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A Review Paper on Energy Efficient Clustering Schemes for WSN Assisted IOT Networks

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"Abstract":WSNs have seen a large improvement in their applications in recent years. WSNs are self-organized, non-wired networks that monitor ambient conditions such as temperature, tension, motion, audio, vibration, or contaminants and transmit data. Because of its sensor-based working standards, the WSN is becoming a common topic among numerous investigators. Clustering is a method used in WSNs to extend network lifecycle & provide more effective operating processes. Clustering is a topology management method that can gather nodes to boost efficiency of the network by controlling resources and distributing duties between many nodes in an adequate way. It divides a sensing field into clusters where cluster's sensor node can be appointed as cluster head. The cluster-dependent routing protocol is a very energy-efficient technique of choosing and relaying information to the CH. Optimized clustering could save a significant amount of energy in the system. This review examines a variety of energy-efficient clustering methods utilized in the wireless sensor area.

Keywords: WSN, Energy Efficiency, Clustering, Cluster Head, Clustering protocols.

I. INTRODUCTION

The Internet of Things is presently viewed as a developing area of study. Because of their minimal price, ability to interact with one another, and simplicity of deployment, IoT meet the needs of many smart apps. Today, IoT is regarded as a blend of heterogeneous networks that poses similar security problems as a WSN. A typical WSN consists of

millions of nodes. Sensory nodes can interact with one another via radio transmissions [1]. Nodes for wireless sensors contain power sources, computation hardware, radio transceivers, and detectors. SN in WSN is naturally resource constrained, with limited processing

power, storage areas, and communication bandwidth. After installation, sensor nodes are in control of self-organizing an appropriate network infrastructure and interacting with them quite often across multiple hops. The self-organizing ability of a system enables it to instantly join new nodes with no demand for manual intervention. These systems are made up of a wide series of tiny as well as low-cost devices known as nodes and one or even more base stations known as sinks. These nodes transmit data to the BS.

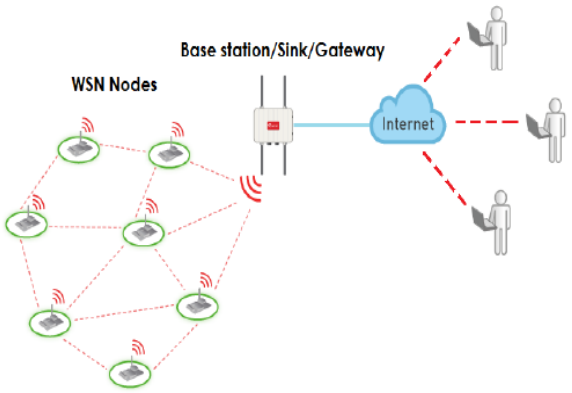

Fig. 1. Architecture of WSN [2]

The base station acts as the central hub for all nodes, whether stationary or mobile, that collect data from sensor nodes and perform complex data processing. Figure 1 depicts a basic WSN structure. It is made up of sensor nodes, a sensor network, users, and the Internet. When source nodes forwards information to Base Station (BS), they consume a substantial amount of energy. As a result, they must rely on intermediate nodes to function. Scientists have successfully used WSNs to identify the beginning of forest fires by varying temperature and humidity levels, as well as to prevent earthquakes by sensing minute soil adjustments that could lead to a large earthquake [3]. WSNs help farmers in a number of ways, as per reports, such as waste reduction, irrigation mechanization that inspires more effective water use, and wiring repairs in difficult places. There are five

basic directions in which current issues in WSNs might be broken down. These directions necessitate the attention of researchers. Despite the fact that those difficulties have been examined in various studies, there is still a need to address them in more depth such as scalability, mobility, cost of production, security and energy efficiency [4].

Thus, the structure of this article is as follows: section II describes clustering in WSNs and Section III presents information about clustering protocols Section IV describes literature review. Section V finally concludes this paper.

