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Modified Optimization Techniques in WSN Using Energy Efficient Routing Protocol

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Abstract
Because of varying climatic conditions, individual sensor power sources in Wireless Sensor Networks (WSNs) are usually non-rechargeable or swappable, requiring increased energy efficiency to prolong the network's life. The bulk of sensor energy is used for data transmission, which shortens the network's total lifetime. Various techniques have been suggested to reduce energy waste in wireless sensor network communication protocols. The network is divided into many clusters using the Low-Energy Adaptive Clustering Hierarchy (LEACH), which chooses sensor nodes at random to act as cluster heads (CHs) in order to spread the energy burden equally. To improve WSN energy efficiency, a new modified routing protocol called the Improved Energy-Adjusted LEACH (IL-MLEACH) has been introduced. IL-MLEACH takes into account the average energy of the network as well as the residual energy of individual nodes to reduce sensor energy consumption by determining the ideal CH numbers and excluding nodes closer to the base station (BS) from cluster formation. An improved PSO (particle swarm optimization) variant called DPSO makes it easier to choose a relay node for data transfer, which increases energy efficiency even further. Node cost and delay are taken into account by DPSO in order to guarantee effective relay selection and steady energy consumption. According to simulation studies, the suggested method greatly enhances the energy dissipation, network lifetime, and communication quality of WSNs.

Keywords: *WSN, LEACH, Cluster head selection, PSO, DPSO, IL-MLEACH.*

I. Introduction

The wireless sensor nodes that are part of a Wireless Sensor Network (WSN) are joined and organized into a network in order to collect the necessary data from locations where people are unable to receive the data at all times [1]. In most cases, these networks are set up in territories controlled by the military, because the data gathered in those areas can, under certain conditions, have a significant impact on the overall military operations. Because this network is wireless, energy consumption is a primary consideration that must be taken into account in the processing of any form of data that is sent to or received from this network [2]. There are more widespread protocols that are brought in with the introduction of the energy conservation metrics.

To improve energy efficiency and ease administration, one of the main protocols, called LEACH (Low-Energy Adaptive Clustering Hierarchy), splits the network into clusters [3]. There are two stages to this protocol: the setup phase and the steady phase. Nodes are chosen as cluster heads in the first phase according to a predetermined threshold value. The threshold is calculated as per the below equation

$$TH(n) = \begin{cases} \dfrac{P}{1 - P\left[\left(r \bmod \frac{1}{P}\right)\right]}, & if\ n \in G \\ 0, & otherwise \end{cases}$$

The probability value is shown by P in the above equation, while the threshold value for node n is represented by TH(n). Every node in the network chooses a random number between 0 and 1, beginning with 0. The selected value is then contrasted with the recently established threshold value. The node takes on the function of a Cluster Head (CH) if the chosen value is less than the threshold value. On the other hand, the node acts as a member node if the selected value is greater than the threshold value. Every time a CH selection round is held, this procedure is repeated. Member nodes aggregate their data and send it to the CH for processing after choosing one [4]. The combined data is then sent to the Base Station (BS) via the CHs. A clustered Wireless Sensor Network (WSN) is shown in Figure 1's network structure.

