Comparative Analysis Of Energy Efficient Routing Protocol For Wireless Sensor network

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ABSTRACT

A wireless sensor network is consists of hundreds or thousands of nodes that are densely deployed in a large geographical area. These nodes *are* commonly used for continuously monitoring applications. Also these sensor nodes have small batteries. The energy consumption is the main issue in WSN's. The efficient routing protocol should minimize the energy consumption. In this paper, we compare base station assisted hierarchical cluster based routing with LEACH and also replace data aggregation from set up phase. Instead of a single cluster head group of cluster heads in a cluster manages the network. On rotation basis, a group of cluster heads member receives data from the neighbor nodes and transmits the aggregated data to distance base station. The group of cluster heads saves energy consumption by reducing the number of election. The simulation results shows that's its better than LEACH.

Keywords

Energy Efficiency, Network Lifetime, Wireless Sensor Networks, Group of cluster heads (GCH), Energy efficient routing protocol (EERP).

1. INTRODUCTION

Wireless sensor networks have been identified as one of the most important technologies in the 21st century for various applications. The WSN can monitor various entities such as: temperature, pressure, humidity, metallic objects. This monitoring capability can be effectively used in commercial, military and environmental applications [7]. Some other application includes forecasting, habitat monitoring, remote ecological monitoring, and biomedical applications [1]. With the recent advances in WSN's and embedded computing technologies, miniaturized pervasive health monitoring devices have become practically possible [11].WSN consists of several tiny sensors called nodes. The sensor nodes have the capability to collect and route data (message) either to other sensor and send to the base station [6]. The nodes are typically battery operated sensing devices with limited energy resources. Due to the small size of nodes, the battery of the nodes is fixed. The main problem of sensor nodes is that, their battery has finite energy, which limits the quality as well as lifetime of networks [8]. These nodes deployed in critical terrain. Also large number of nodes is deployed, so it is difficult to replace or recharge the batteries [9] [10].So all the things of the node from the hardware to the protocols must be designed energy efficient. To get the minimum energy consumption we should use the energy efficient routing protocol. We have many routing protocols, but we consider the hierarchical routing protocol. Because it is efficiently maintain the energy consumption of sensor nodes by involving them in ad-hoc communication within a particular cluster and by performing data aggregation in order to decrease the number of transmitted message to the base station. In hierarchical routing Low-Energy Adaptive Clustering Hierarchy (LEACH) is the popular protocol, which gives best communication for wireless sensor networks [4-5]. LEACH randomly select sensor nodes as cluster head and form clusters in the networks. Inside the cluster the non cluster heads nodes directly communicate with cluster heads and the cluster heads directly communicate with base station [3]. In LEACH cluster heads role are dynamically change after every round. But it has drawback, change of cluster head after every round. It wastes energy in again election. But when we compare LEACH with previous techniques, LEACH is energy efficient.

In order to make good protocols for WSN, it is important to understand the parameters that are relevant for the sensor applications. There are many ways in which the properties of a sensor networks protocols can be evaluated; we use the following metrics [5].

1.1 Ease of Deployment of nodes

Sensor networks may consist of hundreds or thousands of nodes, and they are deployed in remote or dangerous environments, allowing users to extract information in ways that would not have been possible otherwise. This requires that nodes able to communicate with each other even absence of an established network infrastructure and predefined node locations.

1.2 Network Lifetime

These networks should function for as long as possible. It may be impossible to recharge node batteries. Therefore all aspects of the nodes from the hardware to the protocols must be designed to be energy efficient.

1.3 Latency of data

Data from sensor networks are time sensitive. Then only it is important to receive the data in a time. Late data will not give us the proper information.

2. Radio Communication Model

The Radio communication model that is being used in our analysis is shown in Figure 1. We use a similar radio model as described in [5]. This radio model is assumed where the transmitter dissipates energy to run the radio electronics and the power amplifier and the receiver dissipates energy to run the radio electronics. It consists of several nodes and each node will be acting as a cluster head for a particular interval of time. This radio communication model have transmission electronic, transmission amplifier and receive electronic. The transmission electronic and amplifier (transmitter past) are separated by receive electronic (receive part) at distance d.

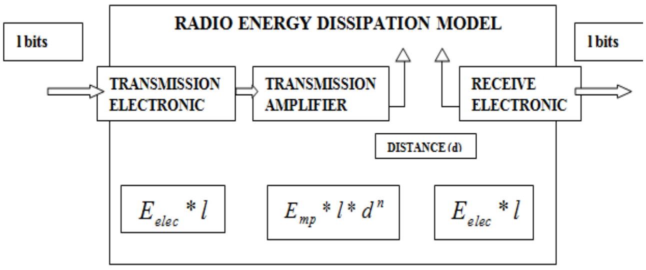

Fig1: Radio energy dissipation model

A long distance such as between a cluster head and the base station is given by d^4.The length of the message is *l* bits. The energy consumed to transmit *l* bits for a long distance (CH to BS), is given by:

$$E_{transmit-LD} = l * E_{elec} + l * E_{mp} * d^4$$

(1)

Energy consumed by amplifier to transmit at long distance is E_{mp}.

