# WSN LIFETIME IMPROVEMENT UTILIZING MODIFIED MULTITIER (MMT) LEACH PROTOCOL

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Abstract— **Energy is the most essential component for nodes in a Wireless Sensor Network (WSN), which cannot be repaired after they have been established. Progressive routing is a method that can extend a network's life by relieving the congestion that it experiences. We are now working on extending the lifespan of the arrange by designing a Multitier Advance LEACH based protocol that takes into consideration residual energy and node separation in a WSN. This will allow us to improve the longevity of the arrange. In order to extend the usefulness of an arrangement for longer periods of time, a fundamental method known as the grouping algorithm can be utilised. It has the potential to make the system more adaptable to new circumstances. The creation of energy-efficient bunching standards for the characteristics of heterogeneous wireless sensor networks is a current focus of research and development efforts. In this paper, a new Multitier Advance LEACH convention that is a combination of the Dispersed Energy Effective Grouping Plan for Heterogeneous Remote Sensor Systems (DEEC) and the Threshold Sensitive Energy Efficient convention is proposed and evaluated. Multitier Advance LEACH is a combination of the Dispersed Energy Effective Grouping Plan for Heterogeneous Remote Sensor Systems (DEEC) (TEEN). In DEEC, the plot the cluster-heads are chosen based on a probability distribution based on the ratio of leftover energy from each node to the normal energy of the remote sensor organization, which is a function of the remaining energy of each node. This distribution is based on the ratio of leftover energy from each node to the normal energy of the remote sensor organization. The quantity of underlying and residual energy that a group possesses is the primary factor that decides how long it will take them to reach their destination nodes. In contrast to the nodes that have the least amount of energy, it is the nodes that have the highest initial and residual energy that are considered for the role of cluster leader. In addition, the outcomes of the reproduction show that MMT-LEACH is capable of achieving a longer lifetime and a more prominent reminder than the primary clustering algorithms that are currently in use when it is applied in heterogeneous contexts.**

**Keywords: Wireless sensor networks (WSNs) Leach, Genetic algorithm, LEACH, E-LEACH, LEACH-EX, GADA-LEACH, Advanced Multitier LEACH, and Network lifetime.**

## I INTRODUCTION

Sensor nodes, a sink node, and an official's node are the three types of nodes that make up unified wireless sensor networks. It has been suggested that the aforementioned zone contains a significant number of sensor nodes, all of which, when put together, make up a framework over the various self-affiliation mechanisms. Asynchronously, the data controlled by sensor nodes is routed to a number of different nodes. Each of these nodes will then transmit data to the sink node via multi-hop guidance, and finally, they will send data to the organization node using wired connections that are comparable to remote Internet [2]. The amount of energy that sensor nodes can store, the capacity of their signaling methods, the accumulation breaking threshold, and the number of connections they can make are all capped. A significant advancement that centers on wireless sensor networks is the utilization of energy in a clear and unambiguous method [3, for instance]. Cluster-based guiding count has a reduced energy consumption [8], as compared to differentiate and non-cluster coordinating computation. According to [3] and [7], the primary goal of employing clustered routing is to lessen the amount of time that must be spent moving data, thereby lessening the energy isolation that exists between sensor nodes and, as a consequence, successfully accomplishing the goal of saving energy on the inspiration driving circuits of sensor nodes.

The LEACH (low-energy versatile clustering progressive system) [4-5] clustering steering algorithm has received a lot of attention for how easy it is to use and how effective it is for distant sensor networks. According to Drain's classification, it is broken up into multiple clusters, and the total amount of time it takes for the system to function is split up into a number of different rounds. Each round consists of a number of rounds in which the nodes that make up a cluster compete against one another. The nodes that make up a cluster compete against one another in each round for the position of cluster head, which is decided according to a predetermined rule. According to the LEACH convention, each sensor node has an equal chance of being a cluster head. This causes the nodes in the system to utilize energy in a slightly different manner so that the lifespan of the system can be extended.

Start the Multitier Advanced LEACH (DEEC+TEEN) demonstration and take a look at the presentation of many clustering estimations for the improvement of compositional lifespan in heterogeneous distant sensor frameworks at this point. Within the framework of the sensor network under discussion, the transmission of recognition data from each node to the base station takes place via a cluster head. The term for this particular network is the sensor network. In certain approaches to clustering, the cluster heads are chosen on a periodic basis. These cluster heads then combine the data from the various cluster fragments that make up their cluster and send it to the base station. The end-customers can then retrieve the information that they require from the base station. Heterogeneity can be considered to have its origins in the fact that all of the nodes that make up the sensor composition are provided with variable amounts of energy, as our hypotheses have it.

It is possible that this is the outcome of re-energizing the sensor organizations in order to increase the lifetime of the system [9], for instance. The energy consumption of the new nodes that are added to the systems will be higher than that of the old nodes that were already present in the system. In spite of the fact that all of the nodes are initially supplied with the same quantity of energy, the systems are unable to develop in an equal manner for each node when the energy is depleted. This is because of the radio correspondence characteristics, arbitrary events, such as transient connection failures, or the morphological characteristics of the field [9]. As a direct consequence of this, the architecture of WSNs is almost certainly that of a heterogeneous system.

Multitier Advance LEACH algorithms, which are among the numerous routing protocols proposed for WSNs, are more successful in achieving WSNs requirements, particularly those related to Network Lifetime [11-12]. This is because Multitier Advance LEACH algorithms are composed of multiple layers of LEACH algorithms. As a result of the grouping of sensor nodes into various categories that are referred to as clusters, sensor nodes inside each cluster send their data to certain sensor nodes that are located within the cluster. These sensor nodes are referred to as Cluster Heads (CH). The information that the CH nodes have gathered is then passed forward to the BS by those CH nodes. As a result of the fact that CH nodes are essential to the operation of cluster-based routing algorithms, the policy that governs the selection of CH nodes has a significant effect on the characteristics of the network, including, amongst other things, the network's lifetime and the rate at which it consumes energy.

A simplified overview of wireless sensor networks (WSNs) can be shown in Figure 1. WSNs are made up of a base station, cluster heads, and sensor nodes or cluster members that are dispersed across a geographic region. This idea has been implemented in a few different protocols, such as LEACH [7], TEEN [8], and LEACH-EX. However, the AMT LEACH protocol, also known as the Multitier Advance LEACH protocol, is one of the cluster-based routing protocols that is utilized the most frequently in wireless sensor networks. This strategy makes use of a random model to select CH nodes in a manner that is dependent on the frequency with which they appear.