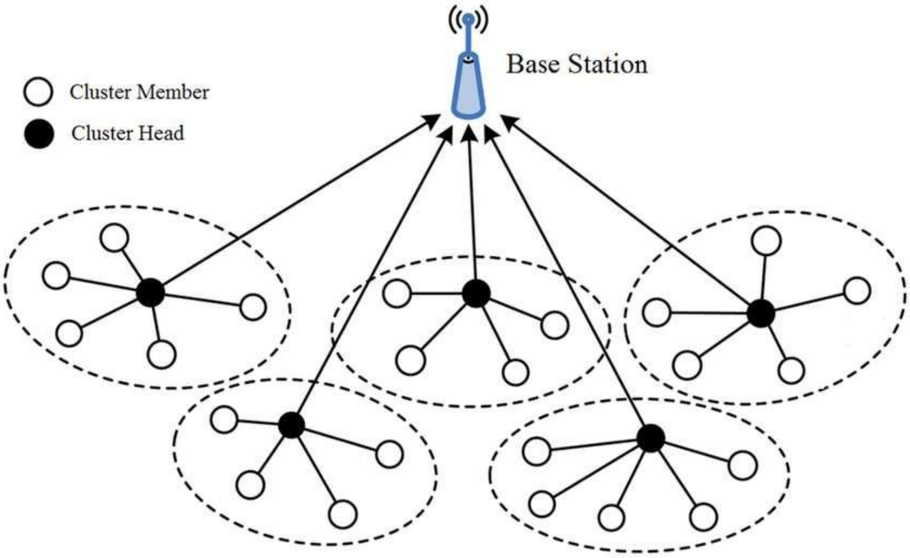

Fig 1: Network topology of a clustered WSN

This iterative procedure keeps on till the allotted amount of time passes. Following the end of the main phase, the CH for the next round is designated during the setup phase [5]. In order to control node energy levels and improve cluster lifetime and network scalability [6], the node that was selected as the CH in the previous round will not be picked again as the CH in the next round. By using a single- hop routing topology, the LEACH Protocol enables direct communication between every node and the sink and the CH for data transfer. Large regions should not use this program, however, since the CH election procedure for every round and the ensuing advertising use up all of the network's energy. As a result, developments are required to tackle the problem of energy consumption related to dynamic clustering, which is a current area of study [7].

Advantages & disadvantages of traditional LEACH

- The LEACH approach has a number of advantages:
- Cluster Heads' data aggregation lowers network traffic.
- Single-hop routing from nodes to cluster heads promotes energy saving.
- Because LEACH functions fully decentralized, it does not need knowledge of the global network or control information from the base station.

But LEACH has disadvantages as well:

- It is challenging to ensure the ideal number and distribution of cluster heads due to the random selection process.
- Because nodes with low residual energy are given the same priority to become cluster heads as those with high residual energy, they may face premature energy depletion.

II. Literature survey

A learning automata-based approach called multilevel heterogeneous routing (LA-MHR) was presented in [8]. Cluster Heads (CHs) are selected by LA-MHR using S-model-based learning automata, while cognitive radio spectrum allocation is handled by the base station (BS). Furthermore, LA-MHR employs a multi-hop communication strategy across different Sensor Nodes (SNs) as opposed to single-hop communication. Nevertheless, this method requires large transmission power since it is not appropriate for situations in which CHs are far from SNs.

The goal of the LEACH-Mobile (LEACH-M) protocol is to increase the success rate of data transmission for mobile nodes. It was introduced in [9]. On the other hand, LEACH-M's cluster creation and cluster head selection closely mirror the LEACH technique. In comparison to LEACH, LEACH-M has greater energy dissipation due to its higher control overheads.

An Energy Efficient Cross-layer Protocol (EECP) was proposed by Fouzi et al. in [10] for use in wireless sensor networks. This protocol would allow for interaction between the physical layer, the MAC layer, and the network layer. In EECP, the qualified nodes might be reawakened to transfer the data if surrounding tables were first created and then maintained. Additionally, a wake-up mechanism is utilized in the MAC layer in order to prevent any overhearing from occurring.

An energy efficient cross-layer based adaptive threshold routing protocol for WSN was developed by Singh et al. in [11]. In this study, we introduce the stages that are conducted in order to execute the provided protocol algorithm. These phases are, in order: startup, deployment, CH selection, cluster building, and transferring aggregated data to the base station.

III. Proposed method

LEACH protocol

The LEACH protocol is important in the context of Wireless Sensor Networks (WSNs). Each cluster's Cluster Head (CH) collects data from member nodes and sends it to the sink node during the Cluster Head (CH) selection phase. The rand function and the threshold value T(n) control the CH selection process. A random number M (0 ≤ M < 1) is generated by every Sensor Node (SN). The node becomes the cluster leader for the current round if M ≤ T(n) holds true. This is how the threshold value T(n) is calculated::

$$T(n) = \begin{cases} \frac{P}{\{1 - P * [(r * mod(1/p))]}, & if\ n \in G \\ 0, & otherwise \end{cases}$$

Where p is the ratio of the total number of CHs to SNs and represents the probability of each node becoming CH during round 0, r is the current number of rounds, G is the set of the nodes that will not be elected as a CH in a recent $1/p$ round, and $mod(\cdot)$ denotes the modulus operator.

