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A Brief Survey on Cluster based Energy Efficient Routing Protocols in IoT based Wireless Sensor Networks

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Abstract—The wireless sensor network (WSN) consists of a large number of randomly distributed nodes capable of detecting environmental data, converting it into a suitable format, and transmitting it to the base station. The most essential issue in WSNs is energy consumption, which is mostly dependent on the energy-efficient clustering and data transfer phases. We compared a variety of algorithms for clustering that balance the number of clusters. The cluster head selection protocol is arbitrary and incorporates energy-conscious considerations. In this survey, we compared different types of energy-efficient clustering-based protocols to determine which one is effective for lowering energy consumption, latency and extending the lifetime of wireless sensor networks (WSN) under various scenarios.

Keywords- WSNs, IoT, LEACH, ECHAT,TCBDGA.

I. INTRODUCTION

The wireless sensing networks (WSNs) and the Internet of Things (IoT) both rely on the sensor node as their primary building block. As a result of developments in sensor technology, it is now possible to create sensing devices that are extremely small, require very little power, are capable of programmable processing, can detect numerous parameters, and can transmit data wirelessly. Additionally, the low price of such sensors makes it feasible to construct a network of hundreds or thousands of them, which in turn boosts the information's accuracy, reliability, and area coverage. This is made possible by the fact that the cost of these sensors is so low. WSNs have many advantages over their wired counterparts, including as ease of deployment, greater coverage area, immunity to node failure, and the ability to self-organize. However, wireless media has some built-in drawbacks, such as limited bandwidth, erratic transmissions, the need for collision-free channels, etc. The wireless nodes also get their power from a portable battery because they are often transportable and do not have a reliable power source. Thus, the node's ability to access energy is limited.

Data gathered by sensors is transmitted to adjacent CHs through multi-hop routing and mobile equipment (ME) then pass by cluster heads to gather the data. In this article, a hybrid strategy known as node density based on clustering and multiple mobile collections (ND-CMMC) is presented. Taking into account a number of sensing area has distributed deployments of sensors, Initially, we suggest a new cluster head selection technique based on Regarding the node density, A node's density property is the quantity of its auxiliary nodes inside a specific range [1].

This translates to the areas where nodes are more thickly deployed tend to form clusters, and there are more nodes at the regions' centres most likely to be elected as CHs.

WSNs are widely accepted in a variety of application fields. Below is a list of a few of them. Agriculture, habitat, home intelligence, forestry, health, vehicular networks, and underwater monitoring Military applications, Natural disaster relief are just a few examples of the monitoring that is done. WSN architecture are explained in the below figure 1. Energy-efficient device nodes are used extensively in

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industrial settings. To meet specific application goals, data from the environment is gathered by a group of sensor nodes.Transceivers can be used to enhance node-to-node communication.

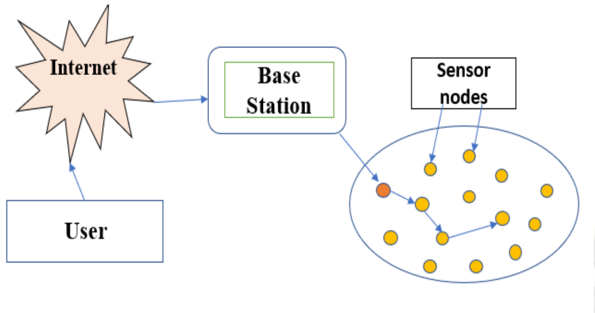

Figure 1. WSN Architecture Diagram

II. RELATED WORK

W. R. Heinzelmanet.al., proposed this paper. LEACH is regarded as being the most well-liked clustering method for WSNs. The LEACH method is well-known not only for its efficiency and clarity, but also for introducing cluster head rotational theory. The load-balancing necessity for the networks of the sensors is met by the rotating of cluster heads. The lifespan of the LEACH algorithm is divided into a number of rounds. These rounds each have a setup and stabilisation phase. In the cluster setup phase, the CH is chosen, and during the stable stages, sensors managed to pick up activities and deliver messages to them via CHs. By utilising the signal strength received, all CHs in LEACH simultaneously announce their responsibilities to the other sensors, causing the other sensors to join the closest cluster heads [2].

