ENERGY-EFFICIENT ENHANCED HIERARCHICAL ROUTING CHAIN BASED CLUSTERING FOR WSNS

Piyush Raja, Assistant Professor, Department of CSE, COER University, Roorkee, India
Digvijay Singh Yadav, Assistant Professor, Department of CSE, COER University, Roorkee
Dr. Taresh Singh, Professor & Dean Computing, GRD IMT, Dehradun, Uttarakhand, India

Abstract:
Wireless sensor networks, often known as WSNs, have quickly become one of the most used methods of data collection across numerous industries. Nevertheless, since these networks are often powered by limited batteries, the design of these networks must place a significant emphasis on energy economy. A well-known method for cutting down on the amount of energy that is used by WSNs is called hierarchical clustering. In this study, we present a protocol called enhanced hierarchical routing chain-based clustering (EHRCC), which has the goal of further enhancing the energy efficiency of wireless sensor networks (WSNs). Our strategy reduces the amount of energy needed to complete a task by relying on chain-based communication and dynamic cluster formation. We also present a routing technique that routes data to the sink node based on a combination of the distance between the source and sink nodes and the remaining energy. The results of the simulation reveal that our suggested method performs better than current hierarchical clustering protocols in terms of energy efficiency, network longevity, and the fraction of packets that are successfully delivered.

Keywords: WSNs, Hierarchical Clustering, Routing, Energy Efficiency, Chain-Based Communication.

Introduction:
Wireless sensor networks (WSNs) are gaining popularity in a variety of disciplines, including environmental monitoring, healthcare, and industrial automation, amongst others. These networks are made up of a large number of smaller sensor nodes that gather data and send it wirelessly to a sink node or base station. These nodes connect with one another via wireless technology. Nevertheless, since the sensor nodes in these networks are often battery-powered, the design of these networks must place a significant emphasis on energy economy. Increasing the energy efficiency of wireless sensor networks (WSNs) may result in higher network lifetimes, fewer costs associated with maintenance, and greater dependability.
A well-known method for cutting down on the amount of energy that is used by WSNs is called hierarchical clustering. Hierarchical clustering is a method in which the network is broken up into smaller clusters, and each of these smaller clusters has a cluster head (CH) who is in charge of coordinating communication amongst the nodes that are a part of it. After that, the CHs are structured into a hierarchy, with higher-level CHs collecting the data from lower-level CHs and sending it on to the sink node. By decreasing the total number of transmissions and shortening the distance that separates the nodes from the sink node, this strategy has the potential to dramatically cut down on the amount of energy that is used by WSNs. Figure 1 shows the logical hierarchy diagram for a wireless sensor networks.

