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Efficient Energy Three Tier Routing Protocol for Wireless Sensor Network

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Abstract
In Wireless Sensor Networks, efficient energy management is always considered as one of the most important part. In this paper, we have proposed a routing protocol; Energy Efficient Three Tire Routing Protocol (EETTRP) for increasing the overall life time of the network. By utilizing Threshold Distributed Energy mechanism and Three Tier Communication Protocol is derived. Simulations are done in MATLAB and the results show that our protocol has longer stability than DEEC, DDEEC and EDEEC as well as much data transmission rate than DEEC, DDEEC and EDEEC.

Keywords
Cluster Heads – Routing Protocol – Wireless Sensor Networks(WSNs)

1. Introduction

Wireless Sensor Network (WSN) is an area of research that has various applications both for mass public and military. A wireless sensor network is composed of many sensors which can be used to monitor physical or environmental conditions, such as temperature , sound, pressure etc. After collecting these data they should pass this data through the network to a main location. A Sensor Node in Wireless Sensor Network lacks resources such as processing capability, capability , memory , capacity, battery , power, and communication capability .Because of the limited resources, on sensor nodes, the use of conventional key management techniques in wireless sensor networks is limited. To eliminate this limitation an Energy Efficient Routing Protocol has been proposed for communication scheme in wireless sensor networks. Due to the poor energy efficiency for routing packets in wireless sensor network, in practice most of our routing protocols do not give importance to the energy. The objective of the study is to develop the energy efficient 3-tier routing algorithm for wireless sensor network.

2. Related Works

In the Wireless Sensor Networks, efficient energy management is of great importance. In TSDDR: Threshold Sensitive Density Controlled Divide and Rule Routing Protocol for Wireless Sensor Networks paper, It proposed a novel routing protocol; Threshold Sensitive Density Controlled Divide and Rule (TSDDR) to prolong network lifetime and stability period . To achieve these targets, it utilized static clustering with threshold aware transmissions. Simulations were done in MATLAB and the results showed that the protocol has 60% longer stability period than LEACH and 36% longer stability period than DDR [1].

Wireless sensor nodes are restricted to computational resources, and are always deployed in a harsh, unattended or unfriendly environment. Therefore, network security becomes a tough task and it involves the authorization of admittance to data in a network .The problem of authentication and pair wise key establishment in sensor networks with mobile sink is still not solved in the mobile sink replication attacks. To determine the above problem the system adduces the three –tier security framework for authentication and pair wise key establishment between mobile sinks and sensor nodes. In order to overcome this problem a random pair wise key pre distribution scheme was suggested and further it helped to improve the network resilience. In addition to this an identity Based encryption was used to encrypt the data and mutual authentication scheme was proposed for the identification and isolation of replicated mobile sink from the network [2].

Regional Energy Efficient Club heads based on Maximum Energy (REECH-ME) Routing protocol for wireless sensor networks (WSNs) was purposed in 2013. The main purpose of this protocol was to improve the network lifetime and particularly the stability period of the network. In REECH-ME, the node with the maximum energy in a region becomes Cluster Head (CH) of that region for that particular round and the number of the cluster heads in each round remains the same [3].

DREMME used a unique technique for clustering to overcome the two problems with energy constraints and the finite lifetime efficiently. DREEM-ME elects a fix number of cluster heads (CHs) in each round instead of probabilistic selection of CHs. In DREEM-ME confidence interval was also shown in each graph which helps in visualizing the maximum deviation from original course. Simulations and results showed that DREEM-Me was much better than existing protocols of the same nature [4].

Reactive routing protocols are gaining popularity due to their event driven nature day by day. Route request, route reply and route transmission phases are modeled with respect to overhead. Control overhead varies with respect to change in various parameters [5, 6].

Tiered sensor networking architecture results in an agile surveillance system with a focus on improved operational flexibility and usability. Performance measurements using an in house simulator are provided using two different scenarios to demonstrate the system's great ability and expandability, operating from possibly a small-scaled single cluster to a cluster to a network of many chained hop-to-hop connections offering a large covering area [7].

3. Motivation

Advancement in the technology has leads to more and more efficient system and small size sensor nodes. Recently many researches have been in the area of WSNs. But most of the protocols have given attention to reduce coverage holes and energy holes to maximize network life time. As the sensor node collect and transmit a sensed data periodically from its environment to the base station they lose energy every time when they transmit data. LEACH uses dynamic clustering that results in a variable clusters. In this mechanism the CHs are selected by probabilistic function. Due to which there is quick death of nodes in LEACH. In DDR, the nodes uses static clustering but the use of periodic transmission makes the nodes die quickly. But there is the need of new protocol that could save more energy. The dynamic clustering technique in the existing reactive protocol (TEEN) [8] leads to quick death of the network. So, in this research, we focused to develop a protocol which can full fill the requirements and increase the lifetime and number of packet received at nodes as well as stability of the network.

