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A New LEACH Algorithm for the Data Aggregation to Improve the Energy Efficiency in WSN

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Abstract

In recent years, the utilization of the WSN have been rapid. Energy consumption of these networks must be as low as possible. LEACH algorithm is one of the clustering technique. We modify the traditional LEACH algorithm in such way that it will be capable to self-organize large number of nodes and for saving communication resources such as processing time and initiation time. The efficiency of the network highly depends on how the algorithm divides cluster area and selects cluster head. The proposed algorithm can be evaluated through the extensive simulation the result we obtained shows that the life time of a network is increased when energy load is distributed equally among the sensor.

Keywords: *Data aggregation, LEACH, WSN.*

1. Introduction

The time function of any Wireless Sensor Network (WSNs) should be very long because of the unhandiness or impossible convention to replace the node batteries, nodes, hardware, clusters, data routing protocols must be designed in accordance to energy proficient plan [1]. Clustering protocol is one of the way to reduce energy consumption in networks and LEACH [2] being the first clustering protocol which is dynamic in nature. Using data accumulation process on the network nodes and by reducing the exchanged messages, this LEACH algorithm distributes the energy consumption in whole network.

Generally, sensor nodes sense the data and then transmits it to the base station, where an end user can access the data. The base station is fixed and located far from the sensor nodes. All the nodes among the networks are homogeneous and energy constrained. Thus, communication between the sensor nodes and the base station is expensive, and there are no “high-energy” nodes through which communication can proceed. Sensor networks contain too much data for an end-user to process. Therefore, automated methods of combining or aggregating the data into a small set of meaningful information is required [3,4].

Leach was developed in order to provide a unique necessities of wireless sensor networks. Most of the application protocols architecture in a sensors network [5] have main function which to forward the data gathered by sensors to a base station. In order to avoid energy consumption many approaches have been proposed to achieve low energy consumption. Base station is not near all sensor nodes; therefore, the node will use excessive energy to deliver data.

The main task for clustering-based routing protocols over the static clustering algorithms is to minimize

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global energy consumption by the nodes. The nodes are required to distribute the load not in same time but over period of time [6]. Since the sensor nodes will connect the appropriate cluster heads depending on the signal strength, this methodology require the nodes which have the highest energy within the cluster to volunteer to be the cluster head and transmit the aggregate data to Base.

2. Related work

In order to balance the energy consumption of each node, in every round, all groups have the opportunity to become the cluster head. In this protocol cluster head nodes are used as route protocol cluster head nodes are used as route finders (to the base station) [7]. All data processing such as data accumulation and combination in each cluster are performed locally. LEACH protocol breaks down into rounds. Each round consists of a setup phase and a steady-state phase. In the setup phase, nodes organized themselves as clusters. Each node decides to become cluster head by P probability and broadcasts the decision. Each node selects random T number (between 0 and 1). The node in current cycle round becomes cluster head if T number in equation is lower than the threshold in the formulae below.

$$\mathrm{T(i)} = \begin{cases} \dfrac{P}{1-p\times\left(r mod \frac{1}{p}\right)} & , i \in G \\ 0 & , otherwise \end{cases} \quad (1)$$

where P is the demanded percentage of cluster head nodes in all sensors and r is the current round number, and G is the set of nodes that are not cluster head in previous 1/p round. After all cluster heads are selected, a message is broadcasted to other nodes and non-cluster heads nodes determine the cluster that they want to join. Each node selects its cluster such that it communicates with its associated cluster head with lower energy consumption. Non-cluster head nodes, when receive the strongest signal form a cluster head, join it. After joining, each node sends a signal to inform its membership to the head cluster. After cluster formation, setup phase is finished. In the steady state phase, network performance is divided into time frames, so that in each frame, all nodes of a cluster send their data to the head cluster in a specific time interval. As time shear longevity of each node is stable, a time frame length depends on node numbers of clusters. Cluster head creates a time schedule TDMA (Time Division Multiple Access) for its member nodes. This allows the member nodes to save more energy by turning off their receiving radiations during their communication round time schedule. After a predetermined time, this round ends and new round stats which changes the cluster head role among the cluster nodes and balances the load [8].

