NVEO
Natural Volatiles &
Essential Oils

GATEWAY BASED ROUTING(GBR): ENERGY EFFICIENT ROUTING PROTOCOL FOR WIRELESS SENSOR NETWORK

Debnath Bhattacharyya[1], Venkata Naresh Mandhala[2], Hye-jin Kim[3]

[1]*Department of Computer Science and Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, Andhra Pradesh.*

[2]*Department of Computer Science and Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, Andhra Pradesh.*

[3]*kookmin University, 77 Jeongneung-Ro, Seongbuk-Gu, Seoul, 02707, Korea*

*Corresponding author. Email: hyejinaa@daum.net

Abstract

A major method in the development of energy-efficient routing strategies for wireless sensor networks has proved to be one of the most important ways when it comes to wireless sensor networks. A Wireless Sensor Network has limited hardware resources owing to the nature of the network, which means that sensor nodes have limited capabilities. Cluster routing protocols' heterogeneity has been proven to be effective when it comes to topology control, energy consumption, information collection or fusion, dependability and stability in a distributed sensor network, and other aspects of distributed sensor networks. This is a feature of the routing technology that we use today. An energy-efficient heterogeneous clustering technique is proposed in this paper, which is based on distributed energy-efficient clustering and employs threshold criteria to choose cluster heads for use in real-world applications. Assume that the base station is situated beyond the network's coverage area for this task to be completed correctly. Depending on how near the sensors are to reaching the threshold level, they are altered and divided into six-bit values. Notably, sensor nodes below the threshold are closely connected to the door node, while those above the threshold are comparable to those suggested in LEACH. According to the existing knowledge about the methods, the findings in terms of lifespan, throughput, and residual energy are consistent.

Keywords: Wireless Sensor Networks, Energy Efficient Routing, LEACH Protocol, Network Lifetime

1. INTRODUCTION

The Wireless Sensor Network has emerged as a major study topic because of the potentially vast range of applications it may serve. Thousands of smaller nodes, [1] each with its own set of capabilities, come together to form the World Wide Web, which may be used to carry out a wide variety of tasks such as emergency response, fire detection, vehicle tracking, and habitat monitoring. It is determined if any viable communication path to the destination or sinks can be found by hopping data from node to node for the meshed network connection. Sensors, data processing, and transmission components are all included in this tiny sensor node configuration. The primary features of these sensor nodes are that they are infrastructure-free and that they have self-ordering capabilities. The sensor nodes carry out their duties while being randomly distributed and unmanaged. The ability of sensor nodes to communicate with one another is another important characteristic of the sensor network. Sensor nodes have processors that are ready to go. Instead of transmitting raw data sensor nodes, the calculation method is used to send information that [2] has been partially processed. In most cases, the WSN operates unattended after being installed in the network area for each sensor node while using the least amount of power. As a result of the spent energy, the sensor nodes begin to lose their energy, and the sensor node closest to death terminates

all WSN operations. As a result, one of the most significant drawbacks of the sensor network architecture is the inability to sustain the strength of the knots.

Due to the extreme restricted power supply available in the sensor nodes, the power consumption of the source of energy is an essential topic in wireless sensor networks (WSNs). To maximize energy efficiency, information must be transferred between sensor nodes and other nodes. To develop routing algorithms that will allow the sensor network to operate for an [3] extended period, several studies have been conducted. Compared to other types of wireless networks, Wireless Sensor Networks have certain unique characteristics, which affect the overall performance of the system. In wireless sensor networks, methods and protocols that perform tasks such as node density are unique to them.

The task of connecting sensor networks together is very challenging since they differ from conventional ad hoc networks and wireless networks in several important ways. The networks are very difficult to traverse. For a variety of reasons, the development of a global management system for the deployment of pure sensor node numbers is not possible. Among them are the following: It is thus impossible to utilize current IP protocols for sensor network implementations because of this limitation. To begin, in contrast to conventional communication networks, almost all sensor network designs allow for the transmission of sensed data from many locations to a single destination, which contrasts with regular communication networks. In addition, data traffic is highly redundant since many sensors may produce the same data, almost as if it were an anomaly, resulting in extraordinarily high amounts of redundant data traffic. Because of this redundancy, routing methods may optimize the amount of energy and bandwidth they use. To mention a few reasons, sensing devices, which need accurate [4] energy management, are highly constrained in terms of transmission power, onboard power, bandwidth processing, and storage capacity. However, numerous new data routing techniques for sensor networks have been created in recent years, despite these differences. As well as the features of sensor nodes, as well as software and architectural requirements, the routing methods used have taken these into account.

Even though the flow of a network and the quality of service are reliant on just a few different protocols, most routing protocols may be classified as either data center or hierarchical protocols (for example, asymmetric routing). Specifically, the goal of this research is to determine the effect of heterogeneity on node potential. In comparison to other kinds [5] of sensor networks, since it includes a varied population of nodes with differing resource capabilities, this form of sensor network is regarded to have more resources than the others. To assist procedures where understanding the consequences of these heterogeneities would be very helpful, this study was initiated to assist such processes. Due to the powering of the nodes that are not in use, there is a disparity in energy consumption between the nodes that are in use.

2. LITERATURE REVIEW

There is much study in the literature on energy efficient WSN protocol clustering. Routing algorithm for homogeneous WSNs with LEACH clustering adaptation, with sensor nodes randomly calculated to be CHs and the unit power load shared with the WSN.

