A hybrid Optimization Technique based Energy Efficient Cluster Head Election in WSN Using Dijkstra Algorithm

Sakshi Agarwal
Sobhasariya Engineering College
Rajasthan Technical University
Sikar,India

Anwar Hussain Joya
Sobhasariya Engineering College
Rajasthan Technical University
Sikar,India

***Abstract*—Advances to the user-friendly interface, size, or cost of deployment for wireless sensors have led to a range of clever wireless sensor network (WSNs) applications. However, other challenges, such as the efficiency of energy, long life, or reliability of communication, limit their wide use. A clustering approach aims to increase the reliability of data transfer by separating sensor nodes (SNs) into small groups. though, inappropriate selection of cluster head (CH) can influence network life, average network energy as well as other quality of service (QoS) parameters. The goal of this paper is to maximize the power consumption, network life, or network lifetime with a hybrid technique for cluster head (CH) selection. The formulated fitness method is used for an optimal clustering of cluster heads for energy reduction or load balance. A new exercise function-based hybrid clustered protocol is proposed. The Fuzzy inference system is used for the clustering algorithm efficient clustering process. Meanwhile, a minimum spanning tree named Dijkstra algorithm is also constructed to establish the connection between the nodes for finding the shortest and secure path for data transmission hence resulting in faster data sending and receiving process.**

Keywords— WSN, CH selection (CHS), Residual energy (RE), Lifetime, Energy-efficient (EE).

I. INTRODUCTION

In recent years, technical advancement in microelectronics or wireless low-power communication has allowed the growth and deployment of WSNs. The rapidly growing uses of WSNs include realistic military, medical services, environmental surveillance, industrial management, and everyday living services.

A WSN[1,2] that consist of hundreds or thousands of SNs normally battery-powered or deployed for the collection of the information necessary in an unprotected environment. As the sensor network typically requires large numbers of sensor nodes, after installation, it is difficult to regenerate the nodes. The key concern as well as an emphasis on the development of the network is therefore how to increase EE to extend the lifespan of a WSN. There are 3 principal units of a sensor network, called a control unit, a processing unit, and an intercom device. First of all the ADC (Analog to Digital Converter) sensor portion and sensor architecture are used for data sensing. The second part is to use the ADC session to convert sensed data from analog to digital. The three-session of the device is a memory & processor module that stores information received. a control unit is developed with the use of a battery that provides electricity for other sensing & processing devices. WSN consisting of spatially distributed SNs typically executes, manages every node & communicates to other nodes via environmental monitoring.

WSN is used in various industries. This increases WSN 's success every day. Nevertheless, sensor nodes have less memory, poor battery capacity, and a sluggish processor. It is therefore very important for EE & QoS to be increased. Generally, 3 operations such as connectivity, data collection, and aggregation are the source of energy exhaustion. The major part of the energy is absorbed in the contact portion. This ensures that energy consumption (EC) in both sensor networks & sensor nodes is minimized by our operation. The key function of WSN is to gather data and then move it to the specific station for further use by collecting information from sensor nodes. In this process, energy use is very important as the node is a source of contact (i.e. transmission & receipt) [3].

data is collected directly or indirectly in WSN[4]. Direct contact between data or base station means that because of the long distance between the SN or base station (BS) EC in this phase is higher [5, 6]. This limits the length of the network. And indirect communication, nodes are multi-hop information. This feature decreases SNs energy consumption and increases network life. However, further interaction between SNs & routing information is important in multi-hop strategies for node communication that affect network performance. But, after eliminating intrusion, we can utilize cluster-based data processing. Specific no. of SNs are call clusters in WSN. The CH is spread via sensors or through centralized control algo in each cluster. Efficiency control of WSNs can be given by each cluster sensor & CH is able by aggregating false positive data.