While LEACH appears to be a promising protocol, there are some areas for improvement to make protocol more widely applicable [9]. While dealing with more rounds of information transmission with the cluster head, the performance of LEACH protocol decreases. By the end of the information transmission nodes are out of the energy and are called dead nodes. So, we need the different technique where each node performs to the fullest capacity. More nodes should be alive by the end of the information exchange. When more nodes are alive at the end we say that energy consumption of the nodes are equal. To do so we propose "A New LEACH Algorithm for the Data Aggregation to Improve the Energy Efficiency in WSN" where many nodes by the end of the information transmission stays alive.

3. Mathematical Model

Different assumptions about the radio characteristics, including energy dissipation in the transmit and receive modes, will change the advantages of different protocols. Here, we assume simple model where the values of the different variables are shown in the Table 1.

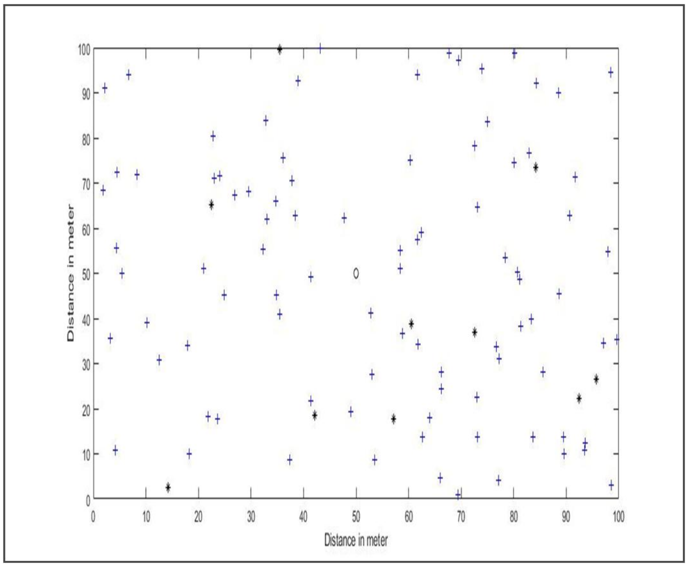

Figure 1. Distribution of the nodes.

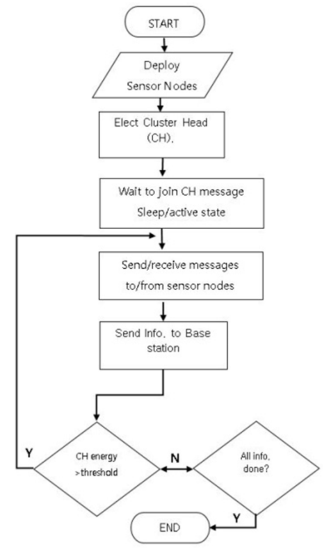

Figure 2. Working flowchart.

Symbols illustrated in the Fig. 1 are as follow:

- +: Anchor nodes
- *: Cluster Heads(CH)
- O: Base station

Table 1. Data communication Model

Parameters	*Values*
Initial Energy	0.5 J
Transmission Energy (E_{TX})	$5*10^{-7}$ J
Receiving Energy(E_{RX})	$1*10^{-7}$ J
Data Aggregation Energy(E_{DA})	$5*10^{-8}$ J
Number of rounds(R_{MAX})	4000
Free space Amplifier value(E_{FS})	$1*10^{-9}$ J/bit/m^2
Multi-Path Amplifier value(E_{MP})	$1.3*10^{-13}$ J/bit/m^2
$E_{Tx\text{-}elec}=E_{Rx\text{-}elec}=E_{elec}$	50 nJ/bit

We assume a simple model for the radio hardware energy dissipation where the transmitter dissipates energy to run the radio electronics and the power amplifier, and the receiver dissipates energy to run the radio electronic. For the simulation described here, both the free space (d^2 power loss) and the multipath fading (d^4 power loss) channel models were used, depending on the distance between the transmitter and receiver. Power control can be used to invert this loss by appropriately setting the power amplifier, if the distance is less than a threshold (d_0), the free space (f_s) model is used; otherwise, the multipath (*mp*) model is used. Thus, to transmit an L-bit message to a distance, the radio expends.