The LEACH protocol utilizes the idea of clustering and collecting data on a periodic basis, both of which have the potential to lessen the amount of data that is transmitted between the nodes and the BS. As a result, this protocol has the potential to not only lessen the amount of energy that is lost but also to increase the lifetime of the network. In addition, the CH makes use of the technique of data aggregation, which can lessen the impact of locally correlated data. This technology also has the potential to optimize the amount of data in the network while reducing the amount of energy that is consumed. Additionally, the time division multiple access (TDMA) scheduling that is utilized by LEACH enables the member nodes to fall into sleep mode. This technique prevents collisions across clusters and lengthens the battery life of the sensors.

The classic LEACH protocol, on the other hand, does not take into account the density of the network's nodes when choosing the CH. When assigning CHs, both the placement of the nodes and the anticipated number of CHs per round are taken into consideration. As a result, following this approach cannot guarantee that the CHs will be distributed uniformly. In addition, when determining the CH, the LEACH procedure does not take into account either the residual energy of the nodes or the average energy of all the nodes. Because of this, a node that has a lower energy level will end up being selected as the CH. As a result, using this protocol will rapidly deplete the energy available in the node. In the final step, a one hop communication mode is utilized so that the CH can have direct conversations with the BS.

Cluster Head Selection Algorithm of the IL-MLEACH Protocol

Although the LEACH procedure has several advantages, it is unable to guarantee the CH's present residual energy. Traditional LEACH-based methods ignore the energy levels of individual nodes and simply evaluate whether a node will be selected as the CH. As a result, CHs are picked at random, which might quickly deplete energy if a low-energy node is chosen. A novel threshold $T(S_i)$ is suggested to solve problem and increase network longevity. It is defined as follows:

$$T(S_i) = \begin{cases} \frac{p_i}{1 - p_i (r\ mod \frac{1}{p_i})}, & s_i \in \\ 0, & otherwise \end{cases}$$

Where s_i is the node and $i \in [1, N]$. The energy adjustment parameter p_i is given by

$$p_i = \frac{p * s_i * E_r^i * E_i}{E_t * E_a}$$

The given equation denotes the following: p is the ratio for choosing the best CH; E_r^i is the residual energy of the ith node as of right now; E_i is the node's initial energy; E_t is the network's total energy; and E_a is the average energy of all SNs in the WSN. The formula makes it clear that the energy adjustment parameter is determined by taking into account the nodes' starting energy, remaining nodes' energy, the network's total energy, and the average node energy. This improvement makes sure that every node uses up its energy at around the same time. As a result, the suggested protocol increases the lifespan of the network by achieving a balanced distribution of the energy burden across nodes. An improved threshold value $T(S_i)$ may increase the chance of the nodes being chosen as the CH if their residual energy is greater than E_a. Following r rounds of operation for IL-MLEACH, the average energy E_a of every node is ascertained.

$$E_a = \frac{E_t\left(1 - \frac{r}{r_{max}}\right)}{S_i}$$

At the outset, as the process of selecting the CH unfolds, the nodes are dispersed randomly throughout the WSN. Subsequently, each node produces a random number, which is then compared with $T(S_i)$. If the outcome is equal to or less than $T(S_i)$, the node assumes the role of the CH.

The newly suggested method has the potential to improve the likelihood that the node whose residual energy is higher than the energy of any of its adjacent nodes or the average energy of the entire network will be chosen as the CH node for the current round. This would be the case if the node's residual energy is higher than the energy of any of its neighbors or the average energy of the entire network. When picking the CH, the IL-MLEACH technique produces different energies for each of the nodes, which is a crucial point to keep in mind. This mechanism may ensure that each node passes away at approximately the same time by selecting as CHs the nodes that have a bigger quantity of residual energy on a more regular basis than it selects the nodes that have a lesser amount of residual energy. This allows the mechanism to guarantee that each node dies at approximately the same time. As a consequence of this, the IL-MLEACH protocol has the potential to result in the network's overall lifetime being increased as a consequence of its implementation.

