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A NOVEL ENERGY-EFFICIENT ROUTING ALGORITHM DESIGN AND SIMULATION

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Abstract:
Wireless sensor networks have a wide range of uses that are unavoidable in modern society. The majority of these wireless sensor network applications will be used in locations where direct human involvement is not possible. Therefore, the little energy that these sensors have poses a risk to the longevity of the entire network. Wireless sensor networks are made up of a sizable number of interconnected sensor nodes that can communicate with one another and share information (and data). The term "sense of the environment" refers to a variety of target regions where sensors are situated. Data will then be transferred to the base station (BS) for analysis after being collected. It may be possible to lower the energy consumption of communications by adopting a routing strategy that is more energy efficient. The energy consumption is significantly high. The problem of effective batteries in sensor nodes is a difficulty for the researchers in ensuring smooth communication among sensor nodes. Frequent battery replacement or recharging in sensor nodes is a crucial operation that is not always possible. In this article proposed two new routing algorithms. Firstly, the NEEP algorithm, which use to initialize the node in the network. Secondly, the Minimum Node Cover algorithm, which use to reduce the power consumption of the network and also increase the battery power of the sensor. Finally, the study focuses on an overview of the various routing protocols that employ multi-hop and multipath approaches to speed up routing and cut down on energy use. The multi-hop and Multipath is suggested, and it is contrasted with the current approach based on the nodes' average energy and longevity matrices. The simulation investigation confirms that the suggested approach uses less energy than the current one.

Keywords: Energy-efficiency, Routing Protocol, Sensor Nodes, NEEP Algorithm, Minimum Node Cover Algorithm

1. Introduction:

Wireless Sensor Networks (WSNs) have the unique ability to precisely monitor the physical world because they typically comprise of a large number of small sensor nodes that are interconnected. Due to their numerous applications in a variety of fields that require surveillance and monitoring, which have become essential in our everyday lives, WSNs have attracted a lot of research interest in recent years. However, the primary drawback of such sensors is that they are resource-constrained, particularly in the sensor nodes' capacity for power backup. As a result, a number of problems have emerged, among which energy efficiency is a significant issue.

In building IoT systems, wireless sensor networks (WSNs), which are made up of numerous sensor nodes in a multi-hop self-organizing way, are crucial. The military, business, agribusiness, and other sectors have all made extensive use of WSN due to its attributes of simple connectivity and high data rate [22-24]. But because a sensor node is battery-powered, its lifespan is constrained by the battery's size.

The deployment of WSN sensors is anticipated to take place virtually in unattended settings. As the majority of the energy is typically used for routing, the distributed nature, dynamic topology, and resource constraints of WSNs present very unique requirements in routing protocols that should be met.

Routing, network failure due to energy leaks or drainage, and other problems are experienced by sensor networks. Energy loss must be managed carefully as it can lead to a variety of other problems. Therefore, it is crucial to increase the energy efficiency of sensor points. In order for a routing protocol to be effective for WSNs, it must have two key characteristics: reduced energy usage and an increased network lifetime.

Numerous energy-efficient routing protocols for WSNs have been suggested in recent years. However, the mobility factor is not taken into account in the bulk of them. Different kinds of mobility, including node mobility, sink mobility, and event or target mobility, can exist in a WSN scenario. According to published research, if sink mobility is attained, a significant amount of energy can be conserved. The criteria for designing routing and other aspects of WSNs rely on the application at hand. Without many difficulties, the sink mobility idea can be implemented in applications like the smart home environment or in the field of medicine for patient monitoring. However, careful consideration must be given to the number of sinks to be introduced, their placement, mobility or pathway, velocity, coverage area, and other variables in order to achieve effective results through improved energy utilisation.

Now a days, numerous apps make use of Wireless Sensor Networks (WSNs), which are made up of a large number of small sensors that are scattered throughout the network. These sensors' small size makes it easy to integrate them into other devices, which has led to their use in a wide range of monitoring and surveillance applications, as well as in the health and medical industries, engineering, and automation, among other areas. The sensors' tiny size is both a benefit and a drawback. A sensing device, a processing unit, memory, and a power source will all be present in each sensor node. Although deployment is simple due to its compact size, other processing, memory, and power backup capabilities must be given up. Figure1 shows the block layout of the parts that make up a sensor node.

