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A CLUSTERING TECHNIQUE BASED ON ENERGY BALANCING ALGORITHM FOR ROUTING IN WIRELESS SENSOR NETWORKS

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ABSTRACT

A Wireless sensor network(WSN) is a collection of large number of tiny sensor nodes deployed in a field to survey the surroundings phenomena. Since, energy consumption is the crucial challenge in those networks, exploiting judiciously the energy reserve of nodes is the key for designing protocols. Distributing the energy dissipated throughout the wireless sensor network in one of used techniques to maximize the service time duration of the WSN. In this paper, we present a hierarchical cluster-based routings protocol for Wireless Sensor Network. The proposed method allows a best distribution of energy load over the whole network nodes, which permits to extend the network lifetime.

Keywords: *Wireless Sensor Networks, Cluster Head Cycling, Energy balancing, Lifetime extension.*

1. INTRODUCTION

A Wireless Sensor Network (WSN) is a collection of small sensor nodes deployed in large numbers to monitor the environment conditions[1]. Since those networks have several domain applications such; military, medicine, agriculture, home, industry, etc., they have many attention for researchers in the last years. Since the nodes are battery powered, and have small dimensions, the available energy at each sensor node is limited. Accordingly, the energy consumption is the major constraint in the development of this kind of networks [2], [3]. Compared to the conventional networks deployed for the same purpose, this kind of networks has major advantages; greater coverage, accuracy, reliability and all of that at a possibly minor cost [4], [5], [6].

Clustering is the technique that organizes the network nodes into groups of sensor nodes called clusters. A cluster is formed by one or more number of cluster heads (CH) and members nodes[7]. Those cluster heads collect all data from their cluster members. The gathered data are routed to the Base Station (BS) that is the gateway for the front end user. Generally, this BS is an immobile node and with high capability, that is able to transmit and receive the data within the entire network and gives the user a gateway to the deployed WSN[8]. The number of cluster head depends on the number of sensor nodes and the network area. Energy consumption is efficiently controlled by selecting more than one cluster head for cluster containing more number of nodes in the network [6][9]. Distributed, dynamic and randomized clustering schemes are attractive due to their simplicity, feasibility, and effectiveness in providing energy-efficient utilization, load balancing and scalability at once [10].

Many literature works have discussed about hierarchical clustering in WSN from different perspectives. A lot of those works have proposed protocols for extending the life of WSN and for routing reliably data to the base station. Some of the proposed hierarchical protocols are LEACH[11], [12], PEGASIS[13], TEEN[14], [15], APTEEN[16], etc.

Even if the formation and the maintenance of clusters involves additional cost due to the control messages required for those purposes, still cluster-based WSNs have taken much attention of the researchers due to their better performance.

In this paper we present a novel method for network clustering allowing the network lifetime extension. The main focus is to equitably distribute the transmission energy load among the network nodes. The remainder of the paper is arranged as follows. Section-2 provides the

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literature review about WSN cluster-based routing protocols. Section-3 details the proposed technique. Simulation parameters and results are given in section-4. In Section-5 conclusions have been made and some recommendations for future work have been proposed.

2. RELATED WORK:

In many WSN applications only an aggregated value to be reported to the end-user is required. Data aggregation is yet searched when nodes are deployed densely and then the closest nodes may collect the same environment value. So, sensors in different regions of the observed field can collaborate to aggregate their data and provide more accurate reports about their local regions. Because of the large part of energy in the network is consumed in wireless communication, several communication protocols have been proposed to realize power efficient communication in these networks. Hierarchical routing is designed to reduce energy consumption by localizing data communication within a cluster and aggregation data to decrease transmissions to base station. Clustering technique is the main schemes used to route information in WSNs. In addition to improving the fidelity of the reported measurements, data aggregation reduces the communication overhead in the network, leading to significant energy savings. In order to support data aggregation through efficient network organization, nodes can be partitioned into a number of small groups called clusters. Many routing protocols have been proposed for WSN. LEACH[11] is one of the most popular and among the first hierarchical routing algorithms for sensor networks.