As soon as the voting for CHs has concluded, the individuals who have been selected to act in that position for this round will inform the other nodes in the network that they have been selected to serve in that capacity. In order to complete this task, each CH node will, by utilizing a non-persistent carrier- sense multiple access (CSMA) MAC protocol, send an advertisement message to each and every one of the other nodes. The message will be delivered via radio or television transmission.

Based on the signal strength of the message that is given from the BS and from each CH node, every member node makes a determination regarding whether or not it will take part in the development of a cluster. This choice is made based on the information provided by the CH nodes. The symmetric propagation channel model is used in the proposed IL-MLEACH protocol; hence, the election of a cluster leader is only tied to the unadulterated signal strength. The strength of the signal that was received was directly proportional to the distance that separated the member nodes from the sink node or the CH. When the distance between the nodes and the base station is compared to the distance between the nodes and the CHs, it can be observed that the nodes that are closer to the base station do not take part in the formation of clusters and instead supply data information directly to the base station. This is because the distance between the nodes and the CHs is greater than the distance between the nodes and the base station.

Following the selection of the cluster head within the network and its broadcasting of messages to other nodes, a non-cluster head node (called Node A) determines the distance (called \(d_{AB} \)) between itself and the nearest cluster head (called Node B) by measuring the intensity of the received signal. In the event where d_{AB} > d_{AtoBS} (d_{AtoBS} (where d_{AtoBS} (d_{AtoBS}) represents the distance between Node A and the base station), Node A does not join any cluster and instead transmits data straight to the base station. In contrast, Node A associates with the cluster in which Cluster Head B is located and operates as a member node inside it if $d_{AB} < d_{AtoBS}$.

This suggests that some of the nodes that are members of the WSN are not participating in the process of creating the cluster. When all of the signal strengths of the messages that are provided by the CHs are compared, a node that is physically closest to the CH will select to become a member of the cluster whose CH gives out the strongest signal to the other nodes. This occurs when all of the signal intensities of the messages that are provided by the CHs are compared. It is the responsibility of each node that is closer to the CH to choose which CH it will join and then to communicate with the CH to let it know that it has joined the cluster and is now a member node. It is the duty of every node in the network that is physically located in closer proximity to the CH to send a join-request message (also known as Join-REQ) to the CH that has been chosen. This message is required to provide the node's identifier in addition to the CH's identity information.

IV. Result and discussion

The method's performance was compared against LEACH, Cell-LEACH, and Multi-LEACH to assess the ranking of IL-MLEACH. The primary goal was to assess system energy efficiency across four scaling case studies (50, 100, 150, and 200 nodes). Evaluations were based on network lifespan and load balancing principles to gauge IL-MLEACH's energy consumption efficiency. Key metrics such as the time from network inception to the first node failure (FND), the duration until all nodes are depleted (AND), average residual energy per round, and energy consumption rate for active sensor nodes were analyzed to gauge IL-MLEACH's effectiveness. Additionally, network lifespan and energy dissipation metrics were observed across ten simulation runs for each scalability case study to ascertain IL-MLEACH's impact on network scalability. The redundant simulation runs were conducted to enhance the reliability of the simulation results.