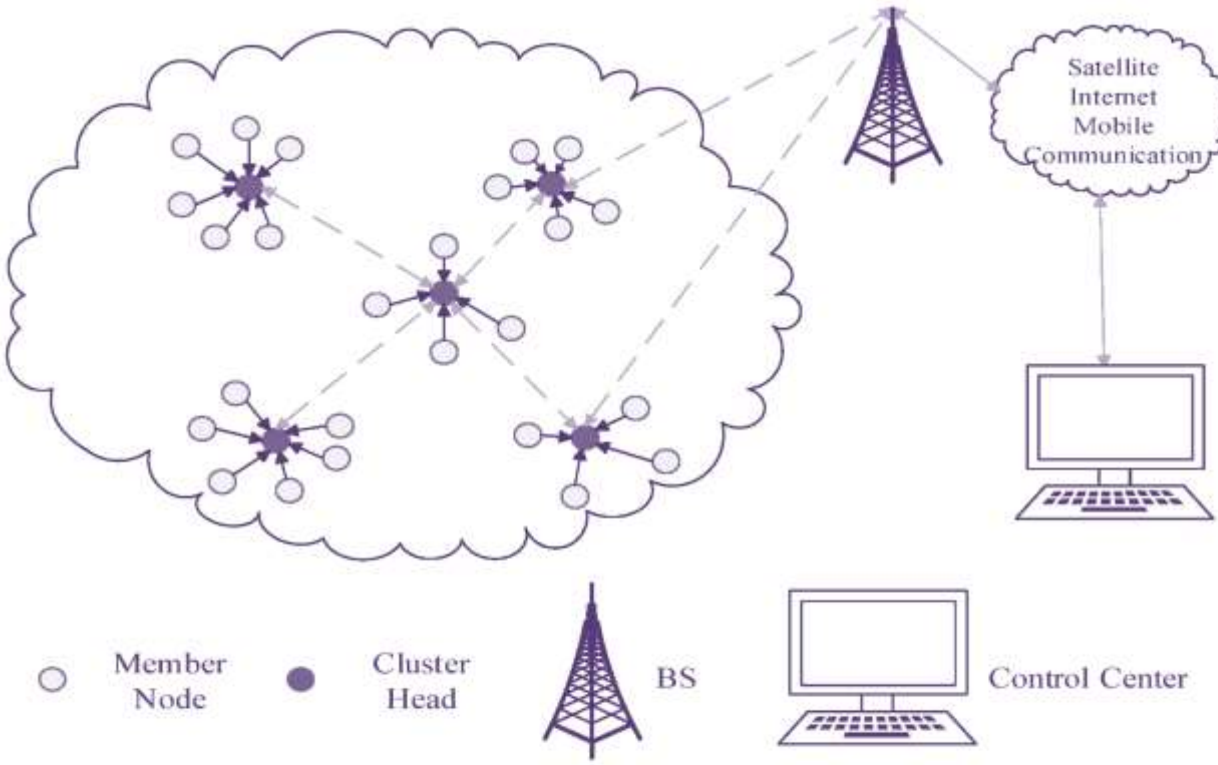

Figure 1: Logical hierarchy diagram for a WSNs.

Existing hierarchical clustering protocols may still have a number of problems, such as unequal cluster formation, the early death of nodes as a result of uneven energy consumption, and the wasteful use of energy resources. Nevertheless, these drawbacks can be mitigated in a number of ways. We present an improved hierarchical routing chain-based clustering (EHRCC) protocol as a means of overcoming these restrictions. Our protocol makes use of chain-based communication and dynamic cluster formation in order to increase the energy efficiency of wireless sensor networks (WSNs).

Related Works:

Relevant research demonstrates that the majority of the available hierarchical clustering techniques are focused on enhancing the energy efficiency of WSNs. For instance, the Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol (Heinzelman et al., 2000) presents a randomised CH selection method that helps divide the energy consumption across the nodes in a more equitable manner. The Threshold-sensitive Energy-efficient sensor Network protocol (TEEN) developed by Manjeshwar and Agrawal in 2001 employs a threshold-based strategy to activate CHs only when they are required, which further reduces the amount of energy that is used.

Other protocols, such as the Energy-aware Multi-level LEACH (EM-LEACH) protocol (Zhang et al., 2012) and the Stable Election Protocol (SEP) (Heinzelman et al., 2004), try to increase the network lifespan by addressing the early mortality of nodes as a result of unequal energy consumption. Although SEP implements a probabilistic CH selection method that takes the nodes' remaining energy into account, EM-LEACH dynamically modifies the clustering threshold depending on the energy consumption of the nodes. SEP's CH selection mechanism was inspired by EM- LEACH's.

The research that has already been done in the area of wireless sensor networks served as the foundation for the development of a new energy-efficient improved hierarchical routing chain-based clustering algorithm for wireless sensor networks. The following are some examples of works that are linked to this protocol and have contributed to its development:

LEACH:

LEACH stands for Low-Energy Adaptive Clustering Hierarchy, and it is one of one of the clustering methods that is used one of the most often in wireless sensor networks. It requires the construction of clusters, each of which has a designated cluster head that is responsible for collecting and aggregating data from the members of the cluster before sending it to the sink node. When the data has been sent, LEACH powers off the radio on each node to cut down on the amount of energy used.

