



A New Method for Energy Saving on Wireless Sensor Network Based on Clustering Method

Ahmad Ayid AHMAD¹, Hüseyin POLAT², Cemal KOÇAK³, Tanygin Maxim OLEGOVICH⁴ & Ali Ayid AHMAD⁵

Keywords

Wireless Sensor Networks, Clustering, Energy Consumption.

Article History

Received
14 Mar, 2022
Accepted
11 May, 2022

Abstract

In this paper we proposed a new clustering method for the saving of energy in overall the network. In proposed scenario we divided the area to 3 regions. At first region the sensors send directly their information to the BS with out any cluster head. In second region all sensors send their information to the cluster heads and these cluster heads send to the BS. At third region we selected the rechargeable nodes and these rechargeable nodes collect the informations and send to the BS. As shown in the simulation results we improved the life time of the sensors and we improved the packed size to sending to BS.

1. Introduction

Wireless Sensor Networks (WSNs) are starting late made to reinforce a great deal of usages, which consolidate development control, home robotization, quick battle region, condition checking moreover, some more. WSN wires diverse sensors that are scattered around a particular center for achieving. In WSN, guiding is a fundamental task that will be dealt with meticulously. The basic premise, which is occupied with this paper, is about the coordinating tradition that adjustments in light of the application. The coordinating issue prompts lessened framework lifetime with extended imperativeness usage. Thusly, unique coordinating traditions have been delivered to restrain the imperativeness use and to grow the framework lifetime. The controlling traditions can be ordered in perspective of the nodes' participation, gathering traditions, technique for working and framework

¹ Corresponding Author. ORCID: 0000-0002-6031-9414. Department of Computer Engineering, Gazi University, Ankara, Turkey, ahmadayid@yahoo.com

² ORCID: 0000-0001-8921-140X. Department of Computer Engineering, Gazi University, Ankara, Turkey, polath@gazi.edu.tr

³ ORCID: 0000-0002-8902-0934. Gazi University, cccokocak@gazi.edu.tr

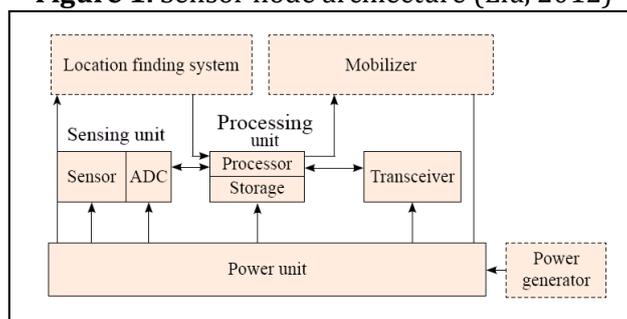
⁴ ORCID: 0000-0002-4099-1414. Southwest State University, Kursk, Russian Federation tanygin@yandex.ru

⁵ ORCID: 0000-0002-6031-9414. Southwest State University Kursk, Russian Federation, aliayid2013@gmail.com

structure. The diverse challenges in coordinating joint essentialness usage, center point plan, versatility, accessibility, scope, security (Sarkar and Murugan, 2016; Raj et al., 2021).

A conventional remote sensor can accumulate information on the framework, in the district of interest, each decoding there are various circled sensors in the breaking point. These sensors assemble the information is sent to the base station. In a remote sensor sort out, the power supply units one of the main problems experienced in view of physical obstacles is compelled it is essentialness. With everything taken into account, if the sensors are presented away or it is possible to change or invigorate it isn't. This prompts the need of using imperativeness beneficially it pulls. Remembering the true objective to use the sensor sources reasonably and successfully, the sensors and sensor stages must be managed. Acting normally dealing with, there is a necessity for an accuse tolerant, preferably working sensor structure. You request adversity, rebuilding and the number from helplessness of the amount of perfect sensors troublesome. Additionally, resource constraints, shaky development, data wealth, sort out components, this change is a result of prerequisites, for instance, essentialness alter, distinctive movement composes, divide it gets altogether harder. Along these lines, various examinations have been made with respect to this issue (Batcha and Geetha, 2021). Shannon information speculation consequently its effect on sensor life and extension are dissected and the effects of entropine it is best to save essentialness the most extraordinary entropy and the base number of running sensors entertainments were made. With a particular ultimate objective to give information from each region, the domain is segregated from the doors and a sensor errand is performed on the structure at each work step it was centered around. The amount of dynamic sensors in each system is the total number of dynamic second sensors a probability is processed by parceling the total entropy using these probabilities it was found (La Rosa et al., 2021). The goal is to have a sensor impelled in each grid. It an edge probability is used as a piece of optmisis that is sent by the base to various sensors and remembering the true objective to extend the framework life, the amount of working sensors has been endeavored to be restricted, same the homogenous extension zone meanwhile with the most outrageous entropy described above It is given. The entropy is used for the general utilization of the sensor essentialness, ordinary imperativeness utilize is given. Gotten scope zone and framework lifetime depending upon the criteria (Elbaşı and Suat, 2012). The Sensor node architecture is shown in figure 1.

