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# Energy Efficient Approach for Multi-level Routing in Wireless Sensor Networks

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**Abstract**—The wireless sensor network is the decentralized kind of network which allows sensor nodes to join or leave the network according to their wish. The implementation of sensor network is done at far places, and they are small sized. Thus, energy consumption becomes the main issue of WSN. The data, whose collection is done from the aimed environment, is transmitted directly to the main station due to the restricted energy of sensor nodes. The sink node receives the data transmitted from various sensor nodes. The decision-making process is deployed by recognizing and eliminating the similarity among the data of diverse sensor nodes. In addition, the sink makes the deployment of obtained data locally as well as transmits these data to the networks which are executed far away. The existing research work employs CTNR, an energy efficient protocol that is capable of enhancing the duration of WSN. The CTNR protocol is consisted of two-level hierarchies for mitigating the energy consumption of wireless sensor network. The CTNR protocol selects the CHs (cluster heads) in the network based on the distance and energy. This research work will focus on enhancing the CTNR routing algorithm so as the life span of network can be prolonged.

**Keywords:** WSN, CTNR, Routing, Multi-level Hierarchy, Energy Efficient, Base station.

## Introduction

Wireless sensor networks (WSNs) belong to a new type of wireless networks that are getting popularity with a large number of civilian and military applications. A wireless sensor network (WSN) refers to a wireless network that comprises distributed autonomous sensor devices so as to monitor physical or environmental conditions. AWSN is composed of a set of connected small sensor nodes, also known as motes. These node share information and data after establishing communication with each other. These nodes gather information of environmental parameters such as temperature, pressure, humidity, or pollutant, and relay this information to a sink or base station. The base station further forwards this information to a wired network or triggers an alarm or an action, according to the sort and dimension of data observed. In a wireless sensor network, all nodes are generally deployed with a radio transceiver, a small microcontroller, and a power source or battery [1]. The most constructive property of these networks does not emerge from the power of the individual sensor devices; it emerges from the whole range of interlinked sensor devices. Therefore, the scale of these networks is generally vast from the stand point that they possess several thousand nodes, and they are suitable to be self-arranging, in order to be reliable. As a wireless sensor node is typically low-priced, a WSN is expected to have a significant number of nodes.

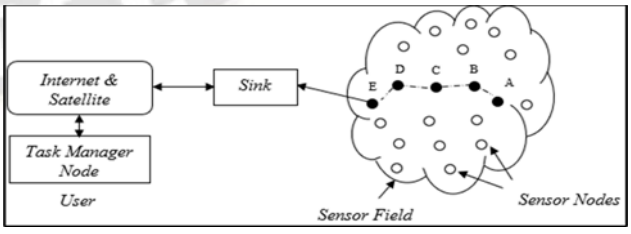


Figure 1: Wireless Sensor Network

In general, sensor nodes use a multi-hop approach to interact with each other. The passage of information and data halts at specific nodes termed as sinks or base stations. A sink or base station typically links the sensor network to an immobile network such that the sensed data could be

distributed for more processing. Usually, sinks have improved potentials over simple nodes to accomplish composite processing. This validates the fact that base stations are equipped with more sophisticated processors including PCs/laptops with more RAM memory, secondary storage, battery, and computing strength as they can accomplish more operations as compared to typical sensor devices. It is important to note that a major shortcoming of sensor networks is energy usage, which is actually the result of communication among nodes [2].Sensor nodes are developed with less difficulty for the implementation at large scale at an alleviated cost. The major issue in Wireless Sensor Network is energy that assists in obtaining a longer life span during their execution on finite battery reserves. The main source of power utilization is to transmit the multi-hop packet across the wireless networks. In the Wireless Sensor Networks, the crucial task is that a less energy must be consumed especially in sensor networks that have included the nodes and taken as a lightweight having a finite battery power. Different network architectures including OSI and Internet are basically functional models which are organised as layers at which the services are offered to the layer above through the layer. The quality of the service metrics of network like delay, throughput, availability, reliability and even security can be utilized to compute a network [3]. But, in case of EC a great complication is occurred due to the evaluation and optimization of the network is considers as a comprehensive model in which the energy consumption is considered hardly exists. The duty cycle of the wireless sensors is controlled by in dynamic way to mitigate the EC. The issue of managing energy management is become very complex especially in various mission-critical sensor applications. The requirements of these applications are that a predetermined level of sensing is maintained at the time of communication performance constraints. Thus, the issue is raised for developing the routing protocols that have scalability and can be executed in effective manner for a wide range of performance constraints and design requirements. For the future of Wireless Sensor Networks, these protocols would be constructed.

