An Advanced Approach for Reducing Energy Consumption in Wireless Sensor Network

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Abstract- In widespread WSN, the nodes closer to the sink are always used to forward packets from all other remote nodes. The sensor nodes absorb more energy within the proximity of the base station and die quicker than those closer to the base station node. At the other side, the network can disconnect if 90 percent of nudity nodes have enough resources. In this study , we examine the problem of energy vacuum and aim to eliminate it. The energy deficit in these protocols is to be analyzed and the current sleep and wake processes of nodes have been supplemented with information so as to improve the network's lifetime. In this research work an advanced approach is proposed to reduce the energy consumption by introducing two level heterogeneity. The results are compared with the existing protocol and fares well in terms of increased lifetime and residual energy.

Keywords—Wireless Sensor Networks, Network Lifetime, Throughput, Residual Energy, Clustering protocol.

I. Introduction

The Wireless Sensor Network has now become an important research subject because of its potentially wide application field. The WSN consists of thousands of smaller nodes that each have limited capacity but can, together, create a useful network for various applications such as disaster management, fire detection, vehicle tracking, habitat monitoring and so on. The mesh networking connectivity finds any possible communication path to the destination or sinks by hopping data from node to node. Such small sensor nodes are made up of sensors , data processing and components for communication. The infrastructure-free and self-organizing functionality are key characteristics of these sensor nodes[1].The sensor nodes are randomly distributed and unattended to perform their mission. The cooperation between sensor nodes is another main feature of the sensor network. There are on-board processors in sensor nodes. Instead of sending raw data sensor nodes, partially processed information is transmitted by performing computation. The WSN normally functions unattended once installed in the network area, with minimal capacity for each sensor node. The sensor nodes begin to lose their energy with consumption and the node closest to death ends the entire WSN service. The retention of the power of the knots is therefore one of the main limitations of the architecture of the sensor network. Several research activities have been carried out in this area, leading to many solutions to energy efficiency in network use.

Several studies have shown that sensor network routing protocols must be configured to efficiently use the limited power in sensor nodes. Sensor networks are very difficult to route as they vary in many ways from conventional networking and wireless ad hoc networks. The networks are very challenging. Firstly, a global management framework for the deployment of pure numbers of sensor nodes can not be developed. Consequently, modern IP protocols can not be used for sensor network applications. Secondly, unlike traditional communication networks, virtually all sensor network implementations allow the flow of sensed data to a certain sink from multiple regions. Thirdly, it has a major redundancy in data traffic since multiple sensors can produce the same data near a phenomenon. The routing protocols will use this redundancy to increase energy and bandwidth usage. Fourthly, sensor nodes are highly restricted in terms of transmitting power, on-board power, processing capacity and storage and therefore require careful management of resources. Despite of these variations, a large number of new algorithms for routing data in sensor networks have been suggested. The routing mechanisms took the properties and the device and architectural specifications of sensor nodes into account. Nearly all routing protocols can be categorized as data center or hierarchic, even though there are few different protocols depending on the flow of the network or on service quality. In this research, a study is carried out on the impact of heterogeneity in node capacity. It is believed that a proportion of the population of nodes in the same network is equipped with more energy than other nodes making it a heterogeneous sensor networks. The explanation for this work is that many systems will benefit considerably from an understanding of the effects of such heterogeneity. The nodes are more energy-equipped than the nodes in use that generate heterogeneity as far as energy is concerned.

II. LITERATURE REVIEW

In recent years, several protocols for routing have been proposed. They can be generally categorized in areas based on blocks, hierarchies or clusters. Flat-based routing protocols give each node the same characteristics and use flood-based data transfer to transmit the packet. Clusters of hierarchical or clustering protocols are created. Each cluster has a head node. The key nodes are the members of their communities with duties such as gathering and aggregating data from their respective Clusters. Location-based protocols use location data to relay data to the appropriate regions instead of to the entire network. Sensor nodes are addressed via their positions in this form of routing. [1].

Heinzelman et al. [2002] introduced one of the most common hierarchically based protocols of routing, which include the Low Energy Adaptive Clustering Hierarchy (LEACH) distributed cluster formation[2]. The principal concept is to create clusters of sensor nodes based on the signal intensity obtained and use a local cluster head (routs) at the sink. Energy is saved from this protocol since only cluster heads are transmitted instead of all sensor nodes. To that inter-cluster and intra-cluster collisions, LEECH uses a TDMA / CODE-Division Multiple Access (CDMA) MAC.