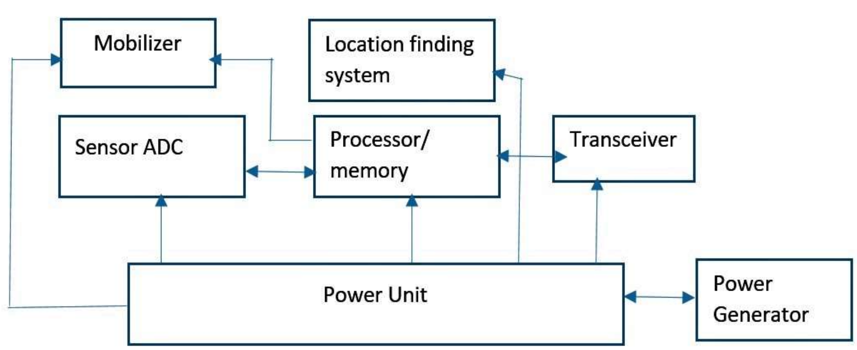


Figure- Component of a sensor node.

The mobilizer and the location finding system are optional parts that are typically skipped because doing so could increase the system's size and expense. The analog signals detected by the sensor are converted to digital signals by the ADC. For processing and storing purposes, there will be a small processor and memory. The transceiver unit handles signal transmission and receiving. Typically, batteries will serve as the power supply. The wireless devices' batteries have a finite capacity and are irreplaceable.

In a location known as the sensor field, where sensing or tracking must take place, the sensor nodes will be dispersed at random. Some nodes have the ability to function as both sensors and routers, gathering data from every node and sending it to a drain that is placed outside the sensor field. From there, users can access the info using the various technologies at their disposal. Figure 2 displays the WSN's basic structure.

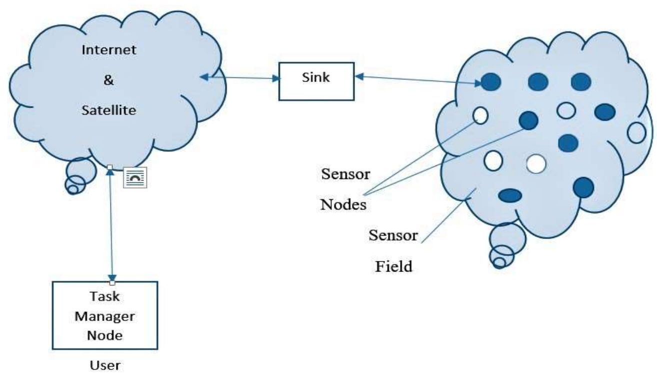


Figure 2. Wireless sensor network

There is a lot of research being done on ways to increase energy efficiency in WSNs, which is a hot study area. To cut back on energy use or to make the best use of the energy that is already accessible, various methods and techniques are used. Some of them are utilizing various node deployment techniques, job cycling theories, the mobility of a few nodes that can serve as data collectors and routers, changing the roles of the nodes appropriately, etc. Each technique will be suitable for a particular purpose. The bulk of energy is reportedly used for communication rather than processing and sensing, according to the literature. To increase the lifespan of the network, an energy-efficient routing algorithm is therefore essential. The clustering idea is used in the hierarchical category, which includes energy-efficient routing protocols [1] [16] [17].

Applications for Wireless Sensor Networks (WSNs) include continuous patient monitoring, threat detection, front line close watch, climate speculation, objective monitoring of environmental conditions like pollutants pressure and temperature, vibration or tracing animal and human movement in fields, forests, and border areas, and many more.

Sensors are one of the key elements of a wireless sensor network. Environmental variables are gathered through sensors, which translate the sensed signals into electrical signals. These electrical impulses are gathered by radio nodes and sent to an access point, or WLAN, for further processing.

Radio nodes are equipped with microcontrollers, memory, and a system for simultaneous signal transmission and reception [1].