When deciding which CH is best, the LEACH algorithm does not take into account either the amount of energy that is left over or the location of the SNs on a map. This is something that needs to be brought to your attention. Because of this, sensor nodes pass away at an earlier age than they should, which causes the lifetime of WSNs to be cut short.

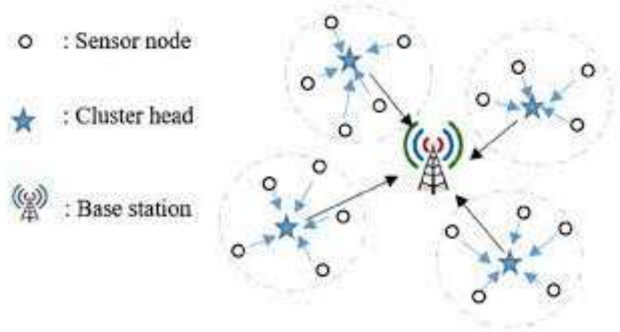


**Figure 1:** Cluster-based Model

## I. LITERATURE REVIEW

In order to set up the wireless sensor network, a number of different approaches to wireless networking were utilized. The 802.11 protocol became the first standard protocol for use in wireless local area networks in 1997 after it was initially made available (WLANs). Additionally, it is now the protocol that has the greatest adoption rate. After that, it was updated to 802.11b, which had a faster data rate and a CSMA/CA mechanism for medium access control. Following that, it was discontinued (see Figure 1). (MAC). 1998 was the year when this group utilized a number of technological advancements in order to build a sensor node of the second generation, which came to be known in the future as Wireless Integrated Network Sensors (WINS). These WINS were outfitted with a CPU board that contained an Intel powerful ARM SA1100 32-bit embedded processor (1 MB SRAM and 4 MB flash memory), a radio board that was capable of transmitting at 100 kbps while consuming power that could be adjusted from 1 to 100 m, a power supply board, and sensor boards. Additionally, these WINS were outfitted with a power supply board.

It is up to each node to first sense its target, and then it is the node's job to communicate any pertinent information to the head of its cluster. The information that has been gathered from each of the nodes is first sent to the cluster head, where it is compiled and then compressed before being sent on to the base station. The nodes that are designated as the cluster head spend more energy than the other nodes because it is their job to broadcast data to the base station, which could be located in a more remote position than the rest of the nodes. As a result, LEACH uses a method known as random rotation of the nodes that are required to function as cluster heads in order to ensure that the amount of energy consumed by the network is distributed evenly. The author ran a number of simulations, and the results of those simulations led to the discovery that just five percent of the total number of nodes are necessary to serve as cluster chiefs. [Citation needed] In order to reduce the amount of collisions that take place both between and within clusters, the TDMA/CDMA MAC is utilized. This protocol is used in circumstances in which continuous monitoring by the sensor nodes is required because data collection occurs centralized (at the base station) and on a periodic basis. Also, data collection is carried out in accordance with the protocol.

In a wireless sensor network (WSN), the sensor nodes collect data from locations that are difficult to reach, submit their report to the base station, which is also referred to as the sink, and then collaborate to send the collected data to the sink through multiple hops of wireless communication. [10] Nodes in wireless sensor networks can be mobile or stationary, and they can be spread out across an area using either a methodical or a random deployment strategy. Additionally, nodes in these networks can be deployed in any order.

It has been suggested that the LEACH approach be made more comprehensive by incorporating a hierarchical structure with two levels [13]. It consists of two levels of cluster heads, as opposed to just one level of cluster heads, which is main and secondary respectively (primary and secondary). To be more specific, the primary cluster head in each cluster is the one that communicates with the secondary cluster head, and the secondary cluster head in each sub-cluster is the one that communicates with the nodes in each sub-cluster, as demonstrated by the diagram. In this environment, it is also feasible to do data fusion, similar to how it is done in LEACH. Additionally, despite being an outdated technology, TDMA time slots are still used to arrange the communication that takes place within a cluster. The organization of a round will consist of selecting the primary and secondary cluster heads using the same mechanism as LEACH, with the a priori probability of being elevated to a primary cluster head being less than the probability of being elevated to a secondary node, and then distributing the remaining nodes in the network after the selection of the primary and secondary cluster heads has been completed. There are two stages involved in the process of transmitting data from a source node to a sink: The secondary nodes are in charge of gathering information from the nodes that are part of their respective clusters. At this level, it is possible to combine many datasets into a single cohesive whole. Primary nodes are in charge of gathering information from the subordinate clusters that are directly under their jurisdiction. Data fusion can also be carried out on the level of the primary cluster head as an alternative. The TL-LEACH system utilizes a two-level structure, which allows for a reduction in the number of nodes that must send data to the base station, which in turn results in a reduction in the overall amount of energy that is spent. Local Clustering and Threshold Sensitive, abbreviated as LCTS [14]: Local clustering as well as sensitivity to thresholds It combines the benefits of LEACH and TEEN [15] into a single system. Specifically, it minimizes the amount of time spent waiting for data transfer and collects data depending on predetermined thresholds. The base station is in charge of making the selection of cluster heads. [13] LS-LEACH, also known as Lightweight Secure LEACH, is an improved routing method that is both more secure and more efficient in its use of energy. To assure the data's authenticity, integrity, and availability, data integrity, authenticity, and availability algorithm has been incorporated into the system. Furthermore, it demonstrates the enhancements to the LEACH protocol that make it more secure, as well as how to make it more energy efficient in order to reduce the impact of the additional security measures' overhead energy consumption. This is accomplished by reducing the impact of the overhead energy consumption caused by the additional security measures. After determining the source and the number of nodes that need to be secured, it augments the LEACH protocol with additional security measures. In addition, we are working on the development of security methods in order to protect wireless sensors and communications from possible attacks without negatively impacting the operation of the network as a whole. For instance, safeguarding the LEACH protocol from denial of service attacks while still enabling it to perform its intended functions is one example. Aside from that, the protocol ensures that only authenticated nodes are permitted to join the network and communicate with one another in it. This is done by making sure that they are the only nodes that are allowed to join. On the other hand, we are able to lessen the overhead costs connected with the security measures that are put into place in order to avoid having an effect on the network's speed. The LEACH protocol is improved in a number of unique ways by a protocol called Sec-LEACH [14], which proposes the protocol. It explains how the key pre distribution system ought to be funded in order to ensure the safety of connections between nodes and CH. At the time of network deployment, a massive pool of keys and their IDs are generated, and each node in the network is then randomly assigned a subset of these keys. This is the fundamental idea behind the system. These keys are utilized during communications between individual nodes as well as communications between individual nodes and the BS. Additionally, each node is assigned a pair-wise key that it shares with the BS. This approach protects the legitimacy of the data, as well as its confidentiality and its most recent state, when used for communication between nodes. The number of nodes does not have an effect on the security levels; rather, the size of the key group that is issued to each node in comparison to the total size of the key pool is what determines the security levels [14].