A variety of solutions to reducing the finite power resources of a wireless sensor network have been suggested in the literature. They can be graded as hierarchical (clustering) and square. The two are the more convenient, effective way of energy saving in large-scale wireless sensor networks, which is also clustering [7]. Clustering requires energy-efficient considerations:

1. To minimize the amount of data transfer, CH will aggregate or compress large volumes of sensor data.
2.
3. Clusters can minimize the number of nodes responsible for long-haul transmission, thereby reducing transmission energy consumption.

In the working of clustering, CHs play a major part. In addition to data aggregation and propagation, cluster heads are also greatly influenced by energy consumption, since a CHS method will decide their scale, location, and no. of clusters in the network.

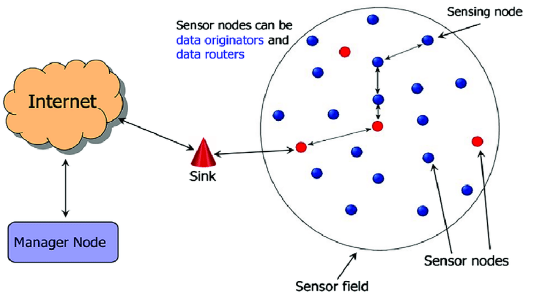

Figure 1. Architecture of WSN

The following paper has been organized. The related clustering approaches for WSNs are given in Section 2. The concept and implementation of our current clustering method were presented in Section 3. Section 4 offers an extensive analysis of the efficiency of our methodology with current clustering techniques. Section 5 includes debates on potential solutions. Section 6 ends the text.

II. LITERATURE REVIEW

Kumar et al. [9] Find the advantage of the energy node heterogeneity of WSN by a specification for the three-stage grid of an EEHC protocol (EnergyEfficient Heterogonous Clustered). It chooses CH based on RE of SNs using probability limit function. EEHC is stronger than LEACH as a heterogène strategy in terms of optimized network life.

Similarly, Sharma et al. [10] Developed a traffic or energy-aware routing paradigm (TEAR) for optimized stability period, believing that SNs with arbitrary first energies or traffic origination disparities will triumph over constraint of network complexity. In addition CREEP protocols, LA-MHR (automate-based heterogeneous clustering) & EDCS (efficient & complex clustering scheme) for heterogeneous clustering network were created for Dutt et al [11] et Tanwar et al. [12]. CREEP protocols were developed respectively. CREEP seeks to reduce no. of CH per round to boost network existence by way of double heterogeneity.

Hong et al. [13] The energy forecast (CTEF) clustering-tree control for the balancing of load and energy efficiency has been established when taking into account different issues (e.g. PLR & relation reliability). In adding to traditional CH-Selection Mechanism & cluster configuration, both central theorem & log-normal distribution measures are useful to reliably estimate the network's average residual energy (RE) differentiation.

Moussaoui & Boukeream [14] et al. QoS-based WSN routing protocols have been scientifically examined. A geographical position QoS protocol called Pace was developed by He et al. [15]. A neighboring table definition was implemented in this protocol. The adjacent tables hold the next location and the delay in each node for the single-hop neighbors. The tension between an optimum distribution and load balance is often taken into account.

Kavi et al. [16] Offer a multi-target optimization strategy for routing. The load, frequency of connexions, and RE parameters are known as output parameters to approximate the efficiency of the routing protocol. It ensures fast package delivery or continuity of links.

Chen [17] The SHE (Self-stabilizing Hop-constrained Energy Efficiency) introduces the harsh real-time protocol. In this technology, traffic packets are routed from CHs to the base station by various paths after a cluster-formation process. You define AT (Aging Tag) for obtaining the QoS requires.

III. RESEARCH METHODOLOGY

PROBLEM FORMULATION

Three specific problems may be outlined in the disadvantages of the HQCA system. The first problem is CH's inaccurate decision. The second issue has emerged since the sensor nodes within each cluster are unequally distributed. For smaller clusters, the energy usage of the sensor nodes is lower than that of a wide cluster. Since the majority of data is sent by the nodes in smaller clusters. In the constant state process, the third problem is formalized. Within the growing cluster, all sensor nodes are sent continuously. The transfer has been carried out even though the sensed data is not modified. The three problems are why inefficient energy consumption has fallen. This decrease limits the life of the network.