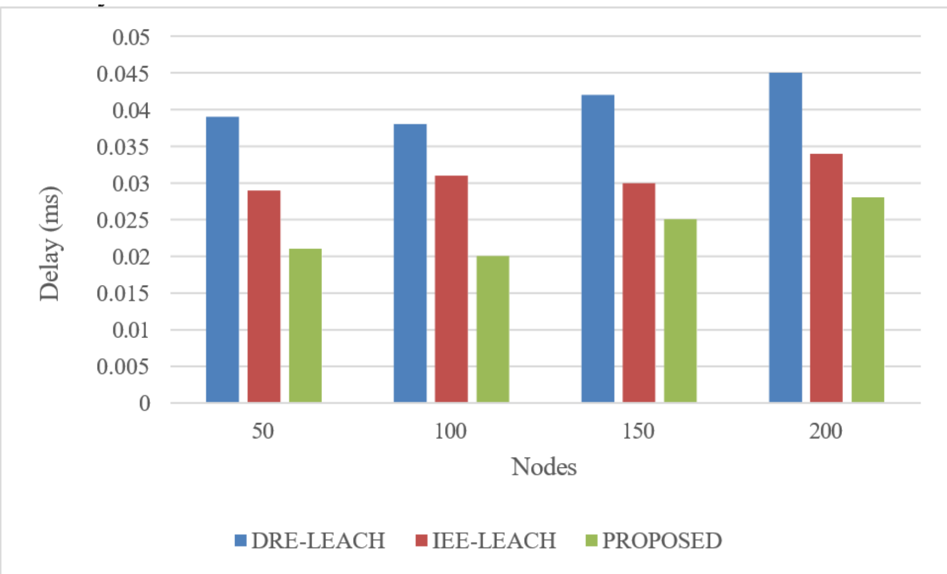

Fig 2: End to End Delay

Figure 2 depicts the end-to-end delay simulation results for proposed IL-MLEACH protocol and other existing methods, like DRE-LEACH and IEE-LEACH. The chances of making the frequent CH reselection would be reduced with the CH selection based on random number; relay selection is improved for data communication using delay-based PSO. Therefore, the network's end-to-end delay is minimized. In the network, the minimum average delay was reported as 0.021 ms, but the earlier techniques experience higher delay than the proposed technique.

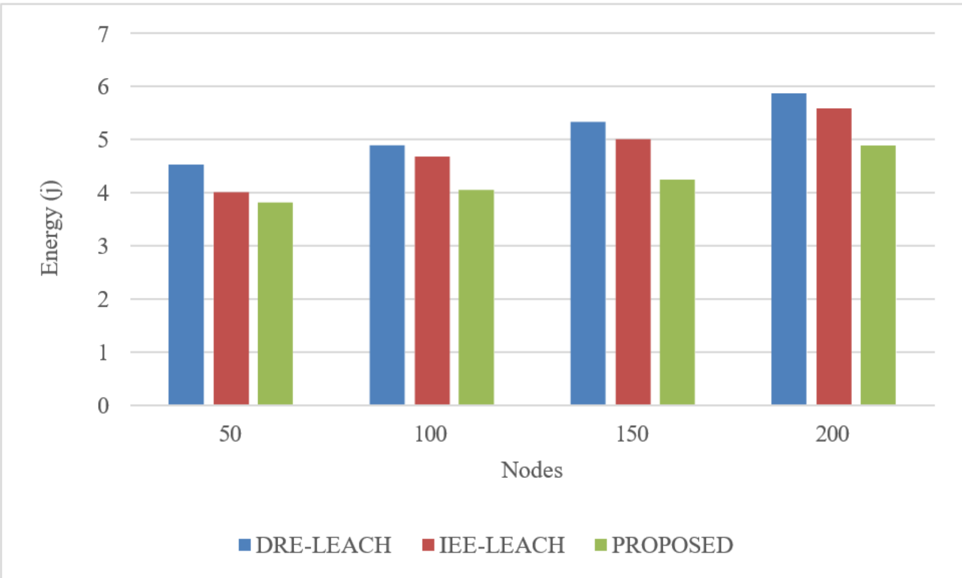

Fig 3: Energy consumption

The consumed energy results are depicted in the Figure 3. In this protocol, the nodes are energized with 100j for longer run and consumed it during each network activity. The energy consumption is controlled with the efficient selection of relay nodes and CH nodes as well. As mentioned in the above graphs, the proposed technique saves the considerable amount of energy compared to the earlier techniques.