**Related Work**

Komalpreet Kaur, et.al (2020) suggested a novel clustering protocol named DEEC along with priority queue for balancing the energy within the Wireless Sensor Network and to prolong the network duration [21]. The distributed Energy Efficient Clustering was utilized along with priority queue in this approach for saving the packet drop. Initially, dropped packet was stirred in the priority queue from which it was obtained and transmitted to the next CH with adequate energy to perform the transmission. Furthermore, the energy consumption was alleviated while transmitting the packets considering the distance amid the nodes and CH. The suggested simulation provided the nodes which were to be dead at different intervals or rounds. The outcomes of simulation demonstrated that the suggested approach performed more efficiently in comparison with other traditional protocol DEEC. The suggested approach assisted in enhancing the outcome about 20%.

Rama Shankar Yadav, et.al (2020) presented the correlations amid hub segments and energy [22]. The EESW algorithm was introduced for dealing with the concerns of energy preservation and life span in Wireless Sensor Network. This algorithm was planned on the basis of modified Network Energy model, novel event trigger technique and Location aware variable. The energy consumption function and threshold function were put forward through the introduced algorithm for WSN. The NS2 simulator was employed to conduct simulation for the Efficient Energy Awareness Scheme, and it was compared with the conventional model concerning various metrics including duration of network, E2E delay and PDR. The outcomes of simulation revealed that the presented algorithm provided superior performance as compared to the conventional AODV protocol.

Salim El Khediri, et.al (2020) recommended a new protocol named MW-LEACH for WSN [23]. The CHs were chosen in the basis of residual energy, the distances among the CHs and an optimal number of member nodes. An initial set of Cluster Head candidates was generated by selecting the nodes from initial set on the basis of high residual energy nearer to the centre of the density. Afterward, the candidates were moved in diverse directions for gathering the data from their members and this data was transmitted to sink. This protocol was less complex with regard to time and message. It was also fast and provided longer life span to network and a proper fault tolerance level. The outcomes of experiment depicted that the recommended protocol was better than the existed protocols concerning PDR, duration of network and latency.

Indra Kumar Shah, et.al (2020) intended a strategy known as DBDDCA algorithm. The long-distance nodes were transmitted from CH in relatively less time for saving the energy in this algorithm [24]. On the other hand, these nodes were broadcasted for the higher time in case of closer distance to the Cluster Head. The comparison of intended DBDDCA was done with the other strategies named as LEACH and two MAC protocols. The certain network

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metrics were utilized for quantifying the performance of the intended and state-of-art strategies. These performance metrics were computed in diverse network scenarios including the increased number of nodes, rounds etc. The outcomes of simulation represented that the intended strategy outperformed the state-of-art strategies in terms of various network components.

Navdeep Singh Randhawa, et.al (2018) established an energy efficient GA based approach in association with VGDRA that assisted in increasing the performance of WSNs [25]. This approach was energy efficient in comparison with LEACH because of its dynamic nature, and it was also useful to balance the load. The optimization was available in the approach that leads to generate more chance of superior result in a smaller number of loops and this was impossible in other approaches. The MATLAB was utilized to obtain the outcomes of simulation conducted for established approach.