PROPOSED APPROACH

In the proposed work, we have used a new clustering algorithm for overcoming the limitations of previous research work in which PSO algo was used. In this proposed paper hybrid PSO-GA is applied for CH election & clustering of nodes. After completing the clustering process, a node is nominated for CH by choosing the limit of CH.

CLUSTERING

GA is an optimization system inspired by genetics that imitates the natural evolution theory, i.e. fittest individuals will live in a generation[5-7]. A gene or human solution is called GA. Several distinct units, called chromosomes, make up each chromosome. Overall, each chromosome in a solution space offers a different solution. GA ends with a set of populations called chromosomes [8, 9].

The following GA steps are provided:

1. Initialization: Arbitrarily produce a population of people in the solution area.
2. Estimation of Fitness: determine each person's health.
3. Selection: it takes out the poor ones and preserves decent ones.
4. Crossover: It produces offspring by mixing features of two or more men.
5. Mutation: In subsequent generations, it retains genetic diversity.
6. Repeat: Continue from stage 2 to not fulfilled the termination criterion.

PSO

PSO is a technique of algo optimization that imitates the cooperative design of birds to locate food. Any solution is referred to as particle or entity & a set of solutions is referred to as a swarm. Particles travel in solution space during the optimization process in PSO. -- Particle has a memory that knows the best person & best place in the universe. The velocity or direction of the particles shall be changed by the following:

$$v_{id} = v_{id} + c_1r_1[p_{id} - x_{id}] + c_2r_2[g_d - x_{id}] \quad (2)$$

$$x_{id} = x_{id} + v_{id} \quad (3)$$

D = {1, 2, ..., D} as seen in the above equation. C1,c2, respectively, are stable cognitive and social stability. Constantly accelerated abstract particles to their best location, constant relational accelerated particles to their best position worldwide. The random r1 value is r2 in [0 , 1]. The following steps of PSO are provided:

1. Initialization: generate particle population randomly to include solution area. Initialization:
2. Fitness estimation: estimation of each particle's fitness.
3. Select the best positions: pick the best positions for "swarm and entity."
4. Velocity and position update: Calculate each particle's current velocity and location using Eqs. (2) and (3), respectively. When extended with a position, velocity operator vi returns a new position for ith atom.
5. Repetition: Beginning with step 2 until the termination requirement is not met.

Hybrid GA-PSO Algo for CH Election

A hybrid GA-PSO algo for the problem of CH Election is being developed during this research. Algorithm 1 demonstrates the dual GA-PSO algorithm. The motive behind this algorithm is to benefit from the high PSO over the GA convergence rate for the CH election. In the photo, you will see a community change to the GA-PSO hybrid. 3. To address this question, a hybrid solution uses a randomly generated population of 4 m individuals. People are sort in decreasing order of fitness & most desirable 2 m individuals are supplied by genetic operators to GA to generate 2 m those. The new 2 m people created by the GA mechanism are employed by the PSO mechanism to improve the worst 2 m, people. Changing the particles involves swarm catching or optimal locations for individuals. The best swarm position is selected for particles with the highest fitness score. Person best positions are picked with the 2 m particles distributed equally first and the correct particles are selected as the best position for individuals. The speed and location are eventually modified for 2 m particles. The hybrid GA-PSO algorithm stops for successive generations until the situation has changed.

