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New Approach in Clustering Technique to Improve Energy and Lifetime in Wireless Sensor Networks

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Abstract- Wireless sensor networks have the potential to monitor the environment for both military and civil applications, and they are becoming increasingly popular. Because of inhospitable conditions, these sensors are not always placed in a uniform manner throughout the area of concern. Because sensors are typically limited in their ability to provide on-board energy, efficient network management is critical to extending the life of the sensors. Sensors do not have the ability to generate energy. Support long-distance communication in order to reach a remote command site, which necessitates the use of multiple hops or the use of a gateway to forward the data on the sensor's behalf. Throughout this paper, an algorithm is proposed for grouping these sensors into well-defined clusters, with gateway nodes that are less energy-constrained acting as cluster heads, and for balancing the load among these gateways. The results of the simulation show that our approach can help to balance the load on the system while also extending its lifetime.

Keywords: Sensors, Clustering, BCH, FLS and DLR.

I. INTRODUCTION

The WSN's most difficult feature is that it limits energy resources and cannot refill them. The issue emerges when all of the sensor nodes send the information packets to sink node. Each node’s energy availability can be squandered due to collisions and overheard by unstoppable listening and broadcasting in this process. Cluster-based routing methods in WSNs efficiently manage and reduce network energy [1].

Small groups of sensor nodes are created using WSN clustering algorithms, each with a coordinator referred to as CH. In cluster- based approaches, the sensors do not need to be connected directly to the BS. On the other side, the CHs are in charge of arranging and submitting the data gathered within the cluster. As a result of this process, the amount of data broadcast to the network has been considerably reduced. As a result, communication overhead and band clustering will be reduced greatly [2-4].

Figure 1 depicts the overall perspective of the clustered WSN. The most difficult aspect of the procedures is maintaining the clusters that have been built. It is necessary to define a node's eligibility before it may be chosen as a CH. This is concentrated on local information regarding current nodes, such as their leftover energy.

However, because sensor nodes use energy to transmit data, the eligibility of selected CHs is lowered. CHs might be labeled as failed if their eligibility is decreased to a particular level. The deployed sensor nodes must be re-clustered in this situation. As a result, the sensor nodes are unable to collect data within the time range that has been set. The issue arises when the failure of the CH, which might result in immediate physical harm, is not anticipated. As a result, the CMs continue to transfer data to the malfunctioning CH, resulting in data loss.

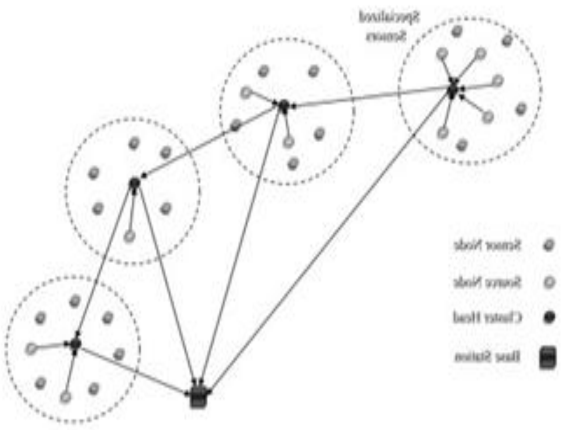

Fig 1. Cluster in Wireless Sensor Network.

Many approaches have been developed to examine the problem and propose using Backup CHs (BCHs) [5-7]. Figure 2 depicts the overall view of a clustered BCH nodes sensor. BCHs assume responsibility in these ways after established CHs are aware of their abilities to be CHs. They discovered that in the WSN, the BCHs are more successful in assuring cluster formation. However, these measures were insufficient in resolving the issue because they spend the majority of their time focusing on CH loss.

If they receive a warning, the CMs will be unable to determine whether or not their CHs are working or have failed to follow specified procedures. In addition, the momentary CH failure was not taken into consideration in these methods. Furthermore, it was presumed that the determined BCH would always be functional and would always be replaced by the specified CH node.

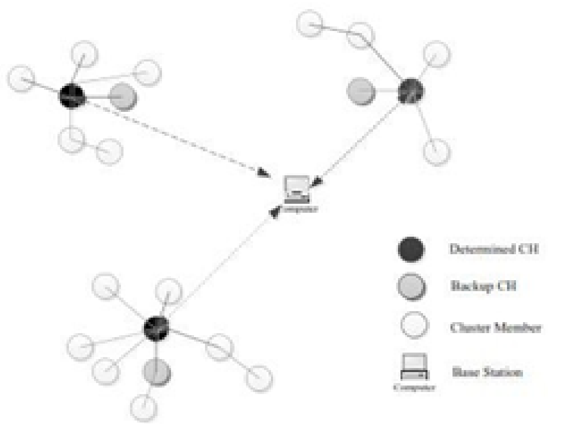

Fig 2. Clustering information.

