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# A NOVEL ENERGY EFFICIENT APPROACH FOR IMPROVING NETWORK LIFETIME USING MULTI-HOP ROUTING PROTOCOL WITH MOBILE WIRELESS SENSOR NETWORKS

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**ABSTRACT**

Sensors are devices that monitor and control the physical environment. They can either be self-propelled through springs, wheels or attached to transporters, such as a truck, in mobile sensor networks Optimizing the sensors' energy usage is crucial for a sensor network that will be in operation for an extended period of time. Because of their proximity to sinks, sensors in static sensor networks are more likely to die than those elsewhere in the network. Sensors near the sink not only provide their own information, but they also assist in forwarding data for those further away. Network partitioning and the network's lifespan are both limited by this uneven energy usage. Wireless sensor networks (WSN) are becoming increasingly used in many New Generation Networks (NWGN) applications. Energy efficiency and data aggregation are two major concerns for these networks. Data aggregation has the dual effect of reducing the amount of data sent and improving the life span of the energy used. Routing protocols are in charge of maximizing network efficiency while minimizing their impact on the environment. Using a multi-hop mobile data collector (MDC), this work presents a novel routing scheme for efficient data aggregation. As a result, the suggested method is superior to current state-of-the-art Wireless Sensor Network Hybrid Multi-Hop Routing Protocols (hybrid multi-hop routing protocol).

**Keywords:** *Clustering Protocol, Routing Protocol, Energy Efficiency, Wireless Sensor Networks, Mobile Sensors*

## 1. INTRODUCTION

In light of recent technological developments, tiny and low-cost sensing devices are now both technically and economically feasible to manufacture [1]. Various environmental parameters can be monitored by the sensors and then transformed into an electrical signal. Each of these sensors may communicate with the Base Station (BS) or with other sensors in the network, making it possible for a wireless sensor network. The region in which we want to maintain tabs on various environmental conditions is where sensor nodes are commonly spread [2]. There must be communication between sensor nodes if they are going to gather information about the real environment. The Base Station receives data from sensor nodes either directly or via other sensor nodes. Sensor networks can be linked to an infrastructure network or the Internet through the Base Station, a permanent or mobile node [3].

Sensors are tools for keeping track on and altering the physical world. A Wireless Sensor Network (WSN) can be built by embedding sensor nodes within or very close to a phenomenon [25,26]. One or more sinks receive data from sensor nodes that have hop-by-hop connectivity. After a sink receives the data, it is processed and then provided to the users [6], springs [9] or wheels [27] can be used to self-propel sensors in mobile sensor networks. It's not uncommon to see battery-powered sensors, like the Berkeley mote [29]. After initial deployment, sensors are typically left unattended due to the difficulty of recharging them.

Eventually, they will run out of power and cease to function. A typical sensor network is projected to operate for several months or possibly a year without the need for recharging. In order to keep WSNs running for as long as possible, they must find a way to maximize energy usage.

Routing in WSNs is complicated because of the unique characteristics of WSNs. Numerous creative algorithms have been created in response to WSNs' unique qualities, as well as the demands of diverse applications and architectures. WSN routing methods include flat network routing, hierarchical network routing, and location-based network routing [7]. Because they all perform the same tasks, nodes in a flat network routing system cannot be distinguished one from the other. SPD and Directed Diffusion are examples of sensor protocols in this area. As an illustration of a hierarchical network routing system that makes efficient use of clustering, the Low-energy adaptive clustering hierarchy (LEACH) [8] was developed. Routing paths in a location-based network are determined based on the nodes' actual locations. GPS devices can be attached to each sensor node to collect this information. Network routing methods based on location include geographic and energy-aware (GEAR) [9] and geographically adaptable (GAF) [10].