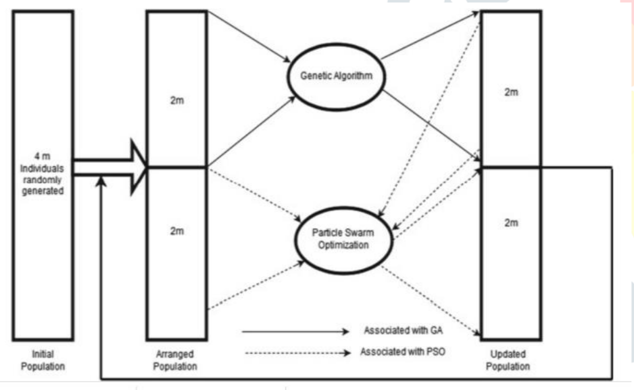

Fig. 3 Population updation in hybrid GA-PSO algo

Algo 1 Hybrid GA-PSO

1. Initialization: a population of 4 m persons is generated randomly.
2. Estimation of Fitness & Arrangement: measure exercise of 4 m people ^ type fitness. Exercise calculation.
3. GA mechanism: add the classical GA to top 2 m persons & generate new 2 m persons.
   a. **Selection:** Using an appropriate range to create a 2 m mattress pool.
   b. **Crossover:** To create new offspring using an order-based cross-over.
   c. **Mutation:** Make the mutation can scamble operator with new offspring.
4. PSO-Mechanism: To update position & velocity of PSO on worst 2 m people.
   a. Select Best Positions: Pick the positions for "swarm and individuals."
   b. Update Velocity & Position Data: Measure novel speed & location with the Eqs for any particle. (2) and (3), respectively. Repeat: Start in phase 2 until you have not reached the termination criteria.

PSO-GA is an important way to evaluate the cluster head node. PSO-GA Algo - node's fitness values consistently have the following constraints, such as capacity, distance, and density.
1. Energy (E1): energy ratio between both energy of component and total energy of all other nodes in a cluster is determined.

$$E1 = \sum_{a=1}^{N} E(P_a^d) \,/\, \sum_{b}^{M_b} \frac{\varepsilon(G_b^d)}{G_n} \qquad ()$$

In this case $E(P_a^d)$ is particulate energy, $E(G_b^d)$ reflects the mean energy of other cluster nodes

2. *Distance (D2)*: transfer of data relies on the length of the sink & node. In cluster extent to sink & particle length to sink is determined by the average length of each node.

$$D2 = d + \frac{range}{2} + \frac{\sum \frac{D_a}{M_b}}{D_p} \qquad ()$$

Here D_p is the distance from the node, M_b is the middle of cluster nodes.

3. *Node Density (N3)*: density is applied for the determination of the Ability to be a cluster head for a particular particle. It too and that Varies depending on neighbor node number.

$$N3 = N_{degr}(P_a^d(t)) \qquad ()$$

Fitness Function (FF) for PSO

The last fitness equ. [11] is as follows for CHs:
$$Fitness_{maximize} = (\varphi 1 * E1 + \varphi 1 * D2 + \varphi 1 * N3) \qquad (4)$$

Here φ1, φ2, φ3 are weightage parameter.
where Φ1+ φ2+φ3= 1
Subject: $E1 > E_{th}$
$D > D_{th}$
$N < N_{th}$

CH energy node The distances as well as the density of the node are smaller than the average value.

CH ELECTION

Fuzzy clustering by FCM Algo:

FCM[12] algo is a fuzzy clustering algo which is EE. The main goal of FCM is to decrease the amount of space between individual instances & cluster centers. N number of SNs is grouped into G classes. WSN scenarios. A growing node is organized by two dimensions. Input instance matrix is I= $\{I_1, I_2, \ldots I_N\}^\tau$, dimension N*2. cluster center matrix is M= $\{M_1, M_2, \ldots M_G\}$, dimension G*2. state of clustering is represented as matrix = [N*G] were 1 ≤ a ≤N, 1 ≤ b ≤ G. To clustering, an objective function is as occurs:

$$J_{FCM}(a, b) = \sum_{a=1}^{N} \sum_{b=1}^{G} Z_{a\,b}^{q} \times d^2(I_a, M_b) \qquad (5)$$

