A New Energy-Efficient Cluster Head Selection Algorithm

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Abstract —The use of wireless sensor networks (WSNs) has grown enormously in the last decade. Energy efficiency is the most important issue in research of wireless sensor networks while the routing protocol plays an import role in achieving energy efficiency in WSN. Because of the limited energy storage capability of sensor nodes, Energy consumption is one of the most challenging factors of these networks and different strategies and protocols deals with this area. To support high scalability and better data aggregation, sensor nodes are often grouped into disjoint, non overlapping subsets called clusters. Today Cluster based routing protocol are well known approach for extending Wireless Sensor Networks.
In this paper we introduce a new technique which is built upon some basic definitions such as mean and standard deviation. In other words the process cluster head selection, which is responsible on the energy consumption distribution, by using mean technique, is the main challenge. Simulation results and comparison with previous protocol (LEACH) prove that our new algorithm is able to extend the lifetime of the network.

Keywords - Energy Based Clustering, Residual energy, Cluster head & Wireless Sensor Network (WSNs).

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1 INTRODUCTION

The main and most important reason of Wireless Sensor Network (WSNs) creation was continuous monitoring of environments where are too hard or impossible for human to access or stay. So there is often low possibility to replace or recharge the dead nodes as well. The other important requirement is that we need a continuous monitoring so the lifetime and network coverage of these networks are our great concerns[1].

Balanced distribution of energy in whole network will lead to balanced death of nodes in all regions preventing from lacking network coverage. Many research studies focused on energy efficient routing protocols to address this problem. Routing protocols can be divided based on different considerations like application, protocol operation, or network structure which is usually divide them into three general categories: flat, hierarchical (cluster based) and location-based routings [2]. In flat networks, each sensor node plays the same role and sends their data to sink node directly which always results in excessive data redundancy and faster energy consumption. In location based routing, sensor nodes are addressed by means of their locations. The sensing area is divided into small virtual grids. All nodes in same virtual grid are equivalent for routing and only one node need to be active at a time. Hierarchical or Cluster based routing protocols, in hierarchical routing, the entire network is divided into several clusters.

Each cluster consists of some source nodes and a cluster head[3] .

Sensor nodes, referred as source nodes, can gather information from the monitoring region and send the sensing information to their corresponding cluster head [4]. The cluster head is elected from all the sensor nodes in a cluster according to some criteria, and is responsible for collecting sensing data from source nods. After receiving data from source nodes, the cluster head also performs data aggregation to reduce the data size before sending data to the sink.

The remainder of this paper is organized as follows: A brief introduction of different LEACH protocols are presented in second Section. In third Section, we introduce some preliminary notions concerning the proposed protocol.

Simulation and results are discussed in forth Section. Finally, conclusions are made in last Section.

2 RELATED WORK

Low Energy Adaptive Clustering Hierarchy (LEACH) [5], [6] is the most famous clustering protocol which had been a basis for many further clustering protocols. The most important goal of LEACH is to have (Cluster Heads) to reduce the energy cost of transmitting data from normal nodes to a sink. In LEACH, nodes organize themselves into clusters, each cluster has one node acting as cluster head. All non-cluster head nodes (normal nodes) transmit their data to the cluster heads. The cluster-head is responsible for: 1) coordination among the cluster nodes and aggregation of their data, and 2) transmission of the aggregated data to the BS, directly or via multi-hop transmission. But the hot spots problem in multi-

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hop wireless sensor networks, When cluster heads cooperate with each other to forward their data to the base station, the cluster heads closer to the base station are burdened with heavy relay traffic and tend to die early, leaving areas of the network uncovered and causing network partition. So in Leach process each CH will transmit their data to sink directly.

The operation of LEACH is divided into rounds. Each round begins with a set-up (clustering) phase when clusters are organized, followed by a steady- state (transmission) phase when data packets are transferred from normal nodes to cluster heads. After data aggregation, cluster heads will transmit the messages to the Base Station. The election of cluster head is done with a probability function: each node selects a random number between 0 and 1 and if the number is less than $T(n)$, the node is elected as a cluster head for current round:

$$T(n) = \begin{cases} \dfrac{p}{1-p\langle r\ mod\ \frac{1}{p}\rangle} & \text{if } n \in G \\ 0 & \text{other wise} \end{cases} \qquad (1)$$

Where, P is the cluster head probability, r is the number of current round and G is the set of nodes that have not been cluster-heads in last 1/P round. Though LEACH uses random election of cluster heads to achieve load balancing among the sensor nodes [7] The strength of LEACH is in its CH rotation mechanism and data aggregation.