Figure 1. Sensor node architecture (Liu, 2012)



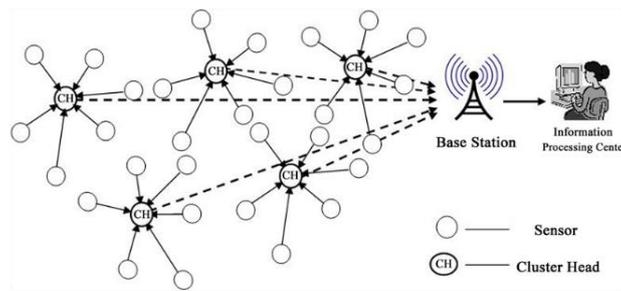
Remote sensor composes as a champion among the most basic advances of the 21 century it is described. Changes in remote advancement are essentially more affordable extreme littler scale sensors make it possible to make. A Wireless Sensor organize physical or biological conditions at different zones (temperature, sound, weight, development, sullyng, et cetera.) use sensors to screen with facilitated exertion, including scattered contraptions it is a framework. The enhancements in remote sensor frameworks started transcendently with military applications. In any case, nowadays, remote sensor sorts out in various zones, for example, regular discernments and live watching, social protection, home computerization and movement control it is used. Sensor frameworks information for astute conditions (structures, houses, industry) it's the catchphrase in the gathering. Each sensor data scattered over a specific region in these frameworks it can assemble and guide data to base station. The arrangement of sensor frameworks is influenced by various components; adjustment to inward disappointment, flexibility, the cost of creation, working condition, and sensor compose topology, gear goals, sensors like correspondences and power use. Sensor sorts out normally, radio recipients, transmitters or it involves distinctive remote particular gadgets and an essentialness source. Sensor estimations it can contrast from particle to shoe box. Four the capriciousness depends upon the need. Sensors long and esteem necessities, distinctive resources, for instance, essentialness, memory, tally speed, and transmission limit, are also unique. As an issue of first significance ask about on sensor frameworks (to check the ocean; channel enormous scale sound) little field sensors for field target area moved (Cevik and Ozyurt, 2015).

Abnormally, information blend is performed at application level. Information securing is including unmistakable flags and transmitting information as a solitary total. Regardless, information gathering is something like separating and plotting the principle information starting from all sensor nodes. Another to an incredible degree most likely comprehended class of frameworks for lifetime prolongation is gathering. The lead thought in bunching is gathering the sensor focus focuses relying on various criteria, as it were, all around that truly matters apportioning the topology into lattices. Clustering can give gigantic centrality hold finances particularly in high thickness systems (Raj et al., 2021).

My understanding point from another paper, remote sensor frameworks are an amassing of spatially coursed independent sensor nodes that casing into frameworks with the objective of distinguishing a particular or various physical wonders, for instance, weight, temperature, sound et cetera inside their range. Diverse employments of such a wsn organize are condition watching, untamed life count, pollution control, prosperity checking, military perception.

Amid the time spent data accumulation, pack heads in like manner performs data weight by taking out any data abundance caused due to distinguishing of constrained data by aggregate people [8, 9]. The One-hop communication is illustrated in figure 2.