MahaAbderrahim, et.al (2019) presented an energy-efficient multi-hop transmission method for WSNs on the basis of Dijkstra algorithm. A Wireless Sensor Network that was set up with N sensor nodes had taken in account [26]. At first, the sensor nodes were assembled into clusters in accordance with their position in the monitoring region. Afterward, a suitable node was selected as CH and the remaining nodes were classified as active nodes and sleeping nodes for organizing the nodes in each cluster. The set of reliable relays that was cooperated for forwarding the data with the least transmission power had chosen. The presented transmission method was capable of enhancing the alleviation of power consumption in comparison with the earlier transmission method in efficient way. The outcomes of simulation demonstrated that the presented novel algorithm was adaptable to enlarge the energy savings for extending the duration of network.

Changjiang Jiang, et.al (2016) analyzed a number of classic clustering routing algorithms for lessening the dead speed of the nodes and increasing the duration of network [27]. A LCUCR protocol was designed in which multi-hop was utilized in inter-cluster communication. The new protocol had considered the energy and distance factors into fitness function for selecting the CHs and sub-CHs. The communication was established amid the CH and sink via sub-CH. In the meantime, the cost function was utilized to generate an optimal path from CH to sink node. The outcomes of simulation depicted that the designed Low-energy Consumption Unequal Clustering protocol had potential for balancing the energy consumed through network and extending the life span of network.

**Research Methodology**

The random distribution of nodes is one of the basic requirements of the clustered wireless sensor network's application. The cluster heads are created due to this random distribution of sensor nodes which further creates several issues. Due to the energy consumption, there is a need to avoid disposability for the cluster head. Also, the long-distance communication in the cluster head is prevented and the addition of nodes below them is also done here. The nodes are not selected by the intended standards which are not perfect in any way and are called cluster head. The conditions of nodes made the nodes difficult to available in the network and almost impossible for them to be available at remote an area which further causes inappropriate nodes. When the intra-cluster energy is increased then these nodes are used as cluster heads. The genuine node consumes less amount of energy in comparisons to the receiver and the sender nodes. When the extensive spectrum is provided to the system in synchronized manner then the battery power consumption is very less as consumed by the nodes. The parent node is selected for ever cluster head so that the actions can be separated and there is increase in productivity. Two value functions are proposed for the competence of each sensory node which further helps the node to be chosen as the cluster head. Degree of nodes generates functions, and the average power of the neighboring nodes is calculated by their distance to the base station. It is necessary to generate higher degree of nodes so that cluster head can be formed. If the cluster head have higher degree can cover large number of nodes which avoids the expensive communications. Hence, in order to increase the lifetime of the network, the energy consumption should be decreased. In the first step, a Hello message is transmitted in which the ID is present. According to the signal strength the distance of base station from every node is calculated. An INTIAL-MSG is transmitted all over the network that involves the presence of ID and distance of every node from the base station. The distance is calculated from node and adjacent nodes. For calculating the cluster head $R_{CH,}$ the calculation method used by the node is shown in equation (1):

$$R_{CH} = R_{min} * [1 + (\frac{d_{BS} - d_{BSmin}}{d_{BSmax} - d_{BSmin}})] \quad \ldots(1)$$

$R_{min}$ here denotes the minimum size of cluster which is used as one of the parameters of the protocol,$d_{BSmin}$denotes the

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distance of the nearest node and base station,$d_{BSmax}$ and represents the distance present inside the farthest node and base station. a value is calculated for every node using the value function in order to make the node appropriate enough to be chosen as cluster head.

$$F_{CH-value} = \alpha * N_{deg} + \frac{\beta}{MSD_{deg}} + \frac{\gamma}{d_{BS}} \quad \ldots (2)$$