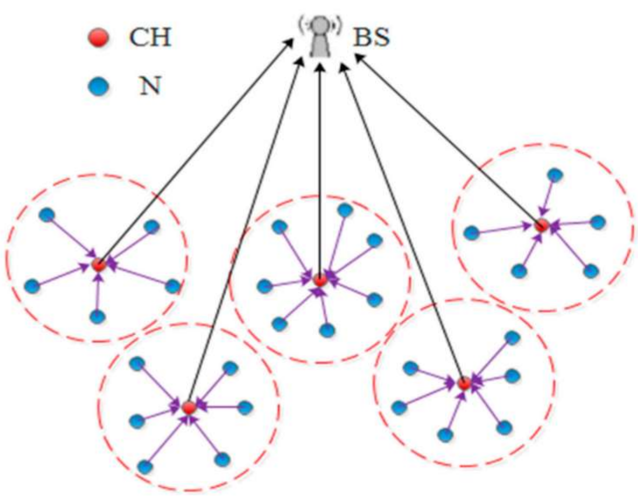


*Figure 1. The Wireless Sensor Network Architecture Uses The Low Energy Adaptive Clustering Hierarchy (LEACH) Protocol*

In WSNs, the architecture of network structure is usually impacted by energy concerns while laying up routes. Due to the fact that the attenuation of a wireless link is related to the square or larger order of the distance between a sender and receiver, it is believed that using multi-hop routing will conserve energy. The structure of a network and the management of medium access become much more complicated when using multi-hop routing. Because of its low network overhead and easy nature, direct communication between all sensor nodes and the BS may be the best option for routing. Multi-hop routing is certainly a defector in most circumstances where sensor nodes are distributed. It has been found that hierarchical network routing and especially clustering methods can significantly reduce WSN energy consumption and overhead [11,12]. Most WSN clustering algorithms, on the other hand, assume that nodes remain stable. Sensor nodes are presumed to be stationary because of the assumption of a basic network design. Because sensor nodes don't have to manage their own mobility or position information, clustering methods can reduce the amount of time spent on communication. A longer network life is a result of the nodes saving more energy. As a result, there are increasing needs for clustering protocols that allow mobile nodes in applications such as animal tracking and search and rescue.

Sensing, communication, and data processing all need different amounts of energy. The sensor node uses the most energy for data transmission out of the three domains. For sensor network applications, energy-efficient routing algorithms are a crucial concern since they assist to extend the network's lifespan by using power more evenly. Many routing techniques have been developed to reduce energy consumption. This strategy increases energy efficiency, but if some nodes are "popular," that is, present on the majority of forwarding channels in the network, it may not necessarily lengthen network lifetime. It's possible that even with dynamic routing, latency and routing loops will be formed (in which data is sent to nodes with the highest residual energy).

Wireless sensor networks may be extended by using clustering techniques. Even the most well-liked node in the cluster eventually falls out of the running to become the weakest link in the chain. Intra and inter-cluster communications can be categorised when a network is partitioned into clusters. There is a cluster head that receives data from all other cluster heads before sending it to the base station (BS). There is a lot of discussion on using single-hop intra-cluster communication. This is due to the fact that wireless channel characteristics show that multi-hop intercluster communication is generally more energy efficient because of the distance between the BS and sensing area. Cluster heads should operate together while sending data to the base station.

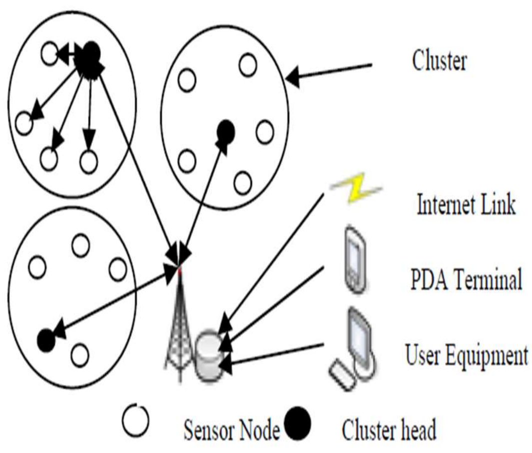


*Figure 2. Wireless Sensor Network Based On Clusters*

Several studies and experiments have shown that hierarchical routing and, in particular, the clustering technique, offer a huge improvement in the field of WSNs. Nodes are treated differently in WSNs when hierarchical routing is used, based on their role and purpose. The base station receives data from a number of nodes, which transmit it to the base station. The routing system includes aggregator nodes, which can be predetermined or dynamically allocated. The aggregator nodes may do both data sensing and routing. Node data will continue to flow to the aggregate node as long as the majority of nodes are still considered to be sensing nodes. Fig. 2 shows a cluster-based WSN design. WSNs are not complete without sensor nodes and clusters, the latter of which serve as organisational units. In a cluster, the cluster leader is the cluster head. [14, 15 and 16]. The base station in a hierarchical WSN serves as a communication link between the sensor network and the end user.