II. CLUSTERING

In recent years, the difficulties associated with energy constraints, due to the limited quantity of energy stored in the battery are inceasing. Because the operation of nodes is entirely dependent on the quantity of energy available, charging and replacing the battery unit is a difficult task. If any network device fails to operate, the entire network fails [5]. SN clusters are formed in clustering concepts, or each cluster is allotted a CH. In this configuration, all SNs initially send information to the CH selected in their cluster, and then these CH transmit data to the BS server. Every cluster has a number of members, and each member is managed by one or more CHs, which also fuse, process, transfer, and manage member data. Every network also has one or more BSs that can act as local data processing units or gateways. Data from CHs is received directly or indirectly by BS(s) via intermediate nodes, which connect the CH and BS. Clustering is usually divided into two stages: grouping nodes and assigning responsibilities. Clusters are various (and unequal) parts of network environment. Each cluster has its own set of nodes and communicates with others via gateways or CHs.

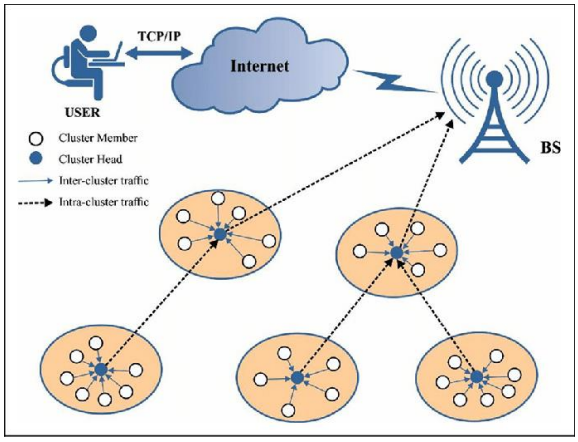

Fig 2: Clustering in WSN [6]

Clustering algorithms have applications in many fields, including visualisation, sampling, theory, computer animation, neural networks, intelligence, and statistical data. Clustering algorithms are used in unattended training scoreboards, proximity studies, time-series forecasting, text analytics, and browsing. The scientific community has repetitively suggested clustering in sensing devices as a solution to sensor network expansion, energy usage, and life problems. Because clustering algorithm limit interactions within local domain, data only must be moved between Internet nodes. CH will create an aggregate group Node to monitor neighbourhood interactions among cluster members [7]. There are many ways to classify the clusters of which the two popular classification are: Heterogeneous and Homogenous clusters, Static and dynamic clusters. Clustering is a key paradigm for creating secure communication between sensor nodes. It offers a better way to get started with secure communication. Clustering algorithms are mainly important for two reasons Sleep scheduling and Density control in the WSNs [8]:

- **Sleep scheduling:** The scheduling of the service cycle in a cluster can not only extend the network's lifespan, but also synchronize usage of resources in the wide network.
- **Density control:** Enabling partial sensors in the network can decrease network density and prevent conflict in the MAC layer. This will reduce delay and retransmission energy consumption.

III. Energy Efficient Clustering Protocols

This section goes through several clustering protocols used in WSNs, with an emphasis on CH selection. These protocols are further categorized into four kinds i.e Grid Schemes, PSO-Based Schemes, Hierarchical Schemes and Miscellaneous Schemes [9]. Various clustering protocols are discussed below:

- **Fuzzy c-Means:** FCM methodology groups various nodes into clusters to a certain point. This approach was invented by Dunn in 1973, and it was enhanced by Bezdek in 1981. This is soft clustering approach where every data instance is given a probability score for belonging to corresponding cluster. FORTRAN IV program is used for the FCM clustering [10]. The data point can belong to more than one cluster with a probability in the fuzzy c-means

method. This technique allocates a data module to belong to numerous clusters. FCM works via minimizing objective function. Clusters are identified using fuzzy c-means based on distance and intensity, which vary depending upon the application or datasets. Fuzzy c-means has a higher time complexity than other clustering techniques since it uses an iterative process to identify the appropriate cluster centers. This technique has a wide range of applications in picture segmentation, business analytics, image processing, and WSNs. For overlapping data sets, fuzzy c-means clustering produces superior results when compared to other protocols.

