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Energy Efficiency in WSN using Node Ranking Based Universal-LEACH

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Abstract: Recent years have gain a tremendous attention in the use of wireless sensor network due to their numerous applications which explores from small to large scale and has became a hot research area for the research. A wireless sensor network comprises of a number of energy constraint sensor nodes deployed in the target region. In this paper , an multihop clustering based routing protocol have been proposed .In this protocol the clustering is elected on the basis of distance from the base station and residual energy of the node. A chain is formed to pass the information to the nearby nodes. The paper presents the comparison graph for the homogeneous network.

Keywords: Wireless sensors network, Sensor network, Base station, Node ranking, Universal LEACH

I. INTRODUCTION

Wireless sensor network is a hybrid, infrastructure based, multihop wireless sensor network technology. A wireless sensor network for a subset of adhoc network [1]. A wireless sensor network can be comprised of thousands of nodes, depending on the requirement of Quality of Service and the capability to tolerate a fault [2]. Wireless sensor network work in an association to achieve a frequent goal of sensing a physical parameter over a huge geographic area with optimal energy consumption. Wireless sensor networks classified as infrastructure based and non infrastructure based network. A sensor node is consisting of small sized nodes with sensing, computation and communication capabilities over a small distance. These components are integrated on a single or multiple boards, and packaged in a few cubic inches [3].These sensor nodes are battery powered devices which consumes energy while transmitting and processing the data. A sensor node typically comprises four parts: one or more sensors, a microcontroller, a wireless transceiver, and a power source. Batteries are commonly used to power nodes in a WSN deployment but have a finite energy budget [7]. Various metrics for evaluation of wireless sensor network includes network lifetime, cost, ease of deployment, coverage, response time, temporal accuracy and security. WSN is now used for many applications domains like military, environmental monitoring, healthcare, commercial, agriculture and fire detection etc. Various design issues includes node deployment, energy consideration, data delivery model, node capabilities, data aggregation.Clustering has been shown to improve network lifetime, a primary metric for evaluating the performance of a sensor network [4].

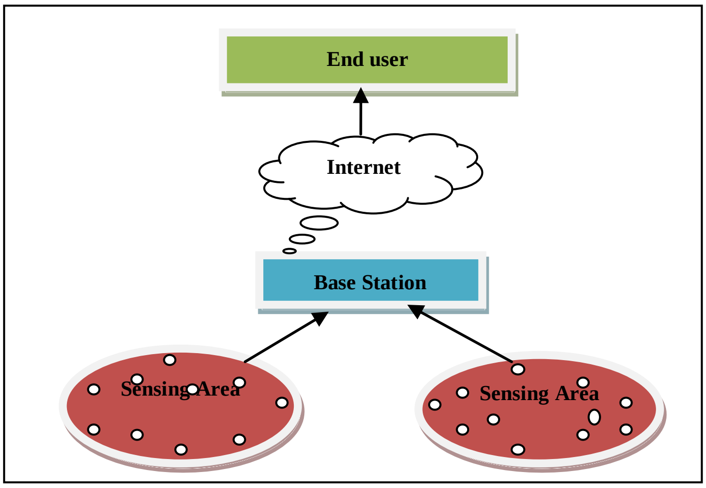


Figure 1.1: Wireless sensor networks

II. NODE RANKING BASED ULEACH

In most of the previously proposed clustering algorithms a node is elected as a cluster head either randomly or based on having the highest residual energy in a cluster. This selection might lead to inefficiencies [5].In the architecture, the region where all the nodes are placed is noted as target region. The data is being collected by all the nodes which are located at the target region. It is assumed that the BS is located far away from the target region and a global knowledge of all the nodes is contained at BS. The LCH is elected by the CH on the basis of distance and total residual energy contained in particular node. The LCH passes their data to the nearby upper level CH, also called MCH .The MCH's are ranked by the BS on the basis of distance and energy, in each cluster. The MCH pass on their data to the higher level MCH, if any. This multihop data communication helps to save the energy. The coverage is assured by the BS by assigning the node to each cluster. Each node respond back in order to pass its data to a particular CH. If any node is not in range of any CH then it become a CH itself. BS will calculate the threshold level energy for each CH. Each CH will act on its role until it reaches to a predetermined threshold energy level. It will reduce the overhead of selecting the CH in each round and CH will be same for the predetermined number of rounds.

