Utilization of Reverse Flooding Scheme to Enhance Energy-Efficiency in Wireless Sensor Networks

Sushruta S. Bhonde[1] Archana R. Raut[2]
[1]M.E Student [2]Assistant Professor
[1,2]Department of Computer Science & Engineering
[1,2]G. H. Raisoni College Of Engineering, Nagpur, India

Abstract— A wireless sensor network that consists of different nodes in hierarchy are considered. Some of these nodes have higher processing power and more energy. They are called manager nodes or super nodes. The second type of nodes has normal power and less energy and is called 'normal' node. In this paper, an energy-efficient method is presented. This method entrusts manager nodes with the responsibility of selecting relay nodes till the sensor nodes. This algorithm is effective in reducing energy consumption and increasing network lifetime. As none of the nodes save information related to routing table and relay nodes, therefore it will have less overload and complexity.

Key words: Wireless Sensor Network, Reverse Flooding, Heterogeneous Network, Energy Efficiency

I. Introduction

These days, wireless sensor networks are used in wide variety of applications. These networks consist of irreplaceable batteries. As the wireless sensor networks consists of limited energy it is of utmost importance to preserve energy. Therefore, techniques enhancing energy efficiency and thereby enhancing network lifetime are quite important.

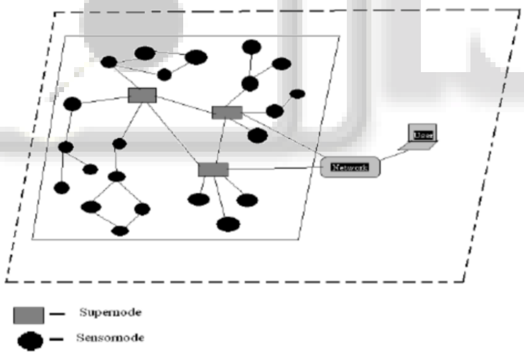

Fig. 1: Heterogeneous Network

Sensor networks are usually deployed in remote areas like desert, forest. As these sensors have batteries which are irreplaceable and in most of the cases it is not possible to charge them, therefore some methods to conserve energy must be employed. One of the best methods to save energy is by putting most of the sensors to sleep i.e. inactive mode. The network connectivity is maintained by letting the base station communicate with any of the active sensors. The system lifetime can be increased tremendously if we allow sensors to work in certain schedule.

In this paper, we propose a method for increasing energy-efficiency by two types of nodes, which form a hierarchy. The first kind of nodes is called 'manager' node. Whereas, second type of nodes is called 'normal' node. 'Managers' have higher capabilities in terms of energy as compared to 'normal' ones. 'Normal' nodes are greater in number than that of 'manager' nodes.

II. Related Work

Amongst area coverage, point coverage and barrier coverage the point i.e. target coverage is considered. Energy Efficient Data Gathering (EEDG)[5] which has been proposed by Awada introduced heterogeneous connected set cover problem. It had objective to find a maximum number of set covers such that each set cover monitors all the targets and is connected to atleast one node with higher capabilities.

Cardei introduced set cover problems with adjustable range to extend network lifetime in wireless sensor networks. In Energy Efficient Distributed Target Coverage algorithm, Liu addresses the target coverage problem in Heterogeneous wireless sensor network i.e. HWSNs. The main concept behind EDTC [11] was to introduce the concept of sensor priority. This priority is obtained from two parameters i.e. sensing ability and remaining energy [11]. The combination of said two parameters is discussed by Liu. The proposed work contains combination of these parameters for selecting relay as well as the sensor nodes. The main aim thus, is to improve the energy-efficiency of the network.

III. Selection of Subsets

Several rounds are considered during a network lifetime. Each round consists of setup phase and steady state phase. During the setup phase, active nodes are identified from the normal nodes. During steady state phase, these nodes operate until the end of current round. Physical position and frequent usage of nodes have most impact on energy utilisation. Also, the distance from the manager node matters as it has to ultimately communicate with the manager. In order to break the communication distance, some nodes act as relays.