Finally, only two BCH were considered in their protocols. Their expectations, on the other hand, are unrealistic. As the nodes not consume energy equally, there is no guarantee that the decided BCHs will always function entirely in a WSN. In certain instances, the BCH may be used more than the other nodes. The creation of the cluster does not also take into consideration a maximum of two BCHs.

II. PROPOSED WORK

A clustering mechanism is proposed for WSNs to overcome this problem. For the purpose of calculating nodes eligibility we are using the Type2 Fuzzy logic (FLS) [8] system and local node information. The node is designated as a CH with the highest level of eligibility. The remaining nodes are saved based on their determined BCH eligibility. As a result, in the event that a CH fails, each cluster still has a BCH. We consider both temporary and permanent failure in the CHs when substituting the BCHs with failed CHs. We also take into account both unpredictable and predictable CH loss. Wireless sensor nodes are strewn across a surface at random. The BS and the sensor nodes are both fixed.

Clustering involves locating and compiling CHs and CMs while covering the full deployment region. Clusters in the WSN are classified into two categories. The first segment is dedicated to the CHs' choosing. During this period, the sensor nodes are unable to collect and exchange data packets. After the cluster is built, the sensor nodes can gather and communicate data to one another. You consume energy when you receive and transmit data packets.

As a result, every sensor node is at risk of being disrupted by its energy loss. Because CHs are responsible for collecting and delivering data packets from other nodes to the BS, the amount of energy lost in them is often higher than in CMs. As a result, they are more likely to run out of energy. As a result, their areas of interest are unable to be tracked. The problem becomes more complex if the unsuccessful CH is not discovered. In this instance, the CMs continue to send data to the CH despite the fact that they are unable to receive it.

Because CH failure may be foreseen, CMs can be detected by a message. The CMs must then swap out the most optimal CHs for the CHs they've defined. However, identifying and replacing BCHs must be

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carefully considered. In the real world, installed sensor nodes do not all consume the same amount of energy. This means that the current node circumstances remain unchanged.

As a result, BCHs for the most appropriate node to be substituted by failure CHs have not always been established. Finding and introducing the best current BCH in CMs is a significant difficulty for CHs. The challenge becomes difficult if the CHs fail in an unpredictable manner. The CMs then continue to relay their data to the failed CHs without warning. As a result, the WSN could lose a significant proportion of data packets. To avoid data loss in the network, it is critical that the CMs determine the failure of CH at an early stage. The CMs must also locate and replace the CH with the BCH. WSN CH failure can be short-term or long-term.

If the issue is persistent, the node must be replaced to provide QoS in the Wireless Sensor Network. Because the components have been destroyed, this is possible. The transitory defect, on the other hand, is caused by temporary or erroneous environmental factors. It must also be realized that the failure of BCHs is not a transitory failure in order to replace them with failing CHs. This indicates that the network's short-term low density isn't a concern as long as it's connected.

III. SELF-CONFIGURABLE CLUSTERING

It is needed to select a suitable CH for each cluster to develop SCCH first. To do this, we develop a FLS to find the best CHs for the clusters. We develop the type-2 FLS. For the calculation of their eligibility as CH, FLS are used by the sensor nodes. The system's input is as follows;

1. Energy (E):
In the election of CHs with an acceptance of energy levels residual energy in candidates of CH is used. All nodes are conscious of their rest.

2. Central node (NC):
It is a value showing how central the node is to its mobile neighbors throughout the network. The lower the centrality value, the less energy the other nodes require to transmit the data as CHs. Eq is the definition of NC (3.1)

$$NC = \frac{\sqrt{M}}{NZ} \qquad (3.1)$$

where $M = \sum_{j\in S_{(i)}} \frac{d^2(i,j)}{|S_i|}$, d is the distance between the CH candidate i and its member nodes, $|S_i|$ in the number of neighbors of node i and NZ is the size of the sensing field area.

3. Local Distance (LD):
Summary of the distances to its neighbors from a deployed node. The sensor knot and its neighbors are shown within r radius in Figure 3.