α, β and $\gamma$written in the above equation are called constant weights which have values varying from zero to one. all the nodes available in the networks having similar and adjustable values.$N_{deg}$denotes the radius $R_{CH}$ of the number of neighboring nodes. $MSD_{deg}$ represent the mean square distance amongst the neighboring nodes. $d_{BS}$here denotes the distance present between the base station and every node. The expected values help in determining the values of total number of cluster heads present in a particular time. Therefore, $F_{CH-value}$ is known to be the improved value achieved for each node. Every node notices other nodes for the improved values being varied from zero to one. Moreover, each node generates a random value which falls from zero to one. When the value is less than the $F_{CH-value}$, then the node is considered as a candidate for being selected as a cluster head. After being chosen as a cluster head, comparisons are made amongst the nodes on the basis of $R_{CH}$ radius and residual energy. A node represents a cluster head that has highest residual energy.This node provides the ID and broadcast code. All the nodes of the network are informed about the stature of cluster head. A non-cluster head node is used to detect the nearest cluster head which depends upon the signal strength provided. The intra-cluster communication which exists inside the energy cluster relies on the appropriate factors. Cluster is one of them factors. The energy consumption of node radio and distance and the communication in the cluster is very expensive, and due to this the intra-cluster energy will be increased. Centrality is another important mechanism described in the paper. When the distance is less amongst the central cluster and receiver node, then the second power average is minimized which minimizes the intra-cluster energy. The energy is affected because of the other several factors. The nodes are not selected by the intended standards which are popularly known as cache nodes under unsuitable conditions. The value of every step is calculated for every non-cluster head node in such a manner that any node can be chosen as a volunteer node.

Access Time= H*Tc+(1-H)(Tc+Tm) … (3)

The cache hit ratio is represented by H, Tc denotes the access time and Tm is used to denote the main memory access. This collected data is forwarded to the base station by these cluster heads.