This study shows how an MDC-based clustered routing strategy in WSNs moves the MDC (mobile agent) along a predetermined route within the environmental applications network. For every five seconds, the MDC sends a beacon transmission to the cluster head and base station to keep them updated on its current location (BS). To send sensor node aggregated data to the base station or central location, MDCs send beacon messages that the CHs receive and then compute the distance by measuring the intensity of the MDCs' received signals. Basic characteristics of the networks include a stationary base station that is positioned a long distance away from the sensor region, homogeneous communication between all of the sensor nodes, energy control, and the absence of any sensors that consume a lot of energy during communication. To eliminate the usage of redundant and overloaded information in existing hierarchical cluster-based routing protocols, data fusion is the best option.

The rest of the paper is structured out as follows: It begins with a brief history of multi-hop routing protocols discussion of similar works in Section 2, a detailed presentation of the proposed approach in Section 3, a quantitative assessment of the energy dissipation model proposed section 4, Results and Discussion for the proposed work are addressed in section 5, and a conclusion and future scope in Section 6

## 2. LITERATURE SURVEY

Clustering strategies that seek to minimize energy consumption and increase the lifespan of WSNs are evaluated in this section. The well-known clustering method LEACH (Low Energy Adaptive Clustering Hierarchy) is used as the first step. Each iteration of LEACH is distinct from the previous one. Each node in the cluster is assigned a random number between [0,1] in order to pick a cluster head. To be elected as CH, one must have a lower number of nodes than T(n) in eq (1).

$$T(n) = \{\frac{P}{1-P*(r mod \frac{1}{P})},\ 0,\ otherwise\quad if\ n \in G, \tag{1}$$

In contrast, because it relies on a random number generator, LEACH cannot ensure that the optimal CHs are selected. There have been several improvements to LEACH, including HEED [18], TEEN [19], and PEGASIS [20].

Uneven node distribution was addressed using a cluster-based routing strategy provided by the author in [21]. A clustering algorithm that takes into account energy consumption is employed here (EADC). The selection of CHs is driven by energy-related factors. Due to the stability of the multipath routing method and its ability to evenly distribute traffic across the network, it was initially employed in wired networks. To improve energy economy and network resiliency in the event of node failure, this technology has been expanded in recent years to wireless ad hoc or sensor networks. The rest of this section discusses various general-purpose wireless sensor network routing methods that employ multiple pathways. For reliable multi-path routing and delivery, DD (Directed Diffusion) [22] is a promising option. Author in [23] investigates a multipath routing strategy based on the directed diffusion concept and

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discovers multiple partially disconnected channels. Multipath routing has been demonstrated to be a feasible choice for WSN failure energy efficient recovery. Author in [24] outlines a routing strategy that takes into account both efficiency and environmental impact. All viable paths between sources and sinks, as well as the corresponding energy expenditures, are found through localized flooding of request signals. Every neighbor in the sensor node's routing table is assigned a transmission probability based on the cost of the path that passes through it. To avoid overloading a single way and extending network life, many paths are maintained available in the system, but only one is used at a time. Energy balancing multipath routing protocol (EBMR) was proposed by the author in [25]. The base station processes sensor data and serves as a client. In order to establish the route, the base station broadcasts messages. Databases are connected to each node in the network. Base stations send out a Data Enquiry (DE) message when they need to look up a piece of information in the network. Data Enquiry Reply (DER) messages will be sent to the nodes that hold the requested information. Base station calculates the quickest way back to source node based on how much energy it takes to send the package back and forth from source to base station after receiving DER message. Node-disjoint multiple pathways between the source and destination nodes were proposed by the author of [26]. Link cost functions take into account energy levels and hop distances while creating multiple pathways. A load-balancing technique also helps to distribute network traffic evenly. MERP uses only localized information to discover node-disjoint pathways and considers network robustness while determining the best route. Paths are arranged by their likelihood of reaching the Sink, and traffic flow is regulated by a load balancing method. Because each sensor must keep track of neighboring node information, the storage requirements for each sensor are increased as a result of this design decision.