AkhileshPanchalet.al., developed ECHAT algorithm. ECHAT, which stands for energy-efficient Cluster head selection with adaptive threshold, the dynamic CH selection approach that is effective and uses adaptive threshold and the node's residual energy. This approach offers greater WSN coverage [3].

PadmalayaNayaket.al., proposed fuzzy based clustering protocol. The concept of fuzzy logic has been proposed as a clustering strategy for wireless sensor networks. One superior cluster head (CH) is chosen by the cluster heads to represent them in transmitting the data to a mobile station by using appropriate fuzzy descriptors. The concept of sink mobility combined with fuzzy logic significantly lengthens the network's life [4].

A TCBDGA algorithm was created by C. Zhu et al. For mobile sink industrial WSNs and Networks for Security and Communications, an innovative new approach to data collection is tree cluster-based (CB). This article presents TCBDGA, a tree cluster-based (CB) data collection method with a transportable sink for condensation. The authors suggested a distributed technique that develops a cluster structure and selects rendezvous node (RN) that have sufficient energy for an adequate amount of time and are close to the mobile synchronisation point (MS). The cluster scheme of this technique generates a cluster structure with different sizes. The size of each cluster has an inverse relationship with the separation between cluster heads along the MS path. The suggested protocol reduces network power and can be applied in a variety of applications, such as industrial settings with significant amounts of diverse sensory input [5].

Jainendra Singh et.al., proposed this research work. It also featured an energy-efficient opportunistic routing method and a fuzzy-GWO approach. The GWO, a relatively recent technique that can be enhanced in a various way, is used to choose the CH. A novel effective routing technique that balances and lowers power consumption among nodes inside a WSN [6].

In this study, G. N. Basavaraj et al. established the MH-LEACH routing mechanism, which is based on the ideal number of cluster head, based on residual, average distance, and nearer nodes to the BS. The lifespan of sensory nodes in a network is determined using this approach in units of "rounds." When a sensor node's energy falls to zero, it is ignored for the network's subsequent CH election. The node's initial energy and consumed energy are subtracted to calculate the remaining energy for each round. The underlying idea behind increasing network lifetime is explained via the MHLEACH protocol technique. The MH-LEACH routing protocol maintains a balanced number of CHs while also determining an average distance to save energy [7].

S. Gupta et.al., developed IDE-LEACH. It employs single-hop network communication. IDE-LEACH verifies that nodes that are far from the mobile sink will become cluster heads only if they have sufficient energy to carry out this function. It enhances the lifetime of the WSN network in a stable region. It uses long-lasting energy and a large-scale mechanism for choosing cluster heads to get the most out of network energy [8].

III. WIRELESS SENSOR NODE ARCHITECTURE

A Wireless Sensor System (WSN) is a special type of ad-hoc network made up of a collection of sensor nodes that cooperate and are dispersed throughout an area to independently monitor environmental or physical occurrences. The sinks and the sensor network are the two major components of WSNs. A WSN can have anywhere from a few hundred to a thousand nodes that talk to each other over

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wireless channels. So, each node has a radio transceiver, a processor unit, and at least one device that can measure things like temperature, humidity, light, pressure etc.