## II. CLUSTERING

In wireless sensor networks (WSNs), sensor nodes are commonly grouped together into distinct unique groups that are referred to as clusters. Clustering is utilized in wireless sensor networks (WSNs) due to the fact that it makes network scalability, resource sharing, and efficient use of limited resources possible. This, in turn, makes network topology stability and energy savings qualities available, amongst other advantages. Clustering strategies for sensor nodes provide lower communication overheads and more effective resource allocations. As a result, total energy consumption is reduced, and there is less interference between sensor nodes. The scalability of a sensor node can be increased by clustering many sensor nodes together, also known as grouping sensor nodes together. There is a single person at the helm of each cluster, and this person is referred to as the cluster head (CH). Either the sensors in a cluster can decide on their own which CH they want to use, or the network designer can choose which CH will be used and assign it.

## III. LEACH PROTOCOL

One of the grouping-based tiered routing systems that is utilized in a variety of contexts is referred to as the Low-Energy Adaptive Clustering Hierarchy, or LEACH for short [15-16]. It is utilized so that information can be obtained from a wireless system. A huge number of hundreds of remote sensors are scattered over the system, where they are responsible for information collection and transmission. These sensor nodes are evaluated, and then the cluster heads are chosen from among them. The probability of a sensor node failing to function properly increases due to the fact that each node only has a limited supply of energy to draw from and the battery cannot be replaced after it has been dispatched. As a consequence of this, the LEACH procedure is necessary in order to lengthen the lifespan of the system. In order to accomplish its goals, the drain convention takes use of an arbitrary selection for the cluster head selection as well as the cluster arrangement. In this scenario, a fair distribution of the energy is achieved by rotating the cluster head at the beginning of each round. The filter convention can be broken down into two sections, which are as follows:

Threshold is given by

$$T(n) = \frac{P}{1-P\left(r\ mod\frac{1}{p}\right)}\ if\ n\epsilon G \qquad (1)$$

The following is a list of the parameters that were used in the equation (1) that came before it: p represents the optimal percentage of CHs in each round, while r indicates the round that is currently being played. The term "G" refers to the set of nodes in the graph that have not been chosen as CH in any of the previous rounds (1/p). The development of clusters: After the cluster head has been selected, each node will then broadcast an advertisement (ADV) message using the (CSMA/CA) MAC protocol. A request to join the cluster is transmitted to the cluster head by the nodes that are geographically close to it. It does the setting up and transmission using a time division multiple access (TDMA) schedule, and it gives various time slots to each of the members of its cluster.

At the steady-state phase, it is essential to ensure that data is transmitted from members of the cluster to the cluster head during the allotted time periods. The cluster head is in charge of compiling information and sending it on to the base station for processing.

Because of this, it is feasible for sensor nodes to run out of energy quite quickly [16].

Cluster-heads are nodes that form a component of the LEACH Network, which is comprised of a collection of these individual nodes.

The cluster-head is responsible for gathering data from the nodes in their immediate vicinity and sending it on to the central station. This is the duty that the cluster-head plays. LEACH is a dynamic system due to the revolving door that serves as its cluster head.

This method can be utilized to choose cluster heads in a manner that is based on chance in a stochastic manner:

$$T(n) = \frac{P}{1 - p \times (rmodp^{-1})} \qquad \forall n\epsilon G$$

$$T(n) = 0 \qquad \forall n\epsilon G \qquad (2)$$

Where n is a random number between 0 and 1, P is the cluster-head probability, and G is the set of nodes that have not been cluster-heads in any of the preceding rounds.

If n < T(n), When this occurs, the node in question transforms into a cluster head. The technique is constructed in such a way that every node will have at least one opportunity to serve as the head of a cluster.

The choosing of Cluster Heads Algorithm Pi(t) is the probability that node I will choose to become the Cluster Head at the start of the round r+1 (which begins at time t), given that the expected number of nodes serving as cluster heads for this round is k.

$$E[\#CH] = \sum_{i=1}^{N} P_i(t) * 1 = k. \qquad (3)$$

k = number of clusters during each round. N = number of nodes in the network. Each node will be Cluster Head once in N/k rounds (Round #1,2,3 … Round #N/K, then Round #1, #2, …). – N/K also means cluster size. In each cluster, each sensor has equal chance to become CH. Probability for each node I to be a cluster-head at time

$$P_i(t) = \begin{cases} \frac{k}{N-k*\left(r mod \frac{N}{k}\right)} & : \quad C_i(t) = 1 \\ 0 & : \quad C_i(t) = 0 \end{cases} \qquad (4)$$

$\sum_{i=1}^{N} C_i(t)$ total no. of nodes eligible to be a cluster head at time t This ensures energy at each node to be 2pprox. Equal after every N/k rounds.

$$E[\#CH] = \sum_{i=1}^{N} P_i(t) * 1 \qquad (5)$$

$$= \left(N - k * \left(r \bmod \frac{N}{k}\right)\right) * \frac{k}{N-k*(r \bmod \frac{N}{k})} = K \qquad (6)$$

## IV. E_LEACH

During the phase in which CH nodes are being selected, the DBEA-LEACH algorithm is utilized in the second proposal, which we name DBEA-LEACH, in order to select the CH nodes that are the most applicable. The DBEA-LEACH algorithm takes into account significant aspects such as the location of the sensor node in relation to the base station (BS) and the quantity of residual energy that is stored in each sensor node. DBEA-LEACH operates in a manner that is analogous to that of DB-LEACH in that it establishes a new threshold on the basis of distance. In addition, the current energy of the node and the starting energy of the node are both included in. This ensures that nodes with a larger amount of remaining energy have a better chance of becoming CHs than nodes with a smaller amount of remaining energy. In a wireless sensor network, the choice of CH nodes has an effect not only on the distribution of the load, but also on the energy efficiency and the longevity of the network (WSN).

$$T(n) = \begin{cases} C \times \frac{|d_{toBSavg} - d(i,BS)|}{d_{toBSavg}} \times \frac{E_i}{E_{init}}, if\ n \epsilon G \\ 0 \end{cases} \qquad (7)$$

In this case, $E_i$ denotes the unused potential energy of the candidate nodes in the active round. The term " $E_{inital}$ " refers to the energy level of the node just before the transmission begins. According to Equation (4), the value of the threshold is determined by the geographic distance that separates the sensor node from the BS as well as the residual energy that the candidate node possesses.