Low-energy, Internet-based gateway was proposed byV. Bhoopathy et. al [4],author had suggested a multi-hop routing approach that uses energy-efficient methods for wireless sensor networks (WSNs). This time, the base station is placed outside the sensing field, whereas several gateway nodes are located near the border of the sensing field. The running expenses are much lowered since these gateway nodes are rechargeable. Additionally, it assists in lowering traffic congestion and increasing the distance between nodes needed for reliable data transfer.Simulations show that there suggested gateway-based protocol is more less reliable and durable than traditional protocols such as SEP.

Vaibhav Pandey et.al proposed a [5] Sensor nodes in a WSN are capable of monitoring and detecting physical and environmental factors in real time. Sustainable farming, cost management, and innovative research were all accomplished via the usage of these networks by the agricultural sector. As a result, power shortages in sensor-based agricultural areas have resulted in bottlenecks and transmission problems. These sensors, which are located closer to the base station relay, often interfere with, or cause the base station to go down. The results suggest a routing method that puts the cluster head in the center of the cluster, where it is most essential to the cluster. Using relaying, the head node of the cluster relieves the gateway node of data. The suggested protocol was compared against existing protocols in a simulation. When tested in the experiment, the suggested approach exceeded expectations, resulting in improved practicality for monitoring temperature, moisture, and lighting in agriculture using wireless sensor networks (WSNs).

Dynamic node clustering was proposed by Nandini. S. Patil et.al [6] may be very effective in solving routing issues in multi-hop mobile ad hoc networks. Data is sent between clusters via cluster gateways and a cluster-based protocol. Routing tables must include information about gateways to ensure that inter-cluster routing remains consistent even when nodes shift. This article presents a cluster dense gateway-based distributed routing method for interclasses communication (DCG). A DCG is a network of linked portals that link two clusters together. An ad hoc network requires at least as many gateways as the features of the network indicate. We needed to guarantee stable inter-cluster connection at the DCG because of the high number of gateways. The K-Tree Core of our protocol outperforms a previous approach based on a cluster of linked rings for clustered routing. It allows many cluster gates to process route data without raising the storage needs for dense cluster gateways. A heuristic is used to reduce the computational burden on cluster heads. Nodes that share workloads with cluster heads are referred to as subcluster heads. On the ns-2 simulator, the protocol has been implemented. The experiment's results have been analyzed and compiled.

Gateway method in WSN was proposed by Kiran Maraiya et al [7] Wireless sensor networks are made up of cheap rechargeable sensor nodes. WSN is often transmitted in hazardous environments, and data must be gathered dynamically many times before saving. Weakly coupled networks (WSNs) need scientists and engineers to create energy-efficient architectures and calculations. The use of load balancing to balance network traffic across clusters ensures the long-term operation of wireless network sensor systems. This study used a gateway method. The nodes are divided into three groups based on their vitality organization: basic, medium, and advanced. The number of active nodes, network resilience, and average energy consumption are all accurate. This research also analyses graphical elements.

M-GEAR is a proposed bySung-Hwa Hong et.al[8]for an energy-efficient routing system for Wireless Sensor Networks based on gateways (WSNs). By determining the field's location, we were able to divide the sensor nodes into four logical regions. A base station (BS) was placed outside the sensing area, and a gateway node was placed within. When the distance between a sensor node and the BS or gateway is less than a predetermined threshold, direct communication is utilized. The threshold distance divides the remaining nodes into two equal parts. Cluster heads (CHs) are chosen for their ability to function independently of one another. These CHs are selected at random from a pool of candidates. The efficacy of our method in the presence of LEACH (Low Energy Adaptive Clustering Hierarchy). In terms of energy consumption and network lifetime, our proposed protocol outperforms the competition.

LEACH, M-GEAR, and the Gateway-Based Stable Election Protocol was proposed by the A. Manjeshwar et.al [9] Energy conservation is important for wireless sensor network longevity (WSNs). Our research focused on energy balancing and avoiding energy gaps. This article shows how to use multi-gateway technology to decrease the distance between the transmitting machine and the sink node. Gateway nodes are strategically positioned across the controlled area. Sensors in sinking zones provide data straight to the

sink, whereas sensors in gateway areas send data directly to the gateway. A cluster head's distance from a sink is smaller than the distance between a sink and a cluster head's distance. The suggested protocol was compared to LEACH, M-GEAR, and the Gateway-Based Stable Election Protocol. Evaluated procedure (GSEP). In terms of performance, the protocol outperforms other protocols.

Low-energy gateway-based multichip routing method was proposed by the D. P. Agarwal et.al[10] for wireless sensor networks is shown here (WSNs). The base station is outside the sensing field, which is surrounded by gateway nodes. These rechargeable gateway nodes are less costly. It also reduces traffic and distance, allowing for more dependable data transmission. It seems that our suggested gateway is feasible.

An efficient multi-hop routing system for WSNs based on gateways ElbhiriBrahim et.al proposed a [11] This article covers M-Gearand LEACH (a low-cost multi-hop routing system for WSNs) (Low-Energy Adaptive Clustering Hierarchy Protocol). While maintaining a high level of output and a wide number of nodes, both protocols are designed to use the least amount of energy feasible. Both methods are simulated in MATLAB, and the results of the simulations are shown. Using the M-Gear Protocol, we were able to further split the network into four communication components. In accordance with the distance between the base station and gateway, the network is divided into zones.

