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Improvement on Multi Group-LEACH Protocol of Wireless Sensor Network

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Abstract— ***Communication is the major cause of energy depletion in the wireless sensor network, so designing of energy efficient routing algorithm is one of the key challenges that need to be addressed for extending life time of network. This paper studies the MGLEACH and puts forward some improvements to it. The suggested changes are for Cluster Head (CH) selection and Communication between CH and Base Station (BS). The CHs are selected based on the parameters such as 1) Remaining Energy 2) Number of neighbor nodes 3) Centrality of the node and 4) Proximity to Base Station. To make the communication much more efficient, Multi-Hoping is used, Multi-Hop selects optimal path for communication between CH and BS. To check our presented scheme we simulate it using Matlab. Simulation results show that Improved Multi Group-LEACH had outperformed MG-LEACH on the basis of Network life time.***

Keywords— ***Wireless Sensor Network (WSN), Cluster Head (CH), Base Station (BS), Multi-Hop, Network life time.***

I. INTRODUCTION

The sensor node has four basic components such as Sensing, Processing, Radio and Power it normally operates in unattended mode. Most of the time sensor nodes are equipped with non-rechargeable battery that is not replaceable in most of the applications. In sensor node, radio communication is the main energy dissipation factor [1] [2]. Due to limited computational and power capabilities of deployed sensor nodes a lot of research is going on to find out energy efficient routing algorithms.

Routing protocol based on clustering is well known solution for enhancing network life time in WSN. The basic idea of clustering routing[3] is to use the information aggregation mechanism in the cluster head to reduce the amount of data transmission, thereby, reduce the energy dissipation in communication and in turn achieve the purpose of saving energy of the sensor nodes. In the clustering routing algorithms for wireless networks, LEACH (low-energy adaptive clustering hierarchy) [3] is well-known because it is simple and efficient. LEACH divides the whole network into several clusters, and the run time of network is broken into many rounds. In each round, the nodes in a cluster contend to be cluster head according to a predefined criterion. In LEACH protocol, all the sensor nodes have the same probability to be a cluster head, which make the nodes in the network consume energy in a relatively balanced way so as to prolong network lifetime. LEACH [3] is renowned for its success in extending the lifetime of Wireless Sensor Networks and Multi Group Based LEACH (MG-LEACH) is addition to LEACH and comparatively it is much more energy efficient, which further improves the Network Life Time [4]. Our proposal is based on the framework of MGLEACH.

LEACH is an adaptive clustering routing protocol proposed by Wendi B. Heinzelman, et al. The implementation process of LEACH includes many rounds. Each round consists of the setup phase and the steady data transmission phase.

A. Set-up Phase

In this phase the CHs are selected based on an elective percentage of deployed nodes, also by considering a factor that so far how many times an individual node performed the role of cluster-head. Each node from the group of deployed nodes ***G*** chooses a random number between ***0*** and ***1***. If the number is less than a set threshold ***T (i),*** the sensor node becomes a cluster-head for the existing round. Where ***T (i)*** is calculated as

$$T(i) = \begin{cases} \dfrac{p}{1 - p \times (r \bmod 1/p)} & If \quad i \in G \\ 0 & Otherwise \end{cases}$$

Where ***p*** is the probability of node becoming cluster head. r is the round index and ***G*** is the set of nodes not perform as CHs in last ***1/p*** rounds.

The selected Cluster-heads broadcast an advertisement message (ADV) to all other nodes in the group. Each non cluster-head node decides its cluster for current round by choosing the Cluster Head that requires minimum communication energy, based on the received signal strength of the advertisement from each Cluster-head. After the selection of cluster, it informs the Cluster Head by transmitting a join request message (***Join-REQ***) back to the Cluster Head. Then the Cluster Head node sets up and broadcast a ***TDMA*** schedule to all member nodes.

B. Steady State Phase

The Steady Sate operation is broken into frames, where nodes send their data to the Cluster Head at most once per frame during their allocated time slot. Cluster Head sends the aggregated data to Base-Station in single hop manner.