## V. LEACH-E & LEACH-EX

When we did some preliminary research, we found that using the ratio of current energy to initial energy in the formula for threshold calculation T(n) produced better results than using the square root; in addition, using the square root leads to an increase in processing overhead. This was discovered as a result of our investigation. Because the square root of a number has a lower value than the number itself, using the square root results in a lower total chance of occurrence. This is due to the fact that the square root of a number always has the same value. The overall probability of electing cluster heads, as well as the number of cluster heads actually chosen, both go down as the overall likelihood of choosing them goes down. (This is a lower number than the probability that was calculated to be P.) When there are fewer cluster heads, certain nodes have to send data over longer distances in order for it to reach the remaining cluster heads. This lowers the individual amount of energy that these nodes require while simultaneously raising the amount of energy that is required by all of the nodes combined. LEACH-EX is capable of producing superior results to LEACH-E because it applies a variety of initial energies to each of the nodes as well. In light of the fact that it is an expansion of LEACH-E, it is referred to as LEACH-EX.
The following formula is used to determine the threshold in LEACH-EX:

$$\mathrm{T}(n) = \begin{cases} \frac{p}{1-p \times r mod(1/p)} \times \frac{E_{current}}{E_0} & n \in G \\ 0 & otherwise \end{cases} \qquad (8)$$

## VI. GADA-LEACH

The suggested energy-efficient protocol known as GADA-LEACH is founded on GA in addition to distance-aware routing. In this scenario, the fitness function is computed based on parameters such as the total energy of all nodes, the total energy of cluster heads, the distance between a cluster head and its associated nodes, the number of nodes in the cluster, the distance between the base station and all cluster heads, and the number of cluster heads formed. In addition, the number of cluster heads formed is also factored into the calculation. The diagram that follows displays the complete flow of GADA-LEACH. The following is a comprehensive rundown of the proposed algorithm's steps, each of which is described in detail:
1) The very first step is to initialize the parameters that are essential to the successful operation of the network as a whole.

2) The second stage involves the process of initializing the energy parameters, which includes determining the initial energy of the sensor nodes, the amount of energy required to run the transmitter and receiver, the amount of energy required for data aggregation, and the amount of energy required for amplification.

A representative sample of the population is collected and organized in order to facilitate the process of determining who would serve as the cluster leader. The nodes that will take on the role of cluster leaders are selected from a group that is made up of other nodes that are a part of the broader network.

The subsequent stage, which comes after the formation of the initial population, involves evaluating the fitness of each node in order to select the nodes that produce the greatest outcomes; the best nodes are then chosen as cluster heads. This stage comes after the formation of the initial population. The fitness function that we use takes into account energy parameters, the distance between a CH and associated nodes, as well as the distance between BS and CH's. The following fitness function was utilized for analyzing the data:

$$Fitness\ function = [(0.3 * F_1) + (0.35 * F_2)(0.35 * F_3)] \quad (9)$$

$$F_1 = \frac{Energy\ of\ all\ nodes}{Energy\ of\ cluster\ heads} \quad (10)$$

$$F_2 = \frac{Eucledian\ Distance\ of\ CH\ with\ its\ associated\ nodes}{Number\ of\ nodes\ in\ cluster} \quad (10)$$

$$F_2 = \frac{Eucledian\ Distance\ of\ BS\ from\ all\ CH's}{Number\ of\ CH'sformed} \quad (11)$$

5) The Roulette Wheel selection method is used to pick the fit people from the population, and the criteria for selection are based on the results of the fitness test.

6) The crossover and mutation processes are utilized so that efficient CHs can be selected for use in the selection process.

7) After the implementation of the GA methods, a second assessment of each person's fitness is performed, and the results are compared to the results of the first assessment.

When the evaluated fitness is lower than the initial population, the current population is updated by the corresponding new generation, and the next iteration is carried out as a result of the minimization of fitness function used by GA. This occurs when the evaluated fitness is lower than the initial population. After the population has been selected initially, it is then updated through the use of a genetic algorithm, and finally, the fitness of the newly updated population is evaluated and compared to the fitness of the population that was selected initially. After that, another sample is taken from the population.

9) If the criteria for stopping the process have been met, the best nodes from the population in question will be chosen to serve as the cluster heads for that round.

10) Once the cluster heads have been chosen, the next step is to create communication between the cluster heads and the nodes. The completion of the final communication between the cluster head and the base station or sink is made possible by the utilization of a relay node, which is incorporated into the system. This relay node is positioned in between the sink and the cluster heads to prevent any data from being lost during transmission. Following the completion of the GA, each of the cluster heads that were selected does a distance calculation using Euclidean terms to determine how far they are from the Base Station (BS) and the relay node. The data that has been aggregated is then sent to the place that is the smallest distance away from the site where it was originally collected.

After that, the concluding calculation of the parameters is finished. 12.

## VII. PROPOSED METHOD

### HETEROGENEOUS NETWORK MODEL

In this part of the article, we will discuss the network model. Assume that there are N sensor nodes and that they are spread out evenly across a M x M square space (Figure: 2)

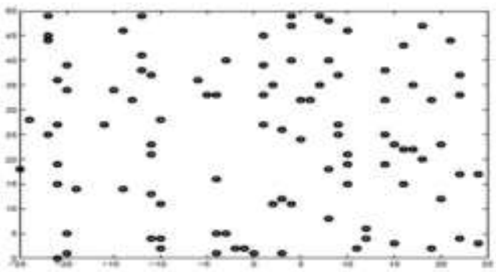

**Figure 2:** A 100-Node Random Network

Always be prepared to transfer data to a base station, which is often situated at a considerable distance from the area being sensed. It is feasible to use this kind of sensor network to track a military item or to monitor the environment around you. Both of these applications are possible. In order to keep things as generic as possible, we are going to proceed under the assumption that the base station can be found in the exact middle of the square area. The correlated data that is used by the cluster-heads in the network comes from the sensor nodes that are located inside the clusters [18]. This data is then reduced by the fusion function that is carried out by the cluster-heads. The network is structured in the form of a hierarchical clustering. The data collected by the cluster heads is sent further by the cluster heads themselves, bypassing the base station entirely. In order to prevent significant shifts in the network's topology on a regular basis, we will pretend that the nodes are either extremely mobile or completely stationary.

