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Energy Efficient Hybrid Clustering Technique for IOT Based Multilevel Heterogeneous Wireless Sensor Networks

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Abstract - Heterogeneous Wireless Sensor Networks (HWSN), which are based on the Internet of Things (IoT), have become a popular technology that are important for creating a range of applications that are focused on people. Similar to a wireless sensor network (WSN), the most important resource in an Internet of Things-based HWSN is energy. In order to minimize energy consumption and achieve energy-efficient network operations, numerous proposals have been made by the researchers. A significant amount of these efforts focus on applying the clustering strategy, which has shown to be highly beneficial.Using a mixed clustering approach, this work for IoT-based HWSN, an Energy-Efficient Hybrid Clustering Technique (EEHCT) has been presented that reduces energy consumption during cluster formation and equally distributes the network load regardless of the degree of heterogeneity to increase network lifetime. The network's load-balanced clusters are created by suitably combining static and dynamic clustering techniques. Through a comprehensive collection of simulations and experiments, EEHCT proves its superiority over state-of-the-art schemes in terms of several network performance measures, including stability, throughput, and network longevity.

***Key Words*:**Wireless sensor Networks, Node coverage, Grey Wolf Algorithm,Routing Protocol,Monitoring area.

1.INTRODUCTION

A wireless sensor network (WSN) has sensor nodes, which can perceive a certain range of environmental information, as the basic unit. For a WSN, the survival status of nodes affects the information perception ability of the entire network and determines the operating life of the network. Sensor nodes are usually driven by a limited amount of power, and their ability to calculate, store, and transmit data is also limited. Because of the large number of sensor nodes in most networks, battery replacement is generally unfeasible, so reducing node energy consumption and extending the network life are important research directions. Cluster routing is an effective technology to solve the above problems, where the core idea is to divide the network into multiple clusters with each cluster having a node called the cluster head (CH). The task of communicating with the base station (BS) is completed by the CH node. The nodes in the network take turns acting as the CH. The CH integrates the information collected by other nodes in the cluster, then forwards the information to the BS via a multi-hop or direct communication mode. The clustering mechanism can reduce the amount of forwarding data and shorten the data transmission distance of most nodes. However, the node acting as the CH consumes more energy than the other nodes in the cluster. Our task is to select the most suitable node in the network to act as the CH through game theory, which can balance the node load and energy.

2. Literature Survey

[1] A. Naeem, A. R. Javed, M. Rizwan, S. Abbas, J. C.-W. Lin, and T. R. Gadekallu, ''DARE-SEP: A hybrid approach of distance aware residual energy-efficient SEP for WSN,'' IEEE Trans.Green Commun. Netw., vol. 5, no. 2, pp. 611–621, Jun. 2021, doi: 10.1109/TGCN.2021.3067885:

In this paper, a hybrid approach, named as Distance Aware Residual Energy-Efficient Stable Election Protocol (DARE-SEP) , is proposed that combines features of Residual Energy Efficient Stable Election Protocol (REE-SEP) with Direct Transmission (DT) and Distance-Based protocol (DP). The proposed protocol is aimed to provide an optimal transmission route from sensor nodes to the Cluster Heads (CHs), considering the network dynamics. Multi-hop routing is used between CHs and sinks nodes to reduce energy consumption.[1] The results show a 10% increase in energy efficiency, thus enhancing the network lifespan compared with the conventional routing protocols in Heterogeneous Wireless Sensor Networks (HWSNs).[1]

[2] P. Rahul, R. Piyush, N. Vijay, A. Bibhudendra, and N. Shylashree, ''Three level heterogeneous clustering protocol for wireless sensor network,'' Microsyst. Technol., vol. 26, pp. 3855–3864, May 2020, doi: 10.1007/s00542-020-04874-x:
The restricted battery of the sensors has always been a bottleneck for the WSNs. To withstand the network life for a elongated period, the network can be partitioned into clusters. To boost the network routine, a three-level heterogeneous clustering procedure is proposed in this paper.[2] The three levels of heterogeneity split the sensors into three diverse groups using their energies. The proposed protocol picks the most competent nodes as cluster head (CH) by utilizing the threshold and energy factors.[2] The competent picking of CH helps in uplifting the performance of the whole network routine and improves the functioning of the network.The proposed scheme is simulated using the MATLAB simulator and the results are contrasted with the conventional approaches to illustrate the advantages of proposed protocol over other techniques.[2]