LEACH provides better results compared to earlier existing protocols e.g. direct communication protocol, minimum-transmission-energy protocol and static clustering protocol in Wireless Sensor Network. In LEACH much more redundant information is available which is subsequently cancelled during aggregation process performed by Cluster Heads.

Multi Group-LEACH consists of three steps. Two of them are the same as used in LEACH e.g. Setup phase and Steady State phase. Before set up phase, Set Building phase is used at the time of deployment and after every ***"x"*** rounds by BS.

In Set building phase deployed nodes are divided in to Sub Groups (***G1….Gk***) depending upon their locations. Number of groups are mainly depends upon node density. These groups are created by the BS at the time of deployment and after every ***"x"*** rounds.

During the random deployments of nodes, each node is equipped with GPS, which sends location information to BS directly. BS will use the provided information for every Set building phase. This step is done only once, so it does not consume too much of energy. Set up and steady state phase works in every group separately. These groups do not work simultaneously but on alternate basis e.g. one at a time as per set duty cycle by BS. At the time of Set building phase the duty cycle is set. Minimum number of nodes required to construct the group is two, but mainly depends upon node density in the given WSN.

II. PROBLEM STATEMENT

Routing in WSN is the primary task for transferring of data from sensor nodes to BS when any physical event occurs at sensor node. The routing algorithm used should be energy efficient so that it can surmount related power constraints. As discussed in last section MG-LEACH is energy efficient cluster based routing protocol used in Wireless sensor network. However the efficiency of the MG-LEACH can further be increased by introducing certain changes in the CH selection process and Multi-Hop communication between CH and BS. The CHs are selected based on the following parameters:

- *Energy remaining in the nodes,*
- *Number of neighbor nodes,*
- *Centrality of the node and*
- *Proximity to Base Station*

By considering above parameters we can make the CH selection very efficient. This selection procedure saves the node energy to greater extent and enhances the network life time.

The single hop transmission is used in LEACH and MG-LEACH protocol [3] [4], but in our proposed method Multi-hop communication is adopted among cluster heads [6]. It selects optimal path and adopts multiple-hops between CH and BS.

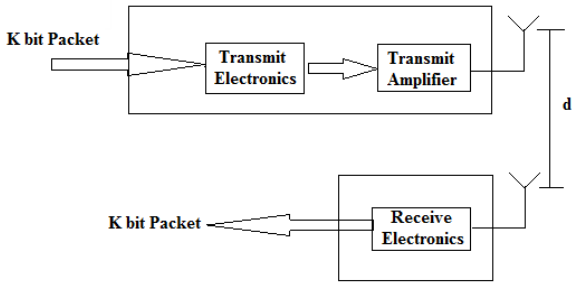
Then, according to the selected optimal path, these cluster heads transmit data to the corresponding cluster head which is nearest to BS. Finally, this selected CH sends data to BS.

We have simulated the improvements on MG-LEACH with above said improvements and find it much more efficient than MG-LEACH. We have checked the performance by taking different initial energy of deployed nodes also with different value of *p*. Improved MG-LEACH has performed much better than MG-LEACH and it has increased network lifetime considerably.

III. SYSTEM AND ENERGY MODEL

Let us consider a system including ***N*** sensors that are uniformly deployed in an area ***A***. To simulate proposed algorithm, let us consider a system including 120 sensor nodes that are randomly distributed in a square area 120x 120. We make some assumptions about the sensor nodes and the underlying network model:

1. The network is homogeneous that all nodes have equal initial energy at the time of deployment.
2. The network is static and nodes are distributed randomly
3. There exists only one base station, which is placed in the middle (100,100)
4. The Energy of sensor nodes cannot be recharged after deployment of network.
5. Sensor nodes are equipped with GPS so aware about their location
6. No power and computational constraints in Base-Station
7. Deployed Nodes can use power control to vary the amount of transmission power, which depends on the distance to the receiver



The Radio energy used in this model is same as used in [3] block diagram is presented in Fig-II, which uses a 914 MHz radio. The node radio energy consumed in transmission is given by:

$$E_{Tx}(k,d) = \begin{cases} k \times E(elec) + (k \times E_{fs} \times d^2) & d < d_0 \\ k \times E(elec) + (k \times E_{mp} \times d^4) & d > d_0 \end{cases}$$

Where,
k: Number of bits transmitted
d: Distance between transmitter and receiver
do: Constant referred as Cross-Over distance.

