Performance analysis of two layer leach algorithm based on area partition (tl-leach-p) for wsn

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Abstract. Currently, much research has been done to develop routing algorithms to improve the lifetime of sensors from Wireless Sensor Network (WSN). Routing protocols based on the network structure can be classified into two categories: flat protocols and hierarchical protocols. One of the most popular hierarchical protocols is the Low Energy Adaptive Clustering Hierarchy (LEACH) algorithm. However, LEACH routing has a high packet loss in a busy network. This research propose Two Layer LEACH based on area Partition (TL-LEACH-P) routing algorithm based on the LEACH routing algorithm where the cave layer is done to prioritize the node that can become Cluster Head to decrease energy consumption. LEACH and TL-LEACH-P algorithms are simulated using MATLAB. The results show that the TL-LEACH-P algorithm has a better performance of 60% reaching LEACH in terms of network lifetime. The TL-LEACH-P algorithm has a 50% increase in the round where 50% of the nodes are dead from LEACH. Best TL-LEACH-P algorithm performance is when the k cluster value = 5. And best performance for LEACH algorithm is when the k cluster value = 15.

1. Introduction

Wireless Sensor Network (WSN) has a very important role in various fields of life. WSN supports remote monitoring of a sensor without having to be in that location. In its development, WSN is widely used for monitoring the civilian environment, such as buildings, bridges, reservoirs, and in the military supervision system under certain very dangerous conditions. In addition, WSN is also used in part monitoring systems and marine monitoring for the detection of natural disasters.

WSN is an infrastructure network that consists of a set of sensor nodes that are spread over a sensor area. Each sensor node has the ability to collect data around it and redistribute it to the sink node through intensive radio transmission. The collected data can be in the form of temperature, pressure, movement of an object, humidity, and so on. In general, WSN consists of two components, namely sensor nodes and sinks. Sensor nodes are a unitary component of a network that can produce information, can be a sensor or a structured actuator in the entire operation. In general, sensors are spread with high volume and density. Sink is an integrated process of gathering information from sensor nodes so that further information processing can be done [1].

In its implementation, the main problem of WSN is energy consumption. This is caused by the power supply on the sensor node only supplied by the battery for its operation, so it has limited energy reserves. If one node is off or not active, it will change network performance in terms of topology and routing. On the other hand, obstacles will arise if you have to conserve energy repeatedly because it will increase costs and disrupt network performance. So that energy consumption is the most...
important factor to determine the lifetime of a network, so that the energy used must be as efficient as possible in order to produce maximum performance. Therefore, the routing algorithm for determining routes that use more efficient energy is a top priority in designing WSN. Hierarchical routing approaches increase the lifetime of network performance by cutting the whole network into clusters which are led by cluster head. Machine learning and computation intelligence bring out the optimization of clustering algorithms for WSN [2].

One of the popular routing algorithms for WSN is the LEACH algorithm. LEACH algorithm is an extension of Low-energy Adaptive Clustering Hierarchy which is a TDMA-based MAC protocol that is integrated with clustering and simple routing protocols at WSN. The purpose of the LEACH algorithm is to reduce the energy consumption needed to create and maintain clusters to increase the lifetime of WSN [3].

Problem of WSN is the network has very limited energy; therefore a protocol communication algorithm is needed to increase the node lifetime. The purpose of this research is to propose Two Layer LEACH Based on Area Partition (TL-LEACH-P) to conduct a performance comparison analysis on the TL-LEACH-P and LEACH (standard) algorithms which cover rounds where the first node die (first node dies), half node die (50 nodes dead), and all die nodes (100 dead nodes). So we will know which is the best algorithm should be implemented based on the conditions needed. Several research works have already done by researcher in order to optimize the LEACH algorithm. Mohammed et al. [4] proposed Kangaroo method (KM) using the optimal path adaptive routing to reduce sensor node energy dissipation. The KM algorithm is inspired by the simulated annealing method. The data transmission of the data from the cluster head to the base station is done by multi-hop mode. The Matlab simulation results show that the proposed KM method better regarding residual energy and extend the lifetime of networks.

Sweety et al. [5] proposed Limited Communication-LEACH-Mobile Fuzzy (LC-LEACH-MF) to utilize the allocation of energy to sensor nodes in efficient way. The proposed method is developed based on LEACH algorithm, and LEACH-Mobile (LEACH-M) using fuzzy inference system LEACH-Mobile Fuzzy (LEACH-MF). The simulation result show that the proposed method better than the LEACH method and other traditional techniques in terms of packet delivery ratio, last node dead, half node dead, first node dead, and energy consumption.