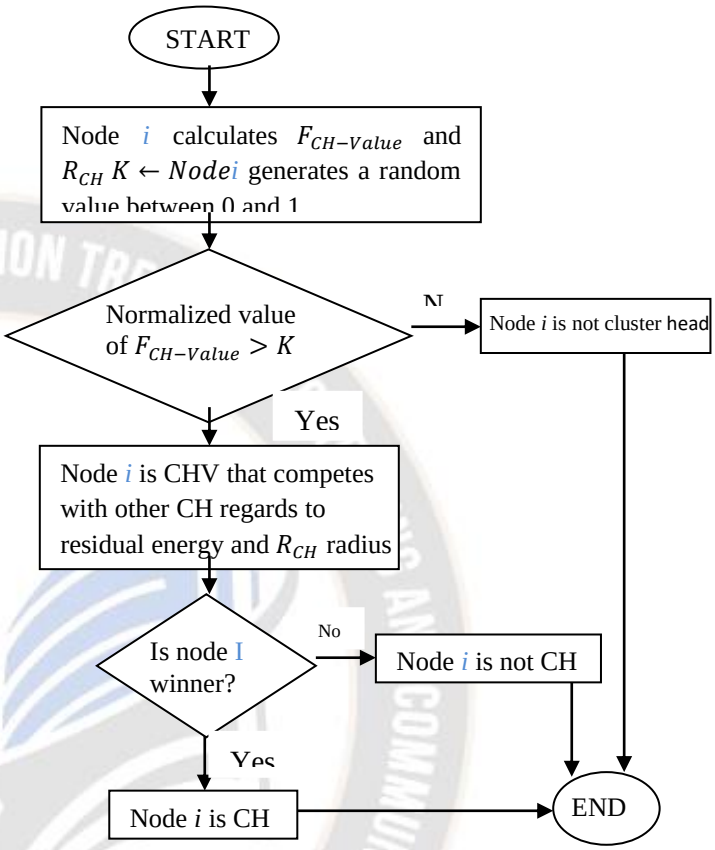


Figure 2: Gateway Node Selection

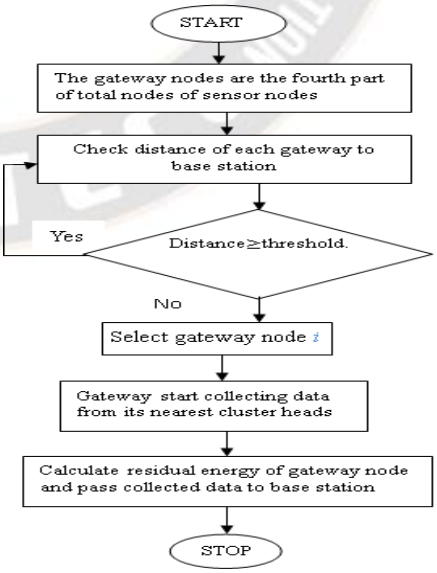


Figure 3: Gateway Node Selection

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**Result and Discussion**

MATLAB is the software which assists in analyzing the performance of the introduced cache based WSNs. MATLAB is a kind of package using which numerical computations such as addition and subtraction etc. can be done and complex functions can be executed such as technical-computation, graphics and animation. The simulations performed are represented in the table 1.

Table 1: Simulation Parameters

| Parameter | Description | Value |
|---|---|---|
| A | area of network | (0, 0)–(200, 250) |
| L-BS | BS location | (150, 250) |
| N | number of nodes in network | 100 |
| $E_{initial}$ | initial energy of all nodes | 0.5 J |
| $E_{fs}$ | free space channel model | 50 nJ/bit |
| $E_{mp}$ | multi-path fading channel model | 0.0013 pJ/bit/$m^4$ |
| $d_0$ | distance threshold | 87 m |
| $E_{DA}$ | data aggregation energy | 5 nJ/bit/signal |
| DP size | data packet size in bit | 4000 |
| CP size | control packet size in bit | 200 |

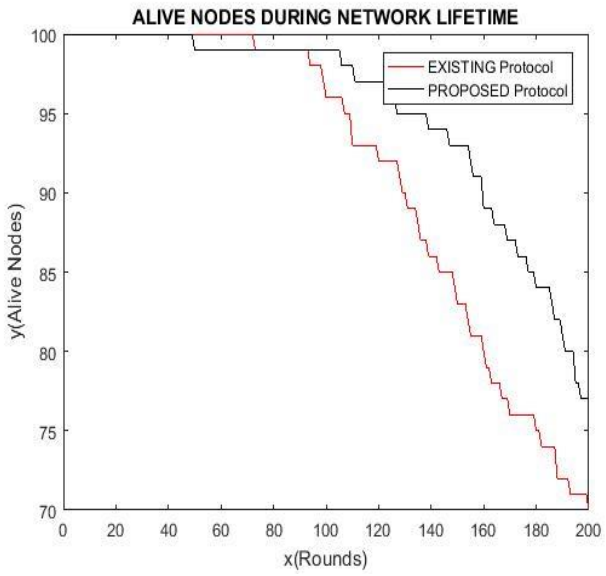


**Figure 4: Alive Nodes Consumption**

Figure 4 illustrates that the base paper is compared with the suggested method. The proposed method is the improvement of CTNR protocol in which gateway nodes are deployed for the communication. When the energy consumption is reduced number of alive nodes are increased in the network as compared to CTNR protocol.

Table 2: Comparison Table for Alive Nodes Consumption

| Number of Rounds | No. of Alive Nodes | |
|---|---|---|
| | Exiting protocol | Proposed Protocol |
| 100 | 90 | 90 |
| 140 | 87 | 97 |
| 160 | 79 | 94 |
| 200 | 72 | 77 |