Depending on the transmission distance both the free space ***Efs*** and the multi-path fading ***Emp*** channel models are used.

For receiving the ***k*** bit message the node radio consumes:

$$E_{Rx}(k) = k \times E(elec)$$

The assumed energy required for running the transmitter and receiver electronic circuitry E (elec) is 50nJ/bit and for acceptable SNR required energy for transmitter amplifier for free space propagation ***Efs*** is 100pJ/bit/m2 and for two ray ground ***Emp*** is 0.0013pJ/bit/m4. The crossover distance ***do*** is assumed to be 87m. All important parameters of simulation have been specified in table-I.

Table-I

Efs *=100pJ/bit/m2*	Transmit amplifier energy dissipation of free space mode
Emp=0.0013pJ/bit	Transmit amplifier energy dissipation of two ray model
EDA=5nJ/bit/signal	Data aggregation energy dissipation
Pidel=0J	Energy dissipated in Ideal mode
Psleep=0J	Energy dissipated in Sleep mode
E0= 0.1 & 0.5 Joul**e**	Initial energy of deployed nodes
G1	Group-1 of Nodes depending on upon location
G2	Group-2 of Nodes depending on upon location
Pke_size=4000 Bytes	Data Packet size
Rmax=8000	Maximum number of Rounds

IV. SIMULATION RESULTS AND ANALYSIS

We have simulated Improved MG-LEACH algorithm in MATLAB to set up a comparative analysis both for MG-LEACH and Improved MG-LEACH proposed in this paper. For the experiment, the random network of 120 Nodes is used & the BS was placed in centre. The bandwidth of the channel was set to 1 Mbps. Each data message was 4000 bytes long along with header packet which is 25 bytes long. The radio electronics energy was set to 50 nJ / bit and the radio transmitter energy (***Efs***) is set to 100pJ/bit/m2 for distances less than 87 and 0.0013pJ/bit/m4 for distances greater than 87m The energy for performing computations to aggregate data was set to 5 nJ / bit / signal. These parameters are recapitulated in Table-I. In order to get improved and quite accurate comments of the algorithm, we establish the same simulation scene for both MG-LEACH and Improved MG-LEACH. For energy model, we assume that each node begins with equal energy and an unlimited amount of data to send to the base station. Once a node runs out of energy, it is considered as dead and can no longer transmit or receive data. The value of ***k*** in set building phase is taken as 20. Initial energy for each node used in simulation is 0.1 Joule, while the experiment is repeated with 0.5 Joule energy both for MG-LEACH and proposed Improved MG-LEACH.

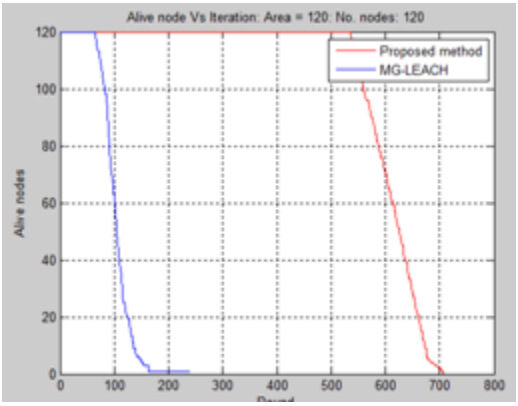


Fig-III

Fig-III illustrates the simulation result that demonstrate relative behavior of both discussed algorithms with parameters values n =120, p= 0.1, Eo=0.1J. The graph shows that Improved MG-LEACH performs significantly better than MG-LEACH by extending life time of network.