LEACH is a self-organizing, adaptive clustering protocol that uses randomization to distribute the energy load evenly between the sensors in the network. In LEACH, the nodes arrange themselves into local clusters. Each cluster has one node acting as the local base station called cluster-head. This cluster-head is the intermediate point for its cluster to the base station. Because of cluster-heads make long-range transmission; the cluster-head task is energy high cost. In order to not drain the battery of a single node, LEACH uses randomized rotation of the high-energy cluster-head position such that it rotates among the entire sensors. In addition, LEACH performs local data aggregation to diminish the amount of data that being transmitted from the clusters to the base station, further reducing energy dissipation and then enhancing system lifetime. At any given transmission round, sensors elect themselves to be local cluster- heads with a certain probability. The decision about whether to be a cluster-head is made locally, independently of the other nodes in the network. So, no additional negotiation is required to determine the cluster-heads. When a node decides to be cluster-head, it broadcasts its status to the other sensors in the network. Based on the received broadcasted status signal strength, the network nodes estimate the communication energy needed to communicate with each cluster-head. And then, each sensor node selects which cluster it desires to belong by choosing the cluster-head that requires the minimum communication energy. Once all the nodes are ordered into clusters, each cluster-head establishes a TDMA schedule for the nodes in its cluster. This scheduling allows nodes to switch off their radio interfaces at all times except during its transmit time, which allows to minimize the energy dissipated in the individual sensors. Once the cluster-head has all the data from the nodes in its cluster, the cluster-head node aggregates the data, by removing redundancy, and then transmits the compressed data to the sink.

In [17], the authors present a new technique to diminish the network energy that is lost in the setup phase. The exchange of control messages to construct the cluster done periodically conduct to energy lost. The authors propose that the competition to be cluster-head must be done not every each transmission round but every a lot of transmission periods. Therefore, when a node becomes cluster-head it plays this role for many consecutive periods, which leads to reduce the transmission of control messages, every round. In [17], the duration of a cluster head periods was determined statistically. So, all the network nodes may use the same periods. But, certain nodes may consume energy more than others because of their locations in the network relatively the base station. Then they will die rapidly compared the rest of network nodes.

Zytoune et al. [18] proposed a distributed technique to select a cluster heads in order to balance energy load over network nodes based on stochastic function depending on the cluster head energy cost.

All the proposed schemes use randomization to distribute the cluster head task over the

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network nodes. Then, the nodes energies may be drained randomly, and no uniform distribution of energy consumption is guaranteed. Our proposed technique is based on exploiting the network energy equitably, so the entire network nodes may die approximately at the same time.

3. CLUSTERING TECHNIQUE BASED ON ENERGY LOAD BALANCING (CTELB):

Based on the work [17], we propose a clustering technique that allows a best repartition of the energy transmission load of the network nodes. Thus, we propose that each node becomes cluster-head for a lot of time. This time is defined based on the required of its energy the reach the base station and to communicate with its neighbour nodes.

We assume a simple model for the radio hardware energy dissipation as described in[11], where the transmitter dissipates energy to run the radio electronics and the power amplifier, and the receiver dissipates energy to run the radio electronics, as shown in figure (1).

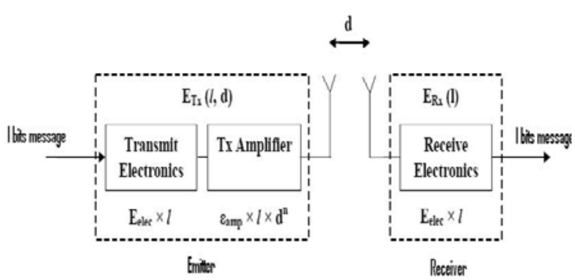

Figure 1: Radio Energy Dissipation Model.