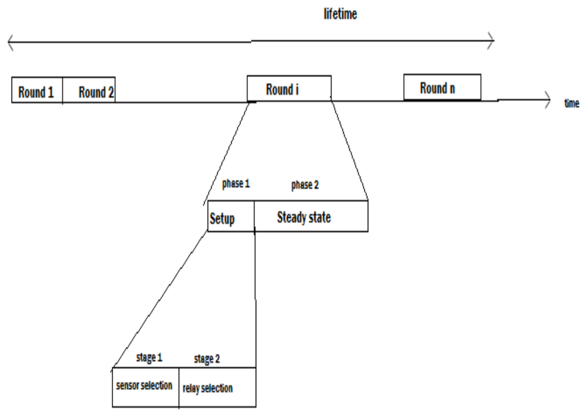

Fig. 2: Organization of Network Lifetime

Thus, the network operates in various phases as shown in Fig 2. The lifetime of network is distributed into several rounds. Each round consists of setup phase and steady state phase. Each setup phase consists of sensor selection and relay selection.

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IV. RESEARCH DESIGN

The Research Design comprises following steps

1) Creating sensor network environment such that some nodes serve as manager nodes and rest as normal nodes. The normal nodes come under the survillience of atleast one manager node in the region.
2) Determining active nodes by a competition set amost the nodes based on following criteria:
   - The residual energy of the node is higher than the minimum energy required for sensing and transmission.
   - There is atleast one point of interest in the node's sensing range.
3) Advertising to announce the corresponding points that will be covered in current round.
4) Relay Selection

As the communication range ofsensor node is not large enough to access a long distant observer, they need to send their data to a nearby manager. As each node cannot individually reach the manager, relays are used to serve the purpose.Thus relay selection comes into scenario.

V. FLOWCHART

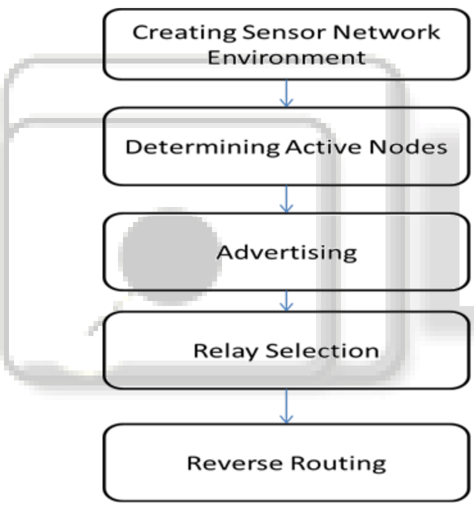

Fig. 3: Basic Flow Diagram

A wireless sensor network scenario is created. As all the nodes do not participate, the active nodes are determined. They advertise the points they cover and their communication and sensing range. A relay node is selected inorder to transmit the data till manager node. Finally, reverse routing is implemented.

VI. PROPOSED METHODOLOGY

In the target coverage scenario, the task of optimal path finding from normal node to manager node has been entrusted to the node having higher capabilities i.e. manager node. Optimum selection of relay groups and sensor nodes is a must for energy-conservation. By using competition between the nodes, it chooses the efficient path such that the energy is conserved. Algorithm used is the Subset Selection Algorithm. This algorithm is mainly divided into two parts viz, setup phase and steady state phase. The subsets of active node are determined amongst normal nodes in setup phase. Steady state phase involves the use of operation of nodes until the end of each corresponding round.

Physical position of the nodes and their frequent usage has the most impact on consumption of energy. Additionally, each and every node has to spend some energy for communication purposes which depends on distance from the manager. Thus, to break this distance, some nodes act as relay nodes.

The determination of active nodes is done by setting a competition among all normal nodes. The requirements for qualification are:

- The residual energy of the node is greater than the minimum amount of energy required for transmission and sensing.
- There is minimum one point of interest in sensing range of the node.

Advertising is done during setup phase where each unqualified node sets its status to inactive mode and active nodes wait till their turn for advertising. Thus every node whose back off time is complete will advertise in its communication range and also announce its corresponding covered points in current round.

Relay selection involves sending relay update information in which relay value of source and relay path to nearest manager node is sent. Although managers are randomly uniform distributed in network, some sensor nodes may not be able to reach it. Relay nodes act as intermediate nodes to carry their traffic till the manager nodes. A route beginning from a sensor node, passing relay node till the manager node is selected at this stage. Active nodes are basically categorized into sensor nodes and relay nodes. A relay selection and routing algorithm based on reverse flooding technique is utilised. This process involves the manager nodes finding best path to active sensor node. Consider R_Value and PR_Value. Suppose R_value is grade of each node to become a relay, while PR_Value is the primary grade of each node to become relay, which depends on maximum received value of its neighbours. At the start of process, the managers set their R_Value as 1. Then they broadcast a R_Update message to their one-hop neighbours. Every node in neighbourhood updates their relay value based on following:

$$\text{R\_Value} = \text{PR\_Value} * \frac{Er}{Ei} * e^{-\frac{N}{Nm}}$$

Here, Er and Ei are residual energy and initial energy of the nodes respectively. N stands for number of nodes and Nm stands for number of managers. The PR_Value is maximum received R_Value from other sources. As it is initiated from the managers it would be 1. Initially, relay nodes are zero. In next step, manager node's algorithm sends R_Value parameter to all normal nodes which are placed at one hop distance from that manager node.It uses R_Update parameter for this purpose. At the beginning, the relay path would only consist manager node ID as it is the starting point or initiator.

