Energy Efficient LEACH protocol for Wireless Sensor Network (I-LEACH)

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Abstract—In the wireless sensor networks (WSNs), the sensor nodes (called motes) are usually scattered in a sensor field an area in which the sensor nodes are deployed. These motes are small in size and have limited processing power, memory and battery life. In WSNs, conservation of energy, which is directly related to network life time, is considered relatively more important souse of energy efficient routing algorithms is one of the ways to reduce the energy conservation. In general, routing algorithms in WSNs can be divided into flat, hierarchical and location based routing. There are two reasons behind the hierarchical routing Low Energy Adaptive Clustering Hierarchy (LEACH) protocol be in explored. One, the sensor networks are dense and a lot of redundancy is involved in communication. Second, in order to increase the scalability of the sensor network keeping in mind the security aspects of communication. Cluster based routing holds great promise for many to one and one to many communication paradigms that are pre valentines or networks.

I. INTRODUCTION

There are lots of work has been done in the area of Wireless Sensor Network, but still a long way to go. Wireless Sensor networks consist of hundreds of thousands of low power multi-functional sensor nodes, operating in an unattended environment, with limited computation and sensing capabilities. Sensor nodes are equipped with small, often irreplaceable batteries with limited power capacities. The use of wireless sensor networks is increasing day by day and at the same time it faces the problem of energy constraints in terms of limited battery lifetime. Various approaches can be taken to save energy caused by communication in wireless sensor networks. One of them is to adopting energy efficient routing algorithms. The routing algorithms in the sensor networks broadly classified into three categories: Flat, Hierarchical (or Cluster) and Location based routing. The idea proposed in LEACH has been an inspiration for many hierarchical routing protocols. The operation of LEACH is broken up into rounds, where each round begins with a set-up phase, when the clusters are organized, followed by a steady-state phase, when data transfers to the base station occur. In order to minimize overhead, the steady-state phase is long compared to the set-up phase.

Set-up phase: During this phase, each node decides whether or not to become a cluster head (CH) for the current round. This decision is based on choosing a random number between 0 and 1 if number is less than a threshold T(n), the node become cluster head for the current round. The threshold value is set as:

$$T(n) = \begin{cases} \dfrac{p}{1-p\cdot(r \bmod \frac{1}{p})} & if\ n \in G \\ 0 & otherwise \end{cases} \qquad (1.1)$$

Where, P = desired percentage of cluster head, r = current round and G is the set of nodes which did not become cluster head in last 1rounds. Once the cluster head is chosen, it will use the CSMA MAC protocol to advertise its status. Remaining nodes will take the decision about their cluster head for current round based on the received signal strength of the advertisement message. Before steady-state phase starts, certain parameters are considered, such as the network topology and the relative costs of computation versus the communication. A Time Division Multiple Access (TDMA) schedule is applied to all the members of the cluster group to send messages to the CH, and then to the cluster head towards the base station. As soon as a cluster head is selected for a region, steady-state phase starts. Fig. 1 shows the flowchart of the phase.

Steady-state phase: Once the clusters are created and the TDMA schedule is fixed, data transmission can begin. Assuming nodes always have data to send, they send it during their allocated transmission time to the cluster head. This transmission uses a minimal amount of energy (chosen based on the received strength of the cluster-head advertisement). The radio of each non-cluster-head node can be turned off until the nodes allocated transmission time, thus minimizing energy dissipation in these nodes.