Signals are further sent to WLAN in a wireless mode, i.e. with the aid of the internet, after being received up to radio nodes. At this phase, a particular piece of software is employed to assess the signal-based data collection. After that, evaluated data is mined and subjected to analysis. A collection of wirelessly connected, microscopic sensor nodes makes up a wireless sensor network. These tiny nodes have very little power. After the power is drained from these tiny sensor nodes, it is exceedingly challenging to supply power or to restore the power, which is why the network is meant to be dead in this case. These nodes are deployed in remote, difficult-to-access regions. It is essential to use the power effectively in this circumstance [2]. So, it is crucial to create an algorithm that is energy efficient. The average network life can be extended and energy can be saved by designing an energy-efficient algorithm. As they process, sense, send, or receive packets, nodes in a WSN lose energy. The studies' findings support the notion that the most energy-intensive kind of consumption is communication. In a network this size, there are several ways to send a packet to the targeted node. In order to address the problem of energy conservation, it is crucial and crucial to decide on and build a routing procedure.

Many studies were conducted in the past to improve the energy-efficient routing algorithm. There are numerous ways to reduce energy use or make the most use of the energy that is already available. Some of them are putting into practice a variety of node deployment tactics, including duty cycle ideas, multi-hop deployment, multipath deployment, moving some nodes that can serve as data collectors and routers, switching the responsibilities of nodes as necessary, and so on[21]. Every tactic will work for a specific application. The literature claims that rather than processing and sensing, conversation uses up most of the energy. As a result, a routing system that uses less energy is essential for increasing network life. The hierarchical category, which embodies the clustering notion, includes the energy-aware routing protocols [3].

This paper proposes a new energy efficient routing technique which uses multiple sensors and duty cycling concepts to improve the energy efficiency. In order to increase energy efficiency, this study suggests a brand-new routing protocol that employs the idea of hierarchical organization to select the cluster head. The paper is organized into different sections. Designing process is covered in Section 2. The proposed algorithm is shown in Section 3. Section 4 discusses comparisons between the proposed method and the earlier algorithms. The paper's conclusion and future scope are covered in Section 5.

2. Designing Process:

The main purpose of a wireless sensor network (WSN) is to sense the environment, gather data, and then send it to the base station (BS) for analysis. The development of MAC protocols is utilised to construct the novel protocol. After MAC protocol has completed his job, routing protocol takes over. Allocating slots and channels is a major function of the MAC protocol. According to channel access policy, a significant variety of MAC protocols that are energy efficient have been created. These protocols are divided into cross layer MAC protocols, contention-based, TDMA-based, and hybrid protocols [13].

The cluster head formation serves as the foundation for the proposed protocol. It is shown that compared to cluster heads, leaf nodes consume less energy. The cluster head nodes collect the data from the leaf nodes and process it, whereas leaf nodes are simply responsible for data sensing [14]. When the cluster head enters the non-performing stage, all associated leaf nodes likewise lose connectivity. All leaf nodes are linked to the cluster head. Thus it's crucial to choose the right cluster head to reduce energy loss. Cluster hierarchy is utilised in the suggested approach to reduce energy loss while choosing a cluster head assortment. As a result, the system as a whole has a longer lifespan [15].

3. Methodology:

In this article we focus on the sensor opportunistic network environment. There are many sensor nodes in the network, and V can be used to represent the collection of these nodes. When traveling through the network, each sensor node v_i (v_i €V) might run into some other nodes. Additionally, any two encountered nodes in a pair have a link between them where the connection weight number represents how closely they encountered one another. We use W to represent the set of encounter link weight, and each weight value $w_{i,j}$ ($w_{i,j} \in W$) indicates the average contact frequency between any two nodes v_i and v_j. We assume that the average inter-encounter time between any two nodes v_i and v_j in a pair follows an exponential distribution with the parameter $\lambda_{i,j}$ (e.g., $w_{i,j} = \lambda_{i,j}$). Thus, the average inter-encounter time between nodes v_i and v_j is $1/\lambda_{i,j.}$ We have proposed some methods related to sensor network which reduce the power consumption.