LEACH-C is the updated LEACH-version, in which the base station randomly selects the cluster heads. All nodes with a higher energy content than average can be group heads. The base station operates a simulated ring algorithm to find the optimum solution with better positions to reduce cluster head energy.

M. Tripathi et.al [2013] introduces a LEACH-C energy efficient protocol (EELEACH-C) where a base station executes a sorting algorithm for the descending value of the cluster candidate head nodes sorted with their residual energy. After evaluating the cluster head nodes of the candidates, it selects those with maximum residual energy, then calculates the quadratic sum of the distances to their member nodes, in order to find the optimal solution. Experience shows that the proposed protocol improves the longevity of the network[5].

B. Manzoor et.al[2013] present Q-LEACH protocol The sensor nodes in the territory are used according to this strategy and divided into four quadrants to achieve better clustering[6]. It is possible to better protect the entire network through such partitioning. Moreover, the exact distribution of nodes is well known in the sector. The network portioning in quadrants results in an effective use of sensor nodes by resources. The optimal positions of CHs are described via this division. In addition, the transmission load of other transmitting nodes is that. In traditional LEACH clusters the size of the clusters is subjective and some of the members are far away. Due to the dynamic formation of this cluster, further nodes suffer from high energy drainage and consequently network performance degrades. Although in the Q-LEACH-network, the clusters within these sub-sectors are more deterministic in nature and are thus divided into sub-sectors. The nodes are thus well distributed within a certain cluster and contribute to an effective drainage of energy.

In order to enhance network existence with a single parameter Samayveer Singh et al [2016] proposes a 3-level heterogeneous network model for WSNs. It can define heterogeneity in 1-level, 2-level and 3-level according to the model parameter value. The authors' network model also helps pick group heads and their individual cluster leaders using a weighted likelihood and threshold role[7].

III. PROPOSED METHODOLOGY

The first order radio model is used in many researches on wireless sensors networks. Energy dissipation takes place, while transmitting and receiving the data and energy consumption for short distance communication is ‘d^2’ when propagation is done in line of sight and ‘d^4’ when transmission is done for the long distance due to multipath fading propagation. It works on the route measurements and sensing takes place constantly resulting in steady volume of data being transmitted to the sink. The following assumptions are considered in an analytical implementation:

1) Base station remains fixed: Wireless sensors are densely populated in the network area and are static. Number of clusters according to the network is predetermined for the network. The nodes will pass the data on the predefined paths, in which clusters and the cluster heads are numbered according to the distance based on received signal strength.

2) Some sensors are located farther away from the base station due to which, the cluster head will consume the 'd^4' energy for transmitting l bit data for direct transmission. Thus, data is transmitted through multiple hops and finally reach the base station by clusters very near to the base station

3) Links in the path are symmetric i.e. same power is required for the communication between any two nodes. No changes in the topologies and the loads are considered.

Thus, to transmit a message of length to a distance d, the transmitter energy is given as:

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

if $d<d_0$,

$$Et_x(k,d)=E_{elec}*k+E_{mp}*k*d_4 \quad (2)$$

if $d \geq d_0$

$$E_{tx}(k,d)=E_{elec}*k+Emp*k*d_4 \quad (3)$$

Receiver Energy:

$$E_{rx}(k)=E_{ele}c*k \quad (4)$$

where Eelec is the energy dissipated in transmission and reception, Efs and Emp are free space and amplifier energy respectively.

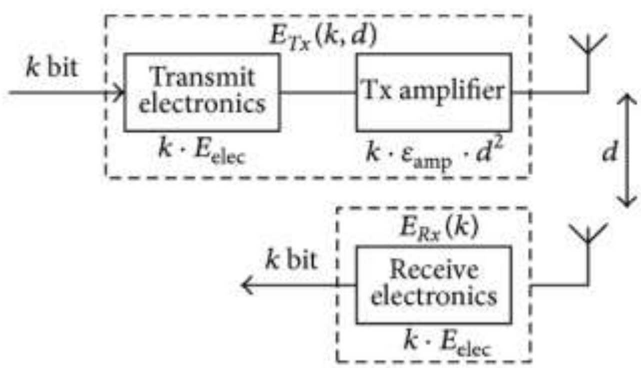

Figure 1: First Order Radio Model

The above diagram shown in Figure 1, shows a graphical representation of a first order radio model [8]. The transmitter and receiver use the same kind of electronic circuitry and thus their energies are accumulated as Eelec, for each data bit transmitted. The sensor nodes are thus symmetric to each other.

