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An Overview on Optimization of Routing-Based Clustering Approaches in Wireless Sensor Network

Ambika Mangalgi[1]* Dr. C. M. Tavade[2]

[1] Assistant Professor, Department of Computer Science and Engineering, Bheemanna Khandre Institute of Technology, Bhalki

[2] Professor, Department of Electronics & Communication Engineering, Bheemanna Khandre Institute of Technology, Bhalki

Abstract – In wireless sensor networks (WSNs), sensors are geographically dispersed and work together to send data to a central base station, such as temperature, sound, pressure, and other environmental variables. The WSN is made up of a large number of nodes, ranging from a few dozen to several thousand, all of which are interconnected through sensors. Clustering is an essential technique in wireless sensor networks for extending the network's lifespan (WSNs). In this process, sensor nodes are grouped into clusters, and cluster heads (CHs) are elected for each cluster. In this study, we have studied the wireless sensor networks, routing protocols in WSN, clustering, advantages of clustering, design challenges of clustering, optimization-based clustering mechanisms which are concluded that a significant strong method for preserving the energy efficiency of a sensor network is through energy restrictions of sensor hubs and the capabilities of the clustering architecture

Keywords – Route, Protocol, Wireless Sensor Network, Clustering

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INTRODUCTION

Wireless Sensor Networks (WSNs) have emerged as new technology for information collection. The sensor units make up an aggregation of hundreds or thousands of sensor nodes implemented across a large geographical area constitute a networked sensor. These micro gadgets are tiny energy devices with small storage and small control power. These inexpensive and small-sized devices have got to be feasible with the newest innovations in Complementary Steel Oxide Semiconductor (CMOS) design and miniaturization methods. Each signal node typically contains a tiny CPU, storage, receiver/transmitter radio, and a power product. The battery is an essential part of a sensor. In most instances, it's possibly not adjustable or regular; therefore, it restricts the time of the warning and affects the main aim of the network. In another region, once they're utilized the detectors are believed, independent. Therefore, a number of a particular therapy may be expected to guarantee their organization. Self-configuration of these sites is required for their performance. To guarantee minimum power consumption and consistent load distribution across the network, sensor nodes are organized into clusters Clustering is one of the most efficient techniques in data forwarding in offering a simple framework for resource management. It may provide many important network operations inside intracluster such as channel access for cluster members and power management, along with inter clusters such as routing and code separation to avoid cross-cluster interference. To increase energy efficiency and decrease transmission latency, nodes are joined into many small groupings called clusters. This technique of merging sensor nodes is known as clustering. For every cluster, a chosen node is called a cluster head (CH) (CH).

CH is in charge of gathering the aggregated information provided by the other sensor node in the cluster and transmit it to the base station or sink. A cluster node is a node that has greater energy and capacity than other sensor nodes. CH provides the scalability for high counts of nodes and reduces energy usage. Choice of cluster head is an important issue in designing clustering procedures.

ROUTING PROTOCOLS IN WSN

Routing protocols select the method the nodes may interact with one another in-network. The larger quantity of electricity or energy of the network is utilized for the transmission of data signals. Routing protocols for WSN are reliant on various categorization criteria such as data-centric, hierarchical, location-based, negotiation-based, multipath-based, quality of service, and mobility. A brief explanation of the following is provided below:

- **Location-Based**

In location-based protocols, sensor nodes are resolved by the manner of their locations. Location information for sensor nodes is required for sensor networks by the majority of the routing protocols to calculate the distance between two particular nodes to guarantee that energy consumption can be predicted. Some location-based protocols are MECN, SMECN, GAF, GEAR, Span, TBF, BVGF, and GeRaF.

- **Data-Centric**

In data-centric protocols when the source sensors send their information to the sink, intermediary sensors may perform some kind of aggregation on the data coming from numerous source sensors and deliver the aggregated data toward the sink. This method may result in energy savings because less transmission is required to transmit the data from the sources to the sink. Data-centric protocols are SPIN, Directed Diffusion, Rumor Routing, COUGAR, ACQUIRE, EAD.