Rachid,Alba-Pages Zamora et.al proposed a [12] WSNs helped monitor people's surroundings in inaccessible regions. Sensor nodes can only detect and transmit data with limited energy. Energy consumption should be optimized to maximize network life and throughput. Several of the WSN's routing methods are energy efficient. Clustering saves energy.

Routing protocols aim to increase network length and speed. LEACH protocols may be tweaked to extend network life and speed. This study examined the network endurance and performance of two WSN protocols, M-GEAR and MODLEACH.

Inbo Sim et.al proposed a [13] cold and dry regions where numerous problems hinder data collection. This limits geoscience study in this area. Exploring the optimum routing strategy for observation tool networks in cold and dry environments is important. We studied and refined the LEACH protocol-based field observation equipment network routing method (FOI-LEACH). First proposed to enhance the LEACH technique [14][15] in three ways: A variety of field observation instrument networking nodes are available with extended M-GEAR.

4. METHODOLOGY

It is common practice to employ a first-order radio model in wireless sensor networks research, and this is true for wireless sensor networks in general. Short-range communication wastes energy, which leads to increased energy consumption. Short-range communication wastes energy [17]. In contrast, long-range communication consumes less energy due to multipath fading, which is a feature of long-range communication. Because it is reliant on route measurements and sensing to give data on a continuous basis, it is also reliant on the sink to supply data on a continuous basis. It is reasonable to suppose that the following assumptions are made during an analytical implementation:

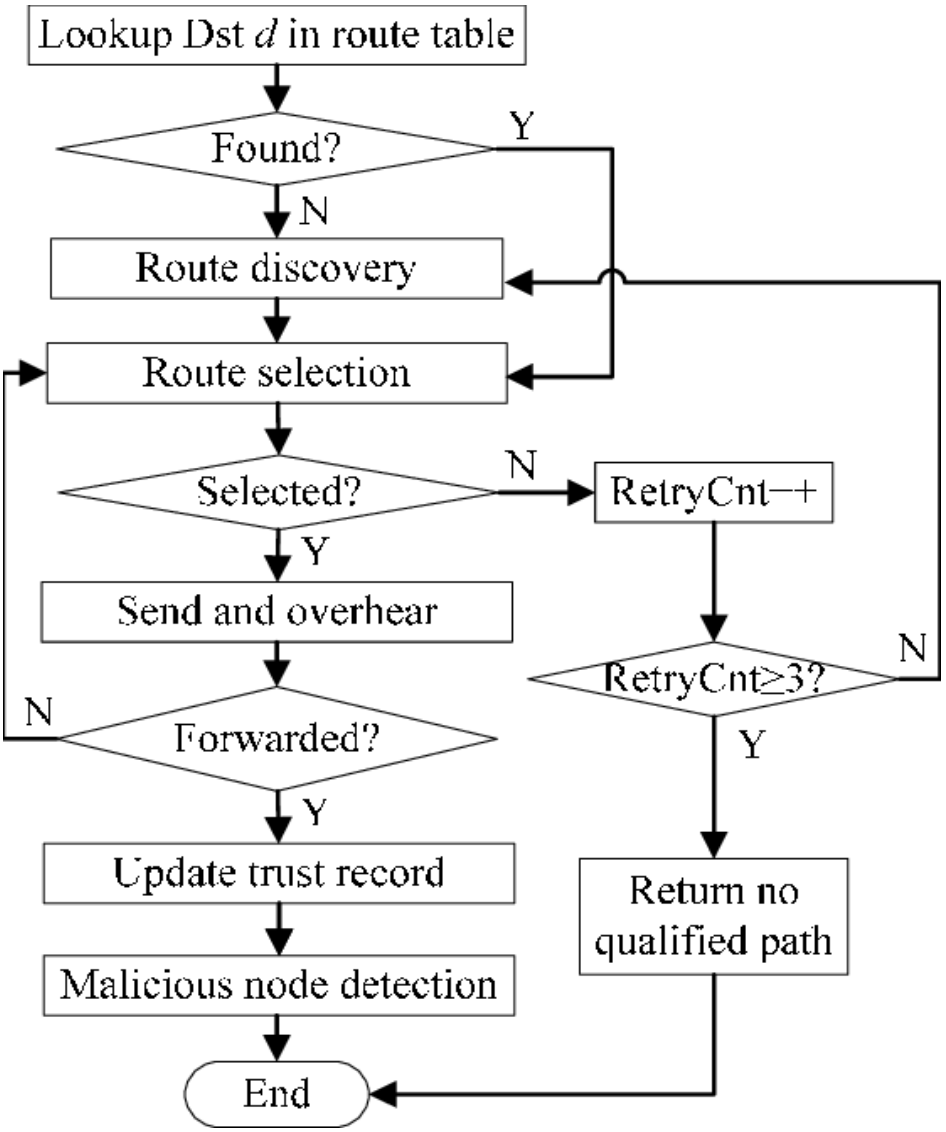

Figure 1. Showing the Flow Chart of Proposed Methodology

In the network region, wireless sensors are densely packed and are static, which allows the base station to stay in one location. Networks are pre-configured with a certain number of clusters according to the network's configuration. The data will be sent between the nodes via the specified routes, which are divided into clusters and cluster heads [18] that are numbered according to the distance between them depending on the received signal strength.Because certain sensors are situated farther distant from the base station, the cluster head will use more ‘d4' energy to send l bit data for direct transmission than is necessary. As a result, data is sent via several hops before arriving at the base station through clusters located extremely close to the base station.The links in the route are symmetric, which means that the same amount of power is needed for communication between any two nodes on the path. There are no modifications to the topologies or loads that are taken into consideration.As a result, the transmitter energy required to broadcast a message of length l to a distance d is given as:

d0 = sqrt (Emp/Efs) (1)

if d<d0,

Etx(k,d)=Eelec*k+Emp*k*d4 (2)

if d=0

Etx(k,d)=Eelec*k+Emp*k*d4 (3)

Receiver Energy:

Erx(k)=Eelec*k (4)

Among other things, the amount of amplifier energy available, the amount of energy wasted during transmission and reception are all taken into consideration while designing a wireless network.