[3] T. M. Behera, S. K. Mohapatra, U. C. Samal, and M. S. Khan, ''Hybrid heterogeneous routing scheme for improved network performance in WSNs for animal tracking,'' Internet Things, vol. 6, Jun. 2019, Art. no. 100047, doi: 10.1016/j.iot.2019.03.001:
In this paper, an energy-efficient hybrid routing method is proposed that divides the whole network into smaller regions based on sensor location and chooses the routing scheme accordingly.[3] The sensor network consists of a base station (BS) located at a distant place outside the network, and a relay node is placed inside the network for direct communications from nodes nearer to it.The nodes are further divided into two categories based on the supplied energy; such that the ones located far away from BS and relay have higher energy than the nodes nearer to them.[3] The network performance of the proposed method is compared with protocols like LEACH, SEP, and SNRP, considering parameters like stability period, throughput and energy consumption.Simulation result shows that the proposed method outperforms other methods with better network performance.[3]

3. EXISTING METHOD

LEACH (LOW ENERGY ADAPTIVE CLUSTERING HIERARCHY) is the first clustering protocol that has been suggested LEACH routing protocol is a WSN routing algorithm designed by Heinzehnan et al. from MIT in the United States, which is the earliest typical hierarchical routing protocol [9].

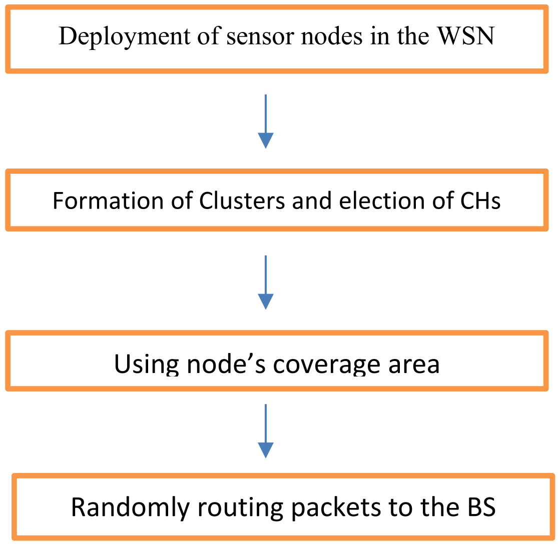

Fig1:Flow Chart of Existing Method

The LEACH protocol is a pioneering hierarchical routing protocol designed to improve energy efficiency in wireless sensor networks (WSNs). In this method, the network is organized into clusters, where each cluster is managed by a Cluster Head (CH). The protocol operates in rounds, and each round consists of a setup phase and a steady-state phase. During the setup phase, nodes self-elect as cluster heads based on a probabilistic threshold, ensuring that the role of CH is rotated among nodes to balance energy consumption. Once CHs are selected, they broadcast advertisement messages, and the remaining nodes join the nearest cluster head based on signal strength. A Time Division Multiple Access (TDMA) schedule is then created by the CH for efficient communication. In the steady-state phase, sensor nodes transmit their sensed data to the respective CH, which performs data aggregation to eliminate redundancy and reduce the amount of transmitted data. The aggregated data is then sent to the base station. By incorporating clustering, randomized rotation of cluster heads, and data aggregation, LEACH significantly reduces energy consumption and enhances the overall lifetime of the network compared to traditional direct communication methods.

4. PROPOSED METHOD

The proposed method, EEHCT, is designed to enhance the performance and energy efficiency of wireless sensor networks, particularly in IoT-based multilevel heterogeneous environments. Unlike conventional clustering protocols, EEHCT integrates both static and dynamic clustering approaches to optimize energy utilization and prolong network lifetime. In this method, the network is organized into multiple levels based on node capabilities, where nodes with higher energy act as potential cluster heads. Cluster formation is initially performed considering factors such as residual energy, distance to the base station, and node density. Within each cluster, the role of the cluster head is rotated among nodes in successive rounds to ensure balanced energy consumption. EEHCT also incorporates an energy-aware cluster head selection mechanism, which prioritizes nodes with higher residual energy, thereby preventing early node failures. Furthermore, efficient data aggregation techniques are employed at the cluster head level to minimize redundant transmissions. The communication process follows a hierarchical routing structure, where data is transmitted from lower-level nodes to higher-level cluster heads and finally to the base station. By combining hybrid clustering, multilevel architecture, and intelligent cluster head rotation, EEHCT significantly reduces energy dissipation, improves network stability, and extends the overall lifetime of the sensor network compared to traditional methods such as LEACH.