3.1. NEEP Routing Method:

In this method, we mainly present the basic idea of the proposed NEEP method, on the basis of the presented system model. Furthermore, for the sake of simplicity, we mainly focus on the description of the transmission process of a specific message only. Here in the initialization phase is designed to collect some useful information for network initialization, and then, the routing phase makes message forwarding decisions on the basis of the collected useful information. The NEEP initialization algorithm is depicted bellow.

Algorithm1: (Initialization)-

Step-1: Input the set of node in the network as a node N_i ($N_i \in N$) and destination node is define by D.

Step-2- Begin:

a) While ($N_i \in N$) do
b) node N_i gathers the encounter frequency ∂i, D between itself and the destination;
c) node N_i computes the probability Pi(k, m) that it concurrently meet m nodes inside the
   present k time slot;
d) node N_i computes the average encounter frequency ∂_i (k) that all the other nodes it meets to encounter the destination D within the k time slot by Equation- $\partial_i(k) = 1/Ne(i, k)| \times \sum_{Ni \in Ne(i,K)} \times \partial_{j,D}$

5: End while

Here in the the NEEP, a novel energy-efficient probabilistic routing method includes the network initialization phase and the routing phase. By exploring the regularity of nodes' mobility and the encounter relationship among nodes, some useful encounter information can be collected during the initialization phase. Based on the accumulated encounter information, the routing process is presented, which includes determining whether to broadcast a message m at present and deciding which node can continuously forward a message m to other nodes two phases. Meanwhile, we take the effective utilization of nodes' energy and the energy fairness among nodes into consideration; thus, a longer network lifetime can be achieved

3.2. Minimum Node Cover Algorithm:

A Minimum Node cover of a Graph G is a set Q, the proper subset of V (G) that contains at least one end point of every edge. The vertices of Q cover E (G). For example, the graph of figure-1 has a minimum Node cover {A, C, D, E} of size 4 that covers all the edges. The minimum Node cover algorithm is a NP complete algorithm. This algorithm can be used in different fields [26, 27, 28].

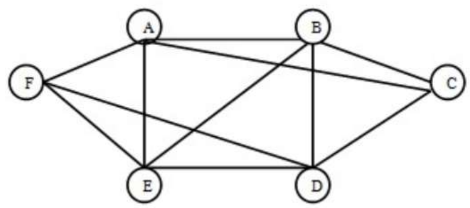


Figure-1 Minimum Node Cover is 4

Algorithm 2: Minimum Node Cover Algorithm

Step 1: while e∈ E = φ do
Step 2: choice Ni with highest (degree (Ni)), ∀i,j = 1,2, 3 .... n
Step 3: if degree (Ni)=degree (Nj) then
Step 4: choice Ni with max (degree (Ni)) and max(weight(Ni))
Step 5: else if (degree (Ni) and weight(Ni)) = (degree(Nj) and weight(Nj)) then
Step 6: choice either Ni or Nj
Step 7: degree (Ni,Nj) = degree (Ni, Nj) - no of joined adjacent E(Ni,Nj)
Step 8: weight (Ni) = weight (Ni,Nj) – no of joined adjacent Weight(Ni,Nj)
Step 9: end if
Step 10: end while

3.3. Application of Minimum Node Cover Algorithm in Wireless sensor network/Sensor Network:

Wireless sensor network (WSN) need to increase the network life time and it is an important and unsolved NP complete problem in WSN. The vertex cover helps with planning to identify the cluster head to minimize power loss and make sure the cluster head can access all of the network's instruments. WSNs are a developing form of communication that provide opportunities to enhance interaction models with the world. In data processing and transmission, sensors are frequently used. Sensors gather information and transmit it to a base station either directly or via a different sensor component. WSN enables node mobility, but sensor capabilities are constrained. WSN have numerous potential uses in both the military and the private world. Numerous power components make up a sensor network.