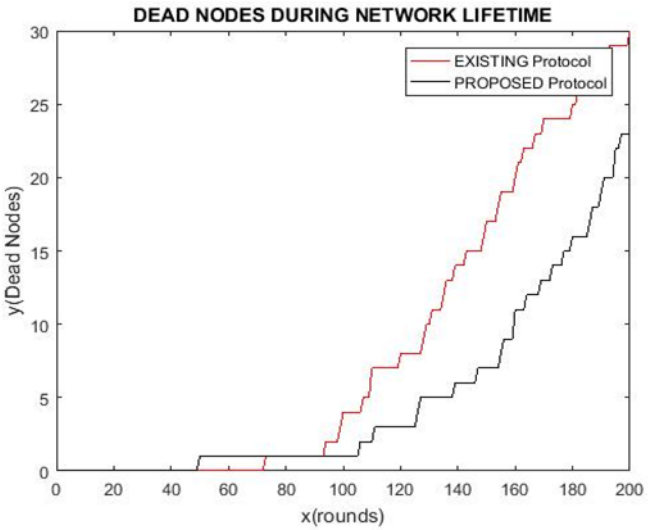


**Figure 5: Number of Dead Node Comparison**

Figure 5 revealed that the LEACH protocol is compared with cache technique with regard to the dead nodes. The suggested method includes lower amounts of dead nodes in the given amount of rounds. The deployment of cache nodes in the network assists in diminishing the energy consumed by the nodes. The reduction in energy consumption of the network results in decreasing the number of dead nodes.

Table 3: Comparison Table for Dead Nodes

| Number of Rounds | No. of Dead Nodes | |
|---|---|---|
| | Exiting protocol | Proposed Protocol |
| 100 | 3 | 2 |
| 140 | 11 | 4 |
| 180 | 24 | 12 |
| 200 | 29 | 23 |

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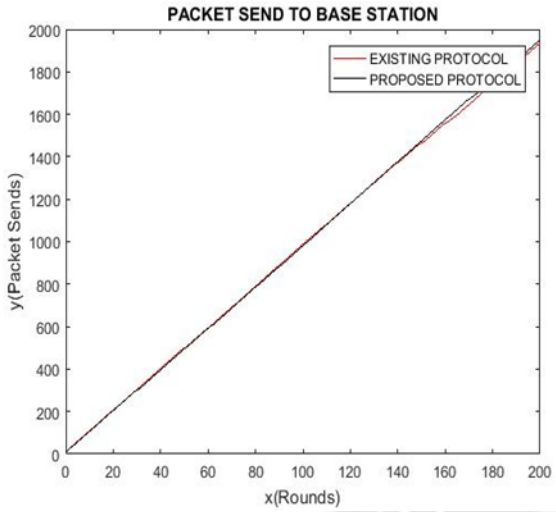


**Figure 6: No of Packets Transmitted**

Figure 6 represented that the number of packets transmitted to the sink using the suggested method, are compared with the base paper, LEACH and cache method. The suggested method is able to transmit a huge number of packets as compared to the other methods. The alleviation of number of dead nodes in the network leads to transmit more number of packets to the sink.

Table 4: Comparison Table for No. Packet Transmission

| Number of Rounds | No. of packets transmitted | |
|---|---|---|
| | Exiting protocol | Proposed Protocol |
| 100 | 940 | 950 |
| 140 | 1240 | 1250 |
| 180 | 1550 | 1600 |
| 200 | 1850 | 1950 |

## Conclusion

The CTNR is an energy efficient routing algorithm that has potential for enhancing the duration of WSN. In this research work, the CTNR protocol is enhanced using gateway nodes. In the proposed protocol, the whole network will be divided into clusters using location-based clustering. The cluster head will be selected in each cluster based on the distance and energy. The sensor node which has least distance to base station and maximum energy will be selected as the cluster head. The nodes which are unable to be selected as cluster head will be elected as leader nodes based on the energy. In the last, the gateway nodes will be deployed in the network. The sensor nodes transmit information to cluster head which will be later transmitted to leader nodes and leader nodes will transmit information to gateway node. The gateway node will forward information to base station. The proposed model is implemented in MATLAB and results are analyzed in terms of number of alive nodes, dead nodes and number of packets transmitted in the network. It is analyzed from the results that number of dead nodes are reduced, number of alive nodes are increased and number of packet transmitted also increased in proposed technique as compared to existing technique

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