Similarly, the energy consumed to transmit a message of length *l* bits for a shorter distance d^2, such as within clusters is given by:

$$E_{transmit-SD} = l * E_{elec} + l * E_{fs} * d^2$$

(2)

The energy consume by an amplifier to transmit at short distance is E_{fs}.

Moreover the energy consumed to receive the *l* bits is given by:

$$E_{receive} = l * E_{elec}$$

(3)

The energy consumed in electronic circuit to transmit or receive the signal is E_{elec}.

2.1 Energy Consumption During the Election Phase

It is assumed that initially all the sensor nodes have same amount of energy and the energy consume is the same for all the clusters. In the election Phase, each cluster head broadcast an advertisement messages to rest of nodes in the networks that they are the new cluster heads. When all non cluster nodes receive this advertisement message, they decide where they want to go. This decision is based on the signal strength of the advertisement. The non cluster heads nodes inform the cluster heads that they will be member of the cluster [6]. It is considered that there are totally *n* number of sensor nodes and *k* clusters. Since we have assumed that the clusters are uniformly distributed there are totally *n/k* nodes in each cluster. The energy consumed by the cluster head is given by equation (4). Using (2) and (3), therefore energy consume by a cluster head is as follows:

$$E_{CH} = \{l * E_{elec} + l * E_{fs} * d^2\} + \{((n/k) - 1) * l * E_{elec}\}$$

(4)

The first part of (4) represents the energy consumed to transmit the advertisement message for sensor nodes on the base of a shorter distance energy dissipation model. The second part of (4) represents the energy consumed to receive (n/k-1) messages from the sensor nodes of the same cluster [7].

Using equation (2) and (3), therefore energy consumed by non cluster head sensor nodes is as follows:

$$E_{Non-CH} = \{k * l * E_{elec}\} + \{l * E_{fs} * d^2 + l * E_{elec}\}$$

(5)

The first part of equation (5) shows the energy consumed to receive the messages from *k* cluster heads node. The second part of equation (5) shows the energy consumed to transmit the decision to the corresponding cluster head.

2.2 Data Transfer Phase

During data transfer phase, the nodes transmit messages to their cluster head and cluster heads transmit aggregated messages to a distant base station. Therefore energy consume by a cluster head is as follows [7][5]:

$$E_{CH/frame} = \{l * E_{elec} + l * E_{mp} * d^4\} + \{(n/k - m) * l * (E_{elec} + E_{DA})\}$$

(6)

The first part of (6) equation shows the energy consumed to transmit a message to the distant base station. The second part of equation (6) shows the energy consumed to receive messages from the remaining nodes that are not part of the group of cluster head [7]. There are m associates in the group of cluster heads.

During steady state phase, the sensor nodes can start sensing the environment and transmitting data to the cluster-heads. The cluster-heads receiving all the data and aggregates it before sending it to the base station [6]. So we need data aggregation only in data transfer phase not in election phase, because in election phase all the non cluster nodes individually transmit the data to cluster head, so it does not requires data aggregation. So we compare LEACH with one of technique [7] by replacing data aggregation from set up phase. Also we consider its name as energy efficient routing protocol for wireless sensor networks and we use to solve much equation by using this [2].

The energy consumed by a non cluster head node to transmit the sensor data to the cluster head is given below [7] [5] [2]:

$$E_{Non-CH/frame} = \{l * E_{elec} + l * E_{fs} * d^2\}$$

(7)

Then the area occupied by each cluster is approximately M^2/k. In general, it is an arbitrary-shaped region with a nodes distribution $\rho(x,y)$. The expected squared distance from the nodes to the cluster head is given by [5] [2]:

$$E[d^2] = \iint (x^2 + y^2)\rho(x,y)dxdy$$

$$E[d^2] = \iint r^2 \rho(r,\theta) r dr d\theta$$

(8)

So if we assumed this area is a circle with radius $R = (M/\sqrt{\prod k})$ and $\rho(r,\theta)$ is constant for and, (8) simplifies to

$$E[d^2] = \rho \int_{\theta}^{2\prod} \int_{r=0}^{M/\sqrt{\prod k}} r^3 dr d\theta = \frac{\rho}{2\prod} \frac{M^4}{k^2}$$

If the nodes have uniform throughout the cluster area, then

$$\rho = \left(\frac{1}{\left(\frac{M^2}{k} \right)} \right)$$

and

$$E[d^2] = \left(\frac{M^2}{2\prod k} \right) \quad (9)$$

Using equation number (7) and (9) we get

$$E_{Non-CH/frame} = l * E_{elec} + l * E_{fs} * \left(\frac{M^2}{2\prod k} \right)$$