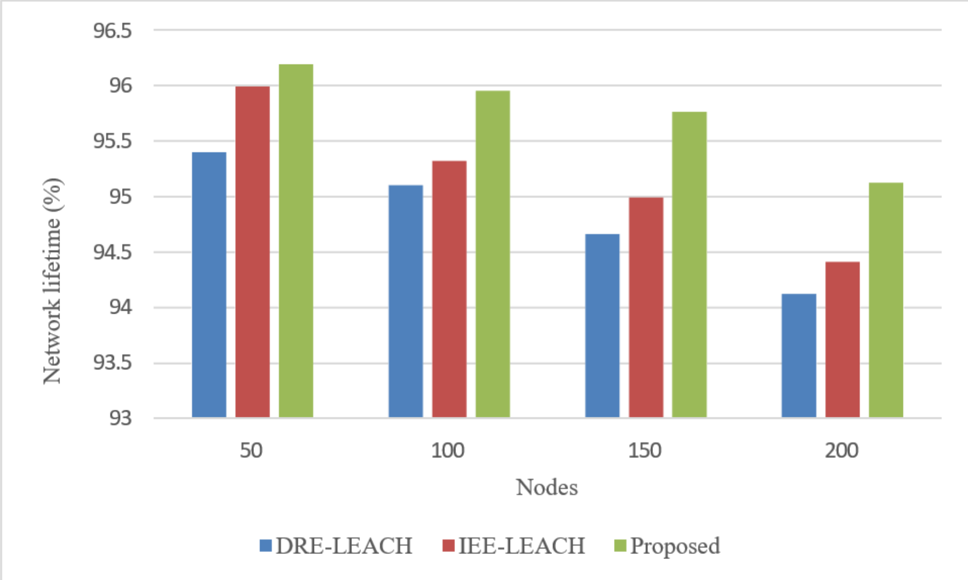

Fig 4: Lifetime of network

Network lifetime describes as the period, during which the first node is running out of energy or the network is being operational. The remaining energy availability of nodes is relevant to the network lifetime once the network operation is stopped. The increased remaining energy enhances the network lifetime. With the proposed method, the overall lifetime of a network is increased than the earlier methods, such as IEE-LEACH and DRE-LEACH. Figure 4 illustrates the network lifetime results for proposed technique.

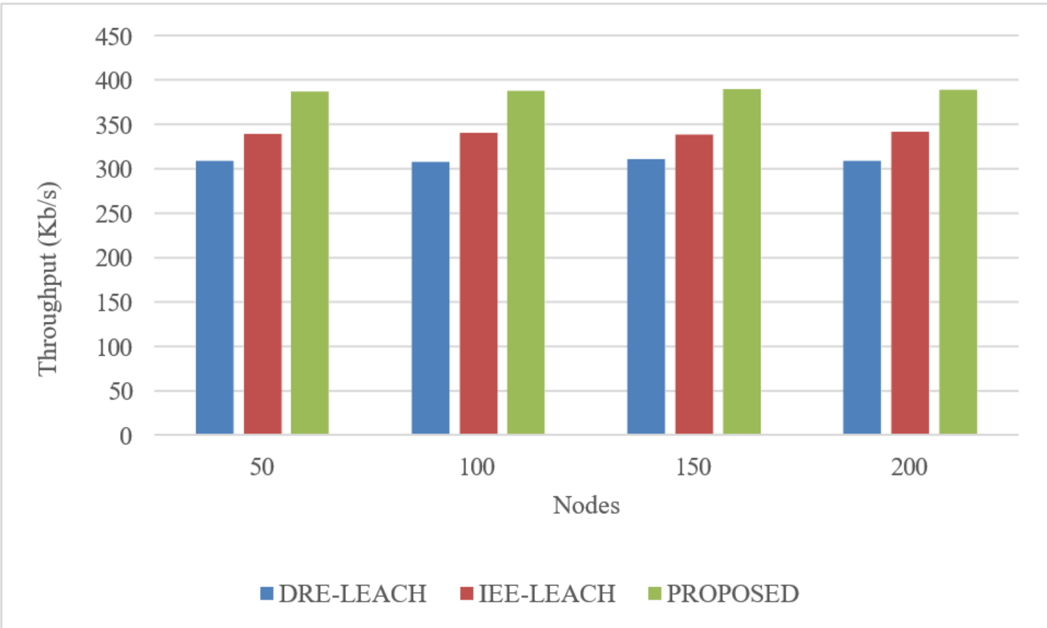

Fig 5: Network performance

Network throughput or performance describes as the amount of data that could be transmitted among sensor nodes in a certain period. The data delivery with higher amount is ensured the increased throughput. The average throughput rate of 377 kbps is maintained with the proposed technique and it is higher than the earlier methods as shown in the Figure 5.