Figure 2. One-hop communication for clustered wireless sensor networks (Anandh and Baburaj, 2016).



2. Energy Model

In our work, it is assumed that the sensor nodes have processed the data. In this case, there are two situations we have wasted; a sensor node spend a moment sending a sensor knob energy and a sensor node from other sensor nodes energy consumed while receiving data (Elbaşı and Özdemir, 2015).

$$P_{tx\ ij} = \rho + \epsilon d \alpha^{ij} \quad (1)$$

$$P_{rx} = \rho \quad (2)$$

$P_{tx\ ij}$: 1 bit data transmission from node i to node j

P_{rx} : Energy consumed to get 1 bit of data

ρ : Energy consumed in the hardware of the sensor node

ϵ : The efficiency factor of the transceiver

α : path loss factor

$d \alpha^{ij}$: distance between node i and node j

3. Data Flow Model

Our model is starting at now a limited movement orchestrate It has; that is, the sensor center point the other sensor is transmitted between the nodes, base station. This model transfer of missing parts of two sorts of models in decision strain. Sensor nodes in a model where the data is sent particularly to the base station as will be grasped from the essentialness indicate unreasonably of the division is too and the most remote sensors quickly eats up the energies, the sensor the created data is traded to the determined neighbors reliably, station, the base station Due to the data pile of adjoining nodes an extreme measure of imperativeness the total framework lifetime we examined They are condensed. Henceforth, every one of the sensor nodes talking with sensor center and base station their imperativeness use is balanced by being favored.

With the sensor nodes 4, 3, 2 on the screen, base station is shown as 1 and i,j node fij as data flows. Our mathematical model is based on linear programming constraints (Elbaşı and Özdemir, 2015; Houssein et al., 2021).

The first restriction is that no data flow is negative it can not be. In the formula (3), via the sensor the amount of data passed is expressed by the equation. Second the energy transmitted by each sensor is unrestrained total energy collected from other sensors is equal to the difference in total energy. We are third party the total

energy consumed by each sensor; i.e. data from spent energy and other sensors the sum of the energy consumed while accumulating, it will not be bigger than its own energy (Elbaşı and Özdemir, 2015).

$$f_{ij} \geq 0 \quad (3)$$

$$\sum f_{ij} - \sum f_{ij} = sit \quad (4)$$

$$\left\{ \left[P_{rx} \left(\sum_j f_{ji} \right) + P_{tx,ij} \left(\sum_j f_{ij} \right) \right] \right\} \leq e_i \quad (5)$$

f_{ij} : the data stream for the j stream

s_i : the number of bits produced at the time of the unit

e_i : the energy of my duo

t : the life of the network

4. Energy Consumption Model

In this paper, the established vitality display as portrayed in LEACH is utilized. As is known, essential components influencing vitality utilization are the quantity of bits transmitted and the separation between the imparting sets. On the off chance that the separation between the imparting nodes is more noteworthy than the edge esteem, at that point the effect of the separation on the vitality utilization develops exponentially as shown in Eq. (1-3) (Cevik and Ozyurt, 2015).

$$E_{snd}(l,d) = E_{snd-elec}(l) + E_{snd-amp}(l,d) \quad (6)$$

$$E_{snd}(l,d) = (l * E_{elec}) + (l * \epsilon_{fs} * d^2), d < d_0 \quad (7)$$

$$(l * E_{elec}) + (l * \epsilon_{mp} * d^4), d \geq d_0 \quad (8)$$

Two or three structure lifetime definitions are proposed in the composed work. Some of them consider the time in which a specific measure of the nodes bomb frightfully. Another course of action to consider is the time after which there is a zone never again secured by the structure. The one that looks great and which we related in this examination is the time when the standard focus point fails spectacularly. Right when a middle kicks the bowl, it would nor be right nor sensible to recognize that the straggling leftovers of the system will work extraordinarily. Finally, the center point is dead and no information can be gotten from the territory for which the right on is solid. Besides, this can accomplish a system separate which proposes there are two nodes which never again can converse with each other (Cevik and Ozyurt, 2015).