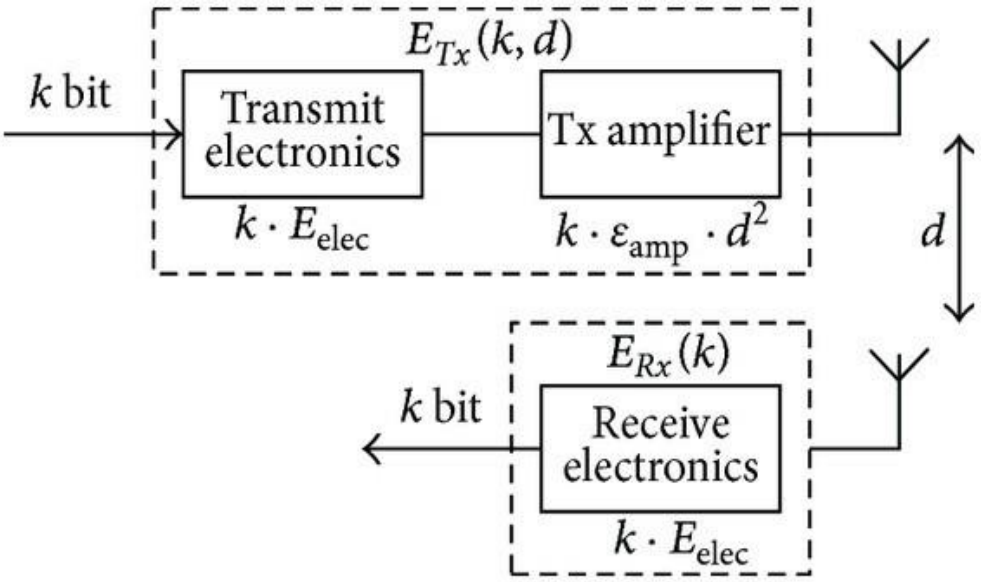

Figure 2:First Order Radio Model

The first order radio model [16] may be visually expressed in the image above, as illustrated in Figure 1. Because the transmitter and receiver utilize the same electrical circuitry, their energy are gathered as Eelec with each data bit transmitted. Consequently, the sensor nodes are perfectly symmetrical.

4. RESULTS & DISCUSSIONS

To evaluate the performance of the proposed protocol, it has been built and simulated in MATLAB. A wireless sensor network with 100 nodes that are randomly distributed over a 200m x 200m region. It is necessary to place a gateway node in the center of the sensing field. The BS is located at a considerable distance from the sensing field. Both the gateway node and the BS become immobile once they have been deployed. The parameters for the simulation are listed in Table 1 below. We used MATLAB to simulate the performance of our proposed method to determine its effectiveness, and we found it to be very effective. Think about a wireless sensor network consisting of 100 nodes that are randomly distributed across a 100m x 100m region. It is necessary to locate a gateway node in the center of the sensing field. The base station is located a long distance distant from the sensing field. Following deployment, both the gateway node and the BS remain in a stationary state. We will be using a packet size of 4000-bits. The LEACH methodology is being used to compare our approach. In our evaluation of the performance of our protocol using LEACH, we do not consider the effects of signal collision and interference in the wireless communication channel. The radio parameters are included in Table 1 for your convenience.

Table1: Simulation Parameters

Parameter	Value
Numberofsensornodes	200
Networksize(m^2)	200*200
Noofround	5000
Basestationlocation	(50,50)
Efs(pJ/bit)	10*10^(-12)
Eamp(pJ/bit)	0.0013*10^(-12)
ETX(nJ/bit)	50*10^(-9)
ERX(nJ/bit)	50*10^(-9)

4.1 THROUGHPUT

It is possible to estimate the average number of packets delivered to BS by running many simulations on the system. The results of the simulations for the M-GEAR protocol indicate that throughput has increased. The M-GEAR and LEACH interval graphs shown in Figure 2 clearly demonstrate the effectiveness of both methods in terms of performance. We make the assumption that CHs can readily communicate with the gateway node in order to calculate throughput. Comparing simulation findings to LEACH, it is shown that there is a fivefold increase in throughput. Sensor nodes situated near the gateway send data directly to the gateway, while sensor nodes located near the base station transmit data directly to the base station. Sensor nodes placed near the gateway transmit data directly to the gateway. Sensor nodes in both regions use less transmission energy than sensor nodes in the other, enabling them to operate for extended periods of time in each area. Increased packet delivery to BS is made possible by the presence of additional active nodes.