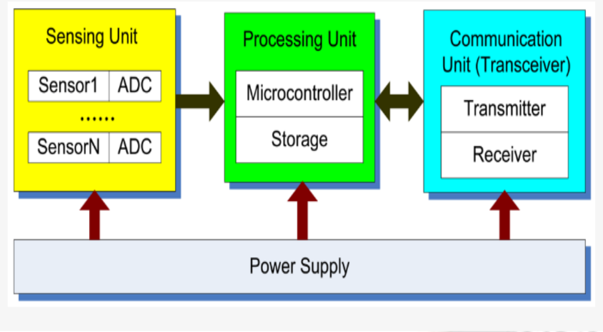

Figure 2.Wireless sensor node architecture

In this sensor node architecture are explained in the above figure 2. The computer and processing power in these networks have been carefully regulated [9], and they contain a huge amount of tiny, geographically scattered embedded devices which are networked to properly gather, process, and convey data to the administrators. In networks, nodes are the individual computers that work together to create larger networks. The sensor network is a wireless, multipurpose, and

Routing Protocols in WSN

The routing protocol struggles to identify the best relay node within the communication range. In order to conserve as much power as possible, the collected data must be transmitted to the BS. Identical values may be detected by adjacent sensor nodes if they are within the exact same transmission range. The data is gathered by the relay node and delivered to the base station efficiently. As a result, constrained sensor nodes at the various levels of a hierarchical structure Wireless sensor networks have a finite amount of power, so it's imperative that their activities minimise power consumption. Making an efficient routing method for WSNs is difficult because of their low power, processing capability, and memory size [10]. There are two types of protocols in WSN

- Cluster Based Routing Protocol
- Non-Cluster Based Routing Protocol

In this paper we briefly discussed about cluster-based protocol and its types.

Cluster based routing protocols

A wireless sensor network may have several sensor nodes. Every one of these sensor networks has a finite energy source and the ability to sense, compute, and communicate. When deployed in an ad hoc manner, the nodes' means of communication are wireless, and they self-organise. Energy efficiency is regarded as a very important issue in creating protocols due to the limited and non-rechargeable energy consumption of resources for such sensor nodes since it greatly influences the network of the sensor's life. Therefore, a collection of nodes is needed to form numerous tiny groups, known as clusters, in order to maximise energy efficiency and reduce transmission delay [11].

Clustering is a means of combining the sensor nodes, and the chosen node within each cluster is referred to as the cluster head. The Cluster Head (CH) is combining and delivering the sensed data to the base station from the other sensing nodes within the cluster (BS). When compared to other sensor nodes, a cluster head is thought to have greater capability and energy. Also, the cluster head uses less energy and makes it possible to scale for a large number of nodes. This clustering techniques are represented in the below figure 3.

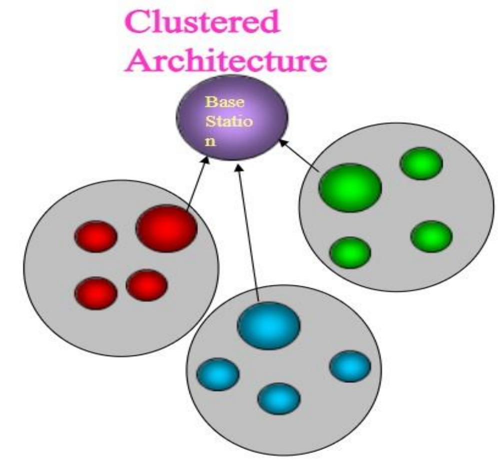

Figure 3. Larger nodes denote Cluster Heads

Cluster Objectives and Advantages

Due to the inherent resource limits in energy utilisation and communication, node clustering techniques have been employed to achieve energy efficiency and flexibility in WSN applications. By gathering and organising the nodes into a hierarchy, clustering offers a flexible and effective network topology for sensor node interactions. Clustering algorithms in WSNs have a big impact on how well the system can adapt, how long it will last, and how efficiently it uses energy. By performing data fusion and aggregation as well as reducing the quantity of messages sent to the base station, it is an effective and acceptable technique to reduce energy consumption through a cluster [12].

The cluster head selection

In cluster-based protocols, choosing a cluster head is regarded as the initial step. It is also referred to as the local coordinator, and the cluster manages a variety of duties, including information gathering within the cluster, data processing integration, and aggregation of sent data for the global sink. The choices for the cluster head rely on the variations in the

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parameters. Additionally, the placement and quantity of cluster heads affect how the nodes are divided into clusters. In order to improve network performance, preserve network longevity, and maximise energy efficiency, the clustering algorithm's selection of the cluster head is crucial to the procedures that follow.