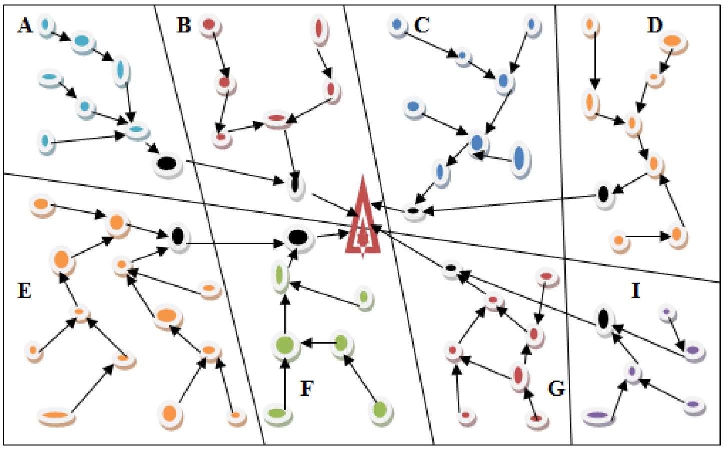


Figure 1.2: Proposed Routing for the Communication in NR-ULEACH

The Figure 1.2 is used to illustrate the route for the communication between LCH, MCH and BS in order to save the energy. In cluster A, the sensor nodes, presented with the help of Sky color, are basically used to collect the data locally and forward the collected data to the local sink i.e. LCH. The LCH will aggregate the collected data and forward it to the BS .The BS is located far from the LCH of cluster A, hence to save the energy the LCH of A will pass the data to the higher ranked LCH of other nearby cluster i.e. MCH and MCH will communicate with the BS .The data is sent to the BS in multihop fashion. For cluster C, the data will be gathered by the sensor nodes in blue color; CH will perform the aggregation function and will send the data to the BS directly because the BS is located near to the LCH of cluster C without any intermediate CH.

III. ALGORITHM

Basic Assumptions

a. The Base Station (BS) is placed in a fixed position and has unlimited energy. Thus no constraints are assumed with regards to power consumption due to data processing and communication.
b. The sensor nodes are energy-constrained.
c. Through the initial step of the below algorithm, the BS becomes aware of the locations of all sensor nodes either via collecting their GPS coordinates or any other mechanism [6].

Used Energy Model

In this paper, the energy model adopted is the same as used for LEACH protocol where Eelec is the radio dissipated energy which is assigned a value of 50 nJ/ bit to run the transmitter or receiver circuitry. The Eamp is the used energy for the transmitting amplifier and assigned a value of 100 pJ/ bit/m^2. ETx (k, d) is the energy that a node dissipates for the radio transmission of a message of k bits over a distance d and expressed by equation (1).

$$\mathbf{ET_X\,(k) = E_{elec} * k + E_{amp} * k * d^2} \qquad (1)$$

In the same way, the equation of the energy dissipated by a node for the reception ERx (k) of a message of k bits which is due to running the receiver circuitry Eelec (k) can be expressed by equation (2).

$$\mathbf{ER_X\,(k) = E_{elec\,*}\,k} \qquad (2)$$

Cluster Head Selection Process

After the forming of clusters, the BS assigns a cluster head for each cluster based on the proposed NR-ULEACH. Nodes in each cluster are ranked based on how far they are from the BS and on their current energy level. Nodes with the maximum residual energy and minimum distance will be chosen as a cluster head based on equation 3 and 4.