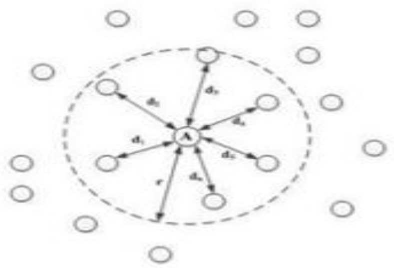


Fig 3. Deployment.

The calculation of radius

$$r = \sqrt{\frac{NZ}{\pi \,.\, |L| \,.\, P}}$$

Distance of Nodes within radius

$$LD_{CH} = \sum_{i=1}^{n} d_i$$

Next, the FLS output will be sent to neighbors for each sensor node by a beacon message. The beacon message structure for sending FLS output is shown in Figure 4.

Packet Type	Node-ID	FLS-OUT

Fig 4. Suitable Node.

When the message is given by the packet type, the node id shall be the message ID, and the system flask output shall be FLS-OUT. FLS-OUT must be checked for nodes from the other nodes. They compare FLS-OUTs with their calculated fugitive output and the received nodes. A highest FLS-OUT sensor node is presented as a CH. It is also listed in its FLS-OUT the other sensor nodes. The list contains the top-to-lower FLS-OUT order of the nodes.

The list gives priority to the BCHs sensor nodes. Consequently, the lower FLS-OUT sensor node knows that it is a higher FLS-OUT BCH of the node. This ensures that BCH for defined CHs is always available. The structure of the CH attachment message is given in Figure 5.

Packet Type	CH-ID	BCH-IDs

Fig 5. Clustering Join Messages.

Where a Packet Type presents the message's purpose, CH-ID shows the CH ID, and BCH-IDs are the highest to the lowest FLs-OUT list of sensor IDs. The next step was to send a confirmation message to each sensor node receiving a CH joining message.

The CHs assign a TDMA (Multi-Access time division) to the CMs once the clusters are created. The sensor nodes can then begin to transfer data packets within the WSN based on the assigned timetable TDMA.

CHs consume electricity at this stage in the sensor nodes. This could lead to energy depletion for both CH and CM. If CHs die, they will not monitor the whole area of their interest. Therefore, it is necessary to replace the failure CH. The eligibility of the chosen CH as NC and LD are also influenced by disordered CMs. To maintain the clusters created, therefore, the

CMs must send residual energy in a single message to their CHs with their sensory data. The CHs are also obliged to frequently monitor their own FLS-OUT. The CHs compare it to a certain threshold (β) in every round of the FLS OUT test. If each CH's FLS-OUT exceeds its threshold, the CMs and the BCH shall be informed as to the switching time.

The sensor nodes can therefore replace the introduced BCH for their CHs. Unable to fix the available BCH in the WSN. The BCHs may be physically damaged, or their residual energy may be altered in certain situations. Thus, the CHs change the BCHs order on the basis that their residual energy was received in the created list. The updated list is regularly forwarded to the CMs to ensure the best available BCH.The CHs can also be disordered suddenly in the WSN, because of physical damage, for example. If a CH dies, CMs must be rapidly notified to prevent network data loss. Even if the CMs die, their CHs must be removed from their list. In order to do this, the CHs and CMs are monitored using TDMA.

Data request receipt message (Data-Req). If at the end of the frame, the requested data were not received by the CH, the CM error is noted. The mistake is to prevent temporary death from permanent failure. Another request is then forwarded to the CH. The error mark will be checked if the CH doesn't receive data at the end of the frame. The CH realizes that, when the error mark exists, it must be removed from the list of its CMs and is a permanent failure.

IV. PERFORMANCE ANALYSIS

The performance of the proposed shame is assessed in this section with a simulation. The efficiency of the network's energy consumption is compared as a performance metric. The energy consumption communication model used in this assessment is discussed [9].

Data loss Radio was analyzed with a difference ratio between the total information transmitted by the nodes received by the sensor and the total data transmitted by the sensor nodes in accordance with the following provisions

$$\mathrm{DLR} = \frac{\text{Total data sent}-\text{total data rece}}{\text{Total data sent}}$$

Energy calculation using

$$E_{Tx}(k,d) = E_{eiec} * k + E_{amp} * k * d^2$$

Energy consumption is

$$E_{Rx}(k,d) = E_{eiec} * k$$

In conclusion, the proposed method analyzes the over head traffic. In order to evaluate overhead traffic from the distributed approach, we tested the average traffic transmitted in the network.