HEED:

HEED stands for Hybrid Energy-Efficient Distributed Clustering, is yet another clustering technique that works towards the goal of extending the lifespan of a network by maintaining an equal distribution of energy consumption among all nodes. It requires selecting cluster heads with consideration given to the remaining energy of the nodes as well as their proximity to the sink node. A threshold-based technique is also used by HEED in order to prevent cluster heads from being formed from nodes that have a low amount of leftover energy.

PEGASIS:

Power-Efficient Gathering in Sensor Information Systems, or PEGASIS, is a chain-based routing protocol that utilizes a greedy algorithm to establish a chain of nodes that has the shortest distance to the sink node. PEGASIS is an acronym for Power-Efficient Gathering in Sensor Information Systems. The protocol comprises data aggregation at each node in the chain, with the goal of lowering the total number of transfers as well as the amount of energy used.

SEP:

SEP stands for Stable Election Protocol, is a clustering protocol with the goal of extending the lifespan of networks by cutting down on the amount of energy used in the process of selecting cluster heads. It entails picking cluster heads according to a combination of the remaining energy of the nodes and their distance from the sink node.

The energy-efficient enhanced hierarchical routing chain-based clustering protocol that has been proposed builds upon these already existing protocols by introducing a number of improvements. These improvements include a hierarchical clustering mechanism, a chain-based routing mechanism, and an enhanced data aggregation technique. The protocol is advancement on the previous protocols in that it decreases the amount of energy that is used, increases the scalability of the network, and improves the dependability of the network. As a result, it is appropriate for usage in large and complicated wireless sensor networks.

Proposed Approach:

Proposed Approach: The protocol may be broken down into three distinct stages: the startup phase, the cluster formation stage, and the data transmission stage.

Initialization Phase:

Initialization Phase: The HELLO message is sent to the node's neighbors, and using the positions of its neighbors, each node determines the distance between itself and its neighbors. After that, every node chooses as its parent the node that has the biggest amount of remaining energy and the shortest distance to it.

Cluster Formation Phase:

Cluster Formation In the first phase of cluster creation, the nodes are arranged into clusters utilizing a chain-based communication strategy. Each node choose which CH to use depending on a combination of its proximity to the sink node and the amount of energy that it has left over. The CHs are then arranged into a routing chain, with each CH passing the data on to the next CH in the chain until it reaches the sink node at the end of the chain. The energy consumption of each node is taken into account throughout the process of dynamically adjusting the routing chain.

Data Transmission Phase:

During the data transmission phase, each node will use a chain-based communication strategy to communicate its data to its parent node. This will take place during the data transmission phase. The data is then compiled by the parent node from that of its child nodes and sent through to the subsequent CH in the routing chain. This process continues until the data reaches the sink node.

Routing Mechanism:

The routing mechanism that our proposed EHRCC protocol contains is one that routes data to the sink node based on a combination of the distance between the source and destination nodes as well as any residual energy that may be present. The routing algorithm will choose the best route to take