Steps to be followed to select a cluster head (CH)

1. Give total area of the system.
2. Give total no of sensors in the network.
3. Give random location of nodes in network.

4. Similarly give location for all the sensor nodes
5. Perform clustering
6. Allotment of nodes to sensor(cluster) head.
7. optimization of sensor location using clustering.

In this step are explained in the below figure.

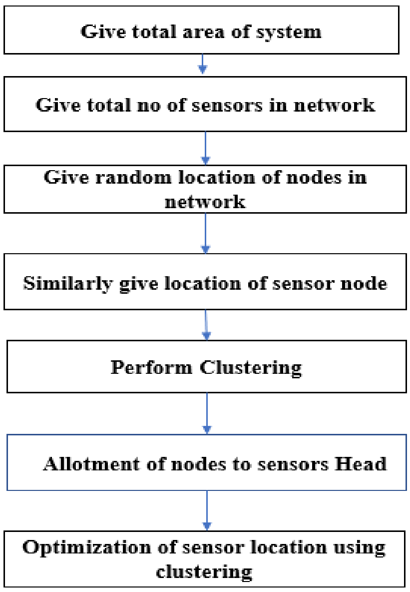


Figure 4. Clustering flowchart

Leach Protocol

A classic example of a hierarchical routing protocol is the LEACH Protocol. It is self-organizing and self-adaptive. Each round in the LEACH protocol consists of a steady-state stage and a set-up stage; the steady-state stage must be substantially longer than the set-up stage in order to cut down on unnecessary energy costs [13]. This protocol's primary objective is to prolong the life of the sensor nodes. LEACH's approach incorporates distributed cluster building at first. The LEACH technique chooses a few sensor networks to serve as cluster heads and uses randomness. To uniformly spread the residual energy among the network's sensors, they are rotated. Some traditional clustering methods pick a specific cluster head and fix it for the duration of the system, which causes them to degrade quickly. They also put an end to the nodes in that cluster's aggregate useful lifetime. However, in LEACH, the high-energy cluster head location is randomly rotated so that it alternates between different sensors in order to avoid depleting the battery of such a single sensor.

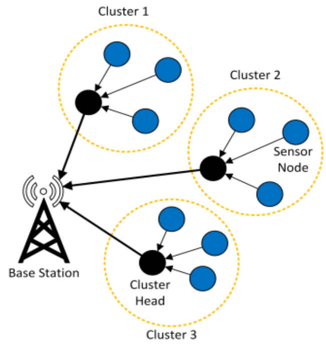


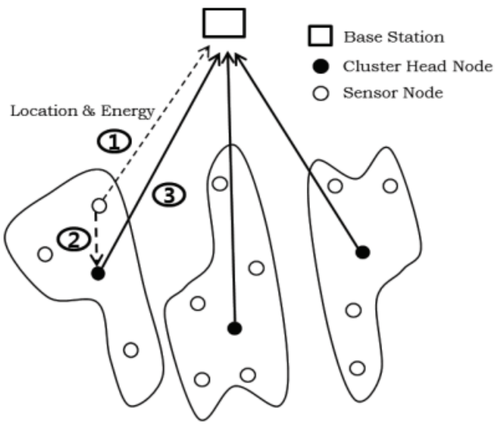
Figure 5: LEACH Protocol architecture

The LEACH procedure is divided into two phases: setup and steady state. The nodes form clusters during the setup phase, with one node chosen to serve as the cluster head. Every node generates a random number ranging from 0 to 1 if the random number it generated falls below a predetermined threshold, which is then evaluated as

$$T(n) = \begin{cases} \left(\frac{P}{1-p^*}\left(r \, mod \frac{1}{p}\right)\right), & If\ n \in G \\ 0 & \text{Otherwise} \end{cases} \quad (1)$$

Centralized Low Energy Adaptive Clustering Hierarchy (LEACH-C)

A centralised LEACH variant is LEACH-C.It is explained in the given figure 6 .The LEACH-C algorithm's premise is that each sensor is aware of its network placement and that the number and positioning of CHs are chosen optimally [14]. Utilizing energy efficiency metrics, the results reveal that LEACH-C outperforms LEACH by 40%.