In [28] introduced a new routing protocol that combines a fuzzy approach with the A-star algorithm in order to extend the lifespan of WSNs while also balancing their energy usage. Because each node sends its criteria to the sink in each cycle, there will be more packet congestion, which will lead to higher energy usage and dropped packets as a result of their proposed strategy. Using the minimum energy level of each node, the A* method was employed in [29] to find the optimal route from the source to sink. Routing will not take place if a node's energy level falls below a predefined threshold. Router loops were avoided and a shorter route was selected via RIDSR, a routing system proposed by the authors in [30]. The abbreviation RIDSR stands for relative identification and sensor routing direction-based. In addition, this group proposed an improved method for identifying sensor nodes that combined a triangle rule with energy-saving sensor node determination (ERIDSR) [31].

The Self-organizing Hybrid Network Protocol for Wireless Sensor Networks relies on multiple hop routing and hierarchical cluster architecture. The hybrid protocol employs multi-hop routing instead of direct transmission for inter-cluster communication between cluster heads and the base station in order to reduce transmission energy consumption and equally distribute network load [32]. Using LEACH's Carrier-Sense Multiple Access (CSMA) MAC protocol during the initial setup phase can minimize convergence, and monitoring nodes in a network using GPS technology can offer multi-hop routing between cluster leaders. Randomly rotating local base stations (CHs) ensures that sensor energy consumption is dispersed appropriately [33].

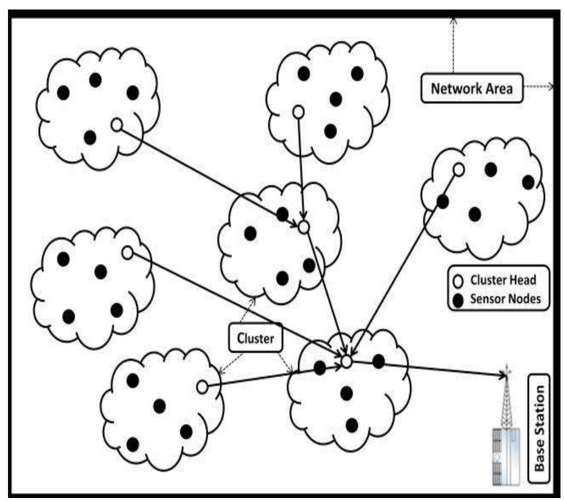

*Figure 3. The Hybrid Multi-Hop LEACH Architecture*

Short message communication is used to manage all nodes in specific clusters during the initial setup phase, with one node chosen as the cluster head based on the procedure for selecting the cluster head nodes. Nodes in the network are assigned random integers between 0 and 1 to decide whether or not they will be cluster heads during the initial configuration. Node takes over as cluster leader if number falls below threshold

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for current round. A basic routing method should be employed to keep the protocol from becoming too complicated because energy is so scarce in remote sensor nodes for environmental monitoring. When it comes to multi-hop routing, the MTE algorithm is the simplest answer, hence it is used as such in this example. Reducing transmission energy depletion improves overall network longevity, but it also increases the amount of time it takes for data to travel across networks, increasing latency and end-to-end delay.

## 3. NETWORK MODEL

There are N sensors in the squared environment with an area of m x m scattered at random. The communication channel is considered bidirectional because the monitoring range is the same as the communication range. The BS has a complete inventory of the network's sensors, including their locations, energies, and unique identifiers. Nodes are aware of other nodes in their immediate area of communication (referred to as "neighbors").

Multiple layers with a defined radius are created, and a BS is placed in each one. The network's nodes are evenly distributed across its layers. The network has been classified as homogeneous. FIGURE 4 depicts an illustration of a network's topology and node distribution. Figure 4 depicts 100 randomly distributed nodes in a 50x50 square unit that are evenly scattered. For each tier of the network, there are six levels. As with the nodes shown by the +, •, ◇, and * the nodes shown by the symbol, and the nodes shown by the symbol * can be found in the following 2,3,4,5, and 6 layers respectively.

