Multipath-LEACH an Energy Efficient Routing Algorithm for Wireless Sensor Network

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***Abstract*—LEACH is one of the algorithms for packet routing in the wireless sensor network by reducing the energy consumption by nodes, but the routing strategy adopted in LEACH, still results in considerable energy consumption of node for transmitting and reception of the data. In order to reduce the consumption of the energy, we have proposed a routing scheme called Multipath-LEACH for energy efficient routing in wireless sensor networks. In this protocol/scheme, the whole network area is divided into cells and each cell will have a cluster head, and each cluster head will communicate with each other and then forward the data to the base station for communication, by following multipath routing strategy. The proposed protocol is developed on LEACH protocol incorporating the Multipath routing schemes in to it. The proposed work is tested for energy consumption and lifetime of the network and it is found that it reduces the energy consumption of the network and hence increasing the lifetime.**

***Index Terms*—LEACH, multipath-LEACH, energy efficiency, network lifetime.**

I. Introduction

Sensing, Processing, Radio and Power are the four basic components of a Sensor node which normally operates in unattended mode. In sensor Node, the main energy dissipation factor is radio communication [1] and typically they consist of number of sensor nodes, sink or gateway sensor node [2].

Due to limited computational and power capabilities of deployed sensor nodes a lot of research is ongoing to design routing algorithms. Recent developments in the sensor networks field initiated for designing new protocols for wireless sensor networks (WSNs) [3], which are simple so that energy utilization of a sensor nodes remain as minimum as possible and increase the network lifetime. The important issue in the wireless sensor networks is collecting information from sensor nodes and sending data to the sink node or data concentration centre at the correct time which is called as routing. Routing in WSNs is very challenging due to the specific characteristics that distinguish WSNs from other wireless networks such as wireless ad hoc networks or cellular networks [4]. Clustering based routing protocol is well known solution for enhancing network life time in WSN. In Clustering based routing algorithms a set of cluster-heads (CHs) are selected and the other member nodes are clustered around the CHs. Data sending to CHs from member nodes will be aggregated to reduce data redundancy by CHs before forwarding it to Base Station (BS).

The Low Energy Adaptive Clustering Hierarchy (LEACH), proposed by Heinzelman, Chandrakasan, and Balakrishnan, is renowned for its success in extending the lifetime of Wireless Sensor Networks. LEACH is a hierarchy routing protocol for WSN (wireless sensor networks), which is superior to direct communication protocol, minimum-transmission-energy protocol and static clustering protocol [5]. Main techniques of LEACH protocol include algorithms for distributing cluster forming, adaptive cluster forming, and cluster header position changing [6]. Hierarchical Multiple-Choice Routing Path Protocol (HMRP), has many paths (sequential select in each transmission) to disseminate data packets to the sink. The data aggregation mechanism involves in every nodes apart from the leaf nodes reducing the energy consumption in the networks [7]. Deployment of multiple base stations as data sinks can reduce the average number of hops between the source nodes and their corresponding data sinks [8]. One important concern on network survivability is energy-balance. If sensor nodes consume energy more equally, the all chance that some nodes use up their energy much earlier [9]. Organization of large multi-hop wireless networks into clusters is essential for achieving basic network performance. In wireless sensor networks (WSN), the clustering is primarily characterized by data aggregation by each cluster head, which significantly reduces the traffic cost [10]. Multipath routing uses multiple paths to transmit data, which can achieve both load balancing and fault tolerance. There are two different multipath routings between the source node and the sink node. One is disjoint multipath routing, where the alternative paths do not intersect with each other [11]. The LEACH algorithm is currently the most widely used algorithm for sensor network clustering [12]. In order to equalize energy consumption, the algorithm uses the random rotation method for electing the CH. Number of variants for LEACH has been proposed in the recent years [13]. The presented idea is equally valid LEACH which claims and proves to increase/prolong network lifetime by addressing the shortcomings associated with it. Along with the current LEACH scheme, to reduce the energy consumption, we have proposed a routing scheme called Multipath-LEACH for energy efficient routing in wireless sensor networks. In this modified protocol/scheme, the whole network area is divided into cells and each cell will have a cluster head, and each cluster head will communicate with each other and then forward the data to the base station for communication, by following multipath routing strategy. The proposed protocol

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is developed on LEACH protocol incorporating the Multipath routing schemes into it. The proposed work is tested for energy consumption and lifetime of the network and it is found that the proposed scheme reduces the energy consumption of the network and hence increasing the lifetime.

