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Energy Management In Clustered Heterogeneous Wireless Sensor Networks- A Study Concept

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ABSTRACT:- Wireless sensor networks are the networks with wireless sensors disseminated in a region which sense various types of information and then transmit this information to the other nodes or to the final destination. These nodes sense the changes in the physical parameters similar to – temperature, pressure, etc. The data sensed by these nodes are then approved to the Base Station (BS) for estimation. Wireless sensor networks are used for the variety of purposes like military surveillances, habitat monitoring, forest fire detections, landslide detections. Clustering is a key technique used to extend the lifetime of a sensor network by reducing energy consumption.It can also increase network scalability. In this project we introduce the new clustering algorithm by modifying SEP (Stable Election Protocol) for heterogeneous wireless sensor network, called EE-SEP. Energy Efficient -SEP protocol is used to increase the number of alive nodes and thereby increasing the energy efficiency, stability period and network lifetime and balancing the energy consumption.

I. INTRODUCTION

Wireless Sensor networks (WSNs) have become the one of the most interesting areas of research in the past few years. A WSN is composed of a number of wireless sensor nodes which form a sensor field and a sink. These large numbers of nodes, having the abilities to sense their surroundings, perform limited computation and communicate wirelessly form the WSNs (Romer 2002). Specific functions such as sensing, tracking, and alerting as described by Shorey (2006), can be obtained through cooperation among these nodes. These functions make wireless sensors very useful for monitoring natural phenomena, environmental changes (Hart 2006), controlling security, estimating traffic flows, monitoring military application (Bokareva 2006), and tracking friendly forces in the battlefields. These tasks require high reliability of the sensor networks.

To make sensor networks more reliable, the attention to research on heterogeneous wireless sensor networks has been increasing in recent past (Duarte-Melo 2002, Lu 2006, Liyang 2007, Chun-Hsien 2007).The wireless sensor networks have been used in a wide range of both civilian and millitary applications and the sensor nodes limited capacity has posed many challenges in the design issues. The resources such as communication bandwidth and the energy are more limited than those in a traditional wireless sensor network. This limitation requires any design protocols and technique to use the resources available effiectively and efficiently. In this thesis, we described about the design of clustering protocol for wireless sensor networks considering the energy consumption issues as the main constraint. Various clustering techniques have been designed for wireless sensor networks in the past. Although many of these techniques performed effectively in many aspects, there are still some areas which are to be addressed in these techniques.

A. Introduction to Wireless Sensor networks

Advances in micro-electromechanical systems, radio and memory technologies and processors have enabled the fast development of wireless sensor networks [1–4]. Figure 1.1(a) and 1.1(b) represents the typical structure of a wireless sensornetwork with single-hop and multi-hop clustering. In the single-hop clustering, each node will sends data to the BS. On the other hand, multi-hop clustering will have some CH's nodes in between the ordinary nodes and BS through which data transmission of the network to the BS takes place. Varous sensor nodes are being scattered in an area of interest with a BS located at a specific location of the network area. Each nodes in the network field must send the high-quality description of events to the sink in order to achieve remote monitoring of an environment through which end-users can communicate the network system through satellite, Internet or wireless communication means.

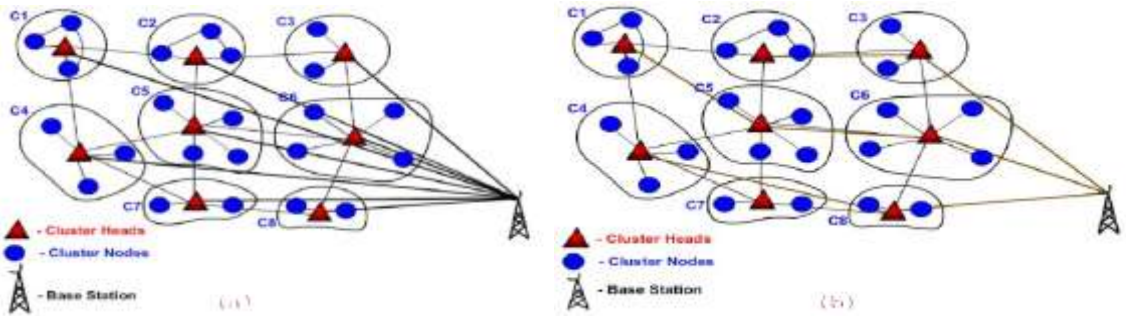

Figure 1.1: (a)Single-hop clustering, (b)Multi-hop clustering

Wireless sensor networks has thus become a new tool for extracting data from the environment. WSN allows the sensor nodes to be deployed as fixed in the monitoring field [5–7]. In addition, the wireless sensor nodes communicates to the base station through a wireless network model instead of directly communicating through a wired means. So, wireless sensor networks are more convenient and flexible for getting data from the monitoring environment. The conventional wired sensor network nodes are very costly and involves large amounts of energy for the network operation. Also, the deployment of these nodes is very expensive.
Therefore, it will be a good idea and feasible to replace these nodes with low-cost nodes which can be easily operated. Wireless sensor networks are fault-tolerant.