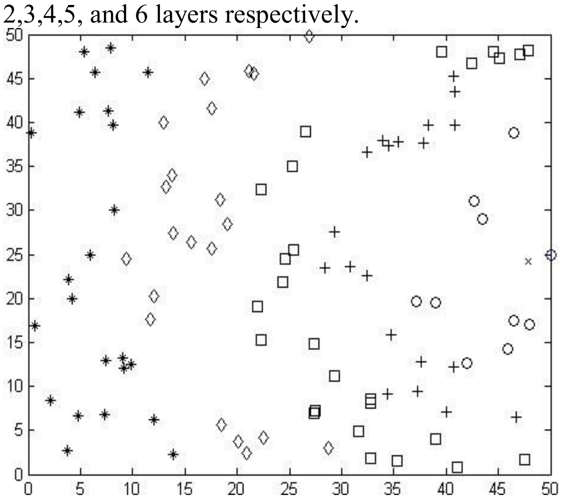


*Figure 4. Distributed Node Layer And Random Node Sample From A Computer Network*

### 3.1. Communication Among Clusters And Within Clusters

The end-to-end data transmission process is divided into several rounds using the multi-hop MDC based clustering routing technology.

Phases of the cluster head selection process: Carrier Sense Multiple Access (CSMA) protocol is used to build clusters, allowing all nodes to be autonomous, self-organized and sorted into groups at the moment of cluster formation. This means that every node in the network must make a judgement on being the cluster head with a probability of Pi. The LEACH algorithm is used to determine the Pi node, as explained in the preceding section. During the initial setup phase, each node utilizes this formula to determine the likelihood that Pi will be positive. The network will contain N clusters and the entire number of nodes will be partitioned into k clusters if k cluster heads are anticipated for every round. On average, a cluster head is selected once per N/k rounds. Nodes' percentage of being cluster leaders, current round, and a set of nodes that haven't been cluster leaders in the past are all factors. Current round cluster heads are ineligible for the next round of voting. When CSMA is used, all network cluster heads broadcast brief messages that include information such as the location of the cluster head node, the message type, and the cluster head node's position. Using signal strength, each member node determines which of the cluster heads' announcement messages is the nearest, and picks the one that is the shortest distance away.

Nodes communicate with each other in accordance with an established TDMA schedule specified by the cluster head, which each node adheres to. Stable Phase: Using Mobile Data Collectors To save energy and minimize data collisions, radio equipment can be turned off when it is not in use as a consequence of this scheduling. When a member of a cluster is chosen as a cluster head, it picks a unique spreading code and advises the rest of the cluster to use it, reducing inter-cluster interference. Even though CDMA codes aren't the most bandwidth-efficient solution, they can help with multiple-access issues. Because the multiple access method in cluster-based WSNs does not partition the channel into discrete time intervals, each CH can concurrently broadcast the aggregated data with his unique pseudo code. You can't use traditional modulation methods. All cluster heads