Thus, in general, nodes receiving R_Update messages from neighbouring nodes simply compare the R_Value of sender with R_Value of all its neighbouring nodes at one hop distance, which have sent this signal, to them. If R_Value is not received from one hop neighbours it sets presumed value as zero. Otherwise presumption value is minimum R_Value amonfg R_Value of one hop neighbours. Active monitoring and relay nodes are kept awake, rest are kept in sleep mode. This will remain same till end of current subsequent round. After the end of round, all the stages

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repeat for choosing sensor nodes and relay nodes for next round. In this method, R_value of each node is calculated and is independent from transmitter node. This leads to reduction in calculation and communication overload is also reduced, thus increasing energy efficiency of the network.

VII. SIMULATION RESULTS

We consider a network of altogether 50 nodes. The reverse flooding algorithm has been compared with algorithms introduced by Cardei and Awada. As shown in Fig.4 and Fig. 5, the simulation results show that the energy-efficiency of suggested algorithm is greater than that of EEDG algorithm.

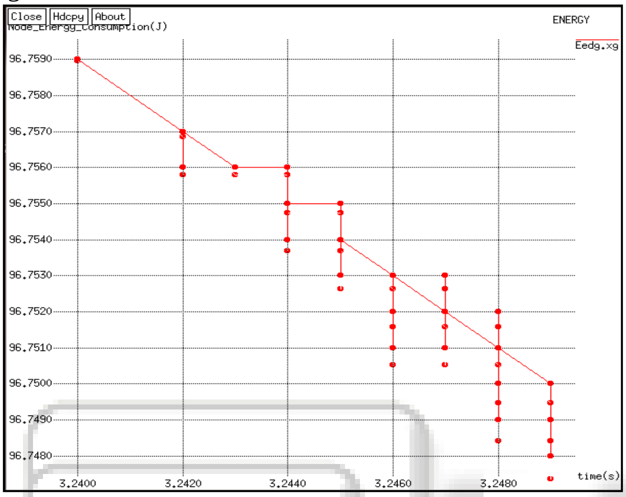


Fig. 4: EEDG Graph

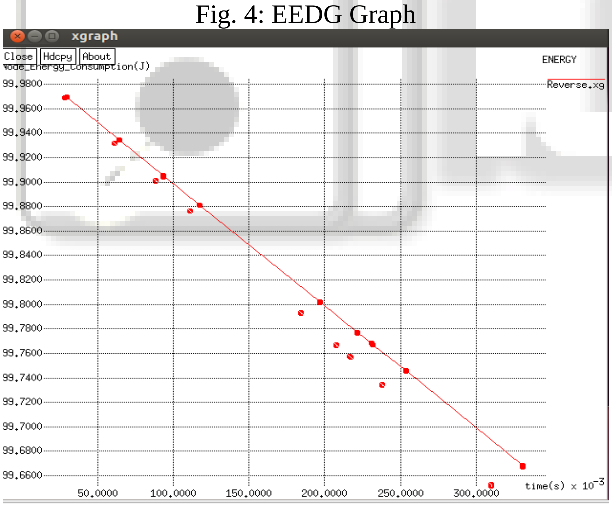


Fig. 5: Reverse Flooding Graph

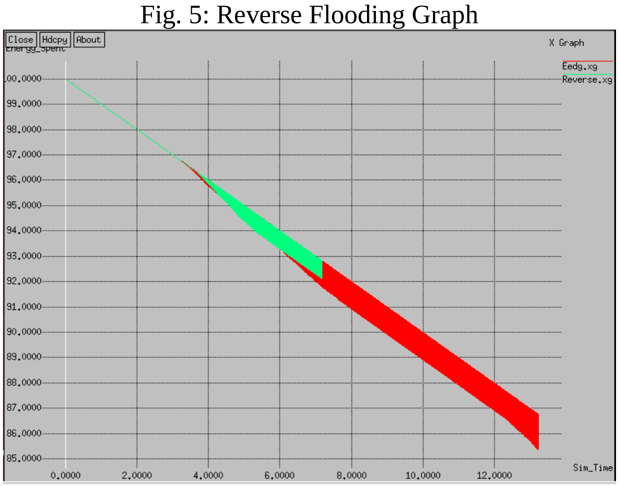
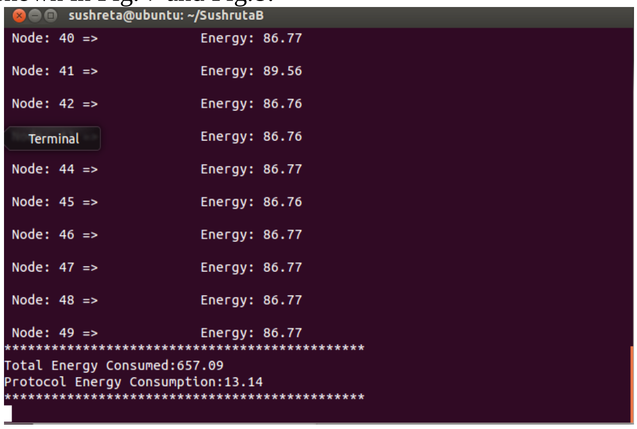


Fig. 6: Energy Consumption in EEDG and Reverse Flooding

The protocol energy required in both the cases is as shown in Fig. 7 and Fig.8.


sushreta@ubuntu: ~/SushrutaB

Node: 40 => Energy: 86.77
Node: 41 => Energy: 89.56
Node: 42 => Energy: 86.76
Terminal Energy: 86.76
Node: 44 => Energy: 86.77
Node: 45 => Energy: 86.76
Node: 46 => Energy: 86.77