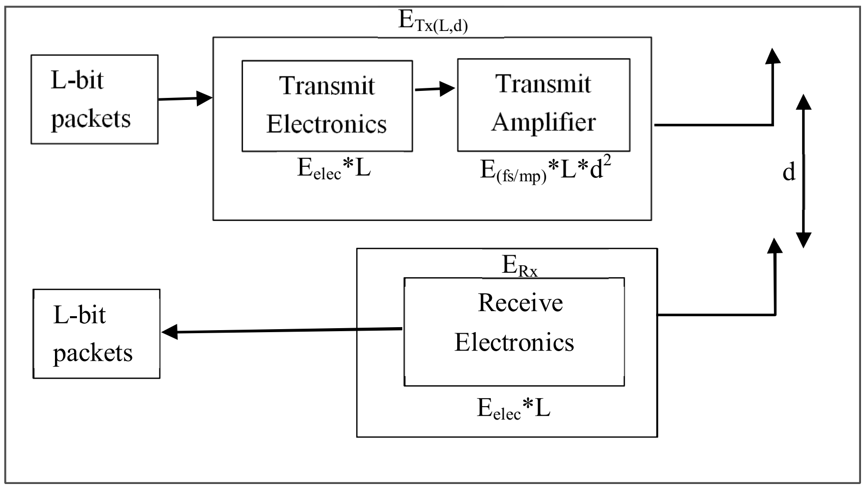

Figure 3. Data Communication Rule.

The another assumption that we made is that, radio channel is symmetric such that the energy required to transmit or receive message is same among two nodes and vice versa for given SNR (Signal to Noise ratio). For the simulation we assume that environmental factors have null effect. We implement an "event-driven" simulation, where sensors only transmit data if some event occurs in the environment.

$$E_{Tx}(L,d) = E_{Tx-elec(L)} + E_{Tx-amp(L,D)} \quad (2)$$

$$E_{Tx}(L,d) = \begin{cases} LE_{elec} + LE_{fs}d^2, d < d_0 \\ LE_{elec} + LE_{mp}d^4, d \geq d_0 \end{cases} \quad (3)$$

And to receive this message,

$$E_{Rx}(L) = E_{Rx-elec(L)} = LE_{elec} \quad (4)$$

Factors such as digital coding, modulation, filtering and spreading of the signal varies the electronic energy E_{elec}. the amplifier energy $E_{fs}d^2$ and $E_{mp}d^4$ depends upon the distance of the receiver and the acceptable bit-error rate. Other parameters are set to the following values.

4. Results

For our simulation, we used a 100 nodes network where nodes were randomly distributed between (x=0, y=0) and (x=100, y=100) with the Base station at location (x=50, y=50) as shown in the figure. The bandwidth of the channel was set to 1 Mb/s. Each data message was 500 bytes long, and the packet header for each type of packet was 25 bytes long. The process of the simulation begins with the setup phase where the cluster area is defined randomly depending upon the density of the nodes within the network. The nodes which can satisfy the Equation 1. is selected as the cluster head, sensing the data from the following nodes. By doing so, the nodes will not communicate with each other, but will communicate to cluster-head nodes assign which will then communicate with Base Station, this cluster will act as cluster-head as long as it has enough energy above than threshold. Rotation of the cluster-head is based on energy load. Moreover, when the cluster head become a normal node, it can communicate to active cluster-head. Implanting centralized K-Means algorithms added high stability in setup phase which aids in longer network lifetime.