Wireless sensor network have been used in a wide range of applications, such as machine failure diagnosis, environment monitoring and biomedical purpose [8–10]. But, the physical constraints of sensor nodes posed many challenging issues in designing the wireless sensor networks. Some of the constraints which may affect the design of wireless sensor networks are as follows-

Limited energy supply. The energy of a sensor node which is initially installed with a battery as the power supply is very limited [9]. The energy of the network is consumed while data processing and data transmission of the nodes takes place. So, it is easy to drain the energy of the node at the time of network operation. The problem of energy drain out is further aggravated by some nodes that are given no attention. For example, in a specific application, sensor nodes are found to be scattered in a very dangerous and inaccessible territory. Recharging or replacing the batteries of such nodes are impossible. Also, to substitute all the batteries of nodes in a large area can be very costly and unreasonable. So, managing limited energy of a node is the most very important and crucial challenging issue for the design of wireless sensor networks.
Limited transmission range. The sensor node's transmission range is very much limited due to the constraint of node energy and antenna capability [3, 4]. The maximum reachable location of a sensor node is comparatively small with the traditional wireless network even though some nodes are able to vary their power level [7, 10]. Therefore, large numbers of sensor nodes have to be deployed for many applications in order to ensure the good coverage of the network. Also, the limited transmission range ensures the requirements of high node density for the purpose of maintaining connection between the nodes as reliable.
Small storage size. The storage capacity of a sensor node is very small as compared to that of traditional networks. This limitation makes the nodesto be unsuitable for applications where there are requirements of of large storage capacity. Also, small capacity of storage will lead to very small communicating and processing capabilities.
Objective: The main objective of this paperare:
To identify the existing clustering techniques in wireless sensor network and implement atleast some of them.
To design and develop a new proposed clustering technique which helps to extend the stable region of the wireless sensor nodes which finally increases the life time of the network and the effcient energy usage.
To analyse and verify the performance of the proposed clustering protocol using a simulator Matlab.
To compare the proposed method with the existing algorithms based on the no. of nodes alive in each of the rounds of the network.

II. RELATED WORKS

W.R. Heinzelman, A.P. Chandrakasan and H. Balakrishnan [1] introduced Low Energy Adaptive Clustering Hierarchy (LEACH) protocol in the year 2000 which is one of the most popular hierarchical clustering algorithms for sensor networks.

The concept here is to make clusters of the sensor nodes depending upon the received signal strength and finally use local cluster heads as the routers to the sink. The energy is being saved by this method since the transmissions are doneby cluster heads rather than all the sensor nodes. Optimally, the number of cluster heads is calculated to be .05× the total number of nodes. The activities like data fusion and aggregation are done locally to the cluster. To balance the energyconsumption of nodes, cluster heads keep changing randomly

over the time. This decision is done by the node through choosing a random number between 0 and 1.It is also the responsibility of the cluster heads to aggregates the data since it decreases the amount of data being transmitted. So energy is consumed in this task.
Some of routing protocols in this group are:

a) LEACH (Heinzelman 2000),
b) PEGASIS (Lindsey 2002),
c) TEEN (Manjeshwar 2001) and
d) APTEEN (Manjeshwar 2001).

Clustering has numerous advantages. Some of these are:
1. Clustering reduces the size of the routing table stored at the individual nodes by localizing the route set up within the cluster (Akkaya 2005).
2. Clustering can conserve communication bandwidth since it limits the scope of inter-cluster interactions to CHs and avoids redundant exchange of messages among sensor nodes.
3. The CH can prolong the battery life of the individual sensors and the network lifetime as well by implementing optimized management strategies (Younis 2003).
4. Clustering cuts on topology maintenance overhead. Sensors would care only for connecting with their CHs (Hou 2005).
5. A CH can perform data aggregation in its cluster and decrease the number of redundant packets (Dasgupta 2003).
6. A CH can reduce the rate of energy consumption by scheduling activities in the cluster.

III. PROPOSAL OPTIMAL CLUSTERING

According to the radio energy dissipation model illustrated in Fig. 2, in order to achieve an acceptable Signal-to-Noise Ratio (SNR) in transmitting an Lbit message over a distance d, the energy expended by the radio is given by:

$$E_{Tx}(l,d) = \begin{cases} L \cdot E_{elec} + L \cdot \epsilon_{fs} \cdot d^2 & \text{if } d \le d_0 \\ L \cdot E_{elec} + L \cdot \epsilon_{mp} \cdot d^4 & \text{if } d > d_0 \end{cases}$$

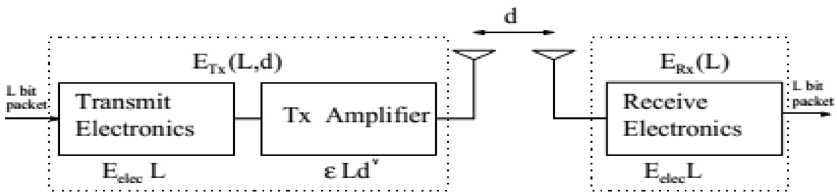

Fig. 2.Radio Energy Dissipation Model.

