Modified Low Energy Adaptive Clustering Hierarchy for Heterogeneous Wireless Sensor Network

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ABSTRACT: -

In wireless sensor network, it is an important task to collect the data periodically from various sensors node for monitoring and recording the physical conditions of the environment. The sensed data must be transmitted and received between the nodes in the network. The Low Energy Adaptive clustering hierarchy (LEACH) is one of the routing protocol to transmit the data between the nodes in the network. In this work, LEACH protocol is modified and developed the new concept called MLEACH. The proposed protocol is energy efficient for heterogeneous network. The performance was analyzed by considering the time period and it shows that the number of alive nodes was less. Since the alive node is less the energy consumption is also less and thereby increasing the energy efficiency of the network. The comparative analysis was made between the existing and the proposed method. Simulation result shows that the proposed method is more energy efficient than the existing LEACH protocol.

Keyword: Wireless sensor networks, Energy Consumption, Energy Efficiency, LEACH protocol, MLEACH protocol.

I. INTRODUCTION

The Wireless sensor network (WSN) is a broadcast network, it consist of large number of sensors that are effective for gathering data in a variety of environment. Since the sensors operate on battery power, it is a great challenging aim to design the energy efficient routing protocols.

Heterogeneous networks are more efficient than the homogeneous network in WSN. The number of individual nodes are grouped together or collected in one place known as clustering. The routing protocols are performed in clustered network. The clustering algorithms such as LEACH [2, 7], PEGASIS and HEED [4] assumes the sensor networks are homogeneous which are poorly performed in heterogeneous environment.

Low Energy Adaptive Clustering Hierarchy (LEACH) is a clustering based protocol to collect data from the number of nodes. The cluster heads are elected out of the sensor nodes to transmit the collected data to the base station. In LEACH protocol heterogeneous clustering algorithm, is used for better energy efficiency and stability period.

All clusters are having one cluster head which perform data collection and data fusion. All the nodes in the network are responsible for sending the data to the cluster head. Hierarchical routing [2] is reservation based scheduling and requires global and local synchronization. It performs good scalability and performs efficient communication.

Modified LEACH algorithm is energy efficient communication protocol for WSN. The communication takes place between all the cluster members and cluster heads. Similarly cluster heads communicate to Base Station. MLEACH achieves energy efficiency and reduces the network traffic.

The remainder of the paper is organized as follows. Section II describes the assumptions used for the related work. Section III shows the performance of LEACH and proposed protocol. Further, the simulation results are shown in section IV and finally Section V gives concluding remarks.

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II. RELATED WORK

Analyzing the basic distributed clustering routing protocol i.e. LEACH (Low Energy Adaptive Clustering Hierarchy) [1], which is a homogeneous system then proposed a new routing protocol and data aggregation method in Leach heterogeneous system which the sensor nodes form the cluster and the cluster-head elected based on the residual energy of the individual node calculation with re-clustering scheme is adopted in each cluster of the WSNs. Energy efficiency of LEACH protocol is better in heterogeneous system than

Homogeneous system. Leach in heterogeneous system significantly reduces energy consumption of the wireless sensor network compared to the homogeneous LEACH protocol.

LEACH [2] uses localized coordination to enable scalability and robustness for dynamic cluster based routing protocol of the networks, and incorporates data fusion into routing protocol to reduce the amount of information that must be transmitted to the base station.

LEACH [3] can achieve as much as a factor of reductions in energy consumption compared with conventional routing protocols. The LEACH protocol is able to distribute energy evenly throughout the sensors between the numbers of nodes.

The cluster number is less than optimum number of clusters the non-cluster head node may exhaust its energy in the process of transmitting data for the long distance from it to the cluster head, or the cluster head has assigned other nodes communication before receiving enough nodes feedback information and then waste much energy for a mass of redundant work [5].

III. PROTOCOL PERFORMANCE

All senor nodes are identical and charged with the same amount of initial energy. All nodes consume energy at the same rate and are able to know their residual energy and control transmission power and distance.

Leach protocol

It uses the initial energy level of the nodes to select the cluster heads. Using Eq (1) ,based on distance (d_0), it decides the parameter values E_{fs} and E_{mp}.