4. Proposed Protocol Design

In this section, we firstly describe the radio model and cluster mechanism. Then we present the communication architecture and cluster head selection. Energy in clusters and operation is explained at the end of the section.

4.1 Radio Model

A simple first order radio model is taken. Where, $d2$ energy loss due to channel transmission is considered. Thus to transmit a k-bit message at distance d, the mathematical expressions are:-

$$d_o = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}} \tag{1}$$

$$E_{Tx(k.d)} = \begin{cases} E_{elec} \times k + \varepsilon_{fs} \times k \times d^2 & \text{if } d < d_o \\ E_{elec} \times k + \varepsilon_{mp} \times k \times d^2 & \text{if } d \geq d_o \end{cases} \tag{2}$$

$$E_{round} = L(2NE_{elec} + NE_{DA} + k\varepsilon_{mp} d^4_{toBS} + N\varepsilon_{f_s} d^2_{toCH} \tag{3}$$

Reception Energy:

$$E_{R_x}(k) = E_{elec} \times k \tag{4}$$

4.2 Network Model

We have taken 100×100 area of network field with BS at the center of the network. A total of 400 nodes are deployed in the field. In our protocol, number of CHs is changed as dynamic. In Cluster formation, nodes are deployed randomly and distributed in the region.

4.3 Communication Architecture

In our proposed model, data from the sensors reach BS by using multi-hop scheme. It consists of 3-Tire communication architecture. In Tire-1, all the non-CH nodes forward their sensed data to their respective CHs. In Tire-2, CHs of the sensed node region will send the data to the nearest CHs. To achieve energy efficiency, CHs find their distance to the next level CHs and send the data to the nearest CHs. In Tire-3, CHs which has received data will transfer to the Bs.

4.4 Cluster Head Selection

In any clustering protocol, selection of CHs is important. Now different CHs are selected in each round. As protocol uses a multi-hop scheme, this significantly brings robustness in the network, and energy consumption is maintained in large amount. CHs are selected on the basis of energy level in nodes.We get the probability threshold, that each node use to determine whether itself to become a cluster-head in each round, as follow

$$T(S_i) = \left[\frac{p_i}{1 - p_i \left(\text{rmod} \frac{1}{p_i} \right)} \text{ if } S_i \varepsilon G \right] \quad (5)$$

Where G is the set of nodes that are eligible to be cluster heads at round r.
The smaller communication distance will save energy.

4.5 Protocol

In the protocol, a WSN is being implemented. The nodes send data to BS and CHs only when the sensed attribute crosses a pre-defined threshold, and keep their transmitters off otherwise. Once the network is deployed, the sensor nodes start sensing. The sensor nodes transmit only if the threshold value is crossed. Two types of the threshold are used. Hard Threshold; in which each sensor nodes compare its sensed attribute when the sensor nodes cross the value, transmitter reports to CH. In the case of the Soft Threshold, it is used when sensor crosses hard threshold. Very small change in the value of the sensed attribute which triggers the node to turn its transmitter on and report to its CH. The change is based on the using a threshold residual energy value TH, Which is equal to:

$$TH_{REV} = E_0 \left(1 + \frac{E_{dis}NN}{E_{dis}NN - E_{dis}AN} \right) \quad (6)$$

Higher value of Soft Threshold lead to lower power consumption and higher network lifetime.

5. Simulation and Results

In this section, we present and discuss the simulation results of our proposed protocol. The results are compared with the existing traditional protocols by considering following metrices: network life time, number of packets received and energy consumption.