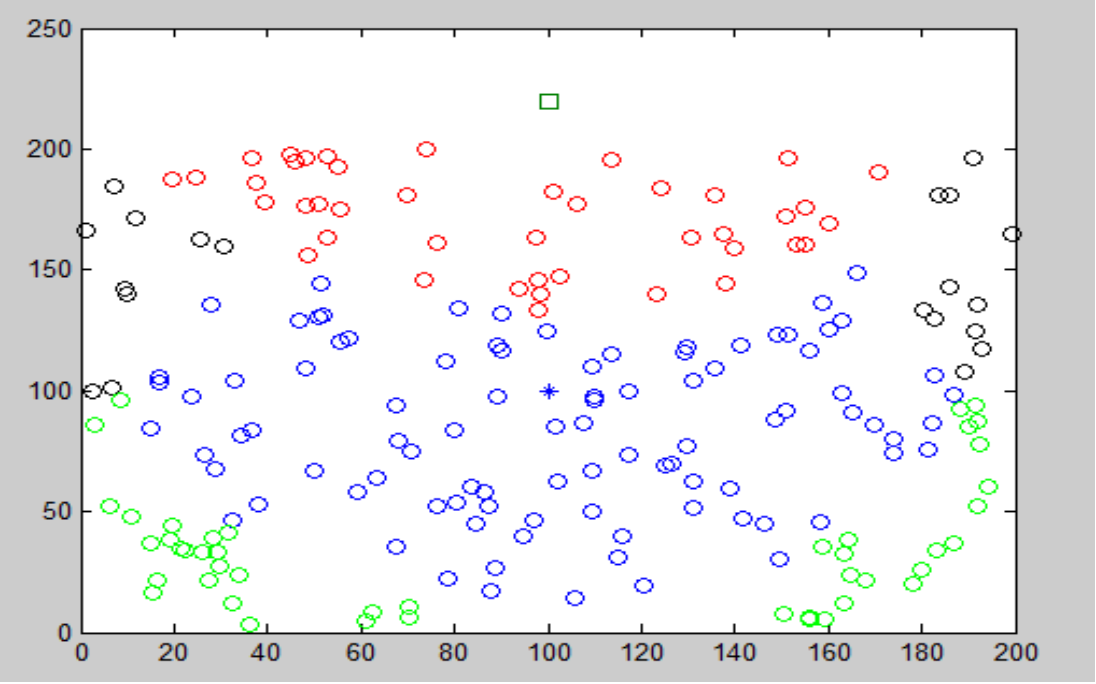

Figure 3: Node Deployment

The above figure 2 shows the different node types based on their location from the base station and gateway node. A total of six different types of clusters [16] can be seen in the figure 3, indicating six regions of node communication with gateway and the base station.In network cycles, this is the amount of energy needed to complete the cycle. The figure is shown in Figure 5. The node energy is often referred to as a half-joule of energy. In table 2 ,It takes 50 joules of energy to keep a network of 100 nodes running while it is up and running. When compared to LEACH, M-GEAR is a more energy-efficient method. This figure shows how

much more efficient our LEACH routing method is compared to other routing techniques. Because of the central gateway node and the potential of CHs in all regions, energy consumption savings are very certain to take place.

Table 2: Network Parameters of the Gateway Based Protocol

S.No	Network Parameters	Value
1	Amplification Energy	10
2	Amplification Energy Intra Cluster Comm.	0.5JS
3	Cluster to BS	400 Bits
4	MODLEACH (Cluster to BS) for d1>d2	5NJ
5	M-Gear	10PJ
6	Nodes	0.014
7	Packet Size	EAJ*100
8	First Energy State	0.6J
9	Size of the Network	200*200

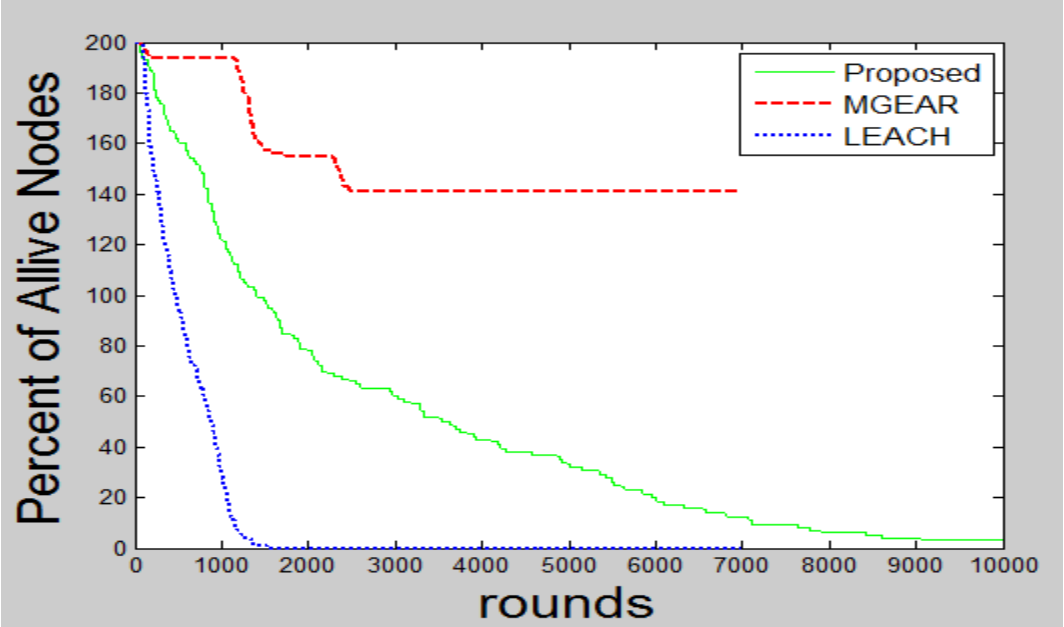

Figure 4: Alive Nodes vs Rounds

The number of alive nodes after each round has been plotted in figure 3. The comparison shows the proposed method compared with LEACH and M-GEAR protocols. The number of nodes alive is better than both LEACH and M-GEAR in simulation until 10000 rounds. The dead nodes vs rounds graph has been shown in figure 4.