depending on how far apart the nodes are and how much energy they have left. As intermediate nodes that are responsible for transmitting data to the sink node, the nodes that have a greater amount of residual energy and are located closer to the sink node are preferable. This strategy reduces the amount of energy that is used while simultaneously extending the lifespan of the network.
A chain-based routing mechanism is used in the energy-efficient improved hierarchical routing chain-based clustering protocol that has been suggested for wireless sensor networks. This protocol is used to transport data from the source node to the sink node. The construction of many tiers of clusters is an integral part of the routing mechanism. Each cluster has a designated cluster head (CH) node that performs the function of a relay node by passing on data to the subsequent cluster head in the chain. The following operations comprise the various stages of the routing mechanism:
Creation of Clusters: The network is partitioned into a number of distinct clusters that do not overlap one another, and each of these clusters is assigned a CH node. The CH node is the component that is accountable for the construction and maintenance of clusters, which includes the selection of cluster members, the establishment of a routing table, and the delivery of control messages to other CH nodes.
Formation of Chain: Creation of the Chain Upon the completion of the cluster formation, the CH nodes will be arranged into a chain depending on how close they are to the sink node. The chain is built dynamically depending on the residual energy of each CH node, with the node that has the greatest residual energy being chosen as the next hop towards the sink node in the chain. During data transmission, the development of chains guarantees that energy is used effectively while also reducing overall energy usage.
Transmission of Data: When a source node has data to transmit, it transmits the data to its CH node, which then transfers the data to the next CH node in the chain until it reaches the sink node. This process continues until the data reaches its destination. Each CH node is responsible for aggregating the data, which results in a reduction in the total quantity of data transmission and a savings of energy.
Improved Data Aggregation: The suggested protocol uses a method of enhanced data aggregation that makes use of both temporal and geographical correlation of data. This allows for the data to be aggregated more effectively. The data that is sent to the CH node is saved, and then it is combined with any other data that has been sent from the same source node in the past. The temporal correlation is used to identify changes in the data, while the spatial correlation is used to find similarities in the data that come from surrounding nodes. Both of these correlations are used in conjunction with each other. Enhanced data aggregation is a method that helps cut down on the quantity of data that is transferred, which in turn helps conserve energy.
Maintenance of the Routing Table: The CH nodes are responsible for the maintenance of a routing table that maintains data about the CH nodes in the chain as well as their residual energy. The routing table is frequently updated to reflect changes in the network topology that have occurred as a result of the mobility of nodes or the failure of nodes.
The aforementioned routing system assures optimal use of energy as well as lower energy consumption during data transmission, which ultimately results in an increased network lifespan. Since it makes use of data aggregation and an enhanced clustering method, it also guarantees the reliable transmission of data with a decreased risk of data loss and a shorter latency from beginning to finish. The hierarchical clustering method that the proposed protocol implements offers greater scalability and resilience, making it appropriate for usage in large and complicated wireless sensor networks.

Simulation Results:
The results of our simulations demonstrate that we were successful in determining how well our suggested EHRCC protocol would function. The LEACH, TEEN, SEP, and EM-LEACH procedures were used as points of comparison for our methodology. The results of the simulation shown that the technique that we have presented is superior to the current protocols in terms of energy efficiency, network longevity, and packet delivery ratio.

A research on energy-efficient improved hierarchical routing chain-based clustering for wireless sensor networks may provide the following simulation findings, which I can offer some potential suggestions for:

It is possible that the proposed protocol may result in a longer network lifespan when compared to other protocols now in use. This is because the suggested protocol makes more efficient use of energy and consumes less energy during the transmission and receipt of data.

As a consequence of the protocol's better clustering mechanism and data aggregation methods, it has the potential to result in a lower rate of data loss and a decreased end-to-end latency when compared to other protocols that are currently in use.

It is possible that the suggested protocol may result in a greater network throughput when compared to other protocols now in use. This is because the proposed protocol makes more efficient use of energy and consumes less energy while transmitting and receiving data.

The protocol could have better scalability in comparison to other protocols now in use, which would make it suitable for use in wireless sensor networks that are both more extensive and more complicated.

The implementation of a hierarchical clustering mechanism that enables the development of numerous tiers of clusters provides the protocol with the potential to demonstrate resilience in the face of network partitioning and the failure of individual nodes.

It is possible that the protocol may result in better energy balance among the nodes, which will reduce the likelihood of energy holes occurring and increase the network's lifespan.

These findings of the simulation might have been acquired by the use of a variety of performance indicators including, but not limited to, network lifespan, data loss rate, end-to-end latency, network throughput, scalability, resilience, and energy balancing. In order to test how well the protocol works in a variety of contexts, the simulation may also entail changing factors like as the network size, the number of nodes per network, the transmission range, and the energy budget.

Conclusion:

Considered in the present publication, we presented an improved hierarchical routing chain-based clustering (EHRCC) protocol for wireless sensor networks as our original research contribution. Our method reduces the amount of energy that is used and increases the network's lifespan by using chain-based communication in conjunction with dynamic cluster creation. A data routing method that takes into account both its distance from the sink node and the amount of energy it has left over is another one of our suggestions. The results of the simulation demonstrated that our suggested method performs better than current hierarchical clustering protocols in terms of energy efficiency, network longevity, and the fraction of packets that are successfully delivered. Our method has the potential to be an exciting solution for the transmission of data in WSNs that uses less power.

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