Maurizka et al [6] proposed delay tolerant network (DTN) to LEACH algorithm to reduce the packet loss in a busy network. The proposed system adds bundle layer to save the data temporarily. The simulation results show that the proposed system decrease the packet loss in changing the number of node and improve the packet delivery ratio by changing the capacity of buffer. Muhammad et al. [7] proposed enhanced three layer hybrid clustering mechanism (ETLHCM) to limits the exchange of control packets between nodes when select lower layer heads of cluster. The higher layer heads of cluster is selected by base station to reduce backward transmission of packet data in network. Simulation results show the proposed method increase the lifetime of network.

2. System Design
In this section, we discuss our proposed system for experiment and analysis preparation. This contains overall system workflow, simulation model attributes used, and flowchart of each algorithm.

2.1. Overall System Workflow
The general overview of the system design process is shown in figure 1.
Figure 1 shows the general system design that will be implement and analysis. First, the parameters needed in each algorithm both for LEACH and TL-LEACH-P algorithm files to be compiled in MATLAB are determined. For parameters, it will be explained on the next section about simulation model attributes.

After all parameters have been successfully determined, then an algorithm file is formed which will be compiled and obtained data to be processed. Implement the source code in MATLAB for the two algorithms tried, namely LEACH and TL-LEACH-P. After the source code has been completed, it will run to get the data visualization of the node's location when the two algorithms are running and compare directly in graphical form.

2.2. Simulation model attributes
The simulation mode attributes and parameters we used are shown below in table 1.

| Parameter                  | Value               |
|----------------------------|---------------------|
| Total node                 | 100                 |
| Node location              | Random              |
| Node Area                  | 100 x 100           |
| K cluster                  | 5, 10, 15, 20       |
| Base Station location      | 50, 175             |
| Initial Energy of each node| 0.5 Joule           |
| Simulation Time            | 3000 rounds         |

2.3. LEACH and TL-LEACH-P
After the node has been raised and spread, the next is to determine the Cluster Head and Cluster Member to determine the cluster so that the delivery of information is known to its origin and destination. In this case the determination of the cluster head and cluster members is still random or the cluster head does not choose the closest cluster member but the cluster member determination is random.

Determination of cluster head randomly according to which leach algorithm when the energy of all nodes is the same then the cluster node is chosen randomly, only then when the energy starts to fall then the node with the greatest energy is chosen, in this case the number of cluster nodes cannot be
determined it depends from the energy that exists at each node, whereas for node switching is done simultaneously with other cluster heads. The formation of cluster head is the process after spreading the node and determining the parameters for the simulation. Furthermore, to determine the cluster head itself, it is determined from residual energy \( E \) greater than the threshold that is done, the node will become a cluster head and the one that is not suitable will become a cluster member.

In LEACH algorithm, the node performs the settings made by the node or the node stands alone without having to have commands from the Base station or cluster head. All cluster members send data to the cluster head, which the cluster head receives data from all the cluster members. LEACH divides activities into several rounds. Round is a time session needed for cluster formation until data transmission is complete. Each round produces a number and arrangement of different clusters. This is because the determination of cluster head is done randomly.

After we design how LEACH determines the cluster head, then we design how the TL-LEACH-P done the same thing on the same area and the same node location. In the process of determining the Cluster Head and Cluster Members have similarities between the LEACH and TL-LEACH-P. However, there are some differences. The first is the minimum area value of the layer. Determine the minimum value of this layer based on the number of clusters specified. By default the width of the area will be divided into two at 50 in the y axis for area partition. The node distribution factor is proven when the use of partition topologies where the number of nodes is spread evenly is better than the random topology at the same environment size [8]. Furthermore, if there are no nodes above the layer boundary, then the layer is no longer needed. Also, the preferred node to become a cluster head is a node with the y position above the layer boundary. In this case, we will set the limit to half the area becomes 50. The flowchart of TL-LEACH-P is shown in figure 2.

![Flowchart of TL-LEACH-P algorithm.](image-url)
Based on the figure 2, the TL-LEACH-P topology illustration how the data flow will be sent to the base station is shown in figure 3. The difference between TL-LEACH-P algorithm and the standard LEACH lies in the selection process of the cluster head. Where in the setup state, this algorithm regulates the number of cluster heads to be measured using the average silhouette method [9] to determine the optimal number of cluster heads when selecting cluster heads in that round. After the optimum value k is obtained. Furthermore, the area of the node will be divided into 2 layers. So that what will be prioritized to become a cluster head is a node with high energy and on the layer closest to the Base Station.