II. Proposed Protocol

The proposed protocol is based on the basic LEACH and uses the Energy Efficient Mutlipath routing strategies for wireless sensor networks [k]. In this work we propose a routing protocol called multipath LEACH based on LEACH protocol to balance the energy consumption of sensor nodes in order to solve the overload energy consumption problem. The multipath LEACH adopts the same round concept with the original LEACH. In hierarchical routing protocols, the number of cluster-heads is a key factor that affects the performance of routing protocols. If the number of cluster-heads is less, each cluster-head needs to cover larger region, this will lead the problem that some cluster-members get far from their cluster-heads and consume much more energy.

The protocol starts with random deployment of sensor nodes forming a network. The networks then partitioned into cells and each cell is to constitute a cluster-head. Cluster-heads are randomly selected from cells, adapting the stochastic model for randomized rotation of Cluster-heads for energy load balancing among sensor nodes in the network. The whole operation can be divided into two phases: **set-up phase and steady state phase**. The former is for clustering and the latter is for data transmission. The system repeats the clustering and transmission in every round. During the setup 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. The selection depends on decision made by the node by choosing a random number between 0 and 1. If the number is less than a set threshold**,** the sensor node becomes a cluster-head for the existing round. **Steady State Phase:** Steady State operation is broken into frames, where nodes send their data to the Cluster-head at most once per frame during their allocated slot. Cluster-Head sends the aggregated data to nearest cluster-head in one hop manner, it is assumed that the cell with the highest information is allowed to transmit to the base station through all other cluster-heads, which will act only as data forwarders. Cluster-heads from each cell involve in communication with each other helping in routing. Multiple paths among the cluster-heads are setup and then the data is sent through the multipath to the sink node.

In proposed multipath LEACH protocol, the "number-of-paths" is introduced. It indicates how far the cluster-head is from the sensing node. This allows nodes to: 1). Select the nearest cluster-head node, which saves energy and reduces messaging, needed to bridge the distance between the cluster-head and the sensor node; 2). allows a node to learn the shortest path to the selected cluster-head.

A. Proposed Algorithm

1) Deploy the nodes
2) Divide the area into partitions (this will reduce the energy consumption of nodes)
3) Create cluster head for each partition
4) Nodes of each partition communicate with their cluster head that will communicate with the nearest cluster head before communicating with sink.(this will result in energy minimization).
5) Continue till all the nodes die (test for lifetime of the network)

III. Simulation Model and Procedure

System includes *N* sensor nodes that are uniformly deployed in an area *A*. 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 is only one base station, 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 (BS).

A simplified model is adopted to compute the energy consumption for communication. If the distance between the transmitter and receiver is less than a threshold, the free space (fs) model will be used. Otherwise, the multipath (mp) model will be used [14]. The energy consumption of transmitting K-bit data over a distance *d* is

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

where *k* is the number of bits transmitted, *d* is the distance between transmitter and receiver and d_o is the constant referred as crossover distance. Depending on the transmission distance both the free space *Efs* and the multi-path fading *Emp* channel models are used. The energy consumption of receiving K-bit data is

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

TABLE I: Simulation Parameters

Sl.no	Simulation Parameters	Values used
1.	Number of sensor nodes (*N*)	100
2.	Network area (*M*×*M*)	100×100
3.	Eelec (transmission & reception energy per bit)	50 nJ
4.	Efs(Transmit amplifier energy dissipation of free space model)	100pJ/bit/m 2
5.	Emp(Transmit amplifier energy dissipation of two model)	0.0013pJ/bi t/m4
6.	E0(Initial energy of deployed node)	0.5J,2J
7.	Eda (data aggregation energy per bit)	5 nJ
8.	K (number of bits in a packet)	4000 bytes
9.	d_0(Cross over distance)	87 m

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 d_o is assumed to be 87m. All parameters are specified in Table I.