Calculate the distance between energy per bit (E_{fs}) and energy per area (E_{mp}).

$$d_0 = \frac{E_{fs}}{E_{mp}} \quad (1)$$

Cluster Head Selection Algorithm:

From Eq. (2) each sensor node k generates a random value and compares it to a predefined threshold T (k). If random < T (k), the sensor node becomes cluster-head in that round, otherwise it acts as a cluster member. P is a probability to become cluster head. Where *P* is the percentage of the number of clusters in the network (usually *P* is 0.05), n is the number of node, is the number of the election rounds, and round (1 / *P*) is the number of nodes which have been elected as cluster heads in the round.

$$T(k) = \frac{P}{\left(1 - P * mod\left(r, round\left(1/P\right)\right)\right)} \quad (2)$$

Distance:

Calculate the distance between initial node and sink node. x, y is the coordinates of the sink denoted by $sink.x, sink.y$.

$$d_1 = \sqrt{(XR(i) - sink.x)^2 + (YR(i) - sink.y)^2} \quad (3)$$

Where E_d is the energy of each node energy per bit and is the amplifier energy that depend on the transmitter amplifier model. ETX is a transmitted the energy. The *EDA* is the energy required for data aggregation. Length of packet pl send the packet from base station to cluster head.

If the distance is greater than or equal to initial energy

$$E_d = E_d - ((ETX + EDA) * pl + E_{mp} * pl * \left({d_1}^4\right)) \quad (4)$$

If the distance less than the initial energy

$$E_d = E_d - ((ETX + EDA) * pl + E_{fs} * pl * ({d_1}^2)) \quad (5)$$

Minimum Distance of only nodes:

Find the minimum distance for election of associated cluster head for normal node. It's denoted by m_d

$$m_d = \sqrt{(XR(i) - C(c).xd)^2 + (YR(i) - C(c).yd)^2} \quad (6)$$

In LEACH we need to find the minimum distance by which only we can send data from base station to cluster head.

If the minimum distance greater than the initial energy

Control length of the packets cpl is send between nodes

$$E_d = E_d - (ETX * (cpl) + E_{mp} * cpl * (m_d{}^4) \quad (7)$$

Packet of the length pl is send between nodes

$$E_d = E_d - (ETX * (pl) + E_{mp} * pl * (m_d{}^4) \quad (8)$$

If the minimum distance less than the initial energy

$$E_d = E_d - (ETX * (cpl) + E_{fs} * cpl * (m_d{}^2) \quad (9)$$
$$E_d = E_d - (ETX * (pl) + E_{mp} * pl * (m_d{}^2) \quad (10)$$

Energy Consumption Analysis in MLEACH:-

MLEACH allows more number of data to send from base station to cluster head in a particular time interval. MLEACH protocol reduces the number of alive nodes in the network. MLEACH enhances the energy efficiency and reduce the network's energy consumption and achieves higher performance.

Clustering

The number of individual nodes grouped together or collected in one Place. It's used to transmit aggregated data to the data sink.

Cluster head per round: -

It is the number of nodes that sends data to the sink directly after aggregating the data.

Cluster head selection Algorithm:-

From Eq. (11) p is a probability to become cluster head. Where *P* is the percentage of the number of clusters in the network (usually *P* is 0.05), the probability is multiply three for reduce the alive nodes from the MLEACH protocol, n is the number of node, is the number of the election rounds, $\mathrm{E_{res}}$ residual energy, *r*, round (1/ *P*) is the number of nodes which have been elected as cluster heads in the round.

$$\mathrm{T\ (k)} = \frac{\mathrm{P}}{\left(1-(3*\mathrm{P})*\mathrm{mod}\left(\mathrm{r,round}\left(1/_{(3*\mathrm{P})}\right)\right)-((3*\mathrm{p})*\mathrm{n})\right)}\frac{\mathrm{E_{res}}}{\mathrm{E_0}} \quad (11)$$

The dead node occurs when the initial energy is less than or equal to zero. If the initial energy is greater than zero means only occurs active node, but that condition is break when the dead node equal to number of nodes

Distance

The distance is calculated based on Eq. (3)

Calculated the Energy Dissipated:

From Eq. (12) (13) the E_{fs} and $E_{mp}$are consumed energy per bit and per area respectively. The d_1 is a distance, which decides the parameter value both energy per bit and energy per area. ETX is a transmitter the energy. The *EDA* is the energy required for data aggregation.