- **Stable Election Protocol:** SEP is a modification to LEACH technique. This heterogeneous protocol extends period before first node dies, that is necessary for number of applications. SEP offers a greater average output and longer stabilization time [11]. Comparing grouping of SEP and LEACH protocols, they are identical.
- **Z-SEP:** Zonal-SEP is created for heterogeneous networks. They have two kinds of nodes: advanced nodes, and regular energy-based nodes. Zone 0, Zone 1 and Zone 2 are three distinct fields. Standard nodes are only used in zone 0 to decrease energy consumption and direct transfer of data to the BS occurs in this zone [12]. The stability period of the network increases around 50% by varying the usage of resources. Advanced Zone Stable Electoral Protocol is heterogeneous routing protocol in which sensor node connects with BS directly. The Z-SEP protocol uses multi-hop communication among nodes and BS. Various assessments such as changing the location of BS and number of nodes are used to determine Z-SEP.
- **K-means Clustering:** It identifies groups in data, with group numbers shown as variable K. The algorithm allocates each point of data to a group iteratively. The data points are grouped together based on their related qualities. The K-means method finds k centroids and assigns each instance to the closest group. The 'means' relates to computing data's average value in order to determine the centroid point [13].
- **HEED:** In Hybrid Energy Efficient Distributed algorithm, a distributive clustering method is implemented for saving energy and communication costs. It is an iterative clustering in which residual energy of node is considered to pick a cluster head that is most appropriate for communication. This protocol takes two factors into account when determining cluster heads: residual energy of node and node density. HEED protocols for homogeneous WSN offer a comprehensive solution for extending the lifetime of sensors [14].
- **LEACH:** Its a TDMA-based MAC protocol which performs clustering to maximize WSN lifespan. LEACH aims to minimize amount of energy used in design and maintenance of clusters. All nodes that aren't cluster heads interact with the cluster head in TDMA manner, as per schedule created by CH. They accomplish so by using the least amount of energy possible to reach CH. The working of LEACH is done in multiple rounds (having two stages) and these stages are can be further divided into number of sub phases. In LEACH, every round having setup phase in which clusters are developed followed by steady phase where actual transmission of data is performed [15].

IV. LITERATURE SURVEY

Many methodologies that are used to create energy efficient networks are described below in which cluster heads are elected based on optimization approaches. In many papers, Clustering in WSNs has been done with the help of nature inspired optimization approaches. Some of those are reviewed and discussed below:

D. Sharma et al [16] suggested novel routing protocol in this paper which primarily depends on Improved Energy Efficient Chain Based Routing. It employs the HBO for optimal node selection operation. To improve Honey Bee Optimization-based IECBR, they enhanced HBO based on autonomous localization, which confirms that nodes aren't depleted of energy beyond their threshold, because load is distributed among nodes, and strength of node in minimum route has attained threshold. Modified H-IECBR is the name given to this new routing protocol (MH-IECBR). MH-IECBR outperforms other methods as per network lifetime.

Altakhayneh et al [17] presented a Genetic LEACH) algorithm which is tested for 100 nodes in aspects of alive nodes, energy usage, cluster head count, and packet delivery to CHs. CH is chosen by using a genetic algorithm that can identify the most efficient CHs. Stability zone of G-LEACH is 358 rounds larger than LEACH because first node in G-LEACH dies after 1544 rounds. That means that using G-LEACH extends network's lifetime by 61.7% and increase CHs efficiency by 10%.

P. Maheshwari et al [18] used Butterfly Optimization in this study to select CH among various nodes and reduce overall energy usage while enhancing network lifetime. Residual energy of nodes, distance to BS and node degree are used to optimise CH selection. ACO finds best route among CH and BS based on node centrality. Proposed methodology is examined with metrics like alive and dead nodes, energy usage, and datagrams obtained at BS. The outcomes of suggested technique is contrasted to LEACH, DEEC, FUCHAR, CRHS, BERA, CPSO, ALOC, and FLION. Proposed methodology has 200 alive nodes after 1500 iterations i.e. greater than CRHS and BERA.

S. Arjunan et al [19] introduces Fuzzy logic-based Unequal clustering algorithm and ACO based Routing in this paper to remove hot spots and enhance network lifespan. Cluster formation and inter-cluster routing are part of this protocol. FL efficiently chooses CHs and segments network into unequal clusters based on remaining energy, distance to BS and neighbouring nodes. It employs ACO for inter-cluster routing between CHs and BS. Furthermore, it transfers data in hybrid mode, that is, both proactive and reactive. In addition to periodic data transfer, a threshold value is used to inform about instant needs in network. A new routing approach is also used for proper load balancing, in which threshold-based data transfer occur in smallest route and periodic data transfer occurs in unused routes. For uniform load distribution, the cross-layer cluster formation is also used. The proposed method has been extensively tested and contrasted to LEACH, TEEN, DEEC, and EAUCF. It achieves better lifetime, removes hot spots, and efficiently balances energy usage across all nodes.