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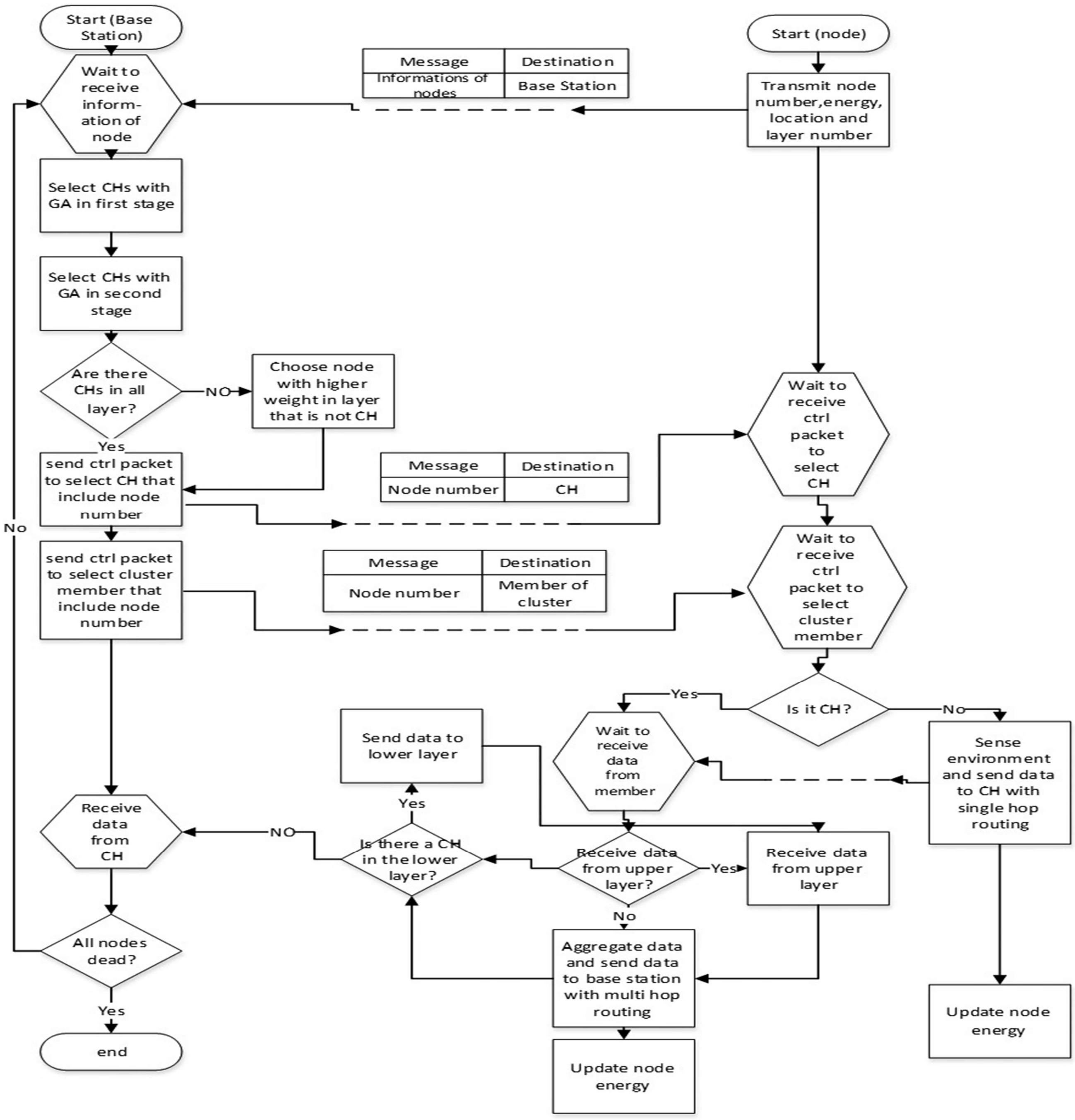


*Figure 5. Flowchart Of The Proposed Protocol.*

get a beacon message from the Mobile Data Collector (mobile agent) informing them of their current position, which the base station may use to perform a data fusion process. In order to determine how near it can go to the base station in terms of transmission energy, sensor node A utilizes the squared distance function S (M), which is in turn based on an inverse square law.

## 4. ENERGY DISSIPATION MODEL

Here, we apply the energy dissipation model presented in [3] to calculate a single node's total energy consumption, including the energy lost in the transmission and reception processes. Eqs. 2 and 3 demonstrate how the transmitter and

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receiver, respectively, lose energy.

$$E_{Tx}(l,d) = lE_{elec} + le_{amp}d^n \quad (2)$$

$$E_{Rx}(l,d) = lE_{elec} \quad (3)$$

were

$E_{elec}$ is the energy required to operate an electronic circuit?

To transmit a single bit, the radio amplifier of the sending node requires $e_{amp}$ of power,

*l* denotes the size in bytes of the data packet being sent or received,

*d* denotes the distance between the transmitter and receiver,

n is proportional to the distance between the transmitter and receiver.

$$\{E_t = lE_{elec} + l\varepsilon_{amp} + lE_{DA} \quad if\ d > d_0\ E_t = lE_{elec} + l\varepsilon_{fs}d^2 + lE_{DA} \quad if\ d \le d_0 \quad (4)$$

Were,

The energy model found in Eq. (4) may be applied to a single sensor node.

## 5. RESULTS AND DISCUSSION

The characteristics of the MDC-based cluster routing protocol are based on wireless sensor networks (WSNs), which are often used outdoors. According to Table 1, shows the most essential simulation parameters.