If the distance is greater than or equal to initial energy

$$E_d = E_d - (2 * (ETX + EDA) * pl + E_{mp} * \ pl * \left(d_1{}^4\right)) \quad (12)$$

If the distance less than the initial energy

$$E_d = E_d - (2 * (ETX + EDA) * pl + E_{fs} * \ pl * (d_1{}^2)) \quad (13)$$

Distance Board:

The distance board denoted by d_b. Square root of field dimensions of x and y maximum (in meter) are multiplied about the x axis position and y axis position of current node show on Eq. (14).

$$d_b = \sqrt{(xm * xm * ym * ym)} \quad (14)$$

From Eq. (15) Send the control of packet from base station to cluster head.

If the distance board is greater than or equal initial energy

$E_d = E_d - (2 * ETX * cpl + E_{mp} * cpl * (d_b{}^4))$ (15)

If the distance board is less than the initial energy

$E_d = E_d - (2 * ETX * cpl + E_{fs} * cpl * (d_b{}^2))$ (16)

Minimum Distance for only nodes:

Minimum distance is called based on Eq. (6)

Calculate distance between the BS and CH. To increase the energy efficiency of each node, multiply by 2.

$E_d = E_d - (2 * ETX * (cpl) + E_{mp} * cpl * (m_d{}^4)$ (17)

$E_d = E_d - (2 * ETX * (pl) + E_{mp} * pl * (m_d{}^4)$ (18)

If the minimum distance less than the initial energy

$E_d = E_d - (2 * ETX * (cpl) + E_{fs} * cpl * (m_d{}^2)$ (19)

$E_d = E_d - (2 * ETX * (pl) + E_{mp} * pl * (m_d{}^2)$ (20)

Minimum distance for cluster head:

If the minimum distance (E_{md}) is greater than to zero

$E_{md} = E_{md} - ((ERX + EDA) * pl)$ (21)

$E_{md} = E_{md} - ERX * cpl)$ (22)

If the minimum distance is greater than to the initial energy

$E_{md} = E_{md} - (ETX * (cpl) + E_{mp} * cpl * (m_d{}^4)$ (23)

Otherwise if the minimum distance is less than to the initial energy

$E_{md} = E_{md} - (ETX * (cpl) + E_{fs} * cpl * (m_d{}^2)$ (24)

Table.1: Simulation parameters

Parameter	Value
N	100
E0	0.5 J
The Length of Packets	6400
Control Packet Length	200
ETX	5×10^{-8}
ERX	5×10^{-8}
Efs	10^{-11}
Emp	1.3×10^{-15}
EDA	5×10^{-9}
P	0.05
Rmax	9999

Table 1: The above parameters are used in the energy

The above table refered from [6]. The simulation parameters used in the experiment is shown in Table 1. In order to explain our idea, we fist define some parameters as follows. N is a number of nodes. P is a optimal election probability of a node to become cluster head. *E0* is an initial energy. The *Eelect* is consumed energy per bit. *Eelec = Ef s= Emp*. The *Efs* and *Emp* are consumed energy per bit and per area respectively. The *do* is a distance, which decides the parameter value both *Efs* and *Emp*. The *EDA* is the energy required for data aggregation. Maximum round is denoting rmax. *ETX* and *ERX* is transmitter and receiver energy of the node.

IV. SIMULATION RESULT

The performance of MLEACH protocol was analysed using MATLAB . The number of rounds(r=1500) is considered in X axis and the number of dead nodes (n=100) in Y axis.

Figure 1, shows the energy efficiency of the LEACH algorithm. The number of alive nodes was calculated for each round in order to find the energy efficiency of the network.