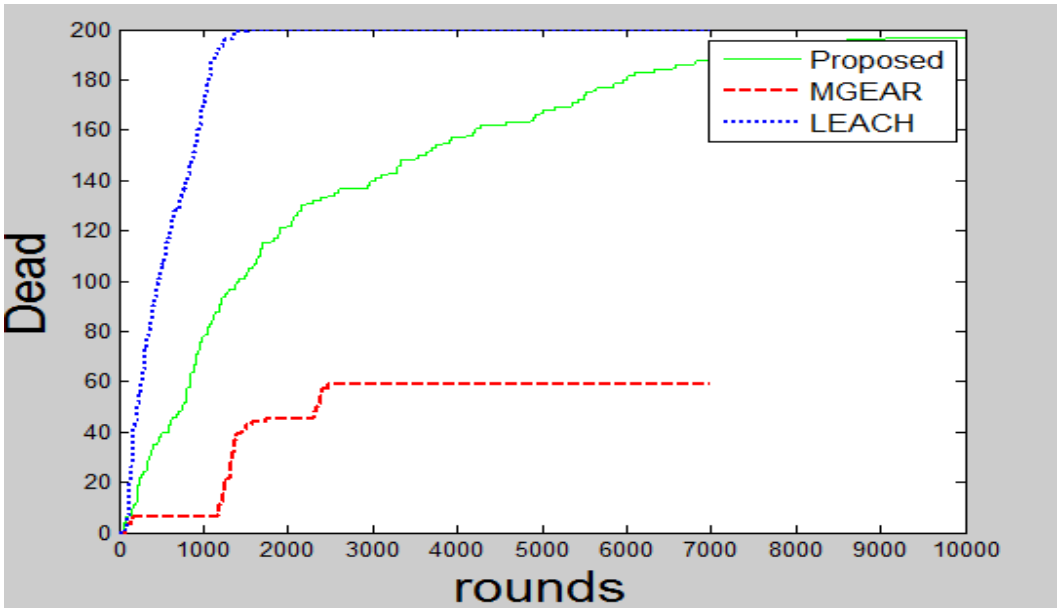

Figure 5: Dead Nodes vs Rounds

Nodes in figure 5 do not have the hierarchical routing that is seen in traditional wireless sensor networks. This has the potential to cause dispersion and the death of certain nodes. This article proposes a hierarchical clustering-routing protocol based on G-means, which is favored by cluster leaders and is described in detail below. It finds structural clusters using G-means and guarantees that they are all Gaussian in nature. Also shown here is the possibility for each class to choose the optimal cluster head node across all clusters. It was discovered that node kill rates for GHPHC-enabled wireless sensor networks were slower and took longer to achieve than node kill rates for conventional routing networks during testing.

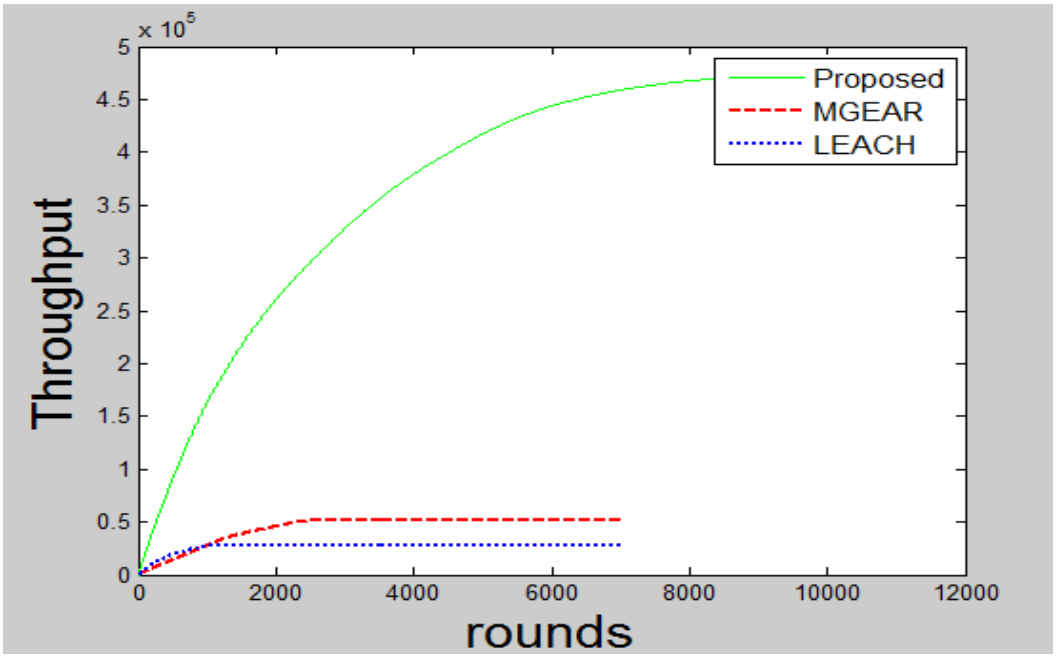

Figure 6: Throughput vs rounds

Figure 6 shows the throughput i.e., number of packets forwarded to the base station form the nodes. The proposed protocol shows better results as compared to other protocols. The methods used in this study were both traditional and contemporary WSN routing approaches. Protocols were divided into three groups based on their communication model, network structure, and reliability in routing. Many of the therapies listed

above have undergone extensive study to determine their advantages and downsides. All protocols try to save energy by making the most of the available network resources.