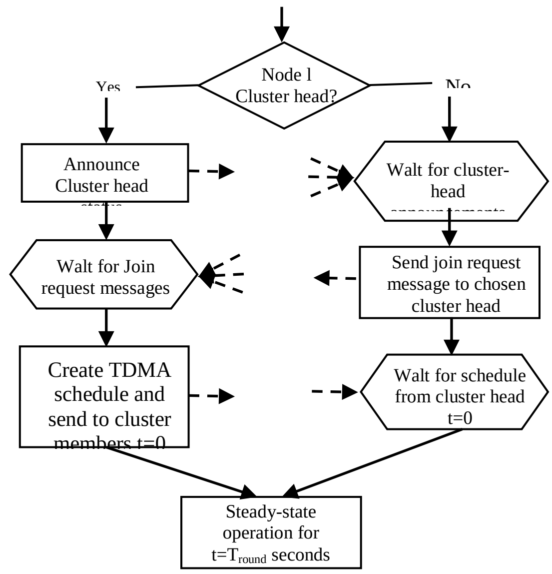

Fig. 1: Flow chart of the Set-up phase of the LEACH protocol

II. RELATED WORK

Wireless sensor networks (WSNs) contain hundreds or thousands of sensor nodes equipped with sensing, computing and communication abilities. Each node has the ability to sense elements of its environment perform simple computations and communicate among its peers or directly to an external base station (BS) Deployment of a sensor network can be in random fashion or planted manually. These networks promise a maintenance-free, fault-tolerant platform for gathering different kinds of data. Because a sensor node needs to operate for a long time on a tiny battery, innovative techniques to eliminate energy inefficiencies that would shorten the lifetime of the network must be used. A greater number of sensors allows for sensing over larger geographical regions with greater accuracy. Fig. 2 shows the basic components of the sensor nodes and wireless sensor network architecture [1].

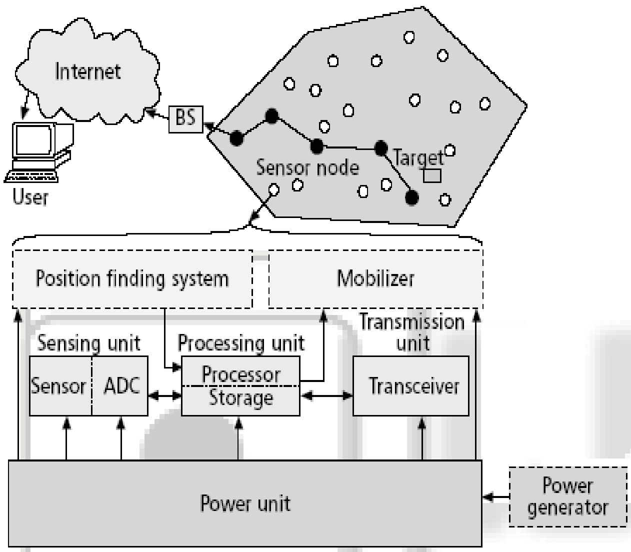

Fig. 2: Components of sensor node and WSN architecture

The design of routing protocols in WSNs is influenced by many challenging factors[1]. Which include Energy consumption without losing accuracy: Due to limited supply of energy performing computations and transmitting information in a wireless environment with reliability.

A. Power-Efficient Gathering in Sensor Information Systems (PEGASIS)

The main idea in PEGASIS is for each node to receive from and transmit to close neighbors and take turns being the leader for transmission to the BS [2]. This approach distributes the energy load evenly among the sensor nodes in the network. Sensor nodes are randomly deployed in the sensor field, and therefore, the node is at a random location. The nodes will be organized to form a chain, which can either be accomplished by the sensor nodes themselves using a greedy algorithm starting from some node. Alternatively, the BS can compute this chain and broadcast it to all the sensor nodes. For constructing the chain, it is assumed that all nodes have global knowledge of the network and employ the greedy algorithm. The greedy approach to constructing the chain works well and this is done before the first round of communication. To construct the chain, it starts with the furthest node from the BS.

B. Threshold sensitive Energy Efficient sensor Network protocol (TEEN)

The nodes in the network periodically switch on their sensors and transmitters, sense the environment and transmit the data of interest [3]. Thus, they provide a snapshot of the relevant parameters at regular intervals called the proactive networks. They are well suited for applications requiring periodic data monitoring.

C. Hybrid Energy Efficient Distributed clustering(HEED)

Hybrid Energy-Efficient Distributed Clustering (HEED) [4] which is a multi-hop clustering algorithm with focus on efficient clustering by proper selection of cluster heads based on the physical distance between nodes.

D. E- LEACH PROTOCOL

Energy-LEACH protocol improves the CH selection procedure. It makes residual energy of node as the main metric which decides whether the nodes turn into CH or not after the first round [5]. Same as LEACH protocol, E-LEACH is divided into rounds, in the first round, every node has the same probability to turn into CH, that mean nodes are randomly selected as CHs, in the next rounds, the residual energy of each node is different after one round communication and taken into account for the selection of the CHs. That mean nodes have more energy will become a CHs rather than nodes with less energy.

E. TL LEACH PROTOCOL

A new version of LEACH called Two-level Leach was proposed. In this protocol; CH collects data from other cluster members as original LEACH, but rather than transfer data to the BS directly, it uses one of the CHs that lies between the CH and the BS as a relay station [6].