There are two different kinds of sensor nodes in two-level heterogeneous networks, which are referred to as advanced nodes and normal nodes, respectively. Take note of E0, which represents the beginning energy of the normal nodes, and m, which represents the fraction of advanced nodes, which have an energy level that is m times higher than that of the regular nodes. Therefore, there are m N advanced nodes that have an initial energy of E0 that is equal to (1 + a), and there are (1 - m) N normal nodes that have an initial energy of E0 that is equal to. The following equation can be used to calculate the total starting energy of two-level heterogeneous networks:

$$E_{total} = N(1-m)E_0 + NmE_0(1+a) = NE_0(1+am) \quad (12)$$

$$E_{total} = \sum_{i=1}^{N} E_0(1+a_i) = E_0\left(N + \sum_{i=1}^{N} a_i\right) \quad (13)$$

The disparity in beginning energy should be taken into account by the clustering method in multi-level heterogeneous networks, just as it is in two-level networks of the same type.

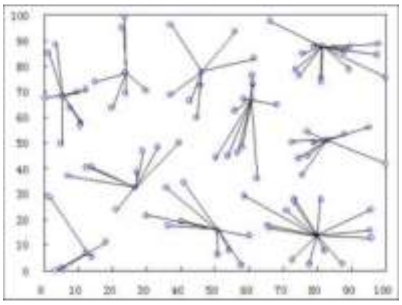

**Figure 3:** Dynamic Cluster Structure by DEEC algorithm

## MULTITIER ADVANCE LEACH PROTOCOL

According to the manufacturer, the DEEC protocol and the TEEN protocol are combined to create the multitier advance leach protocol. This protocol is designed to increase the network lifetime of wireless sensor networks and is a combination of the two protocols. The particulars of the protocols are outlined in this section.

## THE DEEC PROTOCOL

In this section, we will delve further into the particulars of our DEEC technique and cover them in greater detail. The initial and residual energy levels of the nodes are taken into consideration when deciding which nodes will serve as cluster heads. This is done using the DEEC. DEEC estimates the optimal value of network life-time, which is then used to establish the reference energy that each node should spend throughout a round of competition. This is done with the intention of avoiding the requirement that each node be aware of the global knowledge of the networks.

## CLUSTER-HEAD SELECTION ALGORITHM BASED ON RESIDUAL ENERGY

Let denote the number of rounds to be a cluster-head for the node $s_i$, and we refer to it as the rotating epoch. In homogenous networks, to guarantee that there are average $P_{opt}$ N cluster-heads every round, LEACH let each node $S_i$ (i = 1,2,. . .,N) becomes a cluster-head once every $n_i$ = 1/Popt rounds. Note that all the nodes cannot own the same residual energy when the network evolves [19]. If the rotating epoch is the same for all the nodes as proposed in LEACH, the energy will be not well distributed and the low-energy nodes will die more quickly than the high-energy nodes. In our DEEC protocol, we choose different $n_i$ based on the residual energy $E_i(r)$ of node $s_i$ at round r.

Let $p_i = 1/n_i$, which can be also regarded as average probability to be a cluster-head during $n_i$ rounds. When nodes have the same amount of energy at each epoch, choosing the average probability pi to be Popt can ensure that there are Popt N cluster-heads every round and all nodes die approximately at the same time. If nodes have different amounts of energy, $p_i$ of the nodes with more energy should be larger than Popt. Let denote the average energy at round r of the network, which can be obtained by

$$\overline{E} = \frac{1}{N\sum_{i=1}^{N} E_i(r)} \quad (14)$$

To compute E(r) by Eq. (9), each node should have the knowledge of the total energy of all nodes in the network. We will give an estimate of E(r) in the latter subsection of this section. Using E(r) to be the reference energy, we have

$$P_i = p_{opt}\left[1 - \frac{\bar{E}(r) - E_i(r)}{\bar{E}(r)}\right] = p_{opt}\frac{E_{i(r)}}{\bar{E}(r)} \quad (15)$$

This guarantees that the average total number of cluster-heads per round per epoch is equal to:

$$\sum_{i=1}^{N} p_i = \sum_{i=1}^{N} p_{opt}\frac{E_i(r)}{\bar{E}(r)} = p_{opt}\sum_{i=1}^{N}\frac{E_i(r)}{\bar{E}(r)} = Np_{opt.} \quad (16)$$

$$\mathrm{T}(S_i) = \begin{cases} \frac{p_i}{1 - p_i\left(r \bmod \frac{1}{p_i}\right)} & if\ s_i \in G \\ 0 & otherwise \end{cases}, \quad (17)$$

where G is the set of nodes that are eligible to be cluster-heads at round r. If node $s_i$ has not been a cluster-head during the most recent ni rounds, we have si 2 G. In each round r, when node $s_i$ finds it is eligible to be a cluster-head, it will choose a random number between 0 and 1. If the number is less than threshold T ($s_i$), the node $s_i$ becomes a cluster-head during the current round.