4.1. Routing

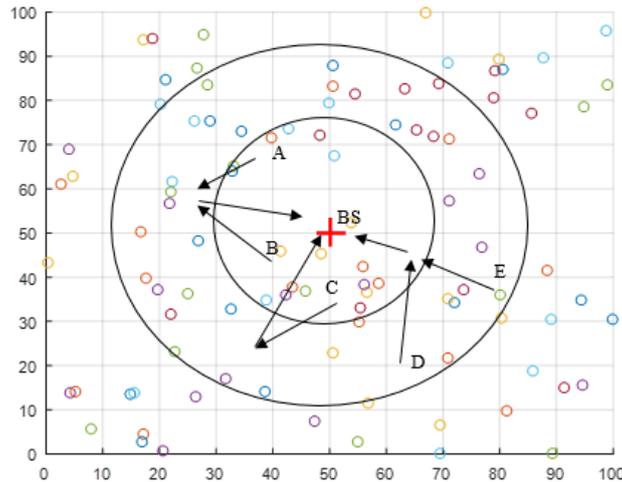
Diverse systems have been proposed in the elucidating limitation and masterminding contemplations. The principal motivating a passionate reaction is that setting up the sensor focus point with a Global Positioning System beneficiary. In any case, that isn't a promising approach by righteousness of sending and cost restrictions. There are other elective strategies proposed, for instance, lateration and angulation systems. Since it is out of level of this examination, no particular organizing strategy is considered in the pape (Cevik and Ozyurt, 2015).

4.2. Node Density

In situations where thickness of nodes in the system is non-uniform, shaping the bunchsizes in view of separation can prompt problem area issues. So it is imperative to register the node thickness as groups are framed powerfully. The work by Bulusu in(Ravichandran and Umamaheswari, 2015) proposed a technique to process the system thickness as where N is the quantity of nodes in unit territory An and r is the sweep of the transmission go. $Dn = N r \pi ^ { 2/A}$

The node setup and proposed scenario is shownin figure 3.

Figure 3. Subdivision of sensing area for non-uniform node distribution.



Alongside remove of a node with neighboring nodes, we have to fuse one-bounce availability of the node with different neighbors ought to be considered. In the event that the thickness of nodes in a region is high, clearly the availability will likewise be high. A limit number of network can be set for a node to have associations. As separation of node from base station expands, this limit esteem can be expanded as the scope territory for those bunches additionally increments (Anandh and Baburaj, 2016).

In 2015, Taner et al. shown that, since the plain nodes in bunches manage their data to their pack heads, issues routinely experienced, for instance, different courses, flooding and coordinating circles are discarded or helped. This paper demonstrates a broad examination of the effects of the diverse assistant elements with respect to imperativeness usage in WSNs. General feeling about cluster based WSNs is that all together to moderate the issue region issue, groups arranged near the sink should be smaller estimated than the ones further from the sink. Other possible factors that may impact the lifetime of the framework are the amount of levels, the center point thickness, the correspondence radio degree traverse, the number and region of the sinks. Each one of these parameters are reviewed for each and every possible blend in detail. Perceiving the basic piece of collection in organize lifetime prolongation, whatever is left of the paper is created as takes after (Cevik and Ozyurt, 2015).

Additionally, in result of controlling circles and various courses, monotonous essentialness uses will come to fruition. Thusly, to the extent turning away dull imperativeness use in the midst of data transmission, grouping approach surrenders greatly immense picks by techniques for unraveling the correspondence and updating the flexibility. The objective is to find the perfect skill for dealing with the centers into bundles and picking the most fitting center as the CH in each cluster in order to achieve essentialness efficiency by recognizing load alter among the centers. Various examinations have been proposed about pack based WSNs. The traverse of a gathering is picked by the incline estimation of its bundle head, and the data aggregated from the pack people should take after the orientation of sliding edge to accomplish the sink. Reenactment comes to fruition exhibit that EBCAG modifies the imperativeness use among the bundle

heads, and in a general sense improves the framework lifetime (Liu et al., 2012; Rana, 2017).