F. M- LEACH PROTOCOL

In Multi hop LEACH protocol selects optimal path between the CH and the BS through other CHs and use these CHs as a relay station to transmit data over through them [7]. First, multi-hop communication is adopted among CHs. Then, according to the selected optimal path, these CHs transmit data to the corresponding CH which is nearest to BS. Finally, this CH sends data to BS. M-LEACH protocol is almost the same as LEACH protocol, only makes communication mode from single hop to multi-hop between CHs and BS.

III. PROPOSED MODIFICATION IN LEACH

The proposed I-LEACH (Improved LEACH) ensures that the elected cluster-heads will be uniformly distributed over the network. Hence, there is no possibility that all cluster-heads will be concentrated in one part of the network. The performance of the proposed I-LEACH protocol is evaluated mainly as per the following metrics:

Average Energy consumption: The average energy consumed by the sensor nodes are measured at equal intervals.

Average Throughput: The average number of packets received at the sink.

Life time of the network: The total number of nodes which are alive at the end of all the cycles of the algorithms.

Proposed algorithm for I-LEACH

I-LEACH employs the distributed clustering approach as compare to LEACH protocol. The total sensor field is divided into the equal sub-region. The choice of the cluster head (CH) from each sub-region is determined by the threshold approach as in LEACH protocol. Following is the algorithm for the I-LEACH protocol.

PROPOSED I-LEACH ALGORITHM

Step: 1 Let Ni or NJ denote a common node
Step: 2 S(Ni) = (N1, N2 ....Nn) denote the set of n nodes
Step: 3 E(Ni) denote energy in a node
Step: 4 Nxyz denote node location
Step: 5 Ci denote a cluster ID
Step: 6 CH(Ni) denotes a cluster head node.
Step: 7 dij denote distance measured from node Ni to Nj
Step: 8 thresh (Ni) denote the threshold value of node Ni Initialization
Step: 9 Create node Ni
Step: 10 Set node position Nxyz Clusters formation
Step: 11 Divide the sensor field into equal sub-region Ri
Step: 12 Select CH from the each sub-region Ri based on threshold value.
Step: 13 if Ni ∈Ri && thresh(Ni) < Threshold && has not been CH yet then
Step: 14 Ni = CH (Ni) for sub-region R
Step: 15 Else
Step: 16 Ni =Nj (normal node)
Step: 17 end if Send Data to Base station
Step: 18 CH(Ni) sends data to Base station Repeat the steps 12 to 18 for different rounds
Step: 19 End of algorithm

The sensor field is divided into equal sub region as shown in fig 3 for 100 nodes

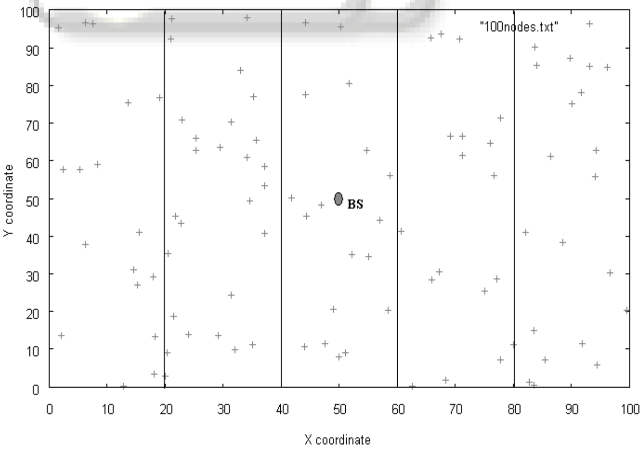

Fig. 3: Sensor network topology for 100 nodes with base station at (50, 50)

IV. SIMULATION RESULTS AND ANALYSIS

The performance of the proposed I-LEACH is compared with basic LEACH protocol in terms of Average energy consumption, Life time of the network and Average throughput. All experiment results presented in this section are average of three simulation runs in 100 nodes network size. The following table shows the simulation results at various simulation runs.

Network Size	Sr. No.	LEACH Life Time(s)	LEACH Throughput	I-LEACH Life Time(s)	I-LEACH Throughput
100	1	372.30	35905	566.90	51106
	2	404.60	27889	603.50	50517
	3	433.80	44871	570.20	50563

Table. 1: Simulation Results

A. *Average energy consumption*

As simulation started with equal amount of energy (2J) with each sensor nodes, so total energy with the network will be 200J for 100 nodes simulation. Fig. 4 shows the comparison of average energy consumption at various time between LEACH and I-LEACH protocols for 100.