As a result, these networks require a lot of battery power. We will use Minimum Vertex Cover in an effort to reduce this high power usage. Due to the limited resources available in sensor networks, maximizing network life is a crucial problem. Therefore, using the Minimum Vertex Cover algorithm reduces power usage and increases network lifespan. Dynamic topology, multihop connectivity, and resource limitations are traits of sensor networks. For an example we consider a network with routing path in figure-3.

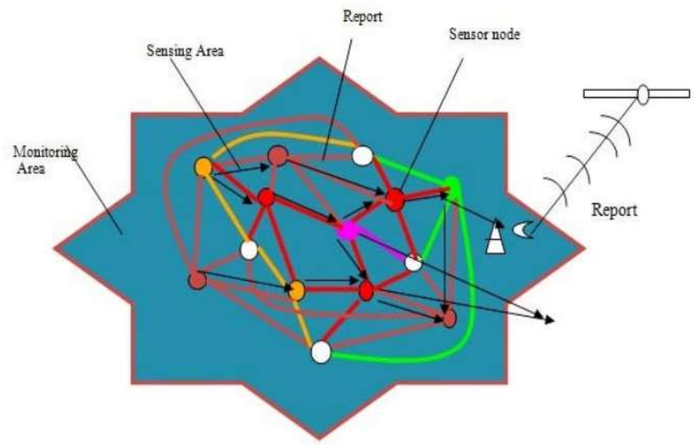


Figure-3: Wireless Sensor Network with path.

In the above Network, contains 14 Nodes or Vertex which are also called sensor. For the connecting of network all the sensors are connected with different path. As a graph it is 4 regular planar graph [25]. Each and every nodes contains four path which are connected to other four nodes. Here in the network in figure-3 contains 14 vertices. In this type of network if we implement Minimum Node cover algorithm then the minimum node cover is 10. The 10 sensor cover all the path and all other sensor. So, in routing process or the network communication process the network properly work with 10 nodes and other 4 nodes is completely idle. If anyone node or sensor have problem or battery is low then the other idle node will active and help to running the routing process or communication process. In this way the minimum Node cover algorithm help in the network and reduce the battery power problem.

On the other hand the network contains 14 nodes or sensors. Instead of 14 nodes we can only use the 10 nodes. 14 nodes contain more power instead of 10 nodes. So the Minimum Nodes cover algorithm also reduce the power consumption of the network.

4. Finding and Results:

This section compares the proposed protocol's energy competence to that of already-in-use protocols like LECHE, etc. The simulation work is completed entirely in MATLAB.

Some network assumptions are listed below. The sensor nodes are dispersed throughout the network region. There are numerous nodes in the network, and each node is connected by a cluster head. Cluster heads handle data exchange. In this case, data travels up the protocol levels from the bottom layers [16].

The findings indicate that the predicted treatment uses less energy than the LEECH protocol. At first, the energy levels of all the sensor nodes are the same. The effectiveness of the intended treatment is assessed in relation to the MODLEACH and LEECH protocols. The simulation is run for the quantity of dead sensor nodes for each round, the number of active sensor nodes, and the presence of sensor nodes in a network.

The simulation findings show that the predicted protocol has more energy efficiency than the current LEECH.