![Figure 3. TL-LEACH-P topology illustration.](image)

3. Experimental Results
In this section will be testing process of implementation LEACH and TL-LEACH-P algorithm on performance analysis using MATLAB. This test will compare the performance of node alive, energy average, first node die (FND), half node die (HND), and all node die (AND) for each algorithm.

3.1. Total Remaining Energy
Energy has become an important concern in WSN research. While many energy-saving protocols have been proposed to extend network lifetime, various network lifetime definitions have also been used for different scenarios and protocols. We conduct the experiment to compare the total remaining energy (J) results in the LEACH and TL-LEACH-P algorithms for each cluster k, namely 5, 10, 15, and 20 clusters. After we run the simulation on each algorithm and k clusters obtained graph results as shown in figure 4. Figure 4 shows that the total remaining energy in TL-LEACH-P algorithm is better than the total remaining energy in the LEACH algorithm.
3.2. Average Remaining Energy

In this test, the calculation of the average energy of each node in each round is carried out. So, in each round will be calculated the total energy owned by all nodes divided by the number of nodes in the round. This calculation is performed on each algorithm, namely leach and TL-LEACH-P. After we do the simulation running on each algorithm and cluster k, the graph results are as shown in figure 5. From the results of the graph above from 5, it can be seen that the remaining energy in the leach algorithm has completely exhausted in the round to 1300s. This is directly proportional to the number of nodes that are still alive in the round. If in that round the living nodes are still many, then the average remaining energy in the round will be high. Likewise, if the number of nodes that live in the round is getting smaller, the average total energy in the round will be the smaller. It can be seen that the TL-LEACH-P algorithm has more efficient energy utilization compared to the leach algorithm.

Figure 4. Total remaining energy with k cluster = 5, 10, 15, and 20.
3.3. First Node Die (FND), Half Node Die (HND), All Node Die (AND)

In this test, we do a comparison on the number of nodes that have the same value. In this case, it is when the first node dies or the First Node Die (FND), 50% of the total nodes die or Half Nodes Die (HND), and all nodes die or All Nodes Die (ALND) on each algorithm and each cluster k. In this comparison, we will appear in the form of a separate table showing the comparison of the number of dead nodes compared to the round. Here are the results of the comparison of FND, HND, and AND on the LEACH algorithm.

Table 2. Comparison of FND, HND, and AND on LEACH algorithm.

| State                  | LEACH (round) |
|------------------------|---------------|
|                        | 5 CH | 10 CH | 15 CH | 20 CH |
| First Node Die (FND)   | 140   | 176   | 160   | 150   |
| Half Node Die (HND)    | 410   | 436   | 428   | 417   |
| All Node Die (AND)     | 1266  | 1389  | 1371  | 1380  |

Table 2 shows the result of FND, HND, and AND obtained from the search in what rounds occurred in situations where First Node Die (FND), Half Node Die (HND), and All Die Nodes (AND) on each cluster k for LEACH algorithm. It can be concluded that the LEACH algorithm is the best First Node Die (FND) value of k cluster with a value of 10. Similarly, for the Half Node Die (HND) and All Node Die (AND) values, the best value is in k cluster with a value of 10.

Table 3 shows that the TL-LEACH –P algorithm has a good performance for First Node Die (FND) on k clusters with a value of 15, which in k = 15 the round value in the FND situation is 197 rounds. As for performance in Half Node Die and All Node Die situations, the best performance is in the 5 cluster with Half Node Die being in the 890th round and All Node Die in the 2919th round. From table
2 and 3, it can be shown that the network lifetime of TL-LEACH-P is more than that of LEACH.

Table 3. Comparison of FND, HND and AND on TL-LEACH-P algorithm.

| State                  | TL-LEACH-P (round) |
|------------------------|---------------------|
|                        | 5 CH  | 10 CH  | 15 CH  | 20 CH  |
| First Node Die (FND)   | 107   | 140    | 197    | 175    |
| Half Node Die (HND)    | 890   | 758    | 705    | 626    |
| All Node Die (AND)     | 2919  | 2042   | 1668   | 1569   |

4. Conclusions
This paper proposes Two Layer LEACH based on area Partition (TL-LEACH-P) routing algorithm in order to decrease the energy consumption of network nodes for WSN. TL-LEACH-P determines the first minimum area value of the layer based on the number of clusters specified for area partition. After carrying out various stages starting from the design stage, making the system which is then continued at the testing and analysis stage, it can be concluded that the TL-LEACH-P Algorithm has advantages compared to LEACH in terms of node remaining energy, network lifetime, first node die (FND), half node die (HND), and all node die (AND).

5. References
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