V. Conclusion

Using a number generator, cluster heads (CHs) are selected at random in the traditional LEACH approach. Owing to the absence of energy-level-based prioritizing, nodes with lower residual energy may prematurely deplete relative to other nodes. In this paper, a unique modified routing protocol called Improved

Lifetime Modified LEACH (IL-MLEACH) is presented to improve the energy efficiency of Wireless Sensor Networks (WSNs). IL-MLEACH takes into account each node's residual energy as well as the average energy of the network. In order to efficiently reduce sensor energy consumption during cluster formation, it optimizes CH selection and filters out nodes that are closer to the base station (BS). Furthermore, DPSO, an enhanced version of Particle Swarm Optimization (PSO), is used to identify the best relay node for data transfer. In order to guarantee effective relay selection and steady energy consumption, DPSO takes node cost and latency into account. According to simulation studies, this strategy might greatly improve WSN energy dissipation, network longevity, and communication quality.

References:

[1] Zhu, C., Quan, K., Han, G. and Rodrigues, J.J., 2018. A high-available and location predictive data gathering scheme with mobile sinks for wireless sensor networks. *Computer Networks*, *145*, pp.156- 164.

[2] Zunino, C., Valenzano, A., Obermaisser, R. and Petersen, S., 2020. Factory communications at the dawn of the fourth industrial revolution. *Computer Standards & Interfaces*, *71*, p.103433.

[3] Rafi, A., Ali, G. and Akram, J., 2019, January. Efficient energy utilization in fog computing based wireless sensor networks. In *2019 2nd International Conference on Computing, Mathematics and Engineering Technologies (iCoMET)* (pp. 1-5). IEEE.

[4] Bongale, A.M., Nirmala, C.R. and Bongale, A.M., 2020. Energy efficient intra-cluster data aggregation technique for wireless sensor network. *International Journal of Information Technology*, pp.1-9.

[5] Kaur, T. and Kumar, D., 2018. Particle swarm optimization-based unequal and fault tolerant clustering protocol for wireless sensor networks. *IEEE Sensors Journal*, *18*(11), pp.4614-4622.

[6] Prasadu Peddi (2018), Data sharing Privacy in Mobile cloud using AES, ISSN 2319-1953, volume 7, issue 4.

[7] Gherbi, C., Aliouat, Z. and Benmohammed, M., 2019. A novel load balancing scheduling algorithm for wireless sensor networks. *Journal of Network and Systems Management*, *27*(2), pp.430-462.

[8] Xiu-Wu, Y.U., Hao, Y.U., Yong, L. and Ren-rong, X., 2020. A clustering routing algorithm based on wolf pack algorithm for heterogeneous wireless sensor networks. *Computer Networks*, *167*, p.106994.

[9] Tanwar, S.; Tyagi, S.; Kumar, N.; Obaidat, M.S. LA-MHR: Learning automata based multilevel heterogeneous routing for opportunistic shared spectrum access to enhance lifetime of WSN. IEEE Syst. J. 2019, 13, 313–323. [CrossRef]

[10] Prasadu peddi (2014) EXPLORING THE IMPACT OF DATA MINING AND MACHINE LEARNING ON STUDENT PERFORMANCE", International Journal of Emerging Technologies and Innovative Research (www.jetir.org), ISSN:2349-5162, Vol.1, Issue 6, page no.314-318, November-2014,

[11] Kim, D.S.; Chung, Y.J. Self-organization routing protocol supporting mobile nodes for wireless sensor network. In Proceedings of the First International Multi-Symposiums on Computer and Computational Sciences (IMSCCS'06), Hangzhou, China, 20–24 June 2006; pp. 622–626.

[12] Semchedine F,; Oukachbi W,; Zaichi N,; Medjkoune L. B. EECP A new cross-layer protocol for routing in Wireless Sensor Networks. International Conference on Advanced Wireless, Information, and Communication Technologies 2015, 336-341.

[13] Singh R; Verma A. K. Energy efficient cross layer based adaptive threshold routing protocol for WSN. International Journal of Electronics and Communications 2017, 72, 166-173.