(10)

2.3 Optimum Number of Clusters

The optimum number of clusters can be found by setting the derivative of the total energy with respect to *k* to zero. The energy dissipates in a cluster when frame transmission is given:

$$E_{Con} = E_{CH/frame} + ((n/k) - m) * E_{Non-CH/frame}$$

(11)

The first part of the equation (11) is the energy consumption as an active member of the group of cluster heads. The second part of equation (11) is the energy consumption of (n/k-m) non-cluster head nodes. Then the total energy consume by k clusters is as follows [7]:

$$E_{total/frame} = kE_{Con}$$

(12)

Using equation number (6) and (10) and (11) we get

$$E_{total/frame} = \{klE_{mp}d^4 + (n - km + k)lE_{elec} + (n - km)lE_{DA}\}$$
$$+\{(n - km)lE_{elec} + (n - km)lE_{fs}(M^2 / 2\prod k)\}$$

The minimum consumed energy for optimum number of cluster k can be determined as follows:

$$\frac{dE_{total/frame}}{dk} = 0$$

(13)

Using (12) and (13) we get

$$k = \sqrt{n/2\prod}\sqrt{E_{fs} / (E_{mp} * d^4 - (2m-1) * E_{elec} - m * E_{DA})} * M$$

SIMULATION RESULTS

In our simulation Mat lab has been used to simulate the results. The energy consumption of LEACH and the energy efficient routing protocol is being compared and the results are shown. Energy efficient routing protocol is begins with a set-up phase, and is followed by data transfer phase. Their sub phases include advertisement, cluster set-up, schedule creation, and data transmission phases. In this simulation the networks diameter is consider as 150 meters. The simulation results have been obtained using the parameter table.

Table 1. Parameters values used for radio communication model.

Description	Symbol	Value
Energy consumed by the amplifier to transmit at s short distance.	E_{fs}	10 pJ/bit/ m^2
Energy consumed by the amplifier to transmit at s long distance.	E_{mp}	0.0013 pJ/bit m^4
Energy consumed in electronic circuit to transmit or receive the signal	E_{elec}	50nJ/ bits
Energy consumed for data aggregation	E_{DA}	5nJ/bits
Number of nodes	n	1000
Length of the message	*l*	4000 bits

First of all we obtained the result between numbers of cluster with group of cluster heads in 3.1. After that we will get the energy consumption with number of cluster in 3.2. The 3.3 shows the energy consumption per round with respect to the distance of the base station for fixed network diameter and 3.3.1 the energy consumption per round with respect to the distance of the base station for fixed network diameter when Group of cluster heads in three.

2.4 Optimum Number of Clusters

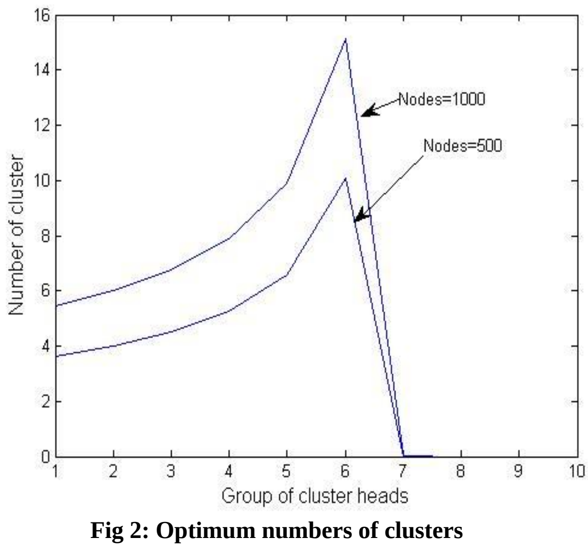

Fig 2: Optimum numbers of clusters

From the figure 2 it can be seen that the group of cluster head size in a cluster can be with in 1 and 6. If the cluster head in a group is greater than 6 then the number of clusters drops. For small number of cluster heads in a group there is small number of clusters, so there are few nodes those are sleep state. If the size of group of cluster heads is increase to a reasonable value then we get optimum number of clusters. So energy consumption is reducing because we have more sleepy nodes. Number of nodes also has effects on it.