Node: 47 => Energy: 86.77
Node: 48 => Energy: 86.77
Node: 49 => Energy: 86.77
****
Total Energy Consumed:657.09
Protocol Energy Consumption:13.14
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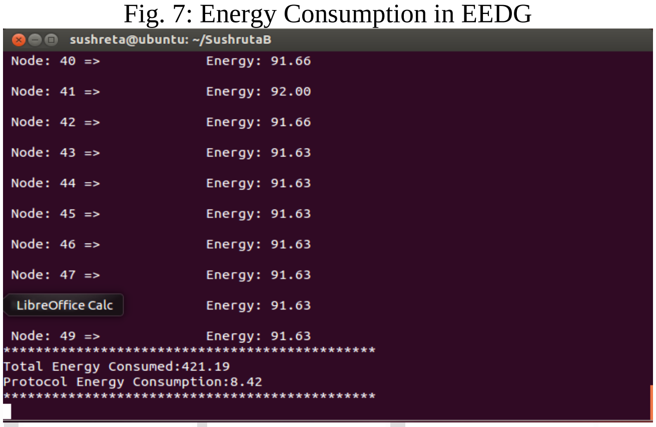
Fig. 7: Energy Consumption in EEDG


sushreta@ubuntu: ~/SushrutaB

Node: 40 => Energy: 91.66
Node: 41 => Energy: 92.00
Node: 42 => Energy: 91.66
Node: 43 => Energy: 91.63
Node: 44 => Energy: 91.63
Node: 45 => Energy: 91.63
Node: 46 => Energy: 91.63
Node: 47 => Energy: 91.63
LibreOffice Calc Energy: 91.63
Node: 49 => Energy: 91.63
****
Total Energy Consumed:421.19
Protocol Energy Consumption:8.42
****

Fig. 8: Energy Consumption in Reverse Flooding

The reverse flooding mechanism used is expected to lessen the energy consumption required by the network as well as improve the network lifetime simultaneously. As there is no need to save the routing table information or the information about the relay nodes, the energy consumption is expected to be lesser, which can improve network lifetime. Additionally, the filtering technique used prevents the inclusion of redundant entries, thus saving energy consumption and network traffic. Thus energy efficiency of the sensor network can be increased.

VIII. CONCLUSION

In this paper, reverse flooding technique is used in order to increase the energy efficiency and network lifetime. Moreover, communication overload and complexity can be reduced as relay nodes selection process is less tedious in given mechanism. No node saves the information about the routing table and relay nodes; therefore, it has less complexity and overload. Thus, efficiency in the method can decrease the energy consumption and can increase the lifetime of the network.

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