- **Hierarchical Protocols**

In a hierarchical structure, sensor nodes are arranged into clusters, in which a node having lower energy can be utilized to do the sensing job and deliver the sensed data to its cluster head at a small range, while a node with higher energy can be picked as a cluster head to aggregate the data from its members and ahead of it to the sink. This technique may not only reduce the energy consumption but in addition balance traffic load and improve the scalability. These protocols include LEACH, PEGASIS, HEED, TEEN, and APTEEN.

- **Multipath-based Protocols**

If data transmission is considered among the source sensors and the sink, there are two methods of routing: single-path routing and multipath routing. In single-path routing, each source sensor delivers its data to the sink through the shortest route. In multipath routing, each source sensor identifies the first k shortest routes to the sink and distributes its load evenly among these paths. The protocols are Disjoint Pathways, Braided paths, N-to-1 Multipath Discovery.

- **QoS**

Along with the lowering power consumption, it is essential to take into consideration QoS requirements when it comes to latency, dependability, and fault tolerance for routing in WSNs. Both fault tolerance and reliability necessitate the installation of more than the necessary sensors so that the network may continue to function efficiently and transmit correct sensed data to the sink despite occasional sensor failures. The QoS protocols are: SAR, SPEED, Energy-aware routing

CLUSTERING

WSN comprises a large number of sensors yet has limited battery power. Naturally, WSN hubs can function in severe and dangerous environmental circumstances; however, the battery cannot be recharged or replaced in these scenarios. Hence, energy-saving is important for the network. Generally, routing protocols have an enormous impact on energy consumption in which energy utilization is regarded as the primary concern when developing the routing protocol.

Cluster-based routing protocols are recognized to be ideal in the notion of energy savings for any kind of sensor to improve the network's lifespan. A collection of sensor hubs is usually described as clusters. In this group, an exceptional hub called the cluster head (CH) and member hubs, known as ordinary nodes (ON), are utilized. The CH may choose high energy and is used for data gathering and transfer of other hubs to the base station (BS) (BS). In this kind of protocol, the messages that travel through the system may be reduced and the detected data can be sent by sensor hubs to the appropriate CH. The BS may gather data from all of the accessible CHs in the network through an intermediary CH, which solely depends on the kind of WSN architecture that is chosen. The CH senses information after receiving the information from the cluster member; this procedure is done to dispose of repeated information so that only the essential information is delivered. This kind of transmission is done to save energy because energy utilization is regarded as one of the main criteria in WSN selection.

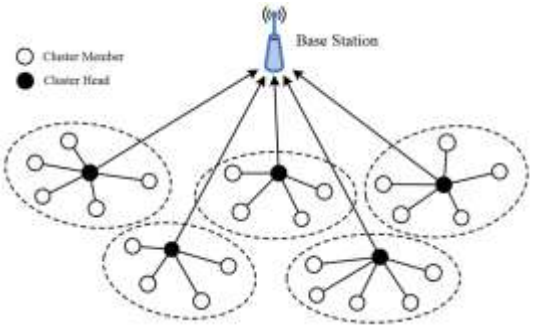

Figure 1: Clustering

Clustering methods typically improve scalability and substantially decrease radio transmissions. A definitive goal of clustering is to offer an answer that maintains dependability among sensors throughout the system's activity.

ADVANTAGES OF CLUSTERING

There are several demerits of the clustering method, outlined as follows: -

- It supports network scalability and reducing energy usage via data aggregation.
- It may concentrate the route setup inside the cluster and therefore decrease the size of the routing table kept at the node.
- It may also store communication bandwidth because it limits the scope of inter-cluster interactions to the cluster head.
- It eliminates duplicate passes of messages among sensor nodes.

DESIGN CHALLENGES OF CLUSTERING

- In a significant part of the WSN open-air applications in certain essential circumstances, such as those that are unattended, maintaining the battery is difficult. With this restriction, it is extremely difficult to prolong the lifespan of the network.
- Alongside the above-stated disadvantages, several other challenges, which need to be properly handled when developing clustering algorithms exist, are given below.
- For clustering protocols, the number of clusters and formation procedures are extremely important. Balance among clusters is extremely essential, and at the same time, message interchange during the creation of the clusters must be avoided.
- The algorithm complexity rises linearly as the network evolves.
- CH selection is extremely essential since it may directly influence the functioning of the system.
- The most ideal hub should be selected with the objective that the system steadiness period and general network lifespan should be extended.
- In most of the methods, CH choice relies on a few factors, for example, energy level and hub location.
- CH will receive the sensed data from the nodes on which the data aggregation procedure is conducted. Why the Procedure is the reason that these stages constitute the main structural difficulty.
- A clustering method should handle all kinds of applications since WSNs are entirely application-dependent.
- The clustering algorithm design must enable defense applications in which data are extremely private, for example, military applications and health monitoring
- Variable energy allocation gets difficult in several of the studies.
- While applying the clustering approach in a bigger network it gets complex and energy consumption will be progressively raised.