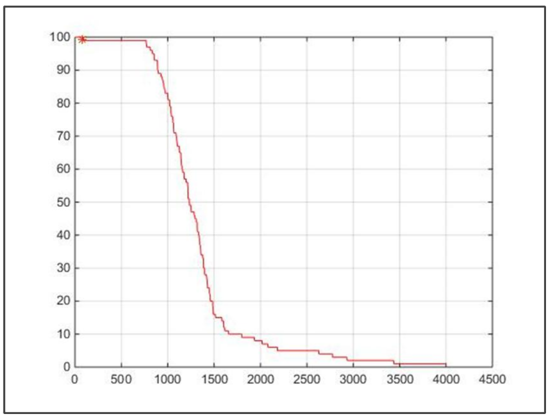

Figure 4. Traditional LEACH

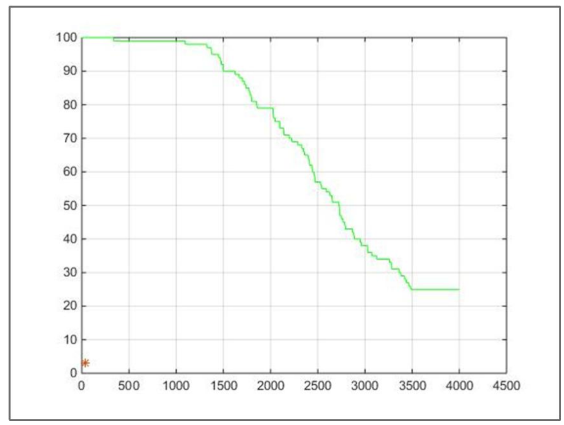

Figure 5. Modified LEACH

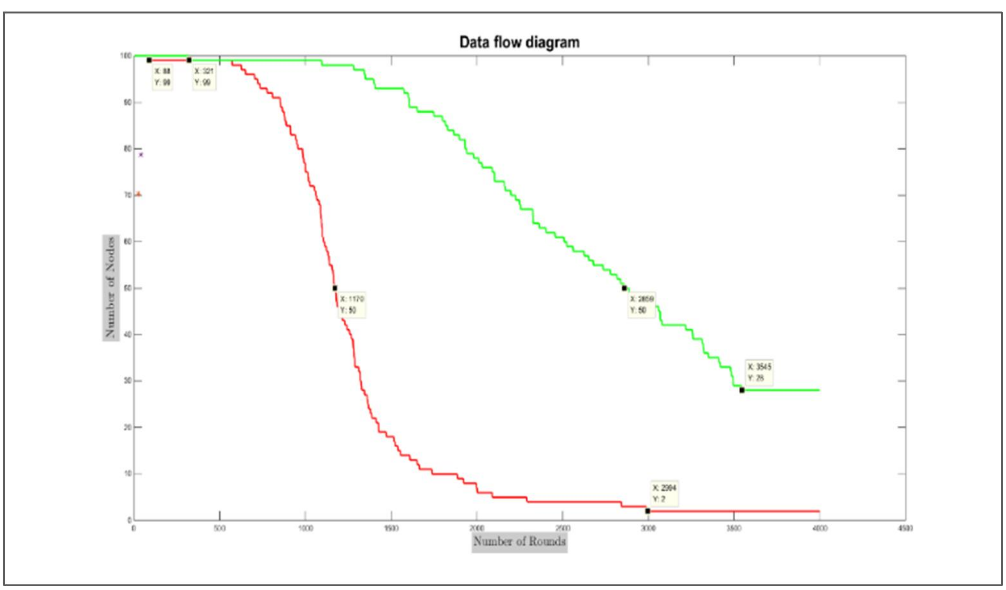

Figure 6. Comparison of traditional LEACH and modified LEACH

This algorithm works for load balancing, that is, equal energy is consumed for all nodes. Generally, energy consumed by the nodes are different but we try to modify the traditional LEACH algorithm so that all the nodes consumes equal energy and the lifetime of the network can be elongated.

In FIG. 6 we can see that the modified algorithm works more efficiently. Efficient in this case means more alive nodes by the end of the data transmission, more rounds performed until first node die, which is 321. The number of nodes alive by the end of the data transmission is found to be 26. If we compare the number of rounds when 50 nodes are dead, we get the difference of 1689 which means performance is better in case of modified algorithm. If we compare the data between two algorithms by the end of the 50% nodes, we found the modified LEACH to be 144% more efficient than the traditional LEACH.

5. Conclusion

In recent years, more attention is paid to WSNs and these networks were used in many applications. Node grouping in clusters is the best way to develop, maintain, protect and improve the efficiency of WSN. In addition, most attentions are paid to clustering algorithms and approaches and one of the most important algorithms is LEACH protocol. Numerous protocols are introduced to improve the LEACH protocol. Cluster features and clustering process and cluster head potentialities of these protocols were classified. Finally, we study them with regard to features like configuration, multi-level, break down retrieve capability etc.

Acknowledgement

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