$$\mathbf{NodeRanking\ (En, Dn)} \qquad (3)$$

Where

$$\mathbf{(Dn\,(i)) = Min\,(D\,(i, BS)),}$$
$$\mathbf{(En\,(i)) = Max\,(ResidualEnergy(i))} \qquad (4)$$
$$\mathbf{|D\,(i, BS)| = \sqrt{(Xi-Xbs)^2 + (Yi-Ybs)^2}} \qquad (5)$$

Residual (En) is the current energy level of the node i and D (i, BS) is the Euclidean distance of node i to the base station. Given a particular deployment region of interest, Xi and Yi is the X and Y positions of node i. Xbs and Ybs are the X and Y positions of the base station.

A cluster head in each cluster will be changed when its energy level reaches a pre-defined threshold or a calculated value and not every round. This will make it possible for a node, i, to continuously play the role of a cluster head for multiple rounds and thus save any energy to be wasted for control and exchanged messages used in replacing it. The following steps give a description of the algorithm and cluster heads' selection process:

Steps for cluster formation

STEP 1 At very initial step i.e. set up phase, each node broadcasts a message to its neighbor node about its location and energy level. Hence, each node maintains an information table containing the status of its neighbor node's status of energy and location and broadcast this recorded information to its neighbor further. This process is carried out by all the nodes until information about all the nodes reaches to the BS. This phase provides the BS with a global knowledge of all the nodes present in the network.

STEP 2 The network area is divided by the BS, into various dynamic sized groups called clusters, on the basis of assumed communication range of the nodes.

STEP 3 If the network is homogenous then the LCH (Local Cluster Head) for the first round will be selected on the basis of distance from the BS (Dn) and for next round, residual energy (En) and distance, both will be considered but if the network is heterogeneous then , for each round including the first round , both energy level and distance will be considered for electing LCH from all the respective clusters.

STEP 4 These Local cluster heads are then ranked on the basis of their location from the BS, and the node with the least distance from the base station becomes the first level master CH. If two LCH have the same energy level (En) then their distance (Dn) from the BS is considered as secondary parameter.

STEP 5 The BS informs each local CH about the nodes which can associate with it and the local CH broadcast a message to all the nodes which can associate with it, nodes join each cluster by replying the message of the CH respectively.

STEP 6 The BS calculate the number of rounds , for which a CH can serve ,on the basis of the residual energy and also calculates a pre defined energy threshold ,then circulate this message to the each local CH.

STEP 7 Cluster heads, which are close to the BS will be having higher threshold value, while the farer located CH will have lower threshold value.