Fihure 6: LEACH-C Architecture

LEACH-C is a centralized protocol that gives complete control for selecting the CH and building clusters to the Sink,

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which in turn produces more robust clusters. Similarly, to LEACH, LEACH-C can be divided into two phases of operation: the initial setup phase, which uses a centralised clustering mechanism, and the steady-state phase, which employs the same LEACH protocol. During setup and the beginning of each round, each sensor node will send its current location and residual energy to the Sink. So that it can build more effective clusters, the Sink calculates the sensor nodes' average energy, and for this round, the sensor nodes with energies just over the average are chosen to take participate inside the CH selection method. The Sink use a simulated annealing strategy to generate K-optimal clusters [15]. The Equation can be used to determine the network's sensor nodes' average energy E_{avg} (2).

$$E_{avg} = \sum_{i=1}^{N} \frac{E_i}{N} \qquad (2)$$

whereEi is the residual energy at the ith node and N is the total amount of sensor nodes.

Using this equation, we can get the optimum cluster size, K. (3).

$$k = \sqrt{\frac{N}{2\pi} \frac{\epsilon_{fs}}{\epsilon_{mP}} \frac{M}{d^2 toBs}} \qquad (3)$$

where ϵ_{fs} and ϵ_{mP} are the free-space transmission and reception circuit parameters; M is the sensing area; d to BS is the typical range between both the CHs and the Sink; and fp is the multi-path fading parameter.

LEACH-M

A cluster-head selection method based on LEACH-M with some tweaks. LEACH-M is a ZigBee-based protocol that makes use of the DAAM to fine-tune CH threshold equation by reconsidering the remaining energy and the network address. This results in a cluster structure that is comparatively stable and consumes less energy. Also, LEACH-M optimises the energy load on the network by using a cluster-head competing mechanism. This makes the network much more energy efficient and extends its life [16].

The residual energy can be calculated by,

$$T(n) = \begin{cases} \frac{p}{1-p[r \bmod (1/p)]} \times \left[w_1 \times \frac{E_{res}}{(1-r/n)E_{init}} + w_2 \times \frac{A_{i,j} - A_{i,j\,min}}{A_{i,j\,max} - A_{i,j\,min}} \right] & n \in G \\ 0 & n \notin G \end{cases} \qquad (4)$$

In order to equalise the network energy load, this part incorporates a cluster-head competitive process into LEACH-M. BS will tally the current E res of each node at the start of each round and then estimate the average energy $Eaver$ by

$$Eaver = \sum_{i=0}^{N-1} \frac{E_{res}^{i}}{N} \qquad (5)$$

I-LEACH

This protocol is mostly based on the MODLEACH protocol, which was the source of the LEACH protocol's inspiration. The network type is heterogeneous network. There are n nodes randomly distributed throughout the area. The primary region would be further divided into smaller sections, commonly known as "clusters." Each cluster consists of a number of nodes, one of which serves as the CH. Each CH gets data from each of its network elements and applies the required compression iterations. The compressed data is sent to the base station by all CHs. Within each cluster, all nodes are seen as either mobile or fixed, so the topology of the network doesn't change suddenly [17]. The I-LEACH architecture is given below figure7.