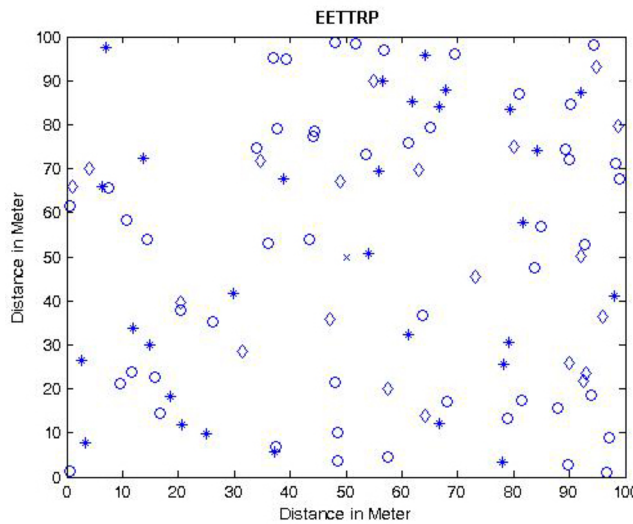

Figure 1: Deployment of sensor nodes

Table 1: Radio Parameters

SN	Parameters	Value
1	Initial Energy	$0.05J$
2	Packet Size	$4000bit$
3	Energy of transceiver	$50J/bit$
4	Energy of data aggregate	$50nJ/bit/message$
5	Transmit amplifier(Free space)	$10pJ/bit/m^2$
6	Transmit amplifier (multipath)	$0.0013pJ/bit/m^4$

A total of 400 nodes are deployed with energy consumption. Initial energy of the nodes is 0.7J. At first each protocol are run separately on their best environment conditions and assumptions. Then the output of the each protocol was recorded and then for comparison all the protocol were run in at the same time.During simulation death of the first node , tenth node and last node were recorded. The network is simulated 100 times and average values of the parameters are plotted. One single time of the simulations are run 10000 rounds for each protocols. Running environment is considered as best environment for previously developed protocols.Under Each condition simulation is run and then output was determined.Uniform Random Model is also implemented in this scheme to find packet drop to make this protocol more practical. The probability of the packet drop has been set to 0.3.

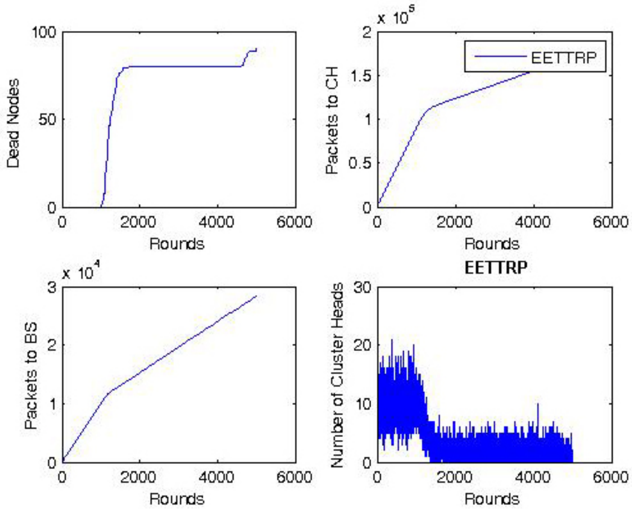

Figure 2: Output of EETTRP

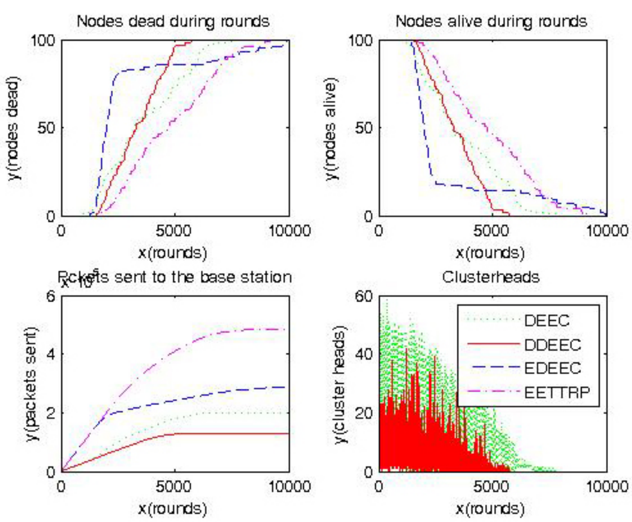

Figure 3: Comparison of outputs

6. Conclusion

In this paper, we focused on efficient utilization of energy to mitigate energy and coverage holes in WSNs. A novel protocol is proposed for communication in wireless sensor networks by using reactive and threshold dependent transmission scheme. Sensors in our protocol transmit only when they received drastic change. CHs are selected on the basis of minimum distance from reference point of their respective position. 3-Tier communication architecture is introduced to minimize the communication distance.

The performance evaluation of our proposed protocol is compared with DEEC, DDEEC and EDEEC. Result validate that EETTRP outperform the exiting routing protocols in terms of network lifetime, packets received and stability of the network. Our approach is 1.5, 1.38 and 1.08 times better than DEEC, DDEEC and EDEEC respectively, in terms of network lifetime.

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