Creating dependable safety efforts against plague of malware will make conceivable the development of remote detecting advancements. The initial move toward this objective is to investigate potential assault methodologies and the measure of harm they can cause. The malware at each infective node may try to contact more helpless nodes by opening up the transmission run and the media filtering rate and along these lines quicken its spread. This may however prompt (a) less demanding identification of the malware and in this way more viable counter-measure by the system, and (b) quicker exhaustion of the battery which may thusly recoil additionally spread of the contamination as well as misuse of that node. We use Pontryagin's greatest rule to locate an ideal arrangement, and demonstrate that the most extreme harm can be achieved utilizing basic three-stage blast techniques (Khouzani and Sarkar, 2011). We decided the express responses for both the regular SI appear and the changed SI illustrate, which can get both the one of a kind and common components of the contamination spread process (Tang and Li, 2011).

4.3. Modeling overall energy consumption in Wireless Sensor Networks

NajmehKamyabpour et al., presents another approach for constraining the total imperativeness usage of remote sensor sort out applications in light of the Hierarchy Energy Driven Architecture. In particular, we perceived fragments of each bit of HEDA. We removed a model for each one of the constituents and sections similar to their dominating factors (or parameters). We proposed an arrangement for the total imperativeness cost fill in to the extent their constituents. Reenactment happens for lifetime and waiting essentialness of a case interface with different sensor extend, transmission traverse and sporadic and particular frameworks showed that our model and definition can be used to enhance the general imperativeness usage, choose the dedication of each constituent and their relative significance. The recommendation is that updating the imperativeness of the general model with respect to each and every constituent parameter will enable one to construct a modify of essentialness dispersal among constituents, enhance the imperativeness use among them and deal with the framework lifetime for the proposed application. It should be seen that various basic issues are still to be researched. This paper just suggests a plan exhibit for each constituent; a bare essential essentialness appear for each one of the constituent of HEDA is to be thought about. The paper recognized different overpowering parameters of each essentialness parts, in any case, not all features of WSNs have been pondered and they should be explored and analyzed out and out. Unmistakably, the relationship among the essentialness constituents and their trade inside an application are basic; we mean to research the cases and the condition of the imperativeness use for a flat application and convey an extensive guide of essentialness use as for a specific application. Preliminary examination acknowledged a weighted straight mix of essentialness use of the constituents, later on, we plan to convey a more exact imperativeness cost work which absolutely put due highlight on parameters, parts and the playoff factors among fragments. We assume that a non-straight cost work rather than a clear direct

blend would empower the model to modify better to a specific WSN application • by fitting parameter game plan, the disease spread can be satisfactorily controlled by the changed SI show (Kamyabpour and Hoang, 2011).

4.4. Modeling of Node Energy Consumption for Wireless Sensor Networks

Hai-Ying Zhou et al. Stream WSN investigates focuses more on correspondence traditions than on imperativeness use illustrating. Traditional essentialness examination procedure is to finish up the imperativeness use statuses of nodes and frameworks in light of the theoretical essentialness use data or speculative models of system parts. An extensive segment of the present imperativeness models simply separate the essentialness status of correspondence module, being nonattendance of think the general essentialness usage from the point of view of nodes. By showing the imperativeness usage of different center point portions in different movement modes and state changes, this paper proposes another center essentialness exhibit in perspective of the event trigger framework. This model can be used to separate the imperativeness status of WSN nodes and systems, to survey the correspondence traditions and to pass on nodes and manufacture WSN application • both the TNP and the PNP designs can achieve mastermind security with respect to the distinction in infectivity and they are affirmed to be useful (Zhou et al., 2011; Mann and Singh, 2017).

Similarly the examination will give an arrangement to the end customers for genuine vaccination and standard usage of antivirus programming to the sensor nodes in the sensor field for influencing the assurance to instrument strong and to restrain the attacks (Mishra and Keshri, 2013). This is in light of the fact that gathering head decision empowers other sensor nodes to simply distinguish and exchange data to the base station rather than controlling data from various nodes. Grouping works proficiently with the revolution of bunch head race and in a littler system (Ponnusamy, 2014).

