Implementation and Analysis of Stable Election Protocol

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Abstract—Wireless sensor network is a new challenging technology of networked system used for research and is characterized by data processing abilities. These operate in hostile environment and interact with sensitive data. One of the major issues in wireless sensor network is developing an energy-efficient routing protocol. Since the sensor nodes have limited available power, energy conservation is a critical issue in wireless sensor network for nodes and network life. Hence, a new heterogeneous network with different types of nodes having different initial energy levels have been considered which is called SEP (Stable Election Protocol) for WSN. SEP provides better network lifetime than the existing protocols. SEP's main aim is to increase the stable region and as a result the unstable region is decreased. Therefore, the quality of the feedback of wireless clustered sensor networks is improved by the use of SEP protocol.

Keywords—Wireless Sensor Network, Stable election protocol, heterogeneous, clustering, Graphical User Interface

I. INTRODUCTION

Wireless sensor network is a large collection of independent nodes, each node having its own sensor, processor and radio transceiver and communicating wirelessly over limited frequency and bandwidth. These networks are densely deployed throughout the area because of their data processing and data acquisition capabilities [4]. Wireless Sensor Networks are networks of tiny, battery powered sensor nodes with limited onboard processing, storage and radio capabilities [1]. Their dependence on the coordination of their tasks makes these networks novel. Due to limited memory, unreliable communication, power limitations, these are more prone to internal and external attacks. The design of protocols for wireless sensor networks has to be energy aware in order to prolong the lifetime of the network, because the replacement of the embedded batteries is a very difficult process once installed. Security in wireless sensor networks is essential to defend various applications from different types of attacks and to protect its services from unauthorized modification, destruction or disclosure. Wireless sensor networks are the most emerging and challenging technology. The traditional techniques used for transmission like direct transmission and minimum transmission energy a part of the field will not be monitored for a significant part of the lifetime of the network [2]. These do not guarantee the well balanced distribution of the energy load among nodes of the sensor network. Hence, the sensing process of the field will be biased. To overcome above limitations, various clustering techniques have been proposed. Clustering techniques in wireless sensor networks aims at gathering data among groups of nodes, which elect leaders among themselves. The leader or cluster-heads has the role of aggregating the data and reporting the refined data to the BS. The advantages of this scheme are that it reduces energy usage of each node and communication cost and thereby extending lifetime [12]. Clustering can be categorized into two parts: Homogeneous and Heterogeneous. A homogeneous sensor network can be defined as a network consisting of identical nodes with same energy level, processing capabilities, and sensing range. On the other hand, heterogeneous sensor network consist of sensor nodes with different energy levels, sensing range and computation power [6]. Most heterogeneous network may have varying level of abilities depending on the deployment scenario. In this paper we present novel heterogeneous clustering network called Stable election protocol.

The SEP was the first to address the impact of energy heterogeneity of nodes in WSNs that are hierarchically clustered. They assign weighted probability to each node based on its energy level as the network evolves. One major characteristic of this approach is that it rotates the cluster-head to adapt the election probability to suit the heterogeneous settings that is the election probabilities are weighted by the initial energy of a node relative to that of other nodes in the network. This prolongs the time interval before the death of the first node.

The original version of LEACH does not take into consideration the heterogeneity of nodes in terms of their initial energy. Hence, the consumption of energy resources of the sensor network is not optimized as LEACH depends only on the spatial density of the sensor network. So we use SEP protocol in the presence of heterogeneity. Its main aim is to increase the stable region and as a result decrease the unstable region and improve the quality of the feedback of wireless clustered sensor networks, in the presence of heterogeneous nodes and assuming both normal and advanced nodes are uniformly distributed in space [3]. The first node dies on average in a round that is close to the round where the first node dies in the homogeneous case wherein each node is equipped with the same energy as that of a normal node in the heterogeneous case. Furthermore, we expect the first dead node to be a normal node. We also expect that in the following rounds the probability of a normal node to die is greater than the probability of an advanced node to die. During the last rounds only advanced nodes are alive. To solve the problem of instability, the authors in SEP redefined a new epoch for...
the sensor network. They used two kinds of nodes: normal nodes and advanced nodes. The advanced nodes have more energy factor than the normal nodes. The advanced nodes take up cluster-head position more than the normal nodes during the same epoch according to SEP model estimation. The new proposed epoch is equal to \(1/P_{\text{opt}}(m+\alpha)\). SEP used an election probability based on the initial energy of each node to elect the cluster-heads by assigning a weight equal to the initial energy of each node divided by initial energy of the normal nodes. The weighted probabilities for normal and advanced nodes in SEP were chosen to react the extra energy introduced into the network system. The probabilities and the total initial energy are given below respectively:

\[ P_{\text{nrm}} = P_{\text{opt}} \frac{1+m\alpha}{1+m} \]

\[ P_{\text{adv}} = P_{\text{opt}} \frac{1+\alpha}{1+m} \]

\[ E_{\text{total}} = n \ E_0 \ (1+m\alpha) \]

Where \( P_{\text{nrm}} \) is the weighted probability for the normal nodes and \( P_{\text{adv}} \) is the weighted probability for the advanced nodes and \( m \) is the proportion of the advanced nodes with times more energy than the normal nodes and finally, \( E_{\text{total}} \) is the total initial energy of the network.

In this paper, we have designed a protocol that can distribute the energy consumption across all nodes equally. The leaders are elected based on the nodes residual energies. This protocol guarantees that additional energies are efficiently and effectively used in the network. The performance of SEP is assessed in the presence of energy heterogeneity.