4.2NETWORK STABABILITY

Network organisational structures and goals, on the other hand, were radically different.It is possible to classify inquiries, consistency and inconsistency, and negotiation processes into several categories. Network nodes communicate with one another and with other network nodes by exchanging data. It is permissible to have dynamic network topologies and a variety of route responses. The fact that data is sent only in response to queries rather than on a continuous basis makes query-based protocols impractical for applications that need continuous data flow, such as those involving environmental monitoring. These protocols are usually used to preprocess data gathered by nodes before it is sent to aggregators, also known as distributers, for further processing.

Negotiational protocols reduce the amount of data that is sent to the destination. Coherent protocols are appropriate for systems that need minimum end-to-end latency and scalability, while incoherent protocols are appropriate for systems that require high throughput and scalability. Point-to-point and satellite communications are both energy-efficient modes of communication. The transmission of data, on the other hand, is not assured. Thus, protocols like as intrusion detection, which need continuous data packets to function, are unable to be implemented. They are unable to be implemented because certain nodes may refuse to receive new data in order to ensure that critical data reaches its destination.Both flat network designs and hierarchical network architectures are energy efficient. In short, whether or not a network node employs flat protocols, all network nodes are treated identically. Their performance is better in small networks, but they suffer in big ones. As a result, they can only identify equipment failure in this situation. As a result, nodes in hierarchical protocol networks are handled differently from nodes in other networks. Data aggregation lowers the cost of data gathering while increasing scalability. Hierarchical protocols are excellent for WSNs with high workloads and a large number of geographically scattered nodes, which are often found in urban areas.When it comes to energy-efficient routing, topology is utilised to gather route data. After that, moveable sites depending on sinks or agents were classified.
Data routing is accomplished by each network node knowing the location of its neighbours as well as the location of the destination node. In this instance, the routes that are the most energy efficient are chosen. For example, it might be used to locate a parking spot in a parking lot. Essentially, a mobile agent is a processing function that travels between network nodes in order to gather information. Several moving platforms are carefully placed across the network to collect data from the network's scattered nodes. Such a technique, which is similar to military activities such as battlefield monitoring, may be beneficial.

Routing methods that check for Quality of Service (QoS) measures and those that span several routes are among the most energy-efficient available. Furthermore, protocols that make use of Quality of Service assessments include not just power usage but also latency and data quality. These protocols are often used in activities that need the transfer of multimedia data. A multi-path routing system directs nodes from a source to a sink via a number of routes in order to avoid route failures and decrease end-to-end latency between the two. The major shortcoming of these methods is their high communication and processing requirements.

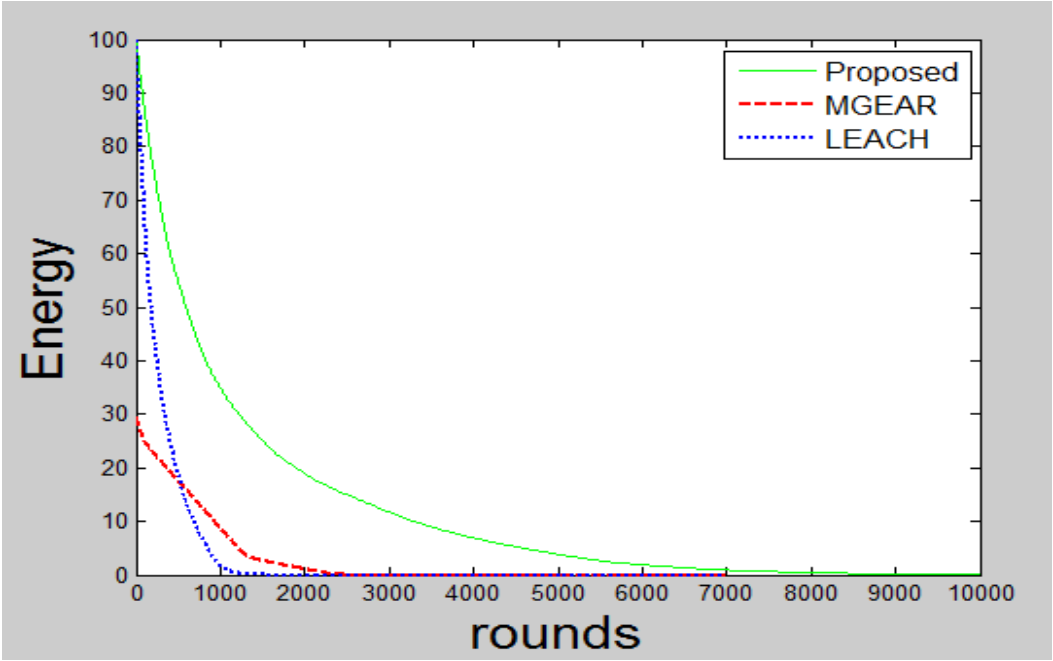

Figure 7: Residual Energy vs rounds

The residual energy graph giving a comparison between the proposed protocol, LEACH protocol [and the M-GEAR protocol is shown in the figure 7. As shown in the graph the energy of the networks is increased in the proposed protocol and hence the networklifetime.