In which $Z_{a\,b}$ part of the cluster b node. $d^2(I_a, M_b)$ as Euclidian distanceI_a, M_b is the same as the euclidian distance.

$$d(I_a, M_b) = \sqrt{[(I_{a1} - M_{b1})^2 + (I_{a2} - M_{b2})^2]} \qquad (6)$$

$Z_{a\,b}$ is a membership value of a_{th} sensor to b_{th} cluster, correlation made known as $Z_{a\,b} \in 0,1$

$$Z_{ab} = \sum_{u=1}^{G} \frac{d(I_a - M_b)_{2/(1-v)}}{d(I_a - M_u)} \qquad ()$$

$$M_b = \frac{\sum_{a=1}^{N} Z_{ab}^{v} \, X \, I_a}{\sum_{a=1}^{N} Z_{ab}^{v}} \qquad ()$$

To complete FCM, each sensor node has the highest fuzzy membership value for a certain cluster.

Input: RE, node density, distance to sink
Output: No. of CHs
1. Initialize the location and speed of each particle.
2. Equation estimation of fitness value (4)
3. When fitness value is higher than the highest
4. Set interest as Pbest 's latest best fitness.
5. The best fitness value of all particles is defined as Gbest.
6. Fuzzy Scheme of Control and equalization of fuzzy membership. (7) The first of these is the following:
7. The cluster core is defined by equ. (8)
8. lastly, we delegate member nodes to a cluster that has the highest membership rating, and cluster node leader is named as CH.

IV. SIMULATION RESULT AND PERFORMANCE ANALYSIS

In software, MATLAB R2018 algo is applied and simulated.

Parameter Setup:
TABLE 1. Parameter for WSN

Table 1 is the representation of the simulation parameters opted for the experimentation purpose which includes network area, the position of the sink, initial energy, etc.

PARAMETER	VALUE
Network dimension	200*200
Sink position	(100, 100) or(200,200)
No. of SN, CH	200, 10
Energy of CH	2J
Primary energy of normal nodes (E_0)	0.5 J
Transfer / Receiver Electronics (E_{elec})	50nJI/bit
Data Aggregation (EDA)	5n.J/bit/signal
Transmit Amplifier If $d_{maxto}BS \leq d_0(\mathcal{E}_{fs})$	10pJ/bit/m_2
Transmit Amplifier If d_{maxto} $BS \geq d_0(\mathcal{E}_{mp})$	0.0013pJ/bit/m_4
Data packet (K)	4000 bits

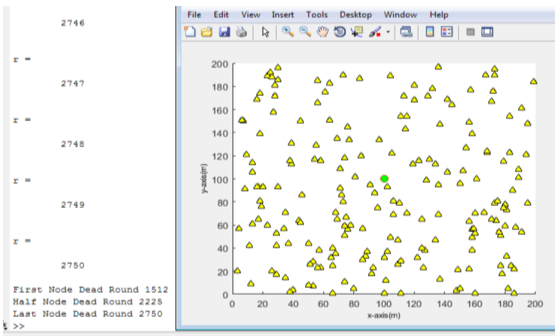

Figure 4: Node deployment based on PSO, sink at the center

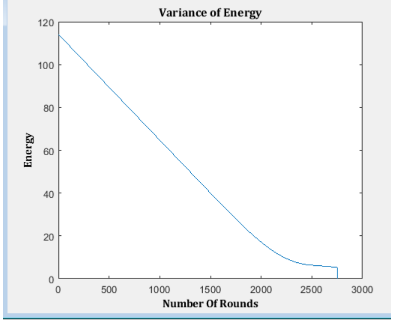

Figure 5: Residual Energy in previous work

Figures 4 and 6 show the location of the sink at the center. It also visualizes the number of rounds at which nodes are dead by PSO and GA-PSO. The variation in both the scenarios is visible about First node dead round (FND), half node dead round (HND) & last node dead round(LND).

