Energy Efficient Hybrid Clustering Approach in Wireless Sensor Network (WSN)

Md. Saiful Islam Rubel
School of Engineering, LRTCS
Université du Québec en Abitibi-Témiscamingue (UQAT)
675, 1ère avenue, Val d'Or, QC, J9P 1Y3, QC, Canada.
md.saifulislam.rubel@uqat.ca

Nahi Kandil, Nadir Hakem
School of Engineering, LRTCS
Université du Québec en Abitibi-Témiscamingue (UQAT)
675, 1ère avenue, Val d'Or, QC, J9P 1Y3, QC, Canada.
Nahi.Kandil@uqat.ca, nadir.hakem@uqat.ca

***Abstract*—Energy-efficiency in Wireless Sensor Networks (WSNs) has been regarded as the core issue for designing any communication protocol. Sensor networks consist of limited battery-powered nodes and recharging or replacing is not practical being deployed in harsh environments like underground mines. So designing of WSNs should be concentrated on energy efficiency. Clustering technique is used very effectively to achieve scaling up and power saving in WSNs. It allows hierarchical structures to be built on the nodes and enables the more efficient use of scares resources. In this work, we have proposed a hybrid clustering scheme which able to meet energy constraints of WSNs. It allows data transmission from sensor nodes to the sink with reasonable consumption of energy.**

Keywords—WSNs; energy efficiency; clustering; hybrid

I. Introduction

Wireless Sensor Networks (WSNs) are collections of sensor nodes which can monitor and control physical and environmental conditions. WSNs hold significant advantages over traditional networks with an unlimited potential to revolutionize many segments of our economy and life. Environmental monitoring and conservation, homeland security, manufacturing and business asset management, automation in transportation industries and healthcare industries are the different application of wireless sensor application.

WSNs can be unreliable in real complex environments. If a source sensor node is not within the range of the sink node then other nodes which are in the range of sink node must deliver the sensed data from the source node to sink node through one or multi-hop routing. Hence for a reliable WSN, it is necessary to have a reliable routing protocol [4].

WSNs mainly use batteries as the power supply for sensor nodes. These sensor nodes usually deploy in large areas and typically are dead when the battery is running out.

In recent years, many studies and researchers focus on solving the problem of energy issue in WSNs. ME (Mobile Elements) has been used to collect data and to reduce energy consumption in [1]. Sink moving strategy to make the system durable and energy efficient proposed in [2] by using LEACH. In [3], authors proposed two new distance-based clustering routing protocols, which called DB LEACH and DBEA-LEACH. A hierarchical clustering scheme called BHC has been proposed in [4] to achieve energy efficiency. Paper [5] presents a QoS aware Energy Efficient Routing (QEER) protocol for clustered WSN. A clustering approach for the homogeneous network proposed in [6], which selects CH based on distance from the sink.

In this work, we have a proposed a hybrid clustering scheme which selects Cluster Head (CH) based on distance from the sink and based on maximum remaining energy in sensor nodes. There are few previous works like [3, 6] which select CH based on distance. But there is no such combination of distance and residual energy that we have done in this work.

II. Proposed Approach

In our proposed approach we have assumed that the sensors are deployed in a fixed position. Each sensor node of the network has a unique ID and knows its current position and remaining energy.

A. CH Selection Algorithm

1) CH Selection Based on Distance: This algorithm will select that node as CH, which is nearest to the sink. To minimize the transmission energy, we have taken the distance criterion into consideration.

$$P_i = 1 - \frac{d_i^2}{\sum_{j=1}^{j=n} d_j^2} \tag{1}$$

Here n is the total number of nodes. d_i is the distance from sensor i to sink, d_j is the distance from each other node j to the sink. The ratio of this two values will give P_i, which is a uniform value between 0 and 1. The sensor i will be selected as CH if the probability of $S_i \leq P_i$. Where S_i indicates the random probability between 0 and 1. Here, randomness and probability are introduced. If we select those nodes as CH, which have the minimum distance from the sink, then those nodes will die soon because of selecting them as CH repeatedly.

2) CH Selection Based on Residual Energy: This algorithm will select that node as CH, which has the maximum remaining energy.

$$P_i = \frac{E_i}{\sum_{j=1}^{j=n} E_j} \quad (2)$$

Here E_i is the residual energy of sensor i, E_j is the residual energy of each other node j and P_i indicates the ratio of this two values which gives a uniform value between 0 and 1. Similarly, the sensor i will be selected as CH if the probability of $S_i \leq P_i$. CH will be selected randomly which has the maximum residual energy after each round on the basis of probability.