LITERATURE REVIEW

Fakhrosadat Fanian, Marjan Kuchaki Rafsanjani (2019) In today's world where all sciences and technologies, including Wireless Sensor Networks (WSNs), are dealing with the enhancement of the current solutions, we are searching for time-saving and cost-effective ways that reveal new methods and ideas in the intended area. Survey studies offer fast and complete access to these ideas in the targeted area. Having this motive in mind and considering the effect of the clustering process on regulating and managing energy consumption of WSNs, we concentrate on clustering and cluster-based multi-hop routing protocols to offer a comprehensive evaluation in terms of approach. In this survey, certain parameters are given for assessing the characteristics of the different techniques. Then, the investigated techniques are categorized from the viewpoint of methodology into four categories: classical approaches, fuzzy-based approaches, metaheuristic-based approaches, and hybrid metaheuristic- and fuzzy-based approaches. In each category of the classification, criteria and parameters are given according to the kind of methodology to assess the methods; thenceforth, all methods in each class are evaluated in terms of the clustering-based parameters and methodology-based parameters and ultimately discussed. To provide accurate and useful information and motivate audiences, this evaluation, regardless of providing a useful assessment, intends to propose a new approach for examining methods by considering the methodology-based parameters such as capabilities and constraints, examined inputs and outputs in each method, type of algorithm used in the methods, the purpose of using algorithms, etc. This survey may be helpful for researchers as the

beginning point for a fast knowledge of inadequacies and deficiencies in this area to carry out additional studies in the future.

I.S. Akila, S.V. Manisekaran, and R. Venkatesan (2017) Wireless sensor networks (WSNs) are used in different applications from healthcare to the military. Due to their restricted, small power sources, energy becomes the most valuable resource for sensor nodes in such networks. To improve the use of energy resources, experts have suggested various solutions from diverse perspectives. Clustering of nodes has a significant function in saving energy of WSNs. Clustering methods concentrate on addressing the conflicts occurring ineffective data transfer. In this chapter, we have described a few contemporary energy-efficient clustering methods to enhance the lifespan of WSNs. The suggested clustering techniques are: I fuzzy-logic-based cluster head election, (ii) efficient sleep duty cycle for sensor nodes, (iii) hierarchical clustering, and (iv) predicted energy harvesting. Classical clustering techniques such as low energy adaptive clustering hierarchy (LEACH) and chosen current clustering methods are examined for assessing the performance of suggested approaches. The suggested contemporary clustering methods show improved lifespan compared to the chosen benchmarked procedures.

Geetha. V, Pranesh.V. Kallapur (2012) Every kind of network, whether it wired or wireless, will be affected by numerous essential elements for its effective operation. The routing problem, relevant to all kinds of networks, is one of the many such important issues. Wireless Sensor Networks (WSN) have not been an exception to this. Moreover, such problems are extremely important owing to severe resource limitations including efficient energy use, the lifespan of the network, and harsh environmental conditions in WSNs. Neither hop-by-hop nor direct reachability is available in the case of WSNs. In this respect, several routing methods have been suggested to improve the efficiency of WSNs despite the above-mentioned severe resource limitations. Out of these, clustering algorithms have acquired greater significance, in extending the lifetime of the WSN, because of their approach in cluster head selection and data aggregation. LEACH (distributed) is the first clustering routing protocol which is shown to be superior compared to other similar algorithms. This article extensively analyses two significant clustering protocols, namely LEACH and LEACH-C (centralized), utilizing NS2 tool for various selected situations, and analysis of simulation results against chosen performance measures with latency and network lifespan being prominent among them. The article will be completed by discussing the findings obtained through analysis of results regarding these procedures.