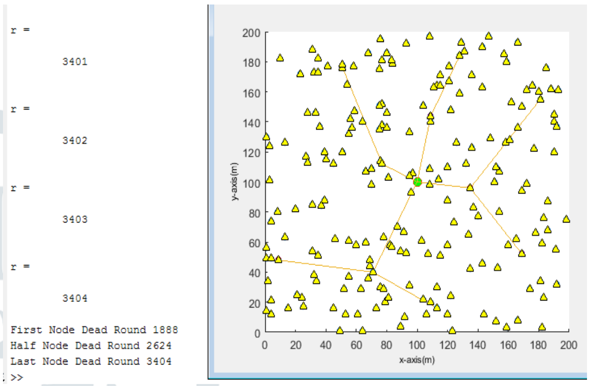

Figure 6: Node deployment based on PSO-GA, sink at the center

Figures 5 and 7 show the resulting residual energy (RE) when the sink is located at the center. Further, we will see the variation in both the cases when the sink is located at the boundary of the area. pictures show that the energy consumed by GA-PSO is lesser than that of the PSO.

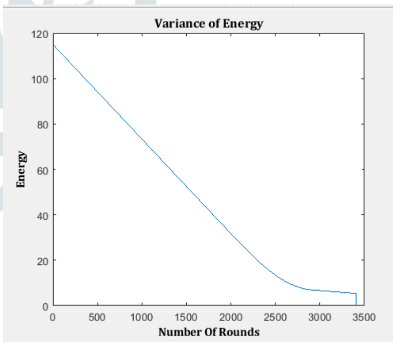

Figure 7: Residual Energy in current work

The below figure (fig. 8) is the scenario with the node deployment and sink located at the border of the area. The scenario also represents the LND, HND, and FND of received in the case of PSO. This network lifetime is further improved using GA-PSO in which the cluster heads (CH) are connected with a tree. It will help to establish a direct connection between the CHs and thus will create fewer chances of packet loss, less energy consumption, and less time complexity.

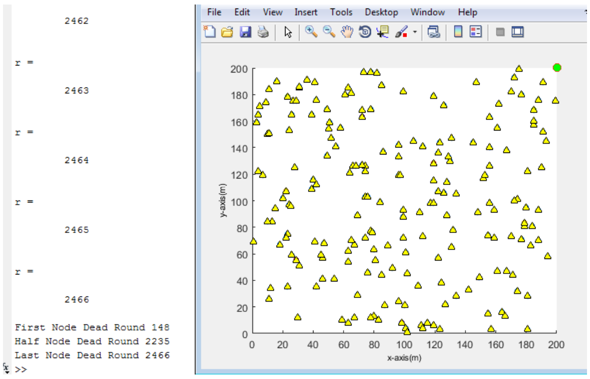

Figure 8: Node deployment based on PSO, sink at the border

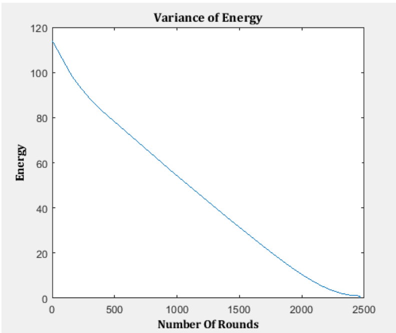

Figure 9: Residual Energy in previous work

PSO consumes energy faster than the GA-PSO algorithm. This paper proposes an updated CH selection algo to prolong a network existence by monitoring the energy dissipation of the network. The findings of the simulation indicate increased network efficiency for metrics like residual energy, network lifetime.