Note the epoch $n_i$ is the inverse of. From Eq. (10), $n_i$ is chosen based on the residual energy $E_i(r)$ at round r of node $s_i$ as follow

$$n_i = \frac{1}{p_i} = \frac{\bar{E}(r)}{p_{opt}E_i(r)} = n_{opt}\frac{E(r)}{E_i(r)}, \quad (18)$$

where $n_{opt}$ = 1/popt denote the reference epoch to be a cluster- head. Eq. (13) shows that the rotating epoch $n_i$ of each node fluctuates around the reference epoch. The nodes with high residual energy take more turns to be the cluster-heads than lower ones.

$$p_{adv} = \frac{p_{opt}}{1+am}, \qquad p_{nm} = \frac{p_{opt}(1+a)}{(1+a)} \quad (19)$$

where G is the set $n_i$ of nodes that are eligible to be cluster-heads at round r. If node $s_i$ has not been a cluster-head during the most recent rounds, we have $s_i$ 2G. In each round r, when node $s_i$ finds it is eligible to be a cluster-head, it will choose a random number between 0 and 1. If the number is less than threshold T ($s_i$), the node $s_i$ becomes a cluster-head during the current round. Note the epoch $n_i$ is the inverse of $p_i$. From Eq. (17), $n_i$ is chosen based on the residual energy $E_i$ (r) at round r of node $s_i$ as follow

$$p_i = \begin{cases} \frac{p_{opt}E_{i(r)}}{(1+am)\overline{E}(r)} \\ \frac{p_{opt(r)}E_i}{(1+am)\overline{E}(r)} \end{cases} \quad (20)$$

Where $n_{opt}$ = 1/Popt denote the reference epoch to be a cluster- head. Eq. (18) shows that the rotating epoch $n_i$ of each node fluctuates around the reference epoch. The nodes with high residual energy take more turns to be the cluster-heads than lower ones.

**COPING WITH HETEROGENEOUS NODES**

From Eq. (20), we can see that $P_{opt}$ is the reference value of the average probability $p_i$, which determine the rotating epoch $n_i$ and threshold T($s_i$) of node si. In homogenous networks, all the nodes are equipped with the same initial energy, thus nodes use the same value to be the reference point of $p_i$. When the networks are heterogeneous, the reference value of each node should be different according to the initial energy. In the two-level heterogeneous networks, we replace the reference value with the weighted probabilities given in Eq. (19) for normal and advanced nodes [9].

$$p_{adv} = \frac{p_{opt}}{1+am}, \qquad p_{nm} = \frac{p_{opt}(1+a)}{(1+a)} \quad (21)$$

Therefore, $p_i$ is changed into

$$p_{(i)} = \frac{p_{opt}N(1+a)E_i(r)}{(N+\sum_{i=1}^{N} a_i)\overline{E}(r)} \quad (22)$$

Substituting Eq. (15) for $p_i$ on (12), we can get the probability threshold used to elect the cluster-heads. Thus the threshold is correlated with the initial energy and residual energy of each node directly. This model can be easily extended to multi-level heterogeneous networks. We use the weighted probability shown in Eq. (20)

$$p_{(s_i)} = \frac{p_{opt}N(1+a_i)}{(N+\sum_{i=1}^{N} a_i)} \quad (23)$$

to replace Popt of Eq. (4) and obtain the $p_i$ for heterogeneous nodes as

$$p_{(i)} = \frac{p_{opt}N(1+a)E_i(r)}{(N+\sum_{i=1}^{N} a_i)\overline{E}(r)} \quad (24)$$

From Eqs. (23) and (17), $I_i = (N + \sum_{i=1}^{N} a_i)/p_{opt}N(1 + a_i)$ expresses the basic rotating epoch of node si, and we call it reference epoch. It is different for each node with different initial energy. Note $n_i = 1/p_i$, thus the rotating epoch ni of each node fluctuates around its reference epoch Ii based on the residual energy $E_i$ (r). If $E_i > E(r)$, we have $n_i < I_i$, and vice versa. This means that the nodes with more energy will have more chances to be the cluster-heads than the nodes with less energy. Thus the energy of network is well distributed in the evolving process.

## ESTIMATING AVERAGE ENERGY OF NETWORKS

From Eqs. (20) and (22), the average energy E(r) is needed to compute the average probability pi. It is difficult to realize such scheme, which presumes that each node knows the average energy of the network. We will estimate E(r) in this paragraph. As shown in Eqs. (18) and (19), the average energy E(r) is just used to be the reference energy for each node. It is the ideal energy that each node should own in current round to keep the network alive to the greatest extent. In such ideal situation, the energy of the network and nodes are uniformly distributed, and all the nodes die at the same time. Thus we can estimate the average energy E(r) of $r_{th}$ round as follows

$$\overline{E}(r) = \frac{1}{N} E_{total} \left(1 - \frac{r}{R}\right), \qquad (25)$$

Where R denote the total rounds of the network lifetime. It means that every node consumes the same amount of energy in each round, which is also the target that energy-efficient algorithms should try to achieve. From Eq. (20), considering E(r) as the standard energy, DEEC controls the rotating epoch $n_i$ of each node according to its current energy, thus controls the energy expenditure of each round. As a result, the actual energy of each node will fluctuate around the reference energy E(r) Therefore, DEEC guarantees that all the nodes die at almost the same time. This can be shown by the simulation results of Section 5. In fact, it is the main idea of DEEC to control the energy expenditure of nodes by means of adaptive approach.
To compute E(r) by Eq. (22), the network lifetime R is needed, which is also the value in an ideal state. Assuming that all the nodes die at the same time, R is the total of rounds from the network begins to all the nodes die. Let $E_{round}$ denote the energy consumed by the network in each round. R can be approximated as follow $E_{round}$ denote the energy consumed by the network in each round. R can be approximated as follow:

$$R = \frac{E_{total}}{E_{round}} \qquad (26)$$

In the analysis, we use the same energy model as proposed in [25]. In the process of transmitting an l-bit message over a distance d, the energy expended by the radio is given by:

$$E_{Tx}(l,d) = \begin{cases} lE_{elec} + l_{\in_{f_x} d^2}, & d < d_0 \\ lE_{elec} + l_{\in_{mp} d^4}, & d \geq d_0 \end{cases} \qquad (27)$$

Where $E_{elec}$ is the energy dissipated per bit to run the transmitter or the receiver circuit, and efsd2 or empd4 is the amplifier energy that depends on the transmitter amplifier model [20].
We assume that the N nodes are distributed uniformly in an M× M region, and the base station is located in the center of the field for simplicity. Each non-cluster-head send L bits data to the cluster-head a round. Thus the total energy dissipated in the network during a round is equal to:
$E_{round} = (2NE_{elec} + NE_{DA} + k \in_{mp} d_{to\,BS}^4 + N \in_{f_s} d_{to\,CH}^2)$, where k is the number of clusters, EDA is the data aggregation cost expended in the cluster-heads, d to BS is the average distance between the cluster-head and the base station, and d to CH is the average distance between the cluster members and the cluster-head. Assuming that the nodes are uniformly distributed, we can get [13, 10]:

$$d_{toCH} = \frac{M}{\sqrt{2\pi k}}, \qquad d_{toBS} = 0.765\frac{M}{2} \qquad (28)$$