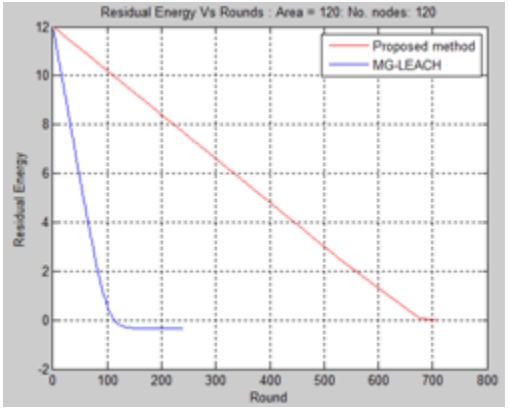


Fig-IV

Fig-IV shows the simulation results of Residual Energy against number of nodes, for both discussed algorithms with parameters n =120, p= 0.1, Eo=0.1J.

Fig-V gives simulation results when the values of used parameters is set to ***n*** =120, ***p***= 0.05, ***Eo*** = 0.5J

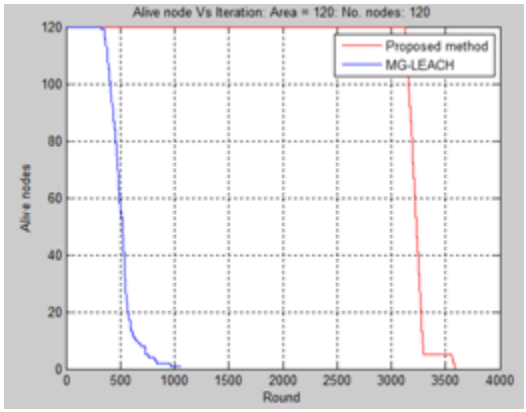


Fig-V

Finally Fig-VI provides behavior of both discussed routing algorithms, when the values of used parameters is set to ***n*** =120, ***p***= 0.05, ***Eo***=0.5J.

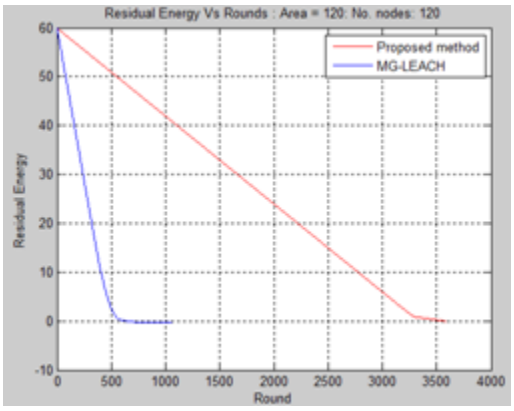


Fig-VI

Three parameters, the times of the first node dies (FND), the times of the last node dies (LND) and the time of half nodes dies (HND), are considered for measuring and examining the performance of both algorithms for different values of Initial Energy ***Eo*** and ***p*** are shown in table-II. From the results obtained we can conclude that the network life time is increased considerably.

Initial Energy	Algorithm	FND	HND	LND
0.1 J	MG-LEACH	65	100	165
0.1 J	Improved MG-LEACH	540	620	700
0.5 J	MG-LEACH	465	500	900
0.5 J	Improved MG-LEACH	3300	3200	3600

Table-II

The proposed improvements for Cluster Head selection and Multi-Hop communication between CH and BS provide the effective ways for enhancing the network life time. This technique can easily be utilized for all other clustering base algorithms.

V. CONCLUSTION AND FUTURE WORK

Energy constraint is one of the major research topics in WSN. Routing consumes the largest amount of energy in WSN so used routing protocol should be energy efficient. The Improved MG-LEACH is using the following parameters for CH selection such as, 1) Remaining Energy 2) Number of neighbor nodes 3) Centrality of the node and 4) Proximity to Base Station, and also it uses the Multi-Hop communication for data communication between CH and BS. These two proposed improvements to MG-LEACH will save the node energy and thus increases the life time of the network, simulation results show enormous increase of network life time. The usage of fuzzy logic for CH selection in the paper would still give better results and thus increase the life time of the network, our future work will be based upon it. Also in future we will try to apply the similar idea on other clustering based protocols and try to increase the lifetime of the WSNs.

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