{10} * \vec{A}\right| \quad (7)$$

$|.|$ to ensure that the value of p be positive, equation (8) is used to switch between two mechanisms.

$$\vec{X}(t+1) = \begin{cases} \vec{X} * (t) - \vec{A}.\vec{D} & \text{if } P < 0.3 \\ \vec{D}.e^{bl}.\cos(2\pi l) + \vec{X} * (t) & \text{if } P \geq 0.3 \end{cases} \quad (8)$$

2.3. Search (exploration)

The value of $\vec{A}$is between [-1,1] used in exploitation, now we use values of $\vec{A}$ greater than 1 or less than -1 to search for global solutions

3. PROPOSED METHODOLOGY

The infrastructure of WSN is assumed to have heterogeneous nodes in term of the role doing, such as cluster head, cluster member, or cluster gateway. All nodes are assumed to be mobile, and initially have the same energy. There is a node in each cluster equipped with GPS, its role is localization for other members. Figure 4 shows the structure assumed for WSN.

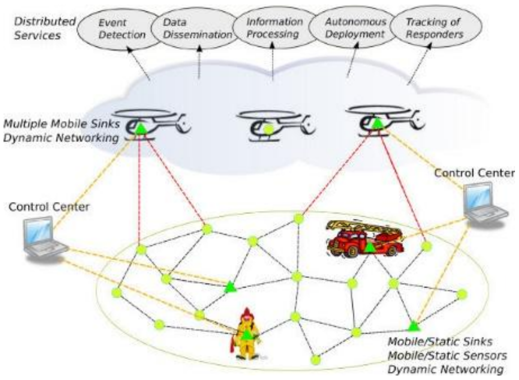

Figure 4structure assumed for WSN

3.1. Energy Consumption

The node transmitting data with less energy consumption is selected as cluster head, initially we assumed all nodes having the same amount of energy, the total energy consumed by the node is calculated by transmission energy, receiving energy, and idle energy.

The transmission energy is calculated as shown in equation (9)

$$E_{trans} = \begin{cases} M * E_{elect} + M * E_{frs} * d^2 & ; if\ d < d_0 \\ M * E_{elect} + M * E_{amp} * d^4 & ; if\ d \geq d_0 \end{cases} \quad (9)$$

Where

E_{elect} is electronic energy, d is distance, d_0 is threshold distance and it is given in equation (10).

$$d_0 = \sqrt{\frac{E_{frs}}{E_{amp}}} \quad (10)$$

Where

E_{frs} is the energy of amplifier while using free space model, E_{amp} is the amplifier energy.

The receiving energy is calculated as shown in equation (11)

$$E_{receive=M*E_b} \quad (11)$$

Where E_b is the energy required in per bit transmit circuitry.

The idle state energy is calculated as shown in equation (12)

$$E_{idle} = P_{idle} * T_{idle} \quad (12)$$

Where P_{idle} is power idle , T_{idle} is idle time.

Then the total energy is calculated by equation (13)

$$f_{energy} = E_{trans} + E_{receive} + E_{idle} \quad (13)$$

3.2. Delay Model

When the number of members inside cluster is increased the delay is also increased, the delay is reduced when the cluster has less cluster members. The delay of the network is given by equation (14).

$$f_{delay} = P_d + Q_d + PR_d + T_d \quad (14)$$

Where P_d is processing delay, Q_d is queuing delay , PR_d is propagation delay, and T_d is transmission delay.

3.3.Mobility Determination

The mobility factor is the measure of movements(frequency) of node from cluster to other, the node with less mobility have more chance to be selected as cluster head, the mobility factor can be measured by the ratio between the times that node enter different clusters to the times that node moves within cluster, the distance that node can move is calculated by equation (15)

$$d = |t_2 - t_1| * velocity \quad (15)$$

When t_1 and t_2 is first and second iterations, if d >$d_{threshold}$, the it assumed to be moved to another cluster. If $0 \leq d < d_{threshold}$, then it assumed to be moved within cluster. These movements are counted to calculate the mobility factor for the node as in equation (16).

$$f_{mobilty} = \frac{times\ of\ mves\ out\ of\ cluster}{time\ of\ moves\ within\ cluster} \quad (16)$$

4. Implemented Algorithm

Now after three fitness function being calculated, the Pseudo code of the work proposed is given in this section:

Pseudo Code of Enhanced WOA in term of Mobility, Energy Efficient, and Delay
Input: Population and Location, terminate condition ***Output:*** Best cluster head (best solution)

Begin:
▪ Generate the population and the initial location of preys randomly.
▪ While (! terminate condition)
{
_Move the Whale for search (exploitation) in switching between shrinking encircling and spiral model according to the value of (p).
_Compute the distance between whale and prey, update the value of (p) from equation (7)
_Update value of $\vec{A}$ for global searching (exploration)
_Calculate the fitness value by equation bellow:
$\boldsymbol{f = min(f_{energy}, f_{delay}, f_{mobilty})}$
_Find Best Cluster head and record its position.
}