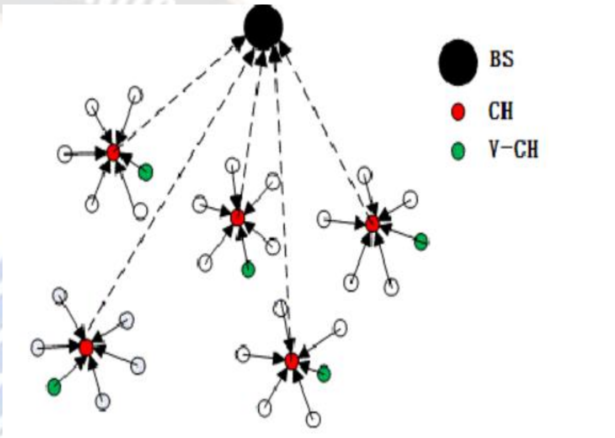

Figure 7: I-LEACH Architecture

DEEC

In the energy-efficient DEEC method, the CH is chosen based on how much energy is likely to be left over. In the DEEC protocol, two types of node energy levels are used. In DEEC, both standard and advanced nodes are employed. The 2-level heterogeneous WSNs model is called DEEC. In DEEC, advanced nodes are utilised to choose the CH depending on the nodes' remaining energy. The sum of the initial energies of the network's advanced and regular nodes is the network's total initial energy. Two-level heterogeneous WSNs have (am) times more energy than homogeneous WSNs [18]. The DEEC protocol can function effectively in multi-level heterogeneous networks as well. The DEEC calculated the usual and advanced nodes using the formula below.

$$p_i = \begin{cases} \frac{p_{opt} E_i(r)}{(1+am)\bar{E}(r)} & if\ S_i\ is\ the\ normal\ node \\ \frac{p_{opt}(1+a)E_i(r)}{(1+am)\bar{E}(r)} & if\ S_i\ is\ the\ advanced\ node \end{cases} \qquad (6)$$

TEEN

The TEEN Protocol, which uses a data-centric approach and has a hierarchical structure, was developed for "Reactive

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Networks." The TEEN protocol is preferable in environments where abrupt changes need to be monitored, such as temperature changes, changes in humidity, etc. The "reactive network" is made up of those that respond to sudden fluctuations in the environment. This protocol makes use of two properties that become active when particular requirements are met. The terms "hard threshold value" (HT) and "soft threshold value" (ST) refer to these two characteristics. A value's HT Threshold refers to how closely it matches the predefined value above which the node that is sensing it must turn on and send its data to the "Cluster Head." A slight difference in the observed value, known as the ST value, should cause the sensed node to activate and communicate data to the CH. This technique chooses CH in a manner similar to the leach [19].

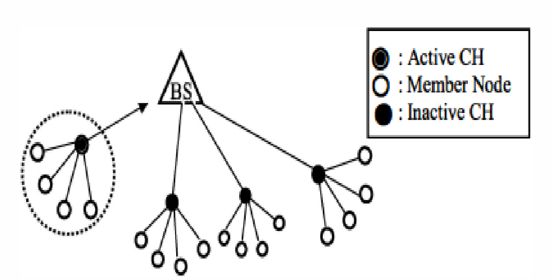

Figure 8. Illustration of TEEN protocol

FUZZY BASED CLUSTERING

A new cluster analysis method is presented to increase the lifespan of WSNs. In this approach, there are two distinct sensor types in the network field: clustered sensors that send observed data to the sink via pre-selected CHs and independent sensors that communicate directly with the sink. Using fuzzy logic, this approach selects open nodes and CHs using four fuzzy parameters. When picking free sensors, these variables include the amount of energy of the sinks and the proximity of the sensor to the sink, and when using CHs, they include the amount of energy of the sensor network and the centrality of the sensors[20].

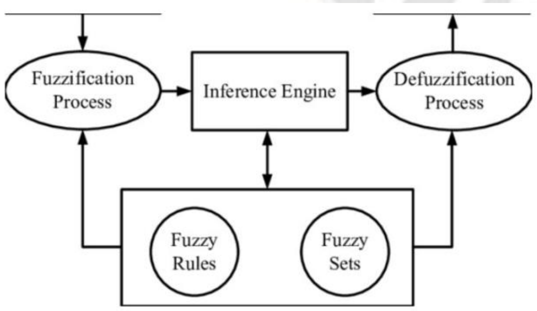

Figure 8a. Illustration of Process

K-MEANS CLUSTERING

The suggested plan makes use of the K-means method, which groups items into clusters based on their Euclidean distances from one another [21]. The suggested CH selection process consists of the following three steps:

Step 1: Initial clustering

The K-means technique is used to create clusters using the target WSN. Assume that there are k clusters in the n node WSN. First, the CHs are chosen at random from k–n nodes. Based on the Euclidean distance, each node in the network chooses the CH that is closest to it.