Ravi Chandra Reddy et al. We proposed a comprehensive method as far as possible the total essentialness ate up by both flexibility of exchanges and remote transmissions. Most past work ignored the imperativeness ate up by moving flexible exchanges. When we demonstrate the two wellsprings of imperativeness usage, the perfect position of a center that gets data from one or distinctive neighbors and transmits it to a lone parent isn't the midpoint of its neighbors; rather, it centers to this circumstance as the measure of data transmitted goes to endlessness. Ideally, we start with the perfect beginning coordinating tree in a static space where no nodes can move. In any case, our approach can work with less perfect starting setups including one created using simply adjacent information, for instance, eager geographic directing. Our approach upgrades the fundamental outline using two iterative designs. The essential installs new nodes into the tree. The second figures the perfect spots of move nodes in the tree given a settled topology. This computation is legitimate for a grouping of data concentrated remote sensor frameworks. It empowers a couple of nodes to move while others don't in light of the fact that any close-by change for a given adaptable hand-off is an overall change. This empowers us to possibly extend our approach to manage handle additional objectives on particular nodes, for instance, low essentialness levels or transportability restrictions in view of use requirements

(Ravichandran and Umamaheswari, 2015). It is moreover watched that if the rate of treatment manufactures the spreading of malignant worms reductions and redesigns the life of remote sensor mastermind. By generation it is found that execution of proposed show is better interestingly with the SIRS appear, spoiled nodes are promptly removed from the system (Shashank et al. 2016; Mohammed et al., 2020).

The steering issues of WSN have been tended to in a huge number of works. On assessing the work, different highlights for example, Energy, security, postponement and blunder that posture challenges are recognized. This area gives an exchange on the works, relating to those highlights, in a different way.

4.4.1. Data aggregation in wireless multimedia sensor networks

Rapid developments in the hardware field allow for a single sensor node to collect multiple pieces of information for visual and auditory wireless Multimedia Sensor Networks with Stamping and Secure Data Clustering modules. For example, the Cyclops image acquisition and processing module can be easily added to the Crossbow nodes. These rapid developments have led to the emergence of the Wireless Multimedia Sensor Network (WMSN) concept in the WSN literature. WMSN is a WSN type consisting of more advanced sensor nodes than KAA, where each node can collect more than one kind of data and processing of these data can make more complicated decision making processes possible. It is often difficult or even impossible to replace the batteries of the multimedia sensor nodes, especially as military deployments are deployed with the aid of an aircraft, which is difficult to access, and remote and dangerous areas are difficult to access. For this reason, WMSN 's have to extend the service life of the network by performing its primary tasks of data collection, transmission and disposal in an energy efficient manner. Generally speaking, which consist of a large number of sensor nodes, the sensors reduce their energy consumption by separating themselves into groups. The purpose of this grouping process is to select a sensor as a group leader in each group and to collect and transfer data through the selected group leader. Data clustering is a very important requirement in order to summarize the energy efficiently collected from which are composed of sensors with limited power resources. To send the data of each sensor separately to the base station, the sensor data in a group is collected and summarized by the group leader, that is, the cluster data is reduced by extracting the data from the cluster, reducing the energy consumption of the sensor and increasing the life span of the WMSN.

5. Simulation Result

We proposed a new scenario of clustering method to improve the energy consumption in wireles sensor network. The Node setup structure is shown in figure 4.

Figure 4. Node setup

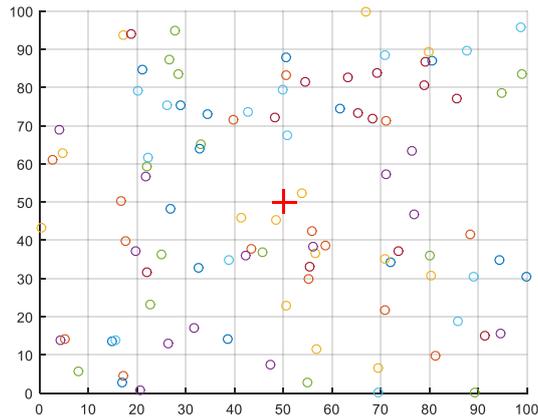


Figure 5 shows the number of packets received at BS against the round.