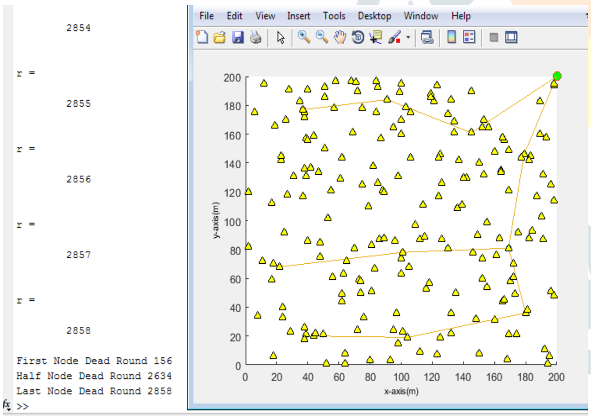

Figure 10: Node deployment based on PSO, sink at the border

Figure 10 tree construction using Dijkstra's algorithm where the sink node is connected with a cluster head node and has constructed a connection with each cluster for the faster routing process.

Fig 11 represents the remaining energy of the nodes in the case of GA-PSO. Comparing the above cases of residual energy, we can conclude that figure 11 is the efficient cause of consuming less energy and also with fewer rounds which are based on the GA-PSO algorithm.

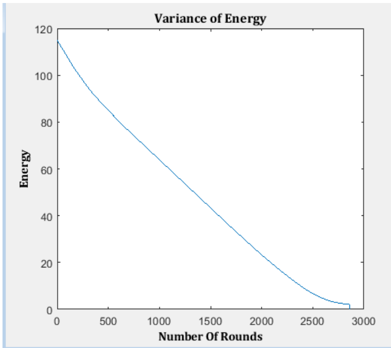

Figure 11: Residual Energy in current work

V. CONCLUSION

An EE-QoS frame for WSNs is presented in this article. In gathering to maintain QoS integrity, the hybrid technology introduced increases EE &network life. A fitness function includes residual node energy, node density as well as the distance to BS by the cluster head nodes. This fitness function affects the selection process for CHs by improving the system with a new optimization algo.

The Dijkstra algorithm established a tree that has evolved new clustering criteria through which we can easily do the routing process and also our data remain secure with this process of clustering. In the future, we can go for a fuzzy-based clustering using a minimum spanning tree,

REFERENCES

[1] 1. Akyildiz, I. F., Su, W., Sankarasubramaniam, Y., & Cayirci, E. (2002). Wireless sensor networks: A survey. Computer Networks, 38(4), 393–422.

[2] Rault, T., Bouabdallah, A., & Challal, Y. (2014). Energy efficiency in wireless sensor networks: A top-down survey. Computer Networks, 67, 104–122.

[3] Yick, J., Mukherjee, B., & Ghosal, D. (2008). Wireless sensor network survey. Computer Networks, 52(12), 2292–2330.

[4] Akkaya, K., & Younis, M. (2005). A survey on routing protocols for wireless sensor networks. Ad Hoc Networks, 3(3), 325–349.

[5] Pantazis, N. A., Nikolidakis, S. A., & Vergados, D. D. (2013). Energy-efficient routing protocols in wireless sensor networks: A survey. Communications Surveys & Tutorials, 15(2), 551–591.

[6] Stavrou, E., & Pitsillides, A. (2010). A survey on secure multipath routing protocols in WSNS.Computer Networks, 54(13), 2215–2238.

[7] Amin Rostami1and Mohammad Hossin Mottar " Wireless Sensor Network Clustering Using Particles Swarm Optimization For Reducing Energy Consumption" (IJMIT) Vol.6, No.4, November 2014, 1-15

[8] Shahraki, A., Taherkordi, A., Haugen, Ø., & Eliassen, F. (2020). Clustering Objectives in Wireless Sensor Networks: A Survey and Research Direction Analysis. Computer Networks, 107376. DOI:10.1016/j.comnet.2020.107376

[9] D. Kumar, T. C. Aseri, and R. B. Patel, "EEHC: energy-efficient heterogeneous clustered scheme for wireless sensor networks," Computer Communications, vol. 32, no. 4, pp. 662–667, 2009.