Step 2: Reclustering

Once each network node has been assigned to one of the k clusters, the median of each cluster is calculated. The centre of a cluster of nodes is determined using a two-dimensional space model.

$$Centroid(X,Y) = \left(\frac{1}{S}\sum_{i=1}^{s} x_i , \frac{1}{S}\sum_{i=1}^{s} y_i\right) \quad (7)$$

A cluster's centroid is a virtualized node that sits in the cluster's exact centre. The randomly chosen CH in the first round is indicated by a ringed sensor node in Figure 9's illustration of a clustering of 13 nodes. Figure 4 shows that the original CH isn't the one that is closest to the centroid; as a result, the closest CH is chosen to act as the replacement CH. The enboxed node is shown here. Step 2 is repeated with each cluster's new CH again until CH is no longer being altered.

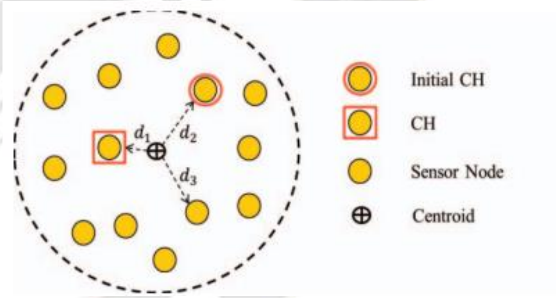

Figure 9. A cluster with the centroid

Following the clustering process, each node in a cluster is given an ID number based on its distance from the centroid, with the closer node receiving a lower number. The sensor nodes are arranged in Figure 9. The sequence to be selected as the CH is indicated by a node's ID number. Therefore, when choosing a node to be CH, the ID number is crucial. Every round, the CH's remaining energy is analysed to maintain network connectivity. The nodes in the following order are chosen as a new CH if the CH's energy is below the predetermined threshold. The newly chosen CH tells other nodes about the change in the CH shows in figure 10.

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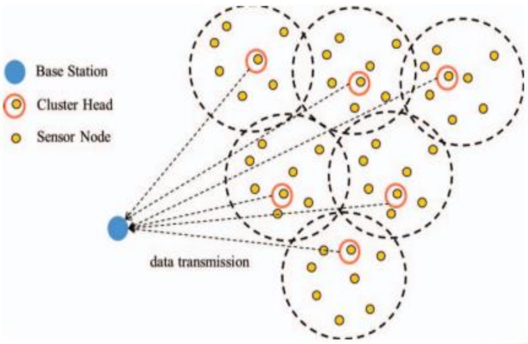

Figure 10. CH selection

V. CONCLUSION

Due to the limited energy resources available to sensors, one of the key difficulties in developing a cluster-based routing protocol for WSNs is energy efficiency. The main goal of the routing algorithm design is to prolong the network lifetime by keeping the sensors operational for as long as possible. Both data transmission and reception use the majority of the sensors' energy. Therefore, in order to increase the lifespan of individual sensors and, by extension, the network lifetime, the routing protocols created for WSNs must be as energy-efficient as possible.

By considering a variety of classification factors, such as geographic location, network architecture, energy efficiency, and network heterogeneity, we have examined a sample of routing algorithms in this study. We have talked about a few sample protocols in each of these areas. Future studies will concentrate on the routing protocols for sensor networks and how they integrate with wireless networks and IoT-based security WSN network applications. In order to do more analysis, data will need to be gathered from the sensor network. As more data is gathered, it is compressed using techniques called "compressive sensing" to reduce the size of the data and make the node last longer.

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