Figure 5. Number of packets received at BS

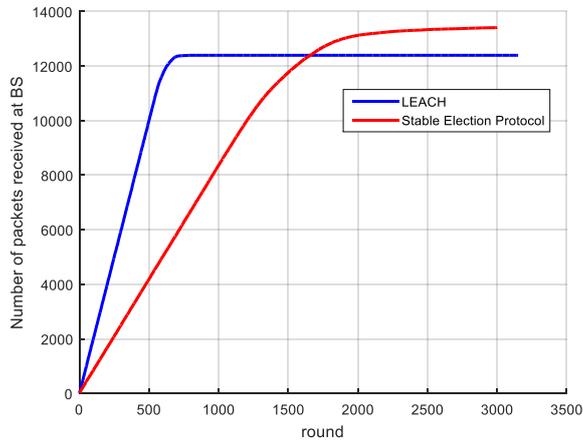
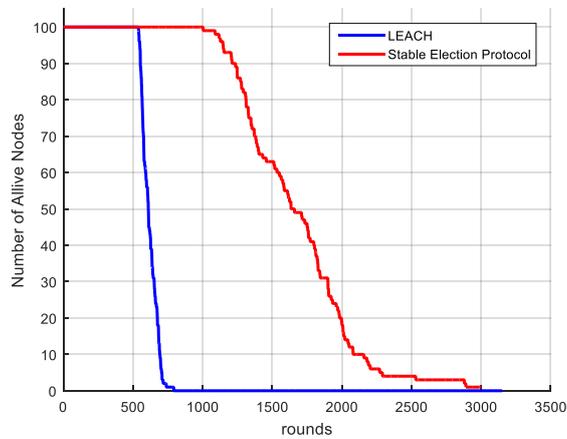


Figure 6 shows the number of allive nodes against of the rounds.

Figure 6. Number of allive nodes against of the rounds



The simulation parameters exploited in every experience are accessible in table 1.

Table 1. values of parameters

Parameter	Value
Position of BS	(50, 50)
X coordinate	[0 100] meter
Y coordinate	[0 100] meter
Number of nodes	100
E0	0.7 J
Eelec	5 nJ/bit
Efs	10 pJ/bit/m ²
Emp	0.0013 pJ/bit/m ⁴
Eda	5 pJ/bit
Message Size	4000 Bit

6. Conclusion

Remote sensor a scientific model of a system of nodes and utilizing direct programming method, this model information transmission by giving decreasing the vitality utilization, the system lifetime we gave the improvement. Other of our work high lifetime perceptions in their means, the topological impacts we set up the situations and these situations and contrast their outcomes with their derivations we did. Accordingly, the decision of the fitting topology it is a vital factor in enhancing the life we were the outcome. As needs be, a round territory design and as little as conceivable around there by keeping the vitality utilization is extreme more sensor nodes nearer to the base station with the goal that this vitality utilization is lastly grouping strategies and particularly to cluster calculations to create different bases by giving a station to the life of a system more beneficial and more steady systems. The eventual fate of our work we give a preparatory to the work.

References

- Anandh, S. J. and Baburaj, E. (2016). "An Improved Energy Balanced Dissimilar Clustered Routing Architecture for Wireless Sensor Networks," *Circuit and Systems, Scientific Research*.
- Batcha, R. R. and Geetha, M. K. (2021). "Internet of Things (IoT)-Based Renewable Energy and Sustainable Power Sources," *Artificial Intelligence and IoT*, pp. 167-198.
- Cevik, T. and Ozyurt, F. (2015). "Impacts of structural factors on energy consumption in cluster-based wireless sensor networks: a comprehensive analysis," *arXiv preprint arXiv:1512.03580*.
- Elbaşı E. and Özdemir, S. (2013). "Kablosuz Çoklu Ortam Algılayıcı Ağlarında Damgalama İle Güvenli Veri Kümeleme," *Gazi Üniversitesi Mühendislik-Mimarlık Fakültesi Dergisi*, vol. 28, no. 3.
- Elbaşı, E. and Suat, Ö. (2012). "Secure data aggregation in wireless multimedia sensor networks via watermarking," in *Application of Information and Communication Technologies (AICT), 2012 6th International Conference on*, IEEE, pp. 1-6.