[10] D. Sharma and A. P. Bhondekar, "Traffic and energy-aware routing for heterogeneous wireless sensor networks," IEEE Communications Letters, vol. 22, no. 8, pp. 1608–1611, 2018.

[11] S. Dutt, S. Agrawal, and R. Vig, "Cluster-head restricted energy efficient protocol (CREEP) for routing in heterogeneous wireless sensor networks," Wireless Personal Communications, vol. 100, no. 4, pp. 1477–1497, 2018.

[12] S. Tanwar, S. Tyagi, N. Kumar, and M. S. Obaidat, “LA-MHR: learning automata-based multilevel heterogeneous routing for opportunistically shared spectrum access to enhance the lifetime of WSN,” IEEE Systems Journal, vol. 13, no. 1, pp. 313–323, 2019.

[13] Z. Hong, R. Wang, and X. Li, “A clustering-tree topology control based on the energy forecast for heterogeneous wireless sensor networks,” IEEE/CAA Journal of Automatica Sinica, vol. 3, no. 1, pp. 68–77, 2016.

[14] A. Moussaoui and A. Boukeream, “A survey of routing protocols based on link-stability in mobile ad hoc networks,” Journal of Network and Computer Applications, vol. 47, no. 1, pp. 1–10, 2015.

[15] Abbasi, A. A., & Younis, M. (2007). A survey on clustering algos for wireless sensor networks. Computer Communications, 30(14-15), 2826–2841. DOI:10.1016/j.comcom.2007.05.024

[16] W.R. Heinzelman, A. Chandrakasan, H. Balakrishnan, Energy-efficient communication protocol for wireless microsensor networks, in Proceedings of the 33rd Hawaii International Conference on System Sciences-Volume 8 - Volume 8, HICSS ’00 (IEEE Computer Society, Washington, DC, 2000), p. 8020

[17] M.A. Alsheikh, S. Lin, D. Niyato, H.P. Tan, Machine learning in wireless sensor networks: algos, strategies, and applications. IEEE Commun. Surv. Tutorials 16(4), 1996–2018 (2014)

[18] O. Younis, S. Fahmy, Heed: A hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks. IEEE Trans. Mob. Comput. 3(4), 366–379 (2004)

[19] P. Ding, J. Holliday, A. Celik, Distributed energy-efficient hierarchical clustering for wireless sensor networks, in Proceedings of the First IEEE International Conference on Distributed Computing in Sensor Systems, DCOSS’05 (Springer, Berlin/Heidelberg, 2005), pp. 322–339

[20] P. Liu, T.l. Huang, X.Y. Zhou, G.X. Wu, An improved energy-efficient unequal clustering algo of the wireless sensor network, in 2010 International Conference on Intelligent Computing and Integrated Systems (2010), pp. 930–933

[21] E. Ever, R. Luchmun, L. Mostarda, A. Navarra, P. Shah, Uheed - an unequal clustering algo for wireless sensor networks, in SENSORNETS (2012)

[22] 1. N. Aierken, R. Gagliardi, L. Mostarda, Z. Ullah, Ruheed-rotated unequal clustering algo for wireless sensor networks, in 29th IEEE International Conference on Advanced Information Networking and Applications Workshops, AINA 2015 Workshops, Gwangju, 24–27 March 2015, pp. 170–174

[23] Z. Ullah, L. Mostarda, R. Gagliardi, D. Cacciagrano, F. Corradini, A comparison of heed based clustering algos – introducing er-heed, in 2016 IEEE 30th International Conference on Advanced Information Networking and Applications (AINA) (2016), pp. 339–345

[24] L. Qing, Q. Zhu, M. Wang, Design of a distributed energy-efficient clustering algo for heterogeneous wireless sensor networks. Comput. Commun. 29(12), 2230–2237 (2006)