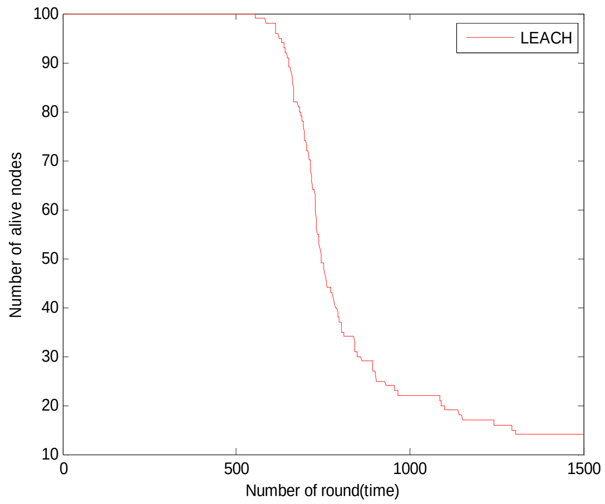

Fig.1 LEACH Algorithm

Figure 1 shows that when the number of rounds is 500,100 nodes were alive and when r=1000,25 nodes are alive and when r=1500,16 nodes are alive in LEACH protocol.

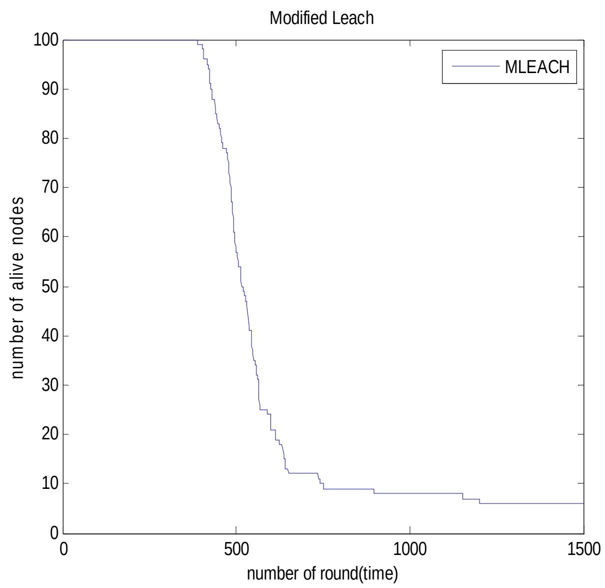

Fig.2. Modified LEACH

Similarly the analysis was performed for MLEACH protocol. The simulation result is shown in figure 2.Number of rounds is considered in x axis and the alive nodes count was measured.

Above the result of MLEACH graph, when the number of rounds is 500, 45 nodes were alive and when r=1000 and 1500, 7 nodes are alive in MLEACH protocol.

The comparative analysis between LEACH and MLEACH protocol was performed in figure 3.

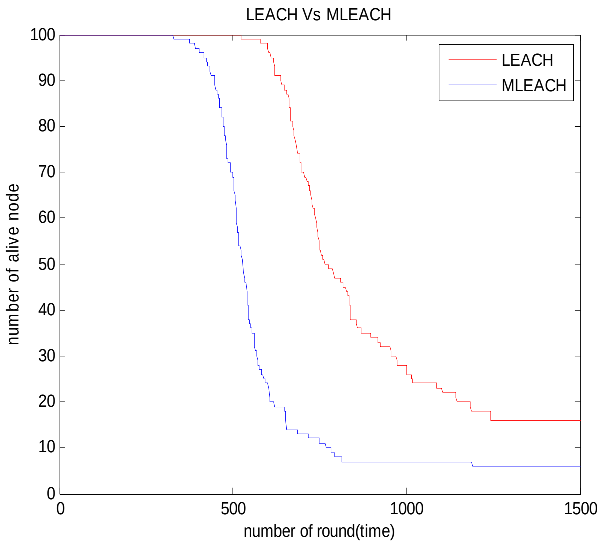

Fig. 3 Comparative analysis of LEACH and MLEACH

From the comparison analysis of figure 3, we analyze that the number of alive nodes is reduced in MLEACH protocol than LEACH protocol.

V. CONCLUSION

The LEACH protocol is one of the routing protocols based on clustering algorithm to calculate the energy efficiency of the network. MLEACH protocol was proposed based on existing LEACH protocol to save the energy of the network. Energy efficiency was analyzed by calculating the number of alive nodes in the network by considering the number of rounds. The performance analysis using MATLAB shows that the number of alive nodes is less in MLEACH protocol. Since the alive nodes are less in the network energy required to transmit the data is less. Since energy is less the energy efficiency of the networks gets increases. Thus MLEACH protocol is suitable to save energy of the network.

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