Thus, to transmit an l−bits message over a distanced, the radio expends the energy given in (1):

$E_{TX-elec}$ is the energy consumed in the transmit electronics and E_{TX-amp} is the energy consumed in the amplifier.

The electronics energy (E_{elec}) depends on many factors such as the digital coding, the modulation, the filtering and the spreading of the signal, whereas the amplifierenergy,$\epsilon fs.d^2$or$\epsilon mp.d^4$, depends on the distance to the receiver and the acceptable bit-error rate.

Where the threshold d_0 is given by:

$$E_{TX}(l,d) = E_{TX-elec}(l) + E_{TX-amp}(l,d) \quad (1)$$

$$E_{TX}(l,d) = \begin{cases} l.E_{elec} + l.\epsilon_{fs}.d^2 & \text{if } d < d_0 \\ l.E_{elec} + l.\epsilon_{mp}.d^4 & \text{if } d \geq d_0 \end{cases}$$

$$d_0 = \sqrt{\frac{\epsilon_{fs}}{\epsilon_{mp}}} \quad (2)$$

To receive an l-bit message, the radio expends (3):

$$E_{RX}(l) = E_{RX-elec}(l) = l.E_{elec} \quad (3)$$

It is also assumed that the radio channel is symmetric, which means the cost of transmitting a message from A to B is the same as the cost of transmitting a message from B to A.

The proposed method is based on distributing the energy load over all the network nodes. Let a network formed of ***N*** nodes and $\boldsymbol{E_{i0}}$ is the initial battery energy of the node ***i***. The node ***i*** deployed in the monitored area can do $\boldsymbol{T_i}$ transmissions in its lifetime (until the depletion of its residual energy) in which it is the cluster-head. The equation (4) gives the relation between the number of becoming clusters heads for the entire network nodes.

$$\begin{bmatrix} E_{1\to BS} & E_{1\to 2} & \dots & E_{1\to N} \\ E_{2\to 1} & E_{2\to BS} & \dots & E_{2\to N} \\ \dots & \dots & \dots & \dots \\ E_{N\to 1} & E_{N\to 2} & \dots & E_{N\to BS} \end{bmatrix} \bullet \begin{bmatrix} T_1 \\ T_2 \\ \dots \\ T_N \end{bmatrix} = \begin{bmatrix} E_{10} \\ E_{20} \\ \dots \\ E_{N0} \end{bmatrix} (4)$$

Where $E_{i\to BS}$ is the required energy for the node ***i*** to transmit to the base station and $E_{i\to j}$ is the energy to transmit from the node ***i*** to node ***j***.

If we consider the node ***1***, it becomes cluster head for $\boldsymbol{T_1}$ transmission periods. Then, it spends the energy $T_1 * E_{1\to BS}$ when it is cluster head. When the node ***2*** is cluster head and node ***1*** is the member of its cluster, node ***1*** consumes $T_2 * E_{1\to 2}$. The same explanation can be done for the entire network nodes.

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The resolution of this equation gives the lot of time that each node can be a cluster-head until the depletion of its residual energy.

In the network, a numeric ID identifies each node. This ID is used to select the clusters-heads. The node with the minimum ID is elected to be the cluster-head first. And the node that had being cluster-head do this role for many consecutive periods corresponding of the duration determined by solving the equation(4).

For our work, the base station that has a sufficient energy and computation capability solves this equation and broadcasts in the network the duration Ti associated with each node i.

Based on the received message, each node can determine when and what many time it will be cluster-head.

K is the number of clusters to create in the network. This parameter is defined a priori to maximize the network lifetime [11] and [12]. So, at any period time, ***K*** clusters must be created. In the last cited work, the network clustering is stochastic then in average ***K*** clusters are formed by time. In the proposed work, at any time exactly ***K*** clusters will be formed, because the schedule is done a priori in the base station.

4. Simulation and results:

To simulate the proposed technique; we consider a square network with N nodes deployed randomly in the field. The used parameter values in our work are given in the table I.