The setup phase is the primitive phase in deploying the network. As, we are simulating the actual network on a virtual software environment, we define the various characteristics which are possible for a network, based on the mathematical and physical modeling of the network. The various properties of the network like the field area, the number of nodes, various kinds of sensor energies are all need to be defined.

- Node Area- 100x100
- Base Station Position: 100,100
- Node Positioning: Randomly

The algorithm for node positioning is as below:

→ For i= 1 100
X(i) = rand(1,1)*100;

Y(i)= rand(1,1)*100;

Two types of heterogeneous node have been considered here based on their energy content viz. normal and advanced. The normal and advanced nodes are positioned randomly and their respective energies are assigned to them. The algorithm for setting up the characteristics of all three types of nodes is as shown below:

temp_rnd0=i
Initially there are no cluster heads only nodes
Random Election of Normal Nodes
  if (temp_rnd0>=m*n+1)
    S.E= E_0
    S(i).ENERGY=0
  end
Random Election of Advanced Nodes
  if (temp_rnd0<m*n+1)
    S(i).E=Eo*(1+a)
    S(i).ENERGY=1;
  end

Steady State Phase:
Once the network becomes operational the sensors become active and start sensing. The hierarchical architecture starts with finding the cluster heads and associating the non-cluster heads with the cluster heads.
Cluster head Selection:
The optimal probability of various categories of nodes i.e. normal and advanced, to be elected as cluster heads is dependent on selection probabilities given by below equations:

Pnormal=(p/(1+a*m)) (5)
Padv= (p*(1+a)/(1+a*m)) (6)

where, p is selection probability, a is additional energy factor for advanced nodes m is proportion of advanced nodes to total number of nodes n with energy more than rest of nodes.
To ensure that CH selection is done in the same way as has been assumed, we have taken another parameter into consideration, which is threshold level. Each node generates randomly a number inclusive of 0 and 1, if generated value is less than threshold then this node becomes CH For all these type of nodes we have different formulas for the calculation of threshold depending on their probabilities, which are given below:

$$Tnrm = \frac{pnrm}{1-pnrm\left(r.mod\left(\frac{1}{pnrm}\right)\right)} \quad \text{if } n_{nrm} \in G'$$
$$0 \quad \text{otherwise}$$

$$Tadv = \frac{padv}{1-padv\left(r.mod\left(\frac{1}{padv}\right)\right)} \quad \text{if } n_{adv} \in G''$$
$$0 \quad \text{otherwise} \qquad (7)$$

Where G’, G’’ represents the number of nodes from normal and advanced nodes who have not earlier become cluster heads.
The optimal probability of selection as a cluster head is based on distance and energy values calculated using below equations.

distance=sqrt((S(i).x-(S(n+1).x))^2 + (S(i).y-(S(n+1).y))^2) (8)

The energy dissipation is calculated as per the given conditions:
if (distance>do)

S(i).E=S(i).E- ((ETX+EDA)*(4000) + Emp*4000*($distance^4$)

if (distance<=do)

$$S(i).E=S(i).E- ((ETX+EDA)*(4000) + Emp*4000*(distance^2) \qquad (9)$$

IV. PERFORMANCE EVALUATION

The implementation results and simulation are discussed and analyzed in detail. Network software setup requires certain parameters derived from the radio model of a typical Wireless Sensor network architecture. The various equations defining the energy dissipation process in the wireless sensor network has been implemented in the software. The various network modelling parameters with their values are shown in the Table I. For this simulation the network area is 200mx200m. The base station is placed at location x=100, y=100 in the network area. The division shows the different cluster formation in the network area. The number of nodes is taken to be 200. The rounds are equivalent to a certain time scale. After every round the energy dissipation factor from different sources is accumulated to calculate the average energy left in each node.