Simulation parameters: We simulate a clustered wireless sensor network in a field with dimensions 100m x 100m. The total number of sensors n = 100. The nodes, both normal and advanced, are randomly uniformly) distributed over the field. This means that the horizontal and vertical coordinates of each sensor are randomly selected between 0 and the maximum value of the dimension.We can evaluate the performance of SEP and EE-SEP protocol under these energy models using MATLAB script.
Field Dimensions - x and y maximum (in meters)
x and y Coordinates of the Sink
Number of Nodes in the field
Optimal Election Probability of a node to become cluster head
Energy Model (all values in Joules)
Transmit Amplifier types
Data Aggregation Energy
maximum number of rounds

B. SEP protocol

In this section we describe SEP, which improves the stable region of the clustering hierarchy process using the characteristic parameters of heterogeneity, namely the fraction of advanced nodes(m) and the additional energy factor between advanced and normalnodes (α).In order to prolong the stable region, SEP attempts to maintainthe constraint of well balanced energy consumption. Intuitively,advanced nodes have to become cluster heads more often than thenormal nodes, which is equivalent to a fairness constraint on energy consumption. Note that the new heterogeneous setting (withadvanced and normal nodes) has no effect on the spatial densityof the network so the apriori setting of p_{opt},does not change. On the other hand, the total energy of the systemchanges. Suppose that E_o is the initial energy of each normal sensor.

IV. PERFORMANCE MEASURES

We define here the measures we use in this paper to evaluate the performance of clustering protocols.

Stability Period: is the time interval from the start of network operation until the death of the first sensor node. We also refer to this period as "stable region."

Instability Period: is the time interval from the death of the first node until the death of the last sensor node. We also refer to this period as "unstable region."

Network lifetime: is the time interval from the start of operation (of the sensor network) until the death of the last alive node.

Number of cluster heads per round: This instantaneous measure reflects the number of nodes which would send directly to the sink information aggregated from their cluster members.

Number of alive (total, advanced and normal) nodes per round: This instantaneous measure reflects the total number of nodes and that of each type that has not yet expended all of their energy.

Throughput: We measure the total rate of data sent over the network, the rate of data sent from cluster heads to the sink as well as the rate of data sent from the nodes to their cluster heads.

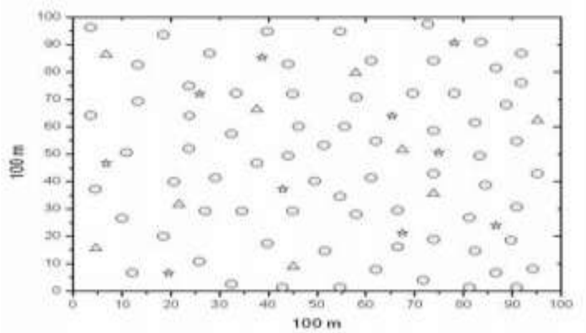

Fig. 3.(a) Network Structure

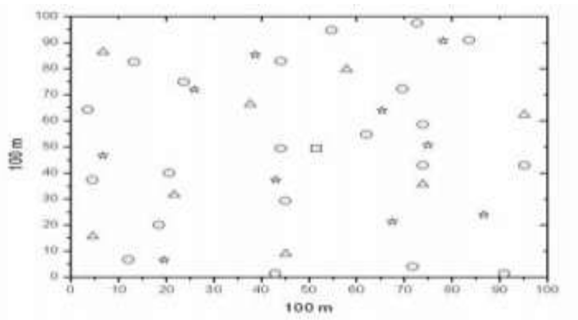

Fig. 3.(b) Network after some rounds

Here from Fig. 3(a) and 3(b) Normal, advanced and super nodes are shown by circle, triangle and star respectively.This algorithm works on the election processes of the cluster head in presence of heterogeneity of nodes. Figure above shows heterogeneity of the network, the snapshots when all nodes are alive and how the normal nodes die after some rounds.

V. CONCLUSIONS

We proposed SEP (Stable Election Protocol) so every sensornode in a heterogeneous two-level hierarchical network independently elects itself as a cluster head based on its initial energy relative to that of other nodes. Unlike [5], we do not require any globalknowledge of energy at every election round. Unlike [4, 8], SEP isdynamic in that we do not assume any prior distribution of the different levels of energy in the sensor nodes. Furthermore, our analysis of SEP is not only asymptotic, i.e. the analysis applies equallywell to small-sized networks.

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