Table I: Simulation Parameter Values

Description	***Symbol***	***Value***
Network dimension	M*M	100m
Number of network nodes	N	100
Data packet length	L	4000bits
Optimal probability of becoming CH in LEACH	P_{opt}	0.05

Figure 2 represents the network lifetime until the depletion of the energy of the entire network nodes for the proposed protocol compared to LEACH. The number of network nodes is set to N=100, the node's initial energy is 1J and the base station is located at (50m, 290m). As we can see, the proposed protocol permits to extend the network lifetime for extra transmission rounds. This enhancement is guaranteed for different base station location.

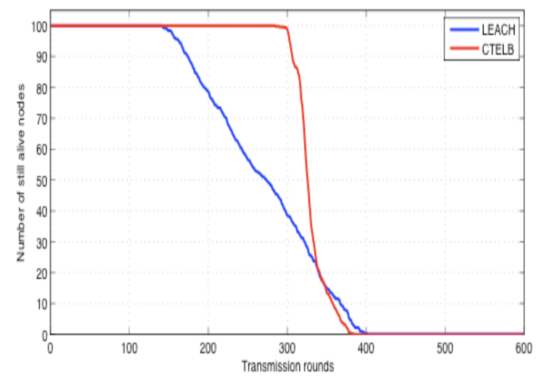

Figure 2: Network Lifetime Until The Death Of The Entire Network Nodes.

Figure 3 gives the network lifetime variation when the network node's initial energy goes from 0.5J to 2J. As depicted, the proposed algorithm permits to extend the network lifetime for different node's initial energy.

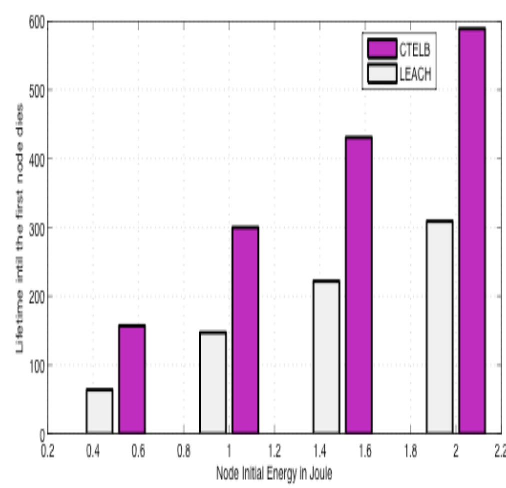

Figure 3: Network Lifetime Until The Death Of The First Node For Different Node's Initial Energy.

Figure 4 gives the network lifetime for different network nodes number. As depicted, the proposed technique allows a constant lifetime extension over LEACH protocol.

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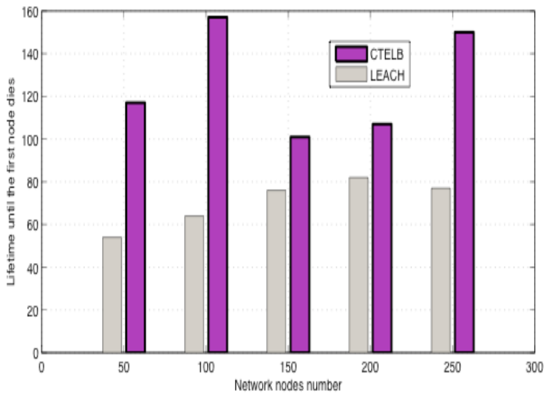

Figure 4: Network Lifetime Vs. Network Nodes Number.

5. CONCLUSION & FUTUREWORK

The proposed technique allows balancing correctly the transmission energy over the whole network nodes, which leads to network lifetime extension. This extension is guaranteed for different number of network nodes and for different nodes initial energies. The simulation results clearly show the improvement provided by our technique compared to the well-known protocol for clustering in wireless sensor networks (LEACH protocol). In future, we will continue the work investigating a distributed kind of the proposed technique.

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