OPTIMIZATION-BASED CLUSTERING MECHANISMS

Several optimization-based clustering algorithms were developed in earlier days such as ant colony optimization (ACO), artificial bee colony optimization (ABCO), fuzzy logic (FL), genetic algorithm (GA), whale algorithm, particle swarm optimization (PSO), and so on.

The researcher presented a comprehensive study of ant colony optimization (ACO) for WSNs. This project evaluated QoS factors, such as energy consumption, bandwidth, latency, dependability, and data aggregation. Favorable conditions and hindrances of ACO-based routing protocols for a WEN were further studied. The main benefits of this method are that it may decrease energy usage and will improve the bandwidth and message success ratio. The downside is that it may increase the network latency.

The researcher attempted an “artificial bee colony optimization” (ABCO)-based LEACH method about varied WSN circumstances by altering the number of rounds and matching the number of sensor hubs. Many factors, for example, dead and active hubs each round and packet to the BS per round were evaluated for execution evaluation. Examination of every parameter beginning with an ordinary LEACH was also added. The main benefits of this method are that it may decrease energy usage. The downside is that it may enhance the interference of the network.

In a review by the Researcher, a wide survey of the ongoing progressive methods dependent on computational intelligence (CI) or machine learning (ML) were examined. To accomplish this task, the calculations were grouped for different CL uses, which could be fuzzy logic (FL), genetic algorithm (GA), neural network (NN), reinforcement learning (RL), or swarm intelligence (SI). To assess and analyses these uses, several parameters, such as data aggregation, data delivery rate, and scalability, were selected. The main benefits are that this technique helps to improve the network lifespan and the quality of service of the network. Due to the integration of the hybrid model, it may enhance the interference of the network.

Wang developed a whale algorithm-based optimization model for WSN. The mathematical concept of hub inclusion in WSN was developed to achieve complete inclusion for a region of interest. For the model, switch learning is introduced into the initial whale swarm streamlining computation to improve the underlying appropriation of the population. This approach leads to an improvement in hub searchability and speeds the global search. The result of this study demonstrated that this method may viably increase the inclusion of hubs in WSN

and boost system execution. The main compensation of this procedure is that it improves the energy efficiency of the network. The downside is that it may increase the network's end-to-end latency.

A review by researcher, Researcher investigated different optimization techniques, such as particle swarm optimization (PSO), artificial bee colony (ABC), ACO, and GA. These techniques are utilized to enhance the performances of different parameters, for example, decreased power consumption, optimum route, and target coverage. ACO and ABC provide high accomplishment rates and longer system lives, particularly for a basic system but for a thick system, they do not perform well. The main benefits are that this technique helps to improve the network lifespan and the quality of service of the network. Due to the integration of the hybrid model, it may enhance the interference of the network.

The researcher provided a review of a PSO-based clustering study. The main reason for choosing the PSO method for clustering is the minimal number of parameters that need to be changed. Single shape, with minor variations, works excellently in a broad variety of applications. PSO has been used for methods that may be utilized across a broad scope of applications, for example, picture segmentation, design of the system, clustering of web usage data, signal processing, pattern recognition, classification, and multi-objective optimization. The hybridization of PSO with other transformational computations, such as GA and differential evolution (DE) has proven a valuable technique for increasing PSO proficiency and accuracy. The main benefit of the model is it may improve the accuracy of the network. The disadvantage is that it may decrease the accuracy of the network.

CONCLUSION

In this study, we have studied the optimization of route-based clustering in wireless sensor networks and we concluded that a significant strong method for preserving the energy efficiency of a sensor network is through energy restrictions of sensor hubs and the capabilities of the clustering architecture. In wireless sensor networks confined energy is a crucial problem. Many pieces of research have previously been conducted to offer different methods of reducing energy consumption in a diverse networking environment. Clustering is one of these methods that accomplish improved energy consumption by dividing the whole network into different clusters. Nonetheless, there are several difficulties or issues to be addressed. As a future scope, we may plan to consider residual energy for the selection of CH, threshold distance between CH and BS for better energy usage that may improve the network lifespan of the network. In the future, we intend to expand our work into other areas of WSN, for example, body area networks, battery-powered sensor systems, and mobile sink planning.

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Corresponding Author

Ambika Mangalgi*

Assistant Professor, Department of Computer Science and Engineering, Bheemanna Khandre Institute of Technology, Bhalki