A.M. Bongale et al [20] describes a CH selection approach for WSNs relying on FA and Harmony Search Algorithm in this paper. Suggested hybrid protocol make following contributions to avoid problems caused by early convergence in nature-inspired optimization techniques. HSA in first stage finds CHs that are isolated from one another by some distance. The firefly algorithm refines the tentatively chosen CHs by taking into account node density and energy consumption. Secondly, cluster formation approach is followed in which a node has the option of joining a CH based on distance or residual energy of CHs. This cluster formation process aids in the reduction of energy usage. Suggested scheme when implemented using NS 2.34 performs better than LEACH, LEACH-C, EOICHD and firefly routing protocol in terms of alive nodes, energy usage, throughput along with First, Half and Last Node Dead.

H. Chen et al [21] proposed ant colony path optimization-based clustering energy-efficient transmission protocol (CEETP-ACPO) for WSN. Distributed cluster computing selects CHs based on node's energy. Secondly, optimal route is chosen by using improved ACO. Next-hop range of nodes is controlled by ring-angle search model and transition probability is assessed by pheromone and proximity of node. Outcomes reveal that proposed protocol work better than others.

X. Zhu et al [22] proposed PSO for routing optimization in this paper. It develops and enhances the mutation operator. This method can find optimized route and solution quality better than genetic algorithm. The results of experiments confirmed that suggested PSO-WSN technique can avoid local minima and therefore has more convergence than GA-WSN. Meanwhile, it has a very higher accuracy, which helps with classification.

S. El Khediri et al [23] suggested K-means clustering technique for WSNs. Given the limited amount of space available, this method manages node energy usage and improve WSN running time. Since there are many nodes and radio channel is not stable, the development of clusters is organized as a k-means sample space partitioning. After measuring total energy usage, best CHs are determined based on network size. For objective function, distance between CH and node is measured, and membership weight are considered. We propose Optimal K-means, a method for forming multiple node clusters that use an improved K-means clustering (OK-means). Authors propose K-means clustering for intra-cluster interaction, whereas inter-cluster interaction uses a multi-hop interaction. Performance is evaluated in Ns-2 simulator. According to the simulation results, suggested technique obtains even distribution in the spatial domain of CH. As a result, energy consumption is properly balanced. Furthermore, extensive simulations with varying node densities have been run to demonstrate OK-means' full potential.

B. Jain et al [24] EKMT is a low-energy k-means clustering technique that is based on the concept of locating CH by minimizing sum of squared distances among nearest cluster centres and sensor nodes, and shortest distance among CHs and BSs. It is partition-based algorithms for grouping patterns in a data collection. By re-selecting CH from all potential CHs based on minimum distance between new chosen CH and BS, the suggested protocol attempts to decrease energy usage of network while reducing throughput and delay

M., Mohapatra et al [25] concentrated on an effective CH election technique where CH location is rotated among nodes with greater energy in this research. The algorithm takes into account initial energy, remaining energy, and an ideal value of CHs to select next set of CHs for network which is appropriate for IoT applications like smart cities etc. According to simulation results, the modified version outperforms LEACH by enhancing throughput by 60%, lifespan by 66%, and remaining energy by 64%.

V. CONCLUSION

WSNs continual development has resulted in a vast area of research in this subject. Sensors depend on the energy of the nodes which cannot be refilled or recharged. As a consequence, establishing an energy-efficient network is crucial in order to extend the network's lifespan. Due to the significance of clustering as an effective solution for minimising energy usage in WSNs, this article considers clustering approaches. These approaches provide information about cluster formation, CH selection and unequal clustering. Different approaches are used in several established studies such as nature inspired approaches to investigate clustering aspects in WSNs. These optimization appraoches are more efficient than traditional based methodologies in selecting CHs. A comparison of various prominent clustering algorithms for creating energy efficient WSNs is presented in this paper.

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