4.1 Evaluation metrics:

i. Packet delivery Ratio

It is a ratio of number of packets delivered to all receivers to number of data packets sent by the source. It is calculated by equation (17)

$$PDR=\frac{Total\ \ packets\ \ received}{Total\ \ packets\ \ sent} \quad (17)$$

ii. Throughput

It is average of message delivered successfully to its destination. It is calculated by equation (18)

$$Throughput = \frac{Number\ \ of\ received\ \ packets * packet\ \ size}{Time} (18)$$

iii. End-to-end delay

refers to the time taken for a packet to be transmitted across a network from source to destination.

iv. Energy Consumption

The energy required to transmit and receive packets. It is calculated by equation (19)

$$Energy\ Consumpption = E_{Trans} + N * E_{Recieve} \quad (19)$$

N is average number of neighborhood nodes of the transmitting node.

4.2 Simulation and Results

For the simulation of our proposed work we used MATLAB. Table 1 shows the parameters that we used through our simulation. We used to compare our results with Hybrid FOA-WOA algorithm in term of metrics mentioned in previous section.

In term of Packet delivery ratio EWOA shows more efficiency than Hybrid FOA-WOA, Figure 5 shows that the packets sent by EWOA have been received 4% more than Hybrid FOA-WOA.

The packets have been delivered to the destination in average in specific time in EWOA is more 6% than that delivered in Hybrid FOA-WOA, figure 6 shows the throughput of EWOA and Hybrid FOA-WOA.

The time needed to transmit the packets from source to destination in the network is reduced in EWOA, figure 7 shows End to End Delay in both algorithms.

In term of Energy consumption, the energy consumed in EWOA is reduced 3% that that consuming in Hybrid FOA-WOA.

CONCLUSIONS

This paper shows the infrastructure of wireless sensor network using proposed EWOA algorithm, the simulation concentrating in energy consumption, packet delivery ratio, throughput, andend to end delay. The results are compared with Hybrid FOA-WOA, which showed that our proposed EWOA is better than Hybrid FOA-WOA in term of end to end delay,energy consumption, packet delivery ratio,and throughput,