3) Hybrid CH Selection: This algorithm will select that node as CH which has a minimum distance from the sink and has maximum remaining energy.

$$P_i = (\alpha) \times \left(1 - \frac{d_i^2}{\sum_{j=1}^{j=n} d_j^2}\right) + (1-\alpha) \times \left(\frac{E_i}{\sum_{j=1}^{j=n} E_j}\right) \quad (3)$$

Here α is the factor of both energy and distance. We can take only distance or only residual energy into consideration, if we take α=1 and α=0 respectively. We can evaluate the performance of Hybrid CH selection algorithm by taking the value of α between 0 and 1.

III. Results

In this section, we will evaluate the performance of our proposed approach and compare it with DBEA-LEACH [3]. We have used MATLAB to simulate our approach.

TABLE I. PARAMETERS CONSIDERED

Parameters	Value
Network size	100*100
Number of nodes	100
Sink location	1m*1m
Initial energy of sensors	0.15J
Transmission/Receiving energy	50 nJ
Data aggregation energy	5 nJ
Maximum round	10000
Transmission speed	10 Kbits
Packet size	400 bytes

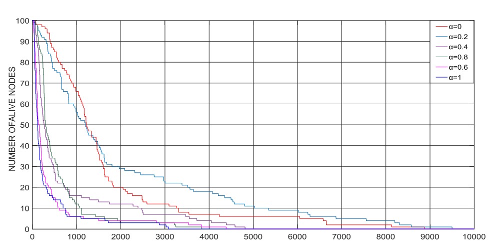

Fig. 1. Lifespan for different value of alpha (α)

Fig. 1 shows the results for the different combination of distance and residual energy by taking the different value of α. We have got the best result by using 80% of residual energy and 20% of distance (α=0.2). We have the worst energy efficiency in case of distance (α=1). In case of distance based CH selection, there always has the chance to select a node as CH which is closer to BS more often. As a result, the sensors closer to BS have a high probability to die soon rather than the nodes that are far from BS. It is the reason that we get the worst result in case of distance.

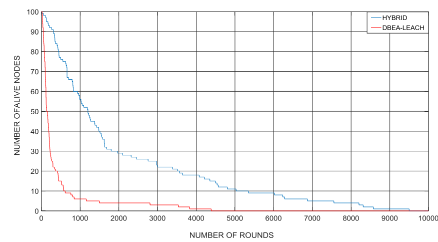

Fig. 2. Comparision between Hybrid and DBEA-LEACH

As shown in Fig. 2, the hybrid approach (for α=0.2) has the more improved network lifetime than the DBEA-LEACH protocol. This enhancement is due to the optimal clustering algorithm and hybrid mechanism. The proposed hybrid approach is much more stable. But in DBEA-LEACH there is a sharp breakdown before 1000 rounds. All the sensor nodes in case of DBEA LEACH die before 5000 rounds whereas the hybrid approach lasts more than 9000 rounds.

IV. Conclusion

In this work, our main goal was to improve the energy efficiency of the WSNs. We have introduced a hybrid algorithm of CH selection by which we can calibrate different combination of distance and residual energy to find the best result in terms of energy. Although CH selection based on distance does not give a good result but taking it with residual energy, we have got a good result comparing to another approach.

References

[1] Ruonan Zhang, Jianping Pan, Di Xie, "NDCMC: A Hybrid Data Collection Approach for Large-Scale WSNs Using Mobile Element and Hierarchical Clustering," in IEEE internet of things journal, 2016, vol. 3, no. 4, pp. 533-543.

[2] Makhl ouf Aliouat, Zibouda Aliouat, "Improved Wireless Sensor Networks Durability through Efficient Sink Motion Strategy," in IEEE Conference on Wireless Sensors (ICWiSE), 2014, pp. 61-66.

[3] Tri Gia Nguyen, Chakchai So-In, Nhu Gia Nguyen, "Two Energy-Efficient Cluster Head Selection Techniques Based on Distance for Wireless Sensor," in 2014 International Computer Science and Engineering Conference (ICSEC), pp. 33-38.

[4] Trong Thua Huynh, Anh-Vu Dinh-Duc, Cong Hung Tran, "Energy Efficient Delay-aware Routing in Multi-tier Architecture for Wireless Sensor Networks," in International Conference on Advanced Technologies for Communications (ATC), 2013, pp. 603-608.

[5] Babar Nazir, Halabi Hasbullah, "QoS aware Energy Efficient Routing Protocol for Wireless Sensor Network," in IEEE Conference on Open System (ICOS) , 2011, pp. 375-380.

[6] S. Taruna, Sheena Kohli, N.Purohit, "Distance Based Energy Efficient Selection of Nodes to Cluster Head in Homogeneous Wireless Sensor Networks," in International Journal of Wireless & Mobile Networks (IJWMN) 2012, vol. 4, no. 4, pp. 243