IV. Results and Analysis

We compare multipath-LEACH with LEACH and multigroup-LEACH based on two performance metrics: total energy consumption and lifetime. Multipath-LEACH protocol has more residual energy than LEACH and multigroup-LEACH. The simulation of LEACH, multigroup-LEACH and multipath-LEACH has 100 sensor nodes, which are randomly distributed in an area of 100m × 100m. BS is put at the location with x = 50, y = 50. The bandwidth of data channel is set to 1 Mbps, the length of data messages is 4000 bytes and packet header for each type of packet was 25 bytes. The number round is set to 10000s. When a node uses energy down to its energy threshold, it can no longer send data and is considered as a dead node.

TABLE II: Evaluation of Network Life Time of LEACH, Multigroup LEACH and Multipath –LEACH

Initial Energy	Protocol	FND	HND	LND
0.5 J	LEACH	480	790	974
	Multigroup –LEACH	660	1060	1330
	MultiPath-LEACH	1247	1769	2390
	Percentage	61.5 %	55.3 %	59.2 %
2 J	LEACH	2215	3134	3503
	Multigroup-LEACH	2300	4290	5310
	Multi Path-LEACH	5371	7104	9380
	Percentage	58.7 %	55.8%	62.6%

FND: First node dies, **HND:** Half node dies, **LND:** Last node dies.

The simulation results from Fig. 1 to Fig. 6, demonstrate relative behavior of LEACH, multigroup-LEACH and discussed algorithms with parameters values n =100, p= 0.1, Eo = 0.5 J. The simulation result showing relative behavior of LEACH, multigroup-LEACH and multipath-LEACH discussed algorithms with parameters values n =100, p= 0.1, Eo = 2 J.

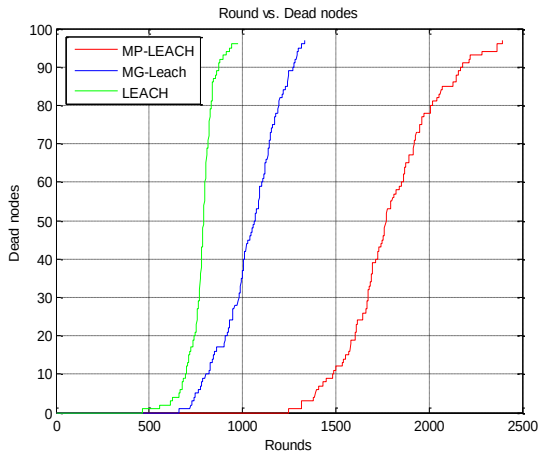

Fig. 1. Round vs dead nodes.

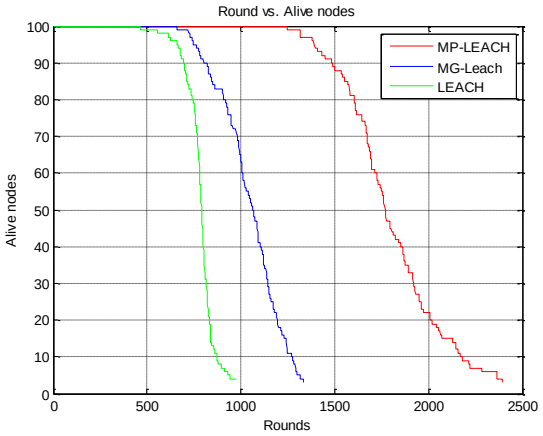

Fig. 2. Round vs alive nodes.