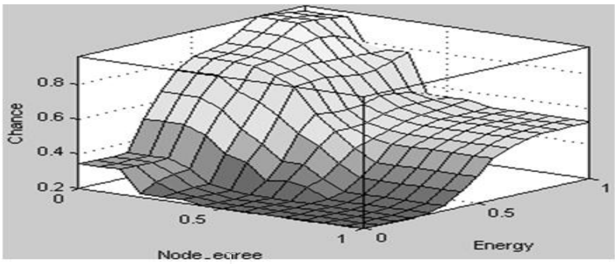
V. EXPERIMENTAL SETUP

MATLAB is used here to compare the approach proposed by PDD [10] with the approach of Reliability to Cluster-based WSN with DBCH- LEACH-

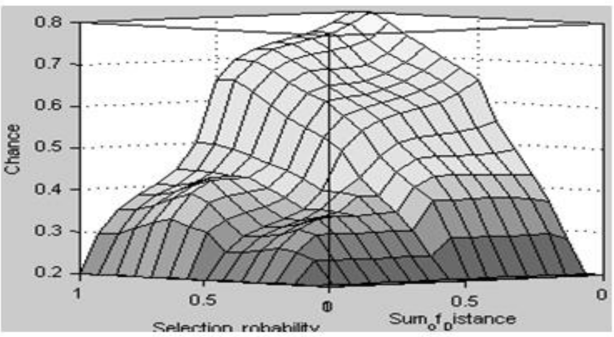
C heads [11], and the approach proposed by the Cluster-based WSN [12]. It is because of a flipping approach that increases the network life and DBCH-LEACH-C is also a clustering WSN, which is shown to improve the performance of the WSN using BCHs.

The network is composed of a BS and 80sensor nodes, $\mathcal{L} = \{s_1, \dots\dots, s_{80}\}$ wireless sensor nodes in the simulation. Each sensor has a sensing range of 25m and a communication range of 50m. Sensor nodes over 200 * 200 meters of surface area are used randomly. Each node has 1J equally for initial energy. There is no limit to BS with regard to energy, memory and computing power. In the centre of the surface is BS. The size of the packet is 100 bytes and 10 bytes of the phone message.

Figure 6. Shows a comparison of the rule surfaces of our scheme and the PDD. Figure 6(a) shows that our system figure 6(b) is more likely than PDD figure 3.8 to find CHs based on the plotted surface (b). In addition, we have added a large amount of smother area to our overall system architecture. This smooth response will therefore result in improved monitoring performance that is more resilient to uncertainties, despite the fact that the system's complexity remains the same as it was under the fumigation rule (no additional fuzzy rules or fuzzy sets were used).



(a) Our proposed system.



(b) PDD

Fig 6. Simulation result.

The energy required is calculated to successfully transmit certain data packets to demonstrate that the proposed approach prolongs the network lifetime. As shown in figure 7, the results demonstrate that the proposed approach produces a comparable amount of data while consuming less energy, outperforming both PDD [13] and DBCH-LEACH-C in this regard. The energy consumption of PDD is less efficient. That is because CH and CM failure in the network are not taken into account. CMs can transfer data packets via networks in the event of CH failure without notification. This negatively influences the efficiency of energy consumption. DBCH- LEACH-C[14] improves PDD by replacing the failed CHs of BCHs.

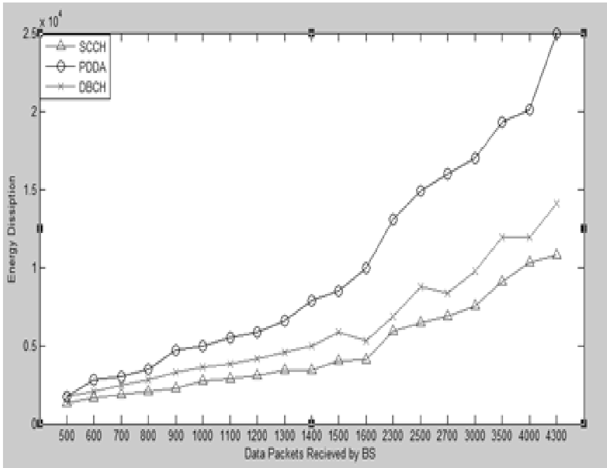


Fig 7. Data Packet Received by Base station.