II. SIMULATION SET UP

The simulation setup of SEP protocol is implemented in MATLAB. An easy representation of the solution can be obtained through MATLAB GUI (graphical user interface). In this, a clustered wireless sensor network is simulated in a field with dimensions 100m x 100m. The total number of sensors \( n \) = 100. The nodes, normal nodes as well as advanced nodes, 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. The sink is in the centre and so, the maximum distance of any node from the sink is approximately 70m. It is assumed that the advanced nodes and intermediate nodes have additional energy levels as: \( \alpha = 1 \) and \( \mu = 0.1 \) respectively. The new heterogeneous epoch is

\[ \frac{1}{P_{\text{opt}} (1 + m\alpha + b\mu)} \]

Since \( P_{\text{opt}} = 0.1 \) on average there should be 10 nodes becoming cluster-heads per round. The parameter settings needed for the implementation of SEP protocol are as shown in table below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>( E_{\text{dec}} )</td>
<td>50 nJ/bit</td>
</tr>
<tr>
<td>( E_{\text{DA}} )</td>
<td>5 nJ/bit/message</td>
</tr>
<tr>
<td>( E_0 )</td>
<td>0.5 J</td>
</tr>
<tr>
<td>( K )</td>
<td>4000</td>
</tr>
<tr>
<td>( P_{\text{gu}} )</td>
<td>0.1</td>
</tr>
<tr>
<td>( \epsilon )</td>
<td>10 pJ/bit/m²</td>
</tr>
<tr>
<td>( \epsilon_{\text{min}} )</td>
<td>0.0013pJ/bit/m²</td>
</tr>
<tr>
<td>( n )</td>
<td>100</td>
</tr>
</tbody>
</table>

The initial energy of a normal node is set to \( E_0 = 0.5 \) Joules. This value is arbitrary and does not affect the behaviour of our SEP protocol. The radio characteristics used in our simulations are summarized in Table I. The horizontal and vertical coordinates of each sensor are randomly selected between 0 and maximum value of the dimension. The size of the message that nodes send to their cluster heads as well as the size of the (aggregate) message that a cluster head sends to the sink is set to 4000 bits. The normal node is denoted with ‘o’, an advanced node with ‘+’, a base station with ‘x’ and is located at point (100, 100). The simulation of the heterogeneous SEP protocol, in the presence of heterogeneity in the initial energy of nodes is carried out. The behaviour of protocol in terms of the performance measures is evaluated and the sensitivity of SEP to the degree of heterogeneity in the network is examined.

III. RESULTS AND DISCUSSIONS

Using the simulation setup, the performance of SEP is observed. To simulate the Stable Election Protocol in MATLAB, we first need to create functions in the editor window. Under the function, the parameters or say, variables are declared. The parameters to be initialized here are X-coordinates, Y-coordinates, number of nodes, number of rounds, etc. different functions are created to perform multiple tasks. This function declaration is called MATLAB Code. We can get an easy representation of the solution through MATLAB GUI (graphical user interface). The text buttons and push buttons works under Call back functions which is coded in M-file for GUI. There are four text buttons for entering the values for X-coordinates, Y-coordinates, Number of Nodes and Number of Rounds as shown below in fig 1. Other two buttons are the push buttons to Start Processing and to exit from the GUI.

Let us assumes the values that are taken here:

X-Coordinates = 100

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Y-Coordinates = 100
Number of nodes= 100
Maximum number of Rounds = 2000.

After that put all these values in GUI we push the Start Processing button and the result is shown as below:

- the colors used in each figure contrast well,
- the image used in each figure is clear,
- all text labels in each figure are legible.

A. Packets send to Cluster Heads from node

In SEP, packets sent to Cluster-head is very high initially near about 85 to 95 packets for more number of rounds as shown in Figure 2. Then it starts decreasing slowly after 1250 rounds. And at 1600 rounds it drops instantly to zero.

B. Packets send to Base station from cluster Head

In SEP, packet size varies from 4 to 16 mostly as the number of rounds increases and which sometimes extends up to 20 packets. SEP performs better up to 1500 rounds which are as shown in Figure 3.
C. Energy dissipated

Energy dissipated means amount of energy used to send packets from nodes to cluster heads and from cluster heads to base stations. In case of SEP, the amount of energy dissipation decreases from 0.5 to 0 as the number of round reaches the 1600 rounds which is as shown in Figure 4.

D. Dead nodes

Dead nodes are those nodes which have no energy to transfer packets from nodes to Cluster head and from Cluster head to Base station. Advance nodes have more energy than Normal nodes. It is clear from the figure 5 that the number of normal dead nodes starts increasing after 1200 rounds and up to 1550 rounds 50% of the normal nodes are dead. But in case of Advance nodes, the number of advance dead nodes is zero up to 2000 rounds.

Therefore, SEP depends upon the number of nodes and the maximum number of ranges. As the number of ranges increases the number of dead nodes increases, energy dissipated decreases and packets that are send to cluster head and the Base Station also decreases as the number of ranges increases.

![Fig.4 Energy dissipated as number of rounds increases](image)

![Fig.5 Dead nodes as number of rounds increases](image)

IV. CONCLUSION

Therefore, in SEP (Stable Election Protocol) where every sensor node is 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. Also, it does not require any global knowledge of energy at every election round. SEP is dynamic in that we do not assume any prior distribution of the different levels of energy in the sensor nodes. Also SEP is heterogeneous-aware which means that the election of Cluster-heads is based on node’s energy relative to that of others.

REFERENCES