LEACH-Centralized (LEACH-C) [8]. Is a Base Station cluster formation algorithm. It uses the same steady state protocol as LEACH. During the steady state phase, each node sends position and energy level to BS. The assumption usually is that each node has a GPS receiver. The BS have to insure the evenly distribution of energy among nodes. So it determines a threshold for energy level and selects the nodes (with higher energy than this threshold) as possible cluster heads. After determining the cluster heads of current round, BS sends a message containing cluster head ID for each node. If a node's cluster head ID matches its own ID, the node is a cluster head; otherwise it's a normal node and can go to sleep until data transmission phase. LEACH-C always insures the existence of K optimal number of cluster heads in every set-up phase while LEACH cannot ensure that.

Low Energy Adaptive Connectionist Clustering (LEA2C) [9]. Uses a two phase clustering method, SOM followed by Kmeans. LEA2C apply the connectionist learning by the minimization of the distance between the input samples (sensor nodes coordinates) and the map prototypes (referents) weighted by an especial neighborhood function. After set-up phase, the cluster heads of every cluster are selected according to one of the three criterions, max energy node, nearest node to BS and nearest node to gravity center of each cluster. The transmission phase continues until the occurrence of first dead

in the network. After that, the reclustering (set-up) phase will repeat.

3 PROPSED ALGORITHEM

The main challenge of any Wireless Sensor Network is keeping most of the nodes alive as long as possible. The main objective of any network is transferring the data among the network nodes. Data is transferred mainly via the cluster heads. Spending the energy is done for receiving and sending the data. Simply the good selection of the cluster heads is based on the energy content of each node. The nodes with the highest energy are the best candidates as a cluster heads.

3.1 Cluster Head Selection Algorithm

For round number from 1 to 900 do the following:
    If round number less than or equal 5
        Generate a random number between 0 and 1
        (uniform distribution)
        Select nodes with more than 0.6 as a cluster head
    Else If round number greater than 5
        Calculate the mean value of the current reserved energy of the nodes.
        Use this mean value as a threshold and select the nodes with more than this value as a cluster heads.
    End;
 End;

This minor change doubles the network lifetime because it uniformly distributes the effort (energy consumption) among all the nodes.
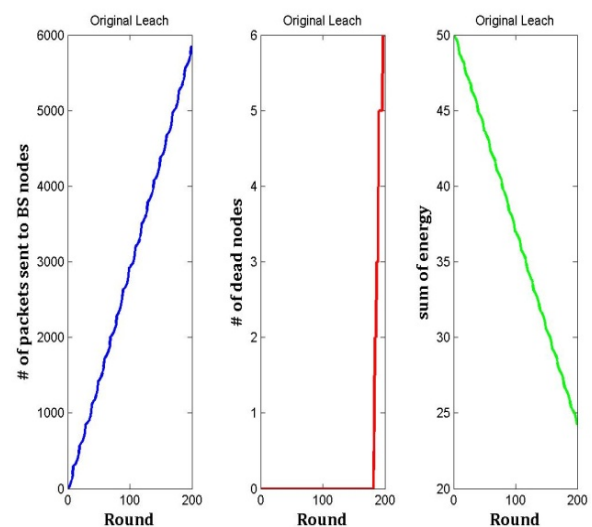
4   RESULTS EVALEUTION

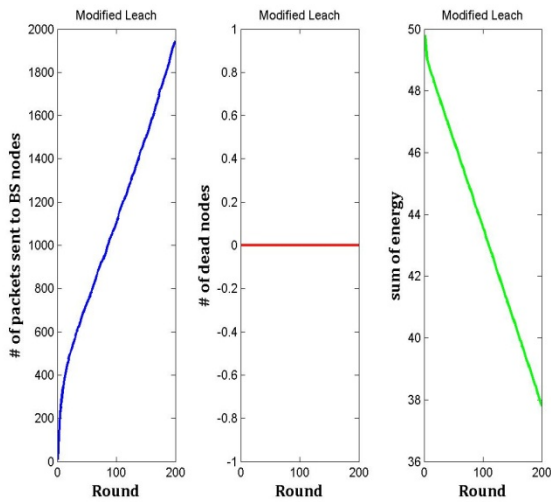Fig 1. From 0 to 200 round(original Leach)