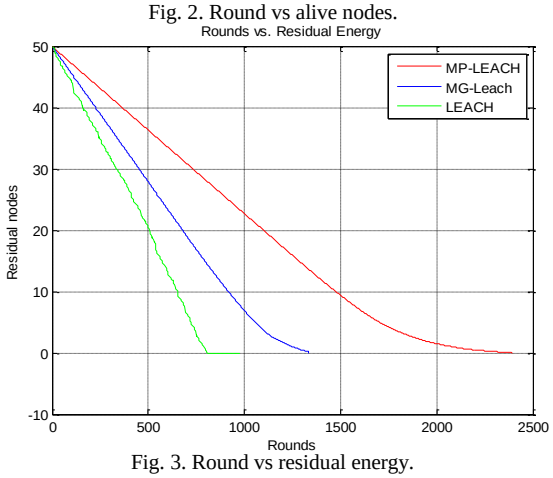

Fig. 3. Round vs residual energy.

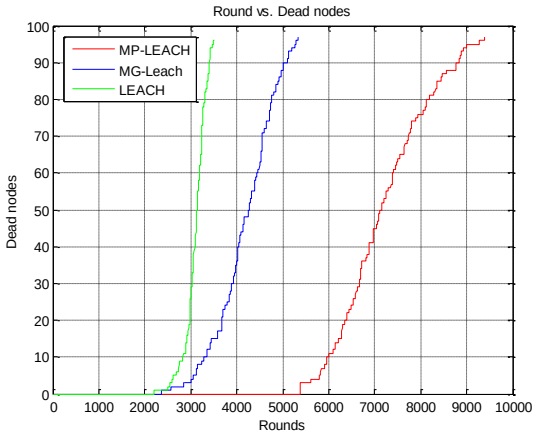

Fig. 4. Round vs dead nodes.

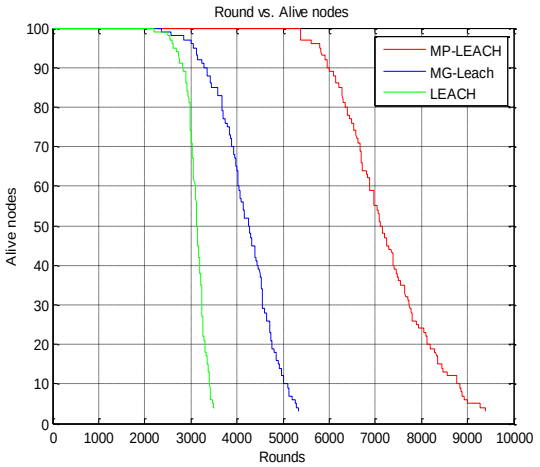

Fig. 5. Round vs alive nodes.

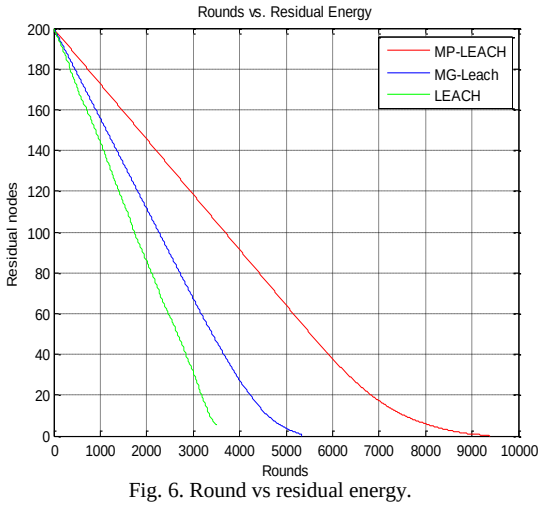

Fig. 6. Round vs residual energy.

V. Conclusion

The LEACH is one of the algorithms for routing the packets in the network. The proposed protocol is a multipath leach algorithm where the area is divided into cells and each area is having a cluster head, so the nodes of that area will communicate with that cluster head only. Cluster-head of each cell will communicate with each other and hence finally with the base station resulting in the multipath communication and hence increasing the efficiency and life time of the network. Results show that, the energy consumption in multipath LEACH is less and hence the lifetime of network is more as compared with LEACH and multigoup LEACH protocol.

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