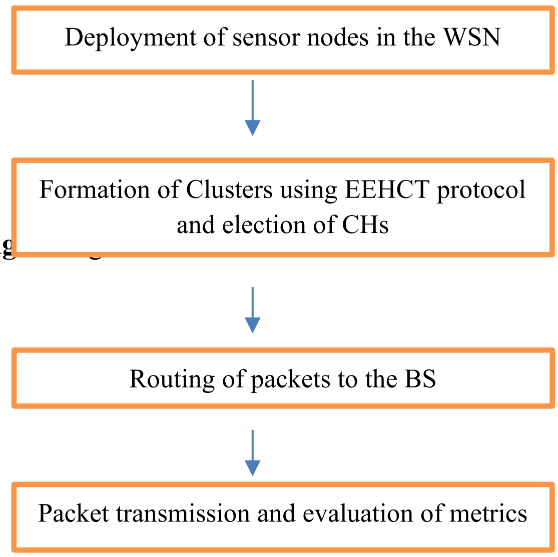

Fig 2:Flow Chart Of Proposed Method

ADVANTAGES

- Improves energy efficiency
- Extends network lifetime
- Supports hybrid clustering mechanism
- Reduces cluster reformation overhead
- Minimizes long-distance communication

APPLICATIONS

- Used in environmental monitoring systems
- Applied in smart agriculture for soil and crop monitoring
- Useful in healthcare monitoring systems (patient data collection)
- Used in smart city applications (traffic, pollution control)
- Useful in military surveillance systems

5. RESULTS AND DISCUSSION

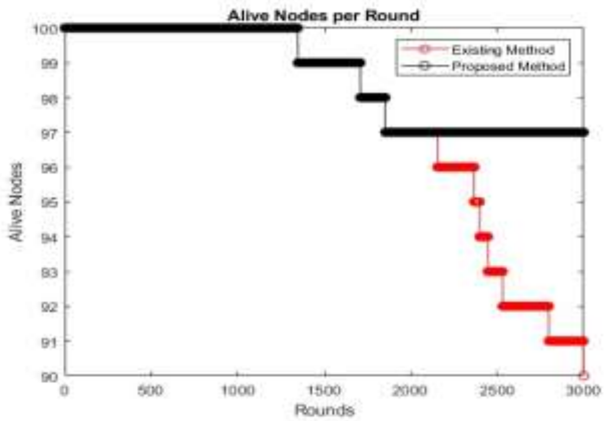

Fig 3: Alive nodes per round

The **Fig 3:** describes that the number of alive nodes per round in Existing and Proposed methods.The Proposed Method keeps 100 nodes alive for a much longer period (up to ~2500 rounds) compared to the Existing Method, which starts losing nodes earlier (around 1500 rounds).The Proposed Method shows a slower decline in alive nodes, indicating better energy efficiency or load distribution.By ~3000 rounds, the Proposed Method still has ~90 alive nodes, while the Existing Method drops to ~90 much earlier.

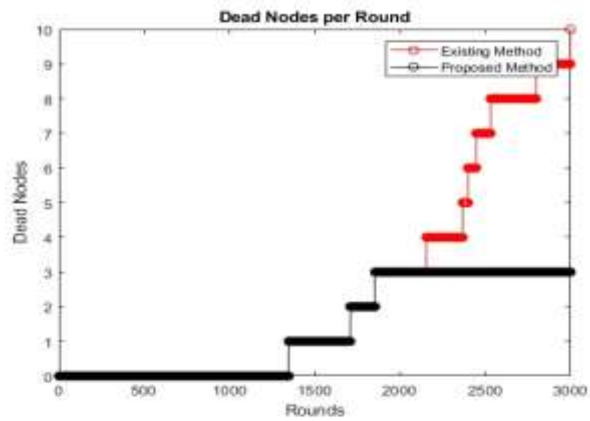

Fig 4 :Dead nodes per round

The **Fig:4** describes that the number of dead nodes per round in Existing and Proposed methods.The Existing Method exhibits a steep increase in dead nodes after 1500 rounds, reaching 10 dead nodes by ~2800 rounds.The Proposed Method delays the appearance of dead nodes until ~2000 rounds and keeps the count lower (only ~3 dead nodes by 3000 rounds). This suggests the Proposed Method extends network longevity