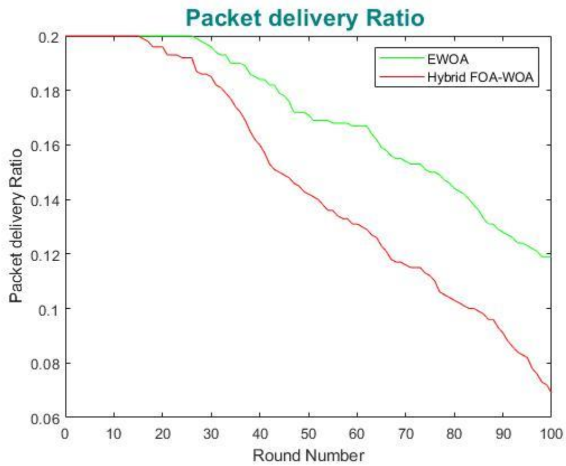

Figure 5 Packet delivery ratio

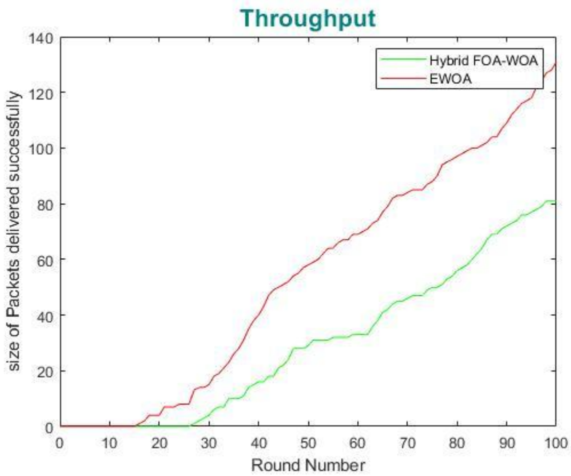

Figure 6 throughput

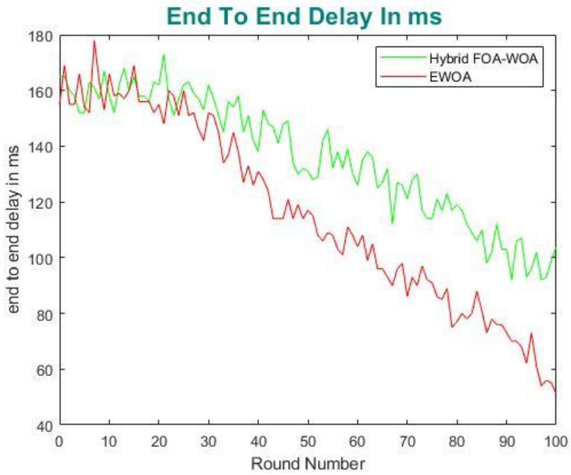

Figure 7 End to End Delay

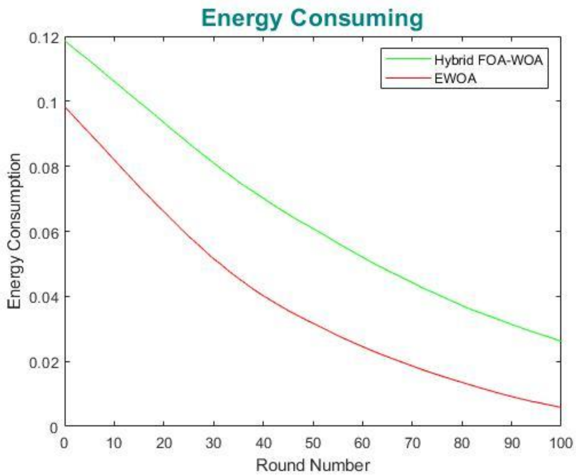

Figure 8 Energy Consumption

Table 1Simulation Parameters

Parameters	Values
Number of nodes	200
Area Size	1000*1000 m
Simulation Time	500 sec
Number of rounds	500
Traffic Model	CBR
Transmission range	250 m
Packets Size	512 bytes
Data rate	11 mbps
Transmission Rate	500 kbps
Propagation Model	Two ray ground reflection model
Mobility model	Random way point
Initial Energy of node	20 j
Electronic Energy	50nj/bit
Amplifier Energy	0.0013 pj/bit/m^4
Amplifier Energy while using propagation Model	10 pj/bit/m^2
Threshold Distance	47 m
Transmitting Energy	50 nj/bit/m^2
Idle Energy	30 nj/bit/m^2

REFERENCES

1. Pathak, S., & Jain, S. (2017). “An optimized stable clustering algorithm for mobile ad hoc networks. EURASIP Journal On Wireless Communications And Networking”, 2017(1). doi:10.1186/s13638-017-0832-4
2. Sathiamoorthy, J., & Ramakrishnan, B. (2015). “Energy and delay efficient dynamic cluster formation using hybrid AGA with FACO in EAACK MANETs”, Wireless Networks, 23(2),371-385. doi: 10.1007/s11276-015-1154-2
3. Frigui, H., &Krishnapuram, R. (1999). “A robust competitive clustering algorithm with applications in computer vision,. IEEE Transactions Pattern Analysis Mach Intelligent, 21, 450–465. doi:10.1109/34.765656
4. Jain, A., &Dubes, R. (1998). “Algorithms for clustering data. Englewood Cliffs, NJ: Prentice-Hall”.
5. Faieghi, M. R., &Baeanu, D. (2012). Anovel adaptive controller for two-degree of freedom polar robot with unkown perturbations. Communications in Nonlinear Science, 17(2), 1021–1030. doi:10.1016/j.cnsns.2011.03.043
6. Maulik, U., & Mukhopadhyay, A. (2010).”Simulated annealing based automatic fuzzy clustering combined with ANN classification for analyzing microarray data”. Computation Operational Researcher, 37,1369–1380. doi:10.1016/j.cor.2009.02.025
7. Mualik, U., & Bandyopadhyay, S. (2000). “Genetic algorithmbased clustering technique. Pattern Recognition”, 33, 1455–1465. doi:10.1016/S0031-3203(99)00137-5
8. Tunchan, C. (2012). “A particle swarm optimization approach to clustering. Experiments System Applications”, 39, 1582–1588.
9. Karaboga, D., & Ozturk, C. (2011). “A novel clustering approach: Artificial bee colony (ABC) algorithm. Applications Soft Computation”, 11(1), 652–657. doi:10.1016/j.asoc.2009.12.025
10. Zhang, C., Ouyang, D., & Ning, J. (2010). “An artificial bee colony approach for clustering. Experiments System Applications”, 37, 4761–4767. doi:10.1016/j.eswa.2009.11.003
11. Armando, G., &Farmani, M. R. (2014). “Clustering analysis with combination of artificial bee colony algorithm and k-means technique”, International Journal of Computer Theory and Engineering, 6(2), 141–145. doi:10.7763/IJCTE.2014.V6.852
12. Ahmed Ali Saihood.” Proposed Smart Technique for Traffic Light System”, Journal of Thi-Qar University Vol.13 No. 2 June 2018.
13. Ahmed Ali Saihood, Rakesh Kumar. “Enhanced Location Based Energy-Efficient Reliable Routing Protocol for Wireless Sensor Networks”, International Journal of Inventive Engineering and Sciences (IJIES), May 2013.