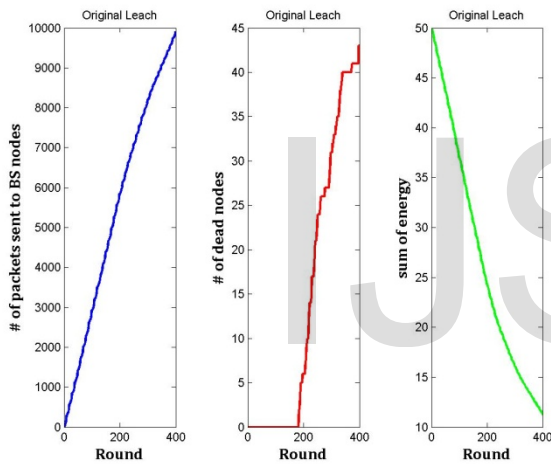Fig 2. From 0 to 200 round (proposed Leach)

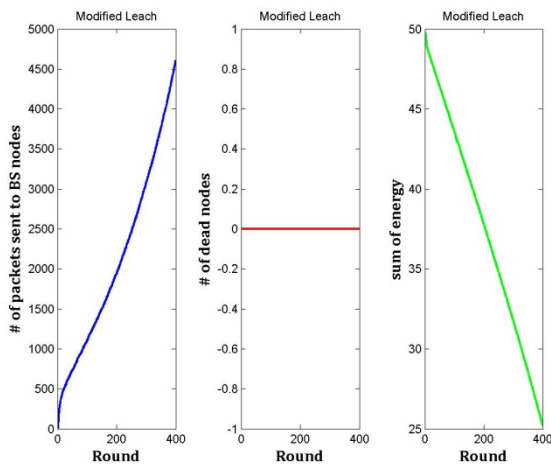Fig 3. From 0 to 400 round (original Leach)

Fig 4. From 0 to 400 round (proposed Leach)

Fig 1,2 and 3,4 illustrate a comparison between the original and the proposed after 200 and 400 rounds respectively. The total consumed energy of the nodes in the original LEACH is higher than the proposed introduced one. Also, from this figure, the original LEACH introduces a dead nodes starting from 200 rounds while the proposed has no dead nodes till 400 rounds.
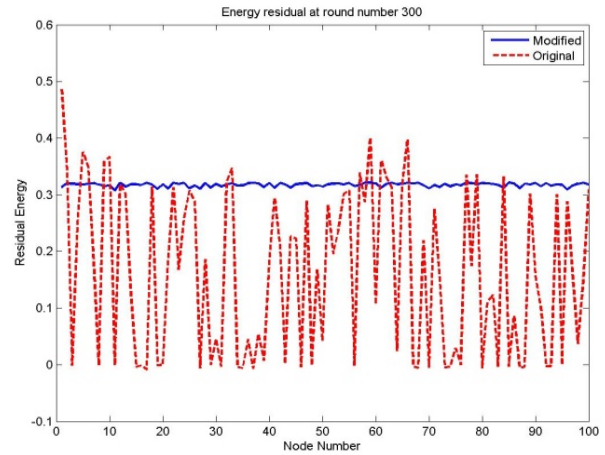

Fig 5. The Residual energy of the nodes for the Original / Modified Leach after 300 rounds.

From Fig 5. it is clear that the reserved energy of the nodes is almost the same with small variation and most of the nodes have higher energy than the original nodes.
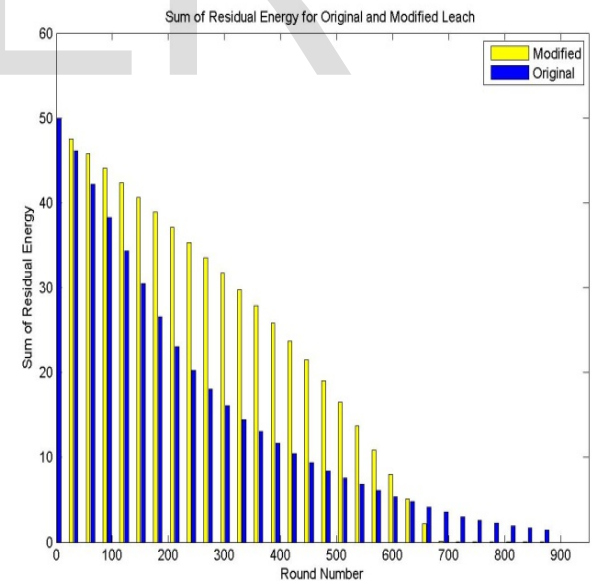