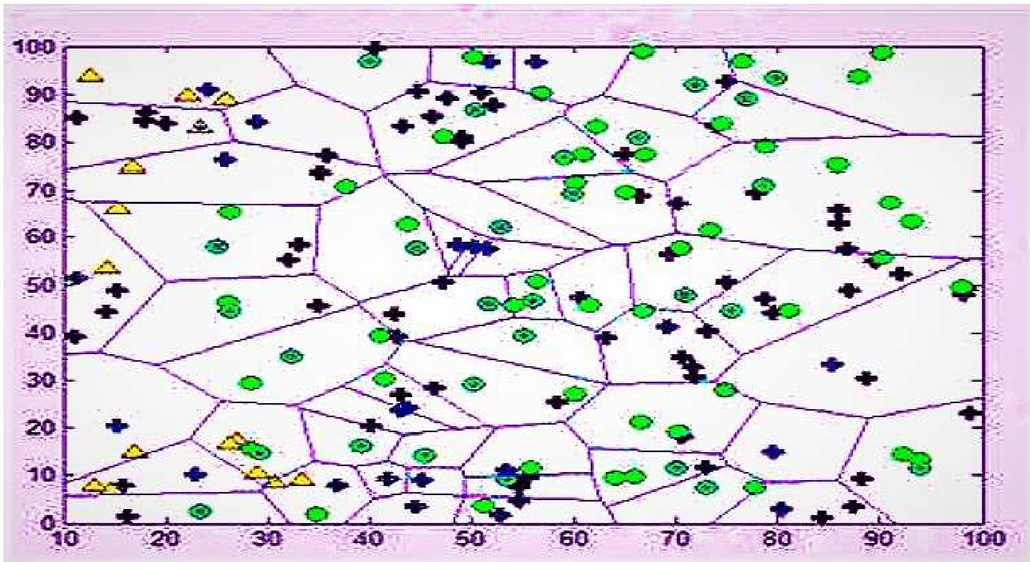
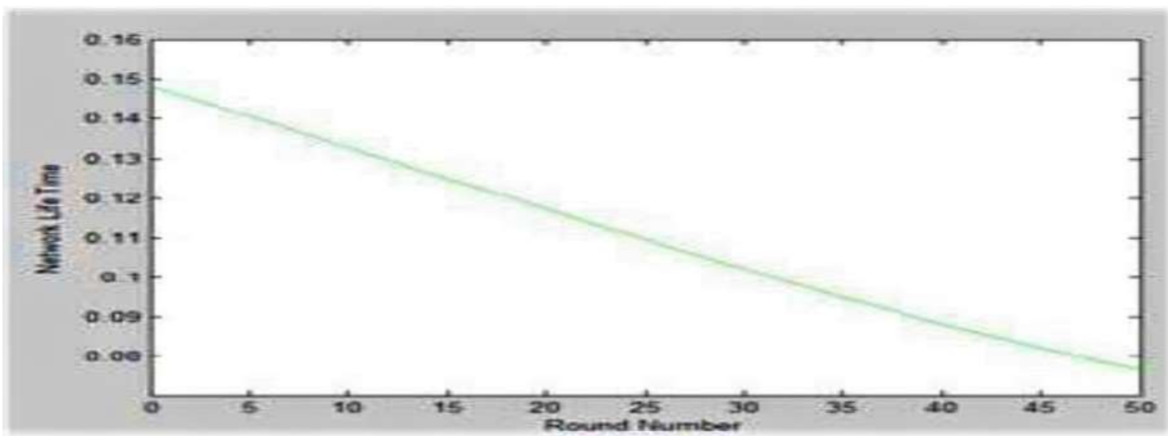


Figure 1. Deployment of sensor nodes

In figure 1 Deployment of the nodes is shown.

The network's lifetime: The network lifetime is depicted in Figure 2. We discovered that the first node dies extremely quickly in every cycle of a non-hierarchical structure construction because all nodes have a tendency to send acquired data to the base station. Due to a forced strain placed on a certain cluster head for a brief period of time, the energy of the cluster head is lowered.



5. Conclusion:

Routing is a significant and difficult issue in mobile opportunistic networks because of the mobility of nodes and the frequent variability of communication links. When nodes' energy cannot be restored in a timely manner, it will be valued as a very scarce resource. Additionally, it is crucial to know when a communication can be forwarded and which nodes can be chosen as suitable relay nodes. We introduced NEEP, a brand-new, energy-efficient probabilistic routing technique, in this article as the method used to initialize the nodes. The Minimum Node cover algorithm which reduce the power consumption of the network and increase the life time of sensor. A novel routing protocol, which follows a hierarchical approach and is designed to consume less energy, is suggested. In this method, the cluster head in wireless sensor networks is chosen based on the estimated energy at the shortest distance to the base station. The suggested method involves transmitting information to the BS and using it to anticipate the route of minimal transmission expenditure. It is noticeable that the network lifetime changes as the number of clusters rises. . It has been determined that hierarchal routing techniques and routing protocols are more energy-efficient in terms of energy consumption.

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