*Table 1. Simulation Parameters Setup*

| PARAMETERS | VALUES |
|---|---|
| The total number of nodes in a network | Forty (40) |
| Simulated Environment | 1000 * 1000 (m) |
| Deployment of Sensor Nodes | Random Deployment |
| Sender and Receiver Electroics (ETX-elec) (ERX-elec) | 50 nj/bit |
| Amplifier for transmitting signals (Eamp) | 100 pj/bit/m$^2$ |
| Packet size | 288 bits/packet or 36 Bytes |
| MDC Beacon Message Rate | 5 sec/message |
| Number of MDC's | 2 |

Computer simulations have been used to measure the following performance metrics. In both mobile and stationary WSNs, battery power is at a minimum and hence energy consumption is important. In order to calculate a sensor node's power usage, you add up all of the different ways it uses energy, including the ones mentioned above as well as the idling and sleeping modes. This study's main focus has been on reducing the use of energy during transmission and reception. To put it another way: Sensor nodes' energy consumption directly affects network performance or lifespan; more energy consumption indicates a shorter network life span, whereas a smaller quantity of energy dissipation means an increased network life span.

### 5.1. *Network Lifetime and Sensor Node Power Consumption*

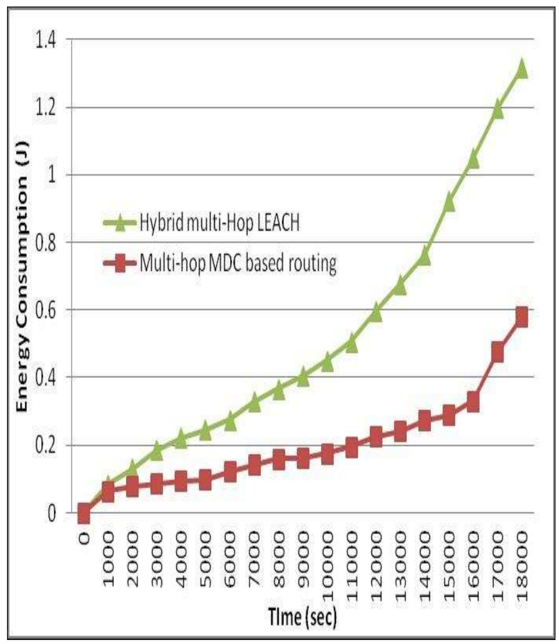


*Figure 6. Node 11 Power Consumption*

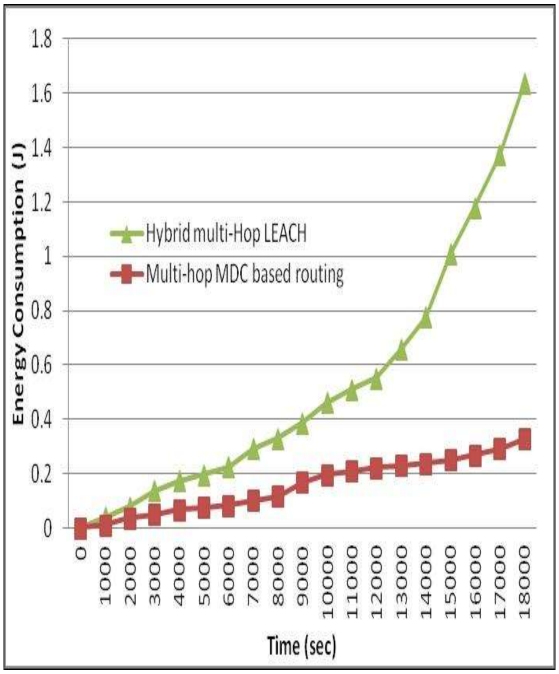


Figure 7. Node 17 Energy Consumption

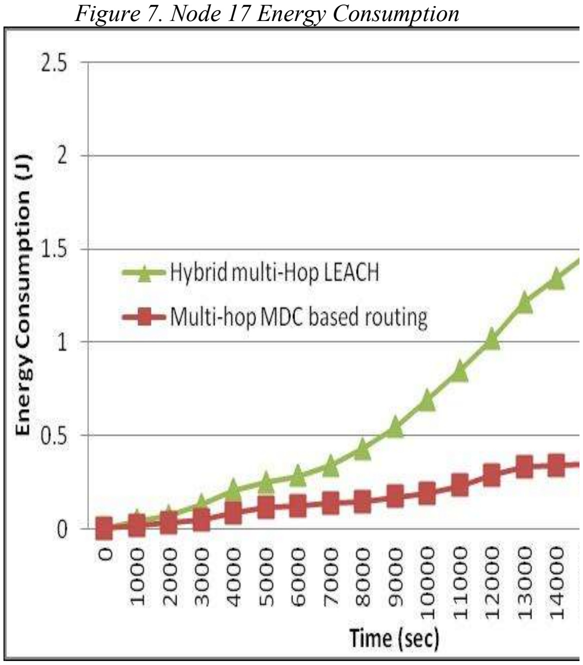


Figure 8. Node 36 Energy Consumption