However, because it is a centralized protocol, the CM failure energy cannot be efficiently utilized and has not been considered. Because the CM is distorted without warning, the network requires energy to seek data from a CM by a CH. SCCH, on the other hand, improves the energy efficiency of the network. The reason for this is that SCCH is a distributed protocol that allows a cluster's CHs and CMs to detect if they have each other. If the CH fails, the best BCH can be replaced by the CMs. Therefore the message on the data request and the data packets will not transmit unless the nodes ensure full functionality of the destination node.

In addition to energy consumption, data loss ratio (DLR) for sending and receiving data for the entire network is calculated at the BS. SCCH has the lowest DLR as illustrated by Figure 8.

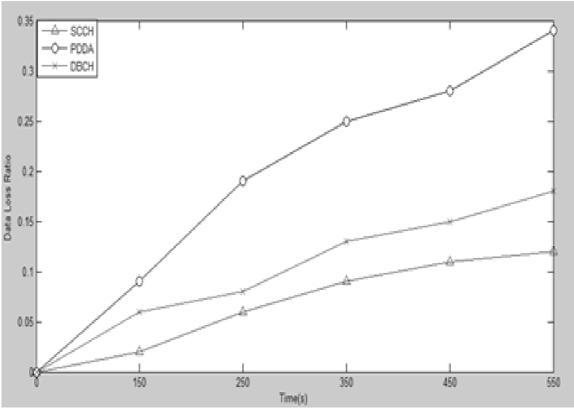


Fig 8. Data Loss Ratio.

This is for the following reasons. It is possible to determine the failure of CHs and CMs first. Data packets are not sent to failed nodes as a result of this. Faulty CMs, on the other hand, are ignored in PDD and BCH-LEACH-C[15]. A BCH for a failed CH is also always available. The CMs don't have to worry about reclustering because they can simply replace a BCH with their chosen CH. BCH-LEACH-C is more effective than PDD since it considers BCH. Its DLR, on the other hand, is lower than the SCCH since only two BCHs are taken into account.

Traffic overflow also serves to demonstrate the performance of the approach proposed. The average traffic transmitted is tested within the network to evaluate the overhead traffic of the SCCH. The mean message for the transfer of data to various network sizes is compared in Figure 9. The traffic is clearly less than PDD and BCH-LEACH-C for our scheme. The PDD message is more than BCH-LEACH-C and SCCH, as nodes need to be connected directly to the BS when there is a CH failure.

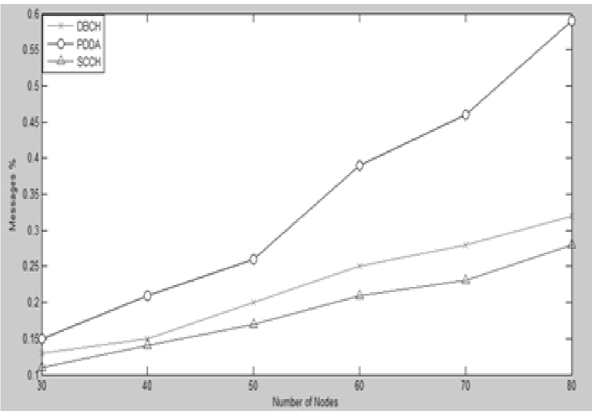


Fig 9. Message Overhead in cluster.

VI. CONCLUSION

In this paper, a new distributed type-2 fuzzy self-configurable (SCCH) technique is presented for extending the lifetime of WSNs while reducing traffic. SCCH begins by cluing the sensor's nodes. The following step is to choose CH. To define CHs, a floating approach and analyzed local information for each sensor node is employed. The sensor nodes can be CHs, according to the system output. The network nodes then assessed the node's eligibility to that of other nodes.

The CH is the node with the highest eligibility, while the remaining nodes are BCHs. As a result, the CMs can ensure that their CHs' BCHs are always available. As a result, CMs may be used to replace the BCH in the event of permanent CH failure. A comparison of the SCCH behavior with a smooth and non-smooth method proved the assertion. It has a longer service life and the capacity to reduce WSN overhead when compared to existing clustering techniques.

In Future protocols to be enhanced to comply with the WSNs' QoS criteria, such as the preservation of cover, because the entire monitoring area is an important issue for a long time. Furthermore, because there is not the same level of uncertainty in different situations, a single fuzzy interval cannot be employed in all applications. As a result, a method for estimating the optimal fluid interval for membership functions must be created.

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