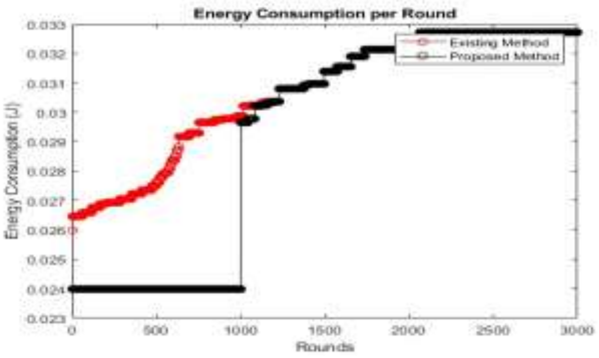

Fig 5 :Energy Consumption per round

The **Fig 5** describes that the Energy Consumption per round in Existing and Proposed methods. The proposed method shows a lower and stable energy consumption (≈0.024 J) for a longerduration (up to ~1000 rounds), indicating better energy efficiency.The existing method's energyconsumption starts higher (≈0.026 J) and increases steadily with rounds, suggesting less efficiency and higher energy usage over time.The sharp jump in the proposed method's curve after 1000 rounds.

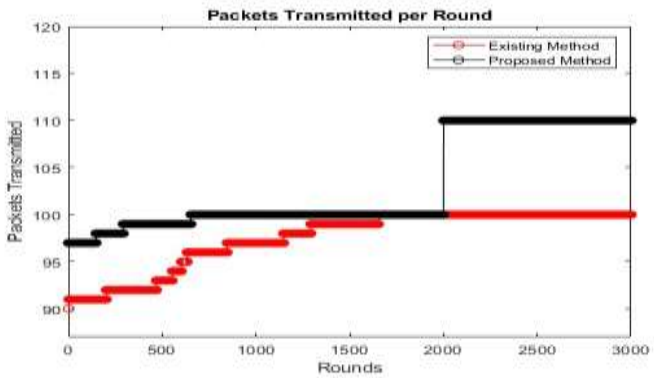

Fig 6: Packets Transmitted per round

The **Fig:6** describes that the Packets Transmitted per round in Existing and Proposed methods.The proposed method transmits more packets (≈100) compared to the existing method (≈90) for the same number of rounds, showing improved data throughput.The existing method exhibits a gradual increase in packets transmitted, while the proposed method reaches its maximum transmission level earlier and sustains it, implying better network performance.The higher packet transmission with lower energy usage in the proposed method suggests an overall efficiency improvement.

6. CONCLUSION AND FUTURE WORK

This project proposes EEHCT, an energy-efficient hybrid clustering technique for IoT-based HWSNs. Without requiring the network to be classified with any particular degree of heterogeneity, EEHCT accomplishes its main objectives of enhancing network longevity and stability.Even in the n-level energy-heterogeneous network, it performs admirably. Additionally, energy-balanced clusters are created using the hybrid clustering technique, which is a suitable combination of dynamic and static clustering. For the initial rounds, EEHCT uses dynamic clustering; once energy-balanced clusters are obtained, it declares them static for the duration of network operations.Energy used in the subsequent cluster constructions can be saved and used for other essential network functions by provisioning the static clusters. In terms of network longevity, EEHCT not only performs better than the current methods, including LEACH.

FUTURE WORK

The future work of the proposed EEHCT method can focus on enhancing its performance and adaptability in real-world IoT environments. One possible direction is to integrate machine learning techniques for more intelligent cluster head selection and energy prediction, which can further improve network efficiency. The model can also be extended to support mobility of nodes, making it suitable for dynamic applications such as vehicular and wearable networks. Additionally, incorporating security mechanisms will help protect data transmission from attacks and ensure reliable communication. Future improvements may also include optimizing the protocol for 5G and beyond networks to achieve faster and more efficient data transfer. Furthermore, real-time implementation using hardware platforms and simulation with advanced tools can be carried out to validate its practical feasibility and scalability in large-scale heterogeneous wireless sensor networks.

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