- Houssein, E. H., Saad, M. R., Hussain, K., Shaban, H., and Hassaballah, M. (2021). "A Review of Metaheuristic Optimization Algorithms in Wireless Sensor Networks," *Metaheuristics in Machine Learning: Theory and Applications*, pp. 193-217.
- Kamyabpour, N. and Hoang, D. B. (2011). "Modeling overall energy consumption in Wireless Sensor Networks," *arXiv preprint arXiv:1112.5800*.
- Khouzani, M. and Sarkar, S. (2011), "Maximum damage battery depletion attack in mobile sensor networks," *IEEE Transactions on Automatic Control*, vol. 56, no. 10, pp. 2358-2368.
- La Rosa, L. E. C., Oliveira, D. A. B., and Feitosa, R. Q. (2021). "End-to-End CNN-CRFs for Multi-date Crop Classification Using Multitemporal Remote Sensing Image Sequences,".
- Liu, T., Li, Q., and Liang, P. (2012). "An energy-balancing clustering approach for gradient-based routing in wireless sensor networks," *Computer Communications*, vol. 35, no. 17, pp. 2150-2161.
- Liu, X. (2012). "A Survey on Clustering Routing Protocols in Wireless Sensor Networks," *Sensors*, vol. 12, no. 8, p. 11113. [Online]. Available: <http://www.mdpi.com/1424-8220/12/8/11113>.
- Mann, P. S. and Singh, S. (2017). "Improved metaheuristic based energy-efficient clustering protocol for wireless sensor networks," *Engineering Applications of Artificial Intelligence*, vol. 57, pp. 142-152.
- Mishra, B. K. and Keshri, N. (2013). "Mathematical model on the transmission of worms in wireless sensor network," *Applied Mathematical Modelling*, vol. 37, no. 6, pp. 4103-4111.
- Mohammed, A. H., Khaleefah, R. M., and Abdulateef, I. A. (2020). "A review software defined networking for internet of things," in *2020 International Congress on Human-Computer Interaction, Optimization and Robotic Applications (HORA)*, IEEE, pp. 1-8.
- Ponnusamy, V. (2014). "Energy analysis in Wireless Sensor Network: a comparison," *International Journal of Computer Networks and Communications Security*, vol. 2, no. 9, pp. 328-338.
- Raj, S. N., Reddy, B. D., Rao, N. T., and Bhattacharyya, D. (2021). "Secure Information Transmission in Bunch-Based WSN," in *Machine Intelligence and Soft Computing*: Springer, pp. 383-392.
- Rana, A. (2017). "Analyze Portrayal of SEP for WSN Using Matlab".
- Ravichandran, S. and Umamaheswari, M. (2015). "Design and Development in Research of Adaptive Multipath Routing for Burden Harmonizing in MANET," *Asian Journal of Computer Science and Technology*, vol. 4, no. 2, pp. 39-43.
- Sarkar, A. and Murugan, T. S. (2016), "Routing protocols for wireless sensor networks: What the literature says?," *Alexandria Engineering Journal*, vol. 55, no. 4, pp. 3173-3183.

- Shashank, A., Pratap, O. R., Kumar, S. P., and Goutam, S. (2016). "Stability Analysis of SITS Model and Non Linear Dynamics in Wireless Sensor Network," *Indian Journal of Science and Technology*, vol. 9, no. 28.
- Suresh, A., Nandagopal, M., Raj, P., Neeba, E. and Lin, J. W. (2020). *Industrial IoT Application Architectures and Use Cases*. CRC Press.
- Tang, S. and Li, W. (2011). "An epidemic model with adaptive virus spread control for Wireless Sensor Networks," *International Journal of Security and Networks*, vol. 6, no. 4, pp. 201-210.
- Zhou, H. Y., Luo, D. Y., Gao, Y., and Zuo, D. C. (2011). "Modeling of node energy consumption for wireless sensor networks," *Wireless Sensor Network*, vol. 3, no. 01, p. 18.



Strategic Research Academy ©

© Copyright of Journal of Current Research on Engineering, Science and Technology (JoCREST) is the property of Strategic Research Academy and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.