By setting the derivative of $E_{round}$ with respect to k to zero, we have the optimal number of clusters as

$$k_{opt} = \frac{\sqrt{N}}{\sqrt{2\pi}} \sqrt{\frac{\epsilon_{fs}}{\epsilon_{mp}}} \frac{M}{d_{toBS}^2} \qquad (29)$$

Substituting Eqs. (28) and (29) into Eq. (21), we obtain the energy $E_{round}$ dissipated during a round. Thus we can compute the lifetime R by (19). Because of the affection of the energy heterogeneity, the nodes can't die exactly at the same time. If let R of the estimate value to avoid such situation. This also means that the premise of the energy of the network and nodes being uniformly distributed is not prerequisite in practical operation of DEEC. The approximation of R is enough to get the reference energy E(r) thus DEEC can adapt well to heterogeneous environments. Initially, all the nodes need to know the total energy and lifetime of the network, which can be determined a priori. In our DEEC protocol, the base station could broadcast the total energy $E_{total}$ and estimate value R of lifetime to all nodes. When a new epoch begins, each node $s_i$ will use this information to compute its average probability pi by Eqs. (20) and (21). Node $s_i$ will substitute pi into Eq. (19), and get the election threshold T ($s_i$), which is used to decide if node $s_i$ should be a cluster-head in the current round [21].

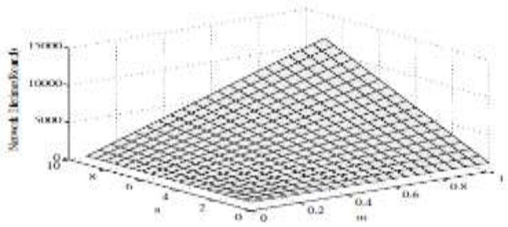

**Figure 4:** Estimation of Network Lifetime

First, consider a random observation order strategy in which the PU pair constructs the observation sequence randomly at every time slot. Since the observation variable set $\{X_1, X_2, \dots, X_M\}$ is independent for each time slot, the efficiency of this order strategy is uncontrollable. Due to the poor performance of the random observation order strategy, take into consideration an intuitive order.

## VIII. RESULTS

The algorithm was implemented in MATLAB simulation tool. The toolbox of MATLAB 9.3.0.713579 (R2017b) is used for simulation of graphical comparison.

This is the result section, here we shows the comparison among the performance of nodes in wireless sensor network based on two parameters (i) with different energy level (0.3J/node, 0.4J/node, 0.5J/node) (ii) with different packet sizes (2000 bit/packet ,3000 bit/packet, 4000 bit/packet) five Routing protocols, LEACH, E-LEACH, LEACH-EX, GADA LEACH ,AMT LEACH . The performance is shown by multiple graphs as describe below (from figure no: 6 to 22 )