Fig 6. Sum of the Residual energy VS round number

Fig 6. shows the sum of the residual energy of the nodes variation with the round number for Original/Proposed Leach. It is clear that almost all the time the original Leach has lower sum than the proposed.
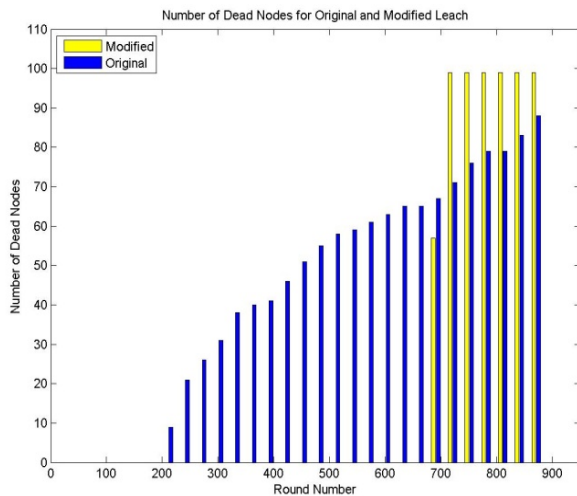
Fig 7. Number of dead nodes VS round number

Fig 7. illustrates the variation of dead nodes with the round number for Original/Proposed Leach. It is clear that the original Leach starts to develop dead nodes after almost 200 rounds whereas the proposed one has no dead nodes till round 670.

5   CONCLUSION

In this paper, we have presented our algorithm, an energy efficient clustering method for WSNs and compared it to the LEACH protocol. Results from our simulations show that proposed Leach provides better performance for energy efficiency and network lifetime. However our protocol can be classified as a protocol with continuous data transfer just like LEACH, which in its general form is intended for static networks. Our protocol can still be improved further. For example, take in consideration the CH position compare to Sink position and center of gravity for each cluster during CH selection process.

References

[1]   I F Akyildiz, W Su, Y Sankarasubramaniam and E Cayirci "Wireless sensor networks: a survey", Computer Networks Vol. 38, No. 4, pp. 393 – 422, 2002 .

[2]   Mishra, Neeraj Kumar, Vikram Jain, and Sandeep Sahu. "Survey on Recent Clustering Algorithms in Wireless Sensor Networks." International Journal of Scientific and Research Publications 3, no. 4, 2013.

[3]   E. Fasoloy, M. Rossiy, J. Widmer,M. Zorziy, "In-network Aggregation Techniques for Wireless Sensor Networks: A Survey," IEEE Wireless Communications, 2007.

[4]   J. Ibriq , I. Mahgoub, "Cluster-based routing in wireless sensor networks: issues and challenges," Proceedings of the 2004 Symposium on Performance, 2004.

[5]   Heinzelman W. R., A. P. Chandrakasan and H. Balakrishnan, "Energy- Efficient Communication Protocol for Wireless Microsensor Networks", Proc. of the 33rd IEEE Int. Conf. on System Sciences, Honolulu, USA, pp. 1–10,Jan. 2000,.

[6]   S.Ozdemir, Y.Xiao, "Secure data aggregation in wireless sensor networks: A comprehensive overview," Computer Networks, vol. 53,pp. 2022-2037, August 2009.

[7]   V.Gupta, R.Pandey, "Data Fusion and Topology Control in Wireless Sensor Networks," Proceedings of the 5th on Applied electromagnetics, wireless and optical communications, pp. 135-140 , 2007.

[8]   Heinzelman W. R., A. P. Chandrakasan and H. Balakrishnan, "An Application-Specific Protocol Architecture for Wireless Microsensor Networks", IEEE Trans. on Wireless Communications, vol. 1, no. 4, pp. 660-670, Oct.2002.

[9]   Enami N, Askari Moghadam R, Haghighat A. ,"A Survey on   Application of Neural Networks in Energy Conservation of Wireless Sensor Networks". In:Recent Trends in Wireless and Mobile Networks, WiMo 2010 Proceedings, Ankara, Turkey, p. 283–294, 2010.