Using a hybrid multi-hop LEACH/MDC clustering routing strategy, the energy consumption of sensor nodes 11, 17, and 36 is shown in Figures 6, 7, and 8. Randomly placed across the network, these sensor nodes used the MDC (mobile agent) to communicate with the base station. As seen in these graphs, the energy consumption of the sensor nodes has a substantial impact on the network's performance or lifespan.

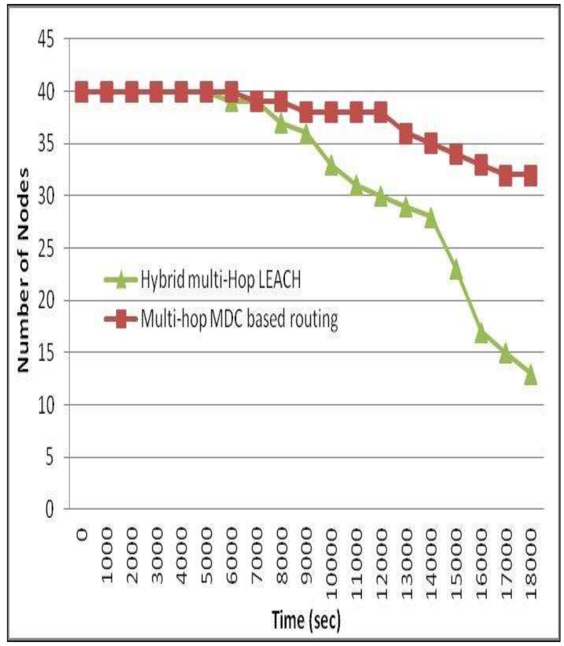


Figure 9. Network Lifetime

Simulated network lifetimes are shown in Figure 9 (below). As a result, the MDC clustering routing protocol has a longer life on the network than the hybrid multi-hop LEACH system. It takes time for a packet to reach at its final destination after it has been broadcast. The coding technique, channel capacity, and packet length all have a role in determining the amount of delay.

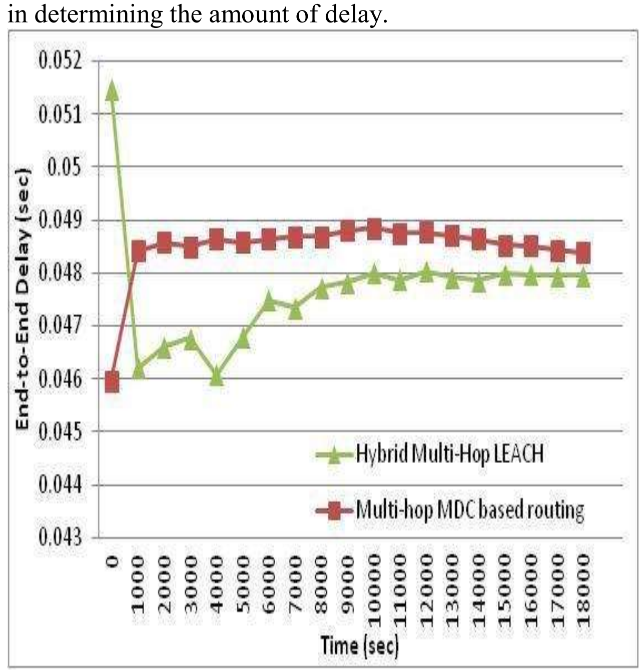


Figure 10. End-To-End Transmission Delay.

## 6. CONCLUSION AND FUTURE SCOPE

The objective of this research is to compare several multi-hop cluster routing strategies in detail. On the other, it was shown that hybrid multi-hop LEACH routing consumes more energy and has a shorter lifespan than MDC-based cluster routing. In future work, the authors aim to adopt a multi-channel approach to assign channels to the network lifetime using energy efficient routing protocol approach for wireless IoT sensor network applications.

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