2.5 Energy consumption Vs number of clusters

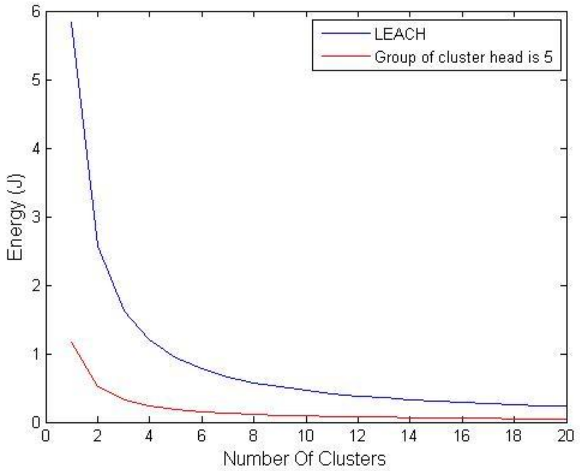

Fig 3: Energy consumption Vs number of clusters

The figure 3 describes number of clusters with respect to the energy consumption. LEACH has more energy consuming when compare with energy efficient routing protocol with five cluster heads in a group. From the graph it can be said that as the number of clusters increases the energy consumed decreases, because in LEACH election will be take place after every round is over and in group of cluster head the election will be only once. When the group of cluster heads is increased the energy consumption is decreases because of the increase in sleeping nodes and reduces the election phase.

2.6 Energy consumption for a round with respect to variable distance(2 GCH)

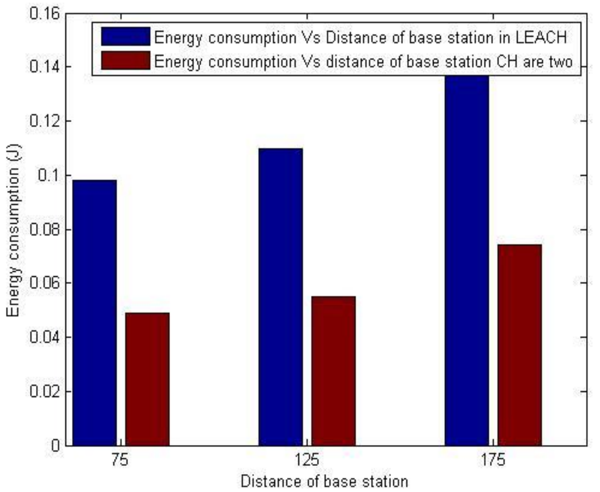

Fig 4: Energy consumption per round with respect to the distance of the BS.

3.3.1Energy consumption for a round with respect to variable distance (3 GCH)

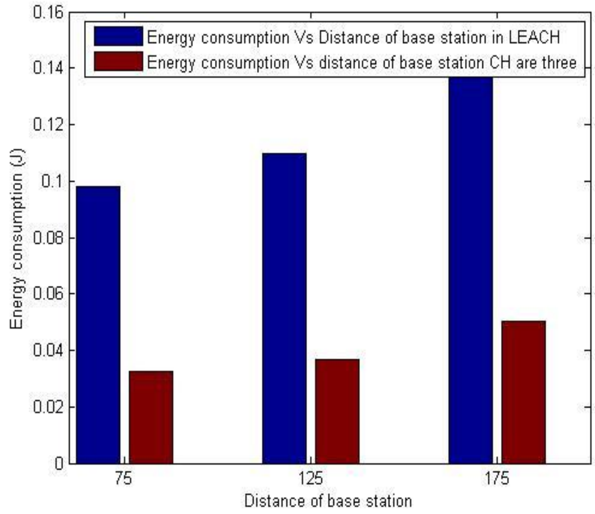

Fig 5: Energy consumption per round with respect to the distance of the BS.

Figure 4 shows the energy consumption per round with respect to the distance of the base station for fixed network diameter. Here the number of clusters is 50.It seen from the figure that the energy consumption is increased when the distance of the base station is increases. The base station position has great effects on the lifetime of the network. If the data or message will not reach to the base station, we lost the important information. Since most of the energy is consumed by transmission from cluster-heads to the base station. Therefore energy savings are not significant for a longer distance between the base station and the sensor nodes. We compare LEACH with EERP. The energy consumption in LEACH is more than EERP. In LEACH there are only one cluster head but in energy efficient routing protocol we have group of cluster heads. In our simulation we have consider two cluster heads in a group. When the number of cluster heads are going to increase for an optimum value in a group the energy consumption is reduces.

Figure 5 shows that energy consumption is going to reduce when the cluster heads in a group is three. Also figure 5 has better results than figure 4. But both the graphs shows that if the cluster heads are going to increase then energy consumption are going to decrease.

3. CONCLUSION AND FUTURE WORK

The energy efficient routing protocol has been shows that the energy consumption is reduced, when compared to LEACH. The simulation result shows that the routing protocol has a good performance in terms of energy and the lifetime of the network is enhanced. This is obtained by increasing the number of cluster heads in a group. When they are increases, the number of nodes that are in the sleep state also increases, that's why it saves the energy. The number of elections is also reduced when compared with LEACH. The future work is to include node heterogeneity in this routing protocol and also consider the node failure. So we considering the node failures fault tolerance feature should be included.

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