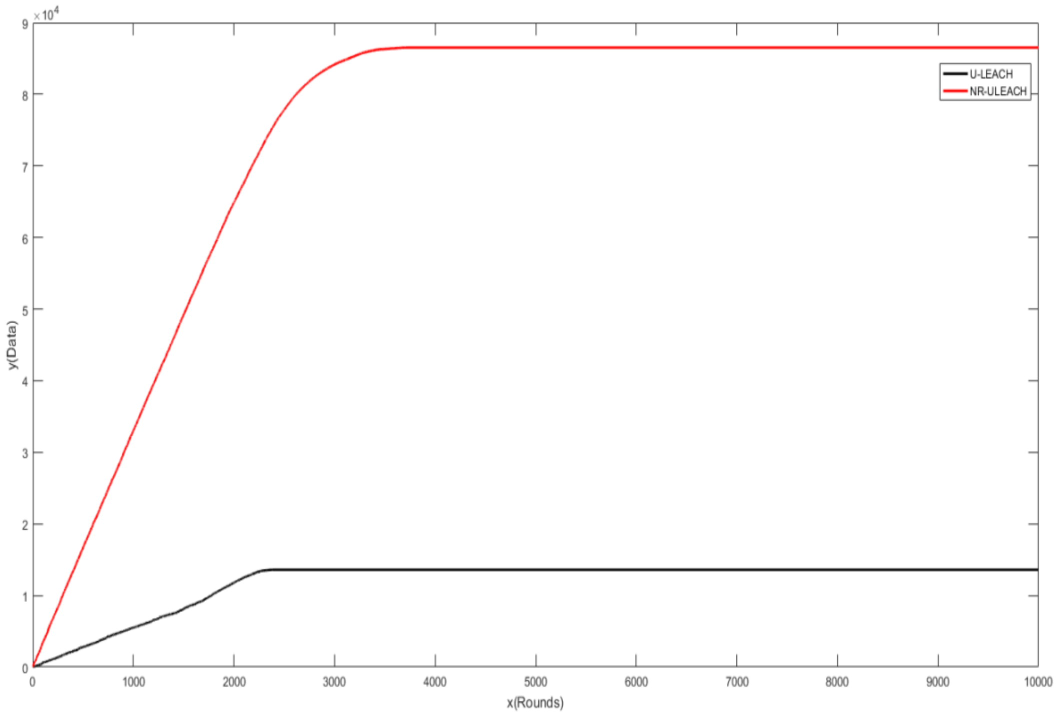
STEP 8 The local CH will be replaced only when their energy level reaches to the pre defined threshold value or when they will complete the rounds calculated by the BS already.

STEP 9 The master CH which is located nearer to the BS will be referred as first level MCH and the CH located at distant location will be second level cluster or third level MCH and so on...

STEP 10 The higher level MCH will transmit their data to the lower level MCH to it which is nearest to it and in order the data will be transmitted to the BS with a least energy consumption and finally from the BS to the end user.

STEP 11 If ever there will be a change in the topology or the CH node will die due to some harsh environmental conditions, the BS will determine the next appropriate local CH by considering new changes.

IV. PACKET DELIVERY RATIO



In Figure, we observed that packet delivery ratio is better than in NR-ULEACH protocol as compared to ULEACH. The stability of route chosen using NR-ULEACH protocol has achieved higher packet delivery ratio compared with ULEACH. In ULEACH, number of rounds was 2000 and packet transmitted was 1 as minimum packet delivery ratio and number of nodes was 10000 and packet transmitted was 1 as maximum packet delivery ratio of nodes. But NR-ULEACH performs better results i.e. number of rounds is 4000 and packet transmission is 8.7 as minimum packet delivery ratio and number of rounds is 10000 and packet transmission is 8.7 as maximum packet delivery ratio.

V. NETWORK LIFETIME

The Table 1.1 describes the network lifetime for the earlier developed ULEACH and proposed NR-ULEACH in the heterogeneous and homogeneous scenario. We can conclude that the heterogeneous network give better results for both ULEACH and NR-ULEACH as compared to the homogeneous network. The table considers FND, HND and LND as the metrics for the comparison.

Table 1.1: COMPARISON TABLE FOR ULEACH and NR-ULEACH

Perimeters	**ULEACH**		**NR-ULEACH**	
	Homogeneous	Heterogeneous	Homogeneous	Heterogeneous
First Node Dead	992	1500	1425	4700
Half Node Dead	1787	2567	2384	5730
Last Node Dead	2693	3156	3426	8753

VI. CONCLUSION

Results demonstrate the effectiveness of proposed protocol in terms of packet delivery and improved network lifetime. The simulation results are compared with ULEACH protocol. The proposed NR-ULEACH protocol provides better results in comparison to other protocols and can be used in wireless sensor network for less energy consumption and prolonging the network lifetime. Results represent that NR-ULEACH performs better in terms of network lifetime and packet transmission. The packet transmission rate in the NR-ULEACH is comparatively more and the number of alive nodes is high in NR-ULEACH which increases the network lifetime. Similarly, the number of dead nodes is more in ULEACH as compared to NR-ULEACH.

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