4. CONCLUSION

The development of a low-energy multi-hop routing technique was necessary to reduce the energy consumption of network sensors. Throughout the course of our investigation, we divided the network into logical sub-parts. Each industry has its own set of communication protocols and systems. One topology is used for one part of the network, while another is a mix-and-multichip hierarchy for the other area. There is no prejudice in selecting a CH, as all nodes within an area choose the same CH regardless of their proximity to other regions. Using this approach, the number of CHs distributed across the network is more evenly distributed than before. The results of our simulations show that our technique outperforms the LEACH method. There are three performance metrics examined in this paper: lifetime network, residual energy, and overall performance. After ETX link measurements have been implemented and incorporated into our system, we will conduct an analysis of them in the future.

References

[1]G. Vijayalakshmi, S. Hema and S. Geethapriya, “Secure Data Aggregation & Query Processing in Wireless Sensor Networks using Enhanced Leach Protocol”, International Journal of Emerging Science and Engineering, Vol. 2, No. 1, pp. 51-56, 2013.

[2]Meeravali, S., Bhattacharyya, D., Rao, N. T., & Hu, Y.-C. (2021). Performance analysis of an improved forked communication network model. Connection Science, 1–29. doi:10.1080/09540091.2020.1867064

[3]KumarPadmanabh and Sunil Kumar Vuppala, “An Adaptive Data Aggregation Algorithm in Wireless Sensor Network with Bursty Source”, Wireless Sensor Network, Vol. 1, No. 3, pp. 222-232, 2009.

[4]V.Bhoopathy and R. M. S. Parvathi, “Energy Efficient Secure Data Aggregation Protocol for Wireless Sensor Networks”, European Journal of Scientific Research, Vol. 50, No. 1, pp. 48-58, 2011.
[5]Vaibhav Pandey, Amarjeet Kaur and Narottam Chand, “A review on data aggregation techniques in wireless sensor network”, Journal of Electronic and Electrical Engineering, Vol. 1, No. 2, pp. 1-8, 2010.
[6]Nandini. S. Patil and P. R. Patil, “Data Aggregation in Wireless Sensor Network”, IEEE International Conference on Computational Intelligence and Computing Research, 2010.
[7]KiranMaraiya, Kamal Kant and Nitin Gupta, “Wireless Sensor Network: A Review on Data Aggregation”, International Journal of Scientific & Engineering Research, Vol. 2, No. 4, pp. 1-6, 2011.
[8]Sung-Hwa Hong, Jeong-Min Park and Joon-Min Gil, “Performance Evaluation of a Simple Cluster- Based Aggregation and Routing in Wireless Sensor Networks”, International Journal of Distributed Sensor Networks, Vol. 2013, Article ID: 501594, pp. 1-9, 2013.
[9]A.Manjeshwar and D. P. Agarwal, "TEEN: a routing protocol for enhanced efficiency in wireless sensor networks," In 1st International Workshop on Parallel and Distributed Computing Issues in Wireless Networks and Mobile Computing, April 2001
[10]A.Manjeshwar and D. P. Agarwal, "APTEEN: A hybrid protocol for efficient routing and comprehensive information retrieval in wireless sensor networks," Parallel and Distributed Processing Symposium., Proceedings International, IPDPS 2002, pp. 195-202.
[11]U.Sajjanhar, P. Mitra, —Distributive Energy Efficient Adaptive Clustering Protocol for Wireless Sensor Networks‖, Proceedings of the 2007 International Conference on Mobil Data Management, pp. 326- 330, 2007.
[12]ElbhiriBrahim,SaadaneRachid,Alba-Pages Zamora, DrisAboutajdine, —Stochastic Distributed Energy-Efficient Clustering (SDEEC) for heterogeneous wireless sensor networks‖, ICGST-CNIR Journal, Volume 9, Issue 2, December 2009.
[13]Inbo Sim, KoungJin Choi, KoungJin Kwon and Jaiyong Lee,—Energy Efficient Cluster header Selection Algorithm in WIRELESS SENSOR NETWORK‖, International Conference on Complex, Intelligent and Software Intensive Systems , IEEE, 2009.
[14]Ma Chaw Mon Thein, Thandar Thein —An Energy Efficient Cluster-Head Selection for Wireless Sensor Networks‖, International Conference on Intelligent Systems, Modeling and Simulation, IEEE 2009
[15]Dilip Kumar, Trilok C. Aseri, R.B. Patel, —EEHC: Energy efficient heterogeneous clustered scheme for WIRELESS SENSOR NETWORKs‖, ELSEVIER, Computer Communications, 32 (2009) 662–667
[16]Yingchi Mao, Zhen Liu, Lili Zhang, Xiaofang Li, —An Effective Data Gathering Scheme in Heterogeneous Energy WIRELESS SENSOR NETWORKs, International Conference on Computational Science and Engineering,2009.
[17]E.M.Petriu, N.D. Georganas, D.C. Petriu, D. Makrakis, and V.Z. Groza, “Sensor-based information appliances,” IEEE Instrumentation and Measurement Magazine (December 2000) 31–35.
[18]SrinivasRao, K., Thirupathi Rao, N., Nageswara Rao, K., & Srinivasa Rao, P. (2014). Stochastic Control and Analysis of Two-node Tandem Communication Network Model with DBA and Binomial Bulk Arrivals with Phase Type Transmission. International Journal of Computer Applications, 87(10), 33–47. doi:10.5120/15246-3792