TABLE I: Simulation parameters

Parameters	**Values**
Network Area	200m
Threshold distance, d0	sqrt(E_{fs}/E_{mp})
Energy consumed in the electronics circuit to transmit in or receive the signal, E_{elec}	50 nJ/bit
Energy consumed by the amplifier to transmit at a short distance, E_{fs}	10 pJ/bit/m_2
Energy consumed by the amplifier to transmit at a longer distance, Emp	0.0013 pJ/bit/m_4
Data Aggregation Energy, EDA	5 nJ/bit/signal
Message Size	4000 bits
Initial Energy, E0	0.5 J

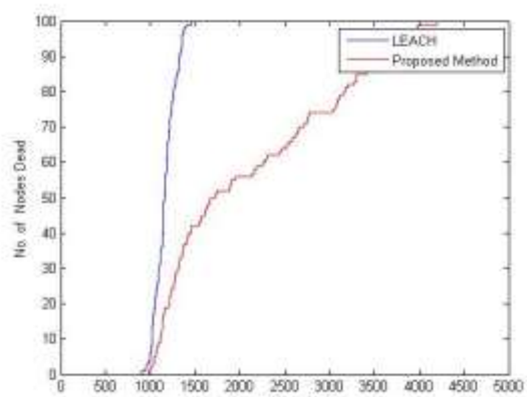

Figure 2: Number of Dead nodes vs rounds

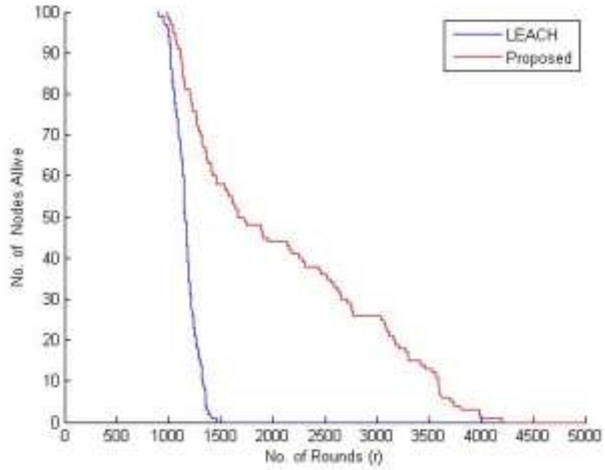

Figure 3: Alive Nodes vs Rounds

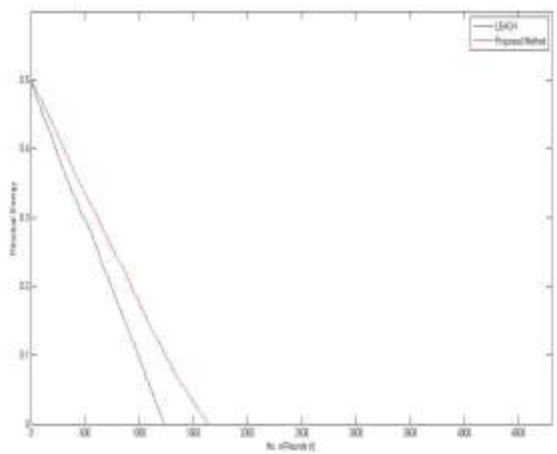

Figure 4: Residual Energy vs rounds

The above figure 2 shows the comparison of the proposed protocol proposed in this research work with that of the LEACH protocol. As shown from the figure 2 the proposed method has a considerable improvement in terms of nodes getting inactive or dead. The first dead node in the LEACH protocol under similar simulation parameters and network parameters occurs at around 949 rounds whereas in the proposed algorithm the first dead node occurs at around 1692 rounds for advanced nodes and 927 for normal nodes.. This is a notable improvement in the lifetime of the network. Similarly, the nodes die out completely at around 1572 rounds in LEACH protocol whereas in the proposed protocol the network dies out at round number 4138. This further affirms the effectiveness of the proposed protocol. Figure 3 shows the number of alive nodes plotted against the number of rounds.
Figure 4 shows the residual energy graph after each round. . As is visible from the graph, the residual energy has shown improvement in the proposed protocol. Thus, the proposed protocol is able to achieve energy efficiency.

V. CONCLUSION

The work presented here examines the routing capability of a Wireless Sensor network. In the network setup, part from the conventional energy threshold criterion being used in most of the LEACH based techniques; this research work also incorporates the distance threshold for deciding the selection of cluster heads in the subsequent rounds. The awareness of the distance of the network helps to understand the network more effectively. Especially, in the case of multi path communication it helps to save the energy wastage. The selection potential i.e. the capability to become the cluster head in a particular round has been evaluated from this distance metric. The energy heterogeneity has been considered with two types of nodes normal and advanced nodes. Proposed method improves the performance of LEACH, as is being shown by different curves like residual energy, number of alive nodes etc. which are a metric for knowing the network lifetime. The method shows that in identical environment as compared to LEACH, which is a standard protocol for comparing the routing methods, the given method improves the performance two-folds.

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