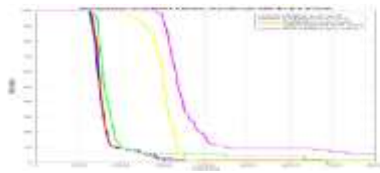

**Figure 5:** Network Lifetime Comparison of different protocols (at Initial energy $E_0 = 0.3J/Node$)

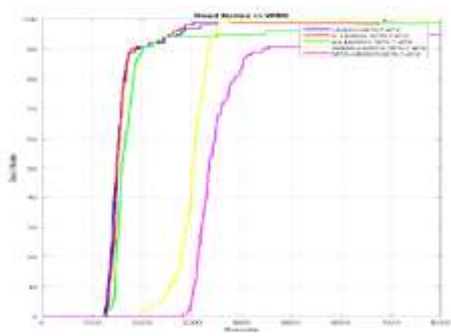

**Figure 6:** Dead Nodes in the WSN

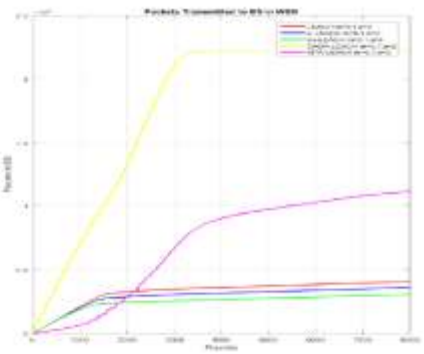

**Figure 7:** Packet Transmitted to BS in WSN

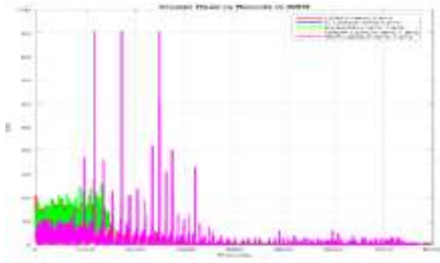

**Figure 8:** Cluster Head Vs Rounds in WSN

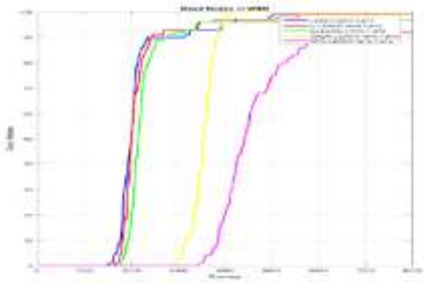

**Figure 9:** Network Lifetime Comparison of different protocols (at energy $E_0 = 0.4\text{J/Node}$)

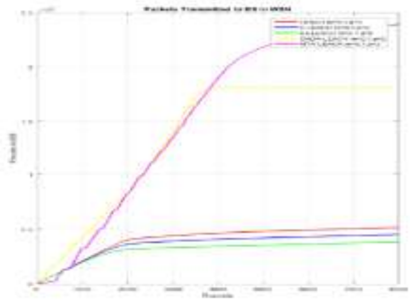

**Figure 10:** End to End Delays

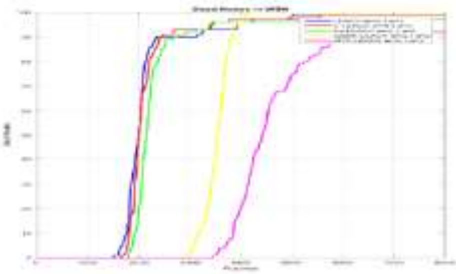

**Figure 11:** Dead Nodes in WSN

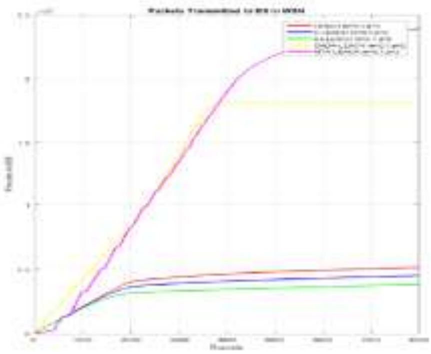

**Figure 12:** Packet Transmitted to BS in WSN

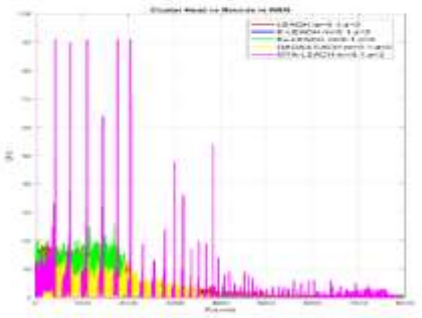

**Figure 13:** Cluster Head Vs Rounds in WSN

Above graph shows the Cluster Head Selection in multiple rounds with Energy 0.4J/node.

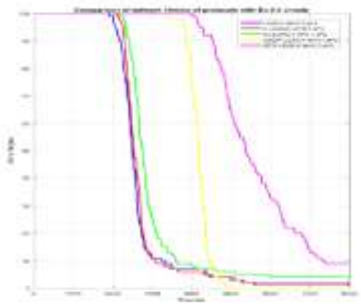

**Figure 14:** Network Lifetime Comparision of different protocols (at energy $E_0 = 0.5J/Node$)

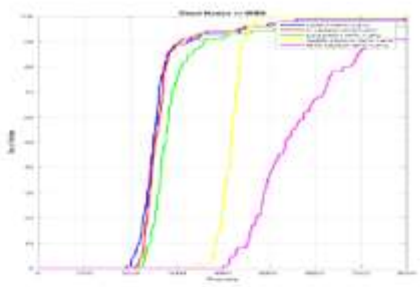

**Figure 15:** Dead Nodes in WSN

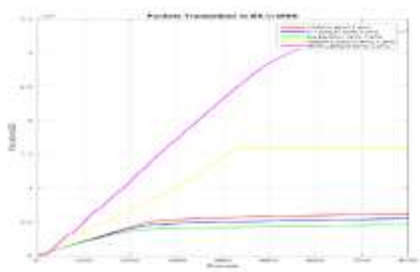

**Figure 16:** Packet Transmitted to BS in WSN

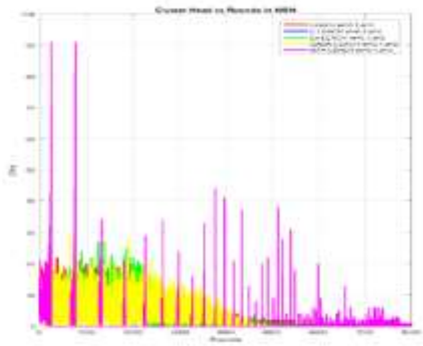

**Figure 17:** Cluster Head Vs Rounds in WSN

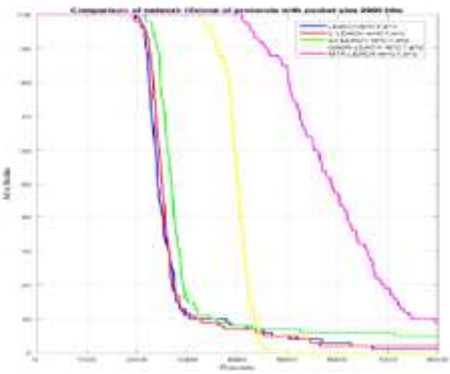

**Figure 18:** Network Lifetime Comparison of different protocols with packet size is of 2000 bits

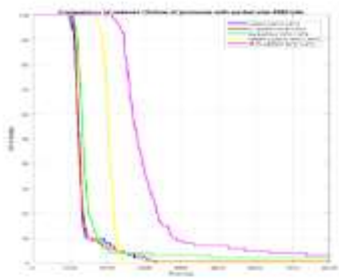

**Figure 19:** Cluster Head variations in multiple Rounds for different protocol with packet size 4000 bits in WSN

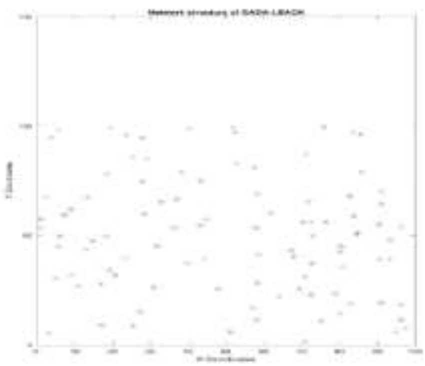

**Figure 20:** Network Structure of GADA-LEACH

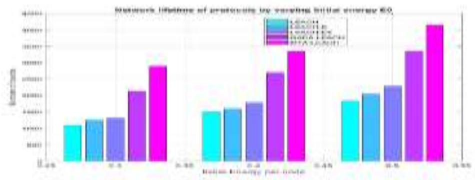

**Figure 21:** Network Lifetime of different routing Protocol by varying initial energy $E_0$

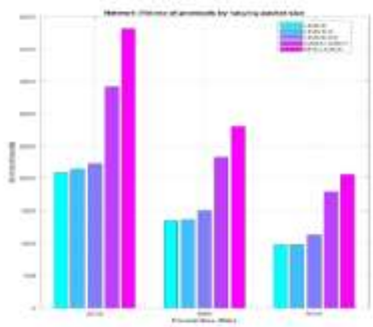

**Figure 22:** Network Lifetime of different number of rounds Protocols by varying packet size

## IX. CONCLUSION

The findings of this study suggest that the efficiency with which energy is used has increased. This study provided a comparison of the network lifetime of nodes in a wireless sensor network when different routing algorithms were utilized to make this comparison. The research was carried out by the University of California, Santa Barbara. This work extends the lifetime of the network by utilizing Multitier LEACH, a protocol that uses hard thresholds and soft thresholds, respectively. This allows for the lifetime of the network to be increased. There is a comparison made of the lifetime of nodes in a network for the various routing protocols, each of which consumes a different amount of energy and has a varied packet size.

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