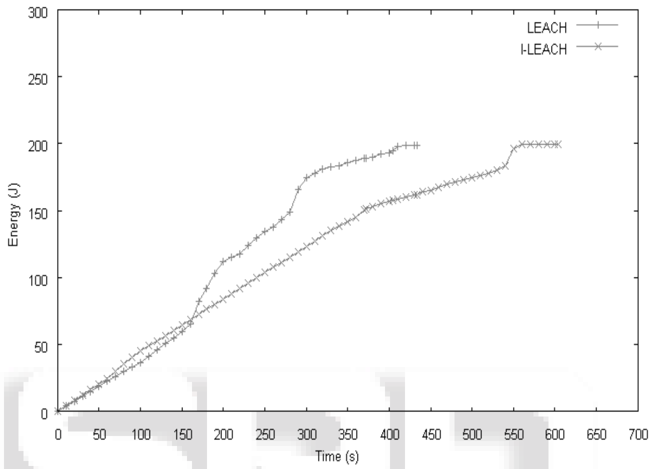

Fig. 4: Average energy consumption comparisons

B. *Lifetime comparison*

The total number of nodes which are alive at the end of each round is shown in fig. 5 for the 100 nodes network. The simulation will stop if total number of live nodes is less than five in the case of 100 nodes network.

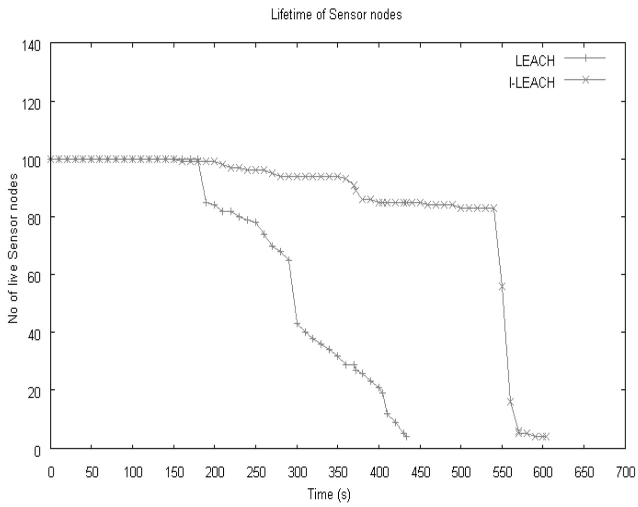

Fig. 5: Life time comparisons

C. *Average throughput*

It will measure the average number of packets reaching at the sink (base station) node. The location of the sink is (50, 50) in the 100 nodes network. Fig. 6 shows throughput achieved.

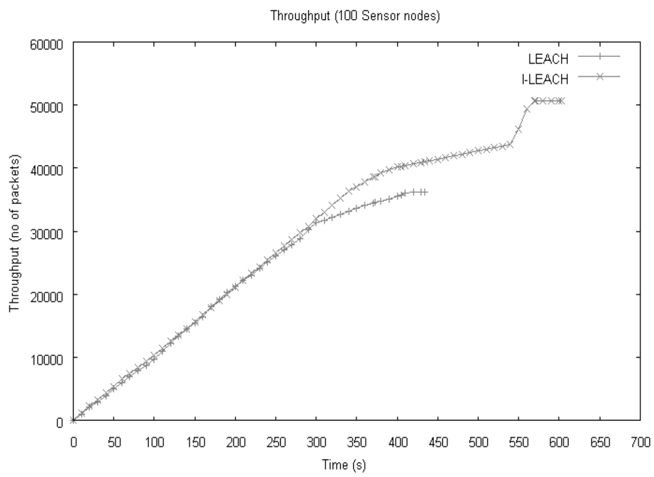

Fig. 6: Throughput comparisons

V. CONCLUSION

The proposed I-LEACH ensures that the elected cluster-heads are uniformly distributed over the network. Hence, there is no possibility that all cluster-heads will be concentrated in one part of the network. The result of simulations conducted indicates that the proposed clustering approach is more energy efficient and scalable and hence effective in prolonging the network life time compared to LEACH. It also outperforms LEACH with respect to throughput of the network. I-LEACH improves energy consumption by around 43% and throughput by 40% in 100 nodes network size.

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