COMPARISON OF I-LEACH AND LEACH ROUTING PROTOCOLS IN WIRELESS SENSOR NETWORK

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Abstract: Wireless sensor network is the latest area of research which is continuously becoming the hotspot topic due its wide range of applications where infrastructure based network are not feasible.But since the nodes of WSN are limited in battery so it is necessary to have proper routing protocols for saving energy and hence nowadays protocols using clusters are getting more concern by many researchers. In this paper, we have compared two cluster based routing protocols viz. LEACH and I-LEACH. Simulation results in terms various lifetime metrics(dead nodes,alive nodes, throughput of the network) are carried out and proved that I-LEACH always outperforms in comparison to LEACH.

***IndexTerms*-Wireless Sensor Network, Clustering, Distributed and Centralized, Homogeneous Network.**

I INTRODUCTION

Recent advances in wireless communication, micro electro-mechanical systems (MEMS) and digital electronics have created tiny nodes that are low-cost, consumes less power and having multiple functions. These nodes are capable of sensing many environmental conditions such as temperature, pressure, humidity level etc., and thus encourage the idea of sensor networks of many sensor nodes with computing and communicating capabilitiess [1].

WSN is contributing in every field and having many application possibilities, such as temperature, pressure, humidity monitoring, controlling military actions, monitoring underground and underwater activities, examine industry environment, forest fire-tracking, disaster management, security surveillance and many more [2].

Once the sensor nodes are deployed, it is often in-feasible or un-desirable to recharge sensor nodes or replace their batteries.Hence Energy efficient routing algorithm is the way by which network lifetime can be increased to some extent as given in [3]**.** [4] has discussed routing techniques for conserving energy in WSN and also discussed routing protocols based on network structure, communication model, topology based and reliable routing.

Clustering is an efficient routing technique which is highly used to conserve energy in WSN. [5] has discussed about clustering of the network which is based on divide and conquer rule. The main objective of the clustering protocols is to organize the network nodes into smaller clusters and elect a cluster head (CH) for each cluster. Data is forwarded from all member nodes to their corresponding CHs and the CHs perform aggregation/diffusion operations on this data before transmitting to BS.Clustering can be done in different ways and thus different methods are opted by [6] which are: **one-hop clustering** and **multiple-hop clustering** **,location-based and non-location based,Distributed & Centralized.** In distributed technique cluster heads are elected randomly based on various factors such as residual energy, distance from nodes and base station by sensor nodes themselves. There is no load on base station for choosing CHs. In centralized technique, CHs are elected by base station only based on routing tables assigned to each sensor node.

Rest of the part of this paper is distributed as: Section 2 describes the radio model for the sensor nodes. Section 3 describes various clustering protocols proposed. In section 4 comparison results are carried out and then conclusions of this paper are discussed.

II RADIO MODEL FOR SENSOR NODES

Data processing unit and radio are the main components of any sensor [1]. Maximum energy is consumed in communicating with another sensor and processing the data received. In general free space and multipath fading channel radio model is considered in wireless sensor network, in which energy consumed in transmitting and receiving k bits is proportional to the distance d [7],and is denoted by $E_{Tx}(k,d)$ and $E_{Rx}(k)$ respectively, as shown in Fig. 1. Equation 1 represents the energy consumed in receiving k bits from transmitter.

$$E_{Rx}(k) = E_{Rx-elec}(k) = E_{elec} \times k, \tag{1}$$

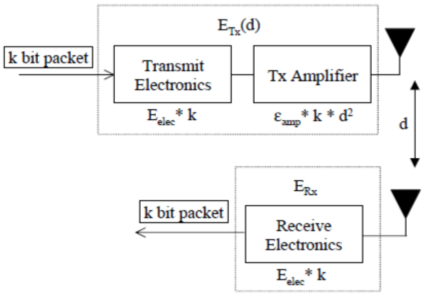


Fig. 1: First Order Radio Model

The energy amount consumed in transmitting *k* bits is given by equation 2.

$$E_{Tx}(k,d) = E_{Tx-elec}(k) + E_{Tx-amp}(k,d)$$
$$= \begin{cases} l * E_{elec} + l * \varepsilon_{fs} * d^2 if & d < d_0; \\ l * E_{elec} + l * \varepsilon_{mp} * d^4 if & d \geq d_0; \end{cases} \qquad (2)$$

- E_{elec} is the energy dissipated per bit by the electronic circuitry like encoder, modulator, filter and quantizer.
- $\mathcal{E}_{fs}$ and $\mathcal{E}_{mp}$ are the transmitter amplifier parameters related to free space and multipath model of the radio model that is based on the distance between the sensing node and receiving node.

As the distance between node and sink is less than d_0, then free space model (energy dissipated is proportional to d^2) is used and if distance is greater or equal to d_0, then multipath channel model (energy dissipated is proportional to d^4) is used. Equation 3 represents the threshold value of distance *i.e.* d_0.

$$d_0 = \sqrt{\varepsilon_{fs} / \varepsilon_{mp}} \qquad (3)$$

III VARIOUS CLUSTERING ALGORITHMS BASED ON CENTRALIZED AND DISTRIBUTED APPROACH

Thus in next section a brief survey on distributed and centralized clustering algorithms is carried out.

For having an energy efficient communication protocol which can be used in remote areas **[13]** has proposed a distributed clustering algorithm which is named as Low energy adaptive clustering hierarchy (LEACH). This is a path-breaker technique in wireless sensor network areas, in which data is processed locally by nodes and data aggregation techniques are applied to fuse many correlated data signals into weensy data sets. In this method randomized rotation of CH increases lifetime of the network.

In 2002 **[8]** has proposed centralized LEACH or LEACH-C protocol in which its operation is divided in to rounds. Each round has set-up phase and steady-state phase. In LEACH-C clustering is done centrally i.e. by BS. This protocol also removes redundancy of data, because at the time of data aggregation member nodes go to sleep state.

[14] gave an equal sized distributed clustering algorithm, in which all clusters have equal no. of nodes and named as Hybrid Energy-Efficient Distributed clustering (HEED). This protocol periodically selects cluster head according to two clustering parameters:1) residual energy of each node and 2) Intracluster communication cost.

To have quick responses and for minimum delay in the network **[9]** has proposed another centralized algorithms which is named as particle swarm optimization (PSO) clustering technique.In this method every particle has its personal best position i.e. p_{best} and global best as $g_{best.}$ This type of algorithm can be used in manufacturing industries where the position of all sensor nodes are known and can be focused on their tasks only.

To form balanced clusters, proper utilization of network resources and proper CH-to-CH routing, **[10]** has proposed another centralized routing protocol named as Base Station Controlled Dynamic Clustering Protocol (BCDCP). This method avoids CH overhead by choosing equal no. of nodes in each cluster.

Dealing with heterogenous network **[11]** has proposed a new centralized protocol named as Balanced and Centralized Distributed Energy Efficient Clustering (BCDEEC) which is an extension of DEEC. In this paper two types of nodes are used in the network, normal and advanced nodes.This improves the stability of the clustering hierarchy.

[12] has accounted the disadvantages of distributed clustering and thus proposed a Centralized Energy Efficient Clustering (CEEC). In this protocol network is divided into three regions viz. low energy region or LER (closest region to BS) , medium energy region or MER and high energy region or HER(farthest region from BS) and thus forming a heterogeneous network.It provides optimal no. of CHs compare all other centralized clustering protocols.

In 2017 **[15]** has created a reactive network based clustering protocol for intra-cluster communication which is an extension of Threshold Energy Efficient Network (TEEN) protocol as TEEN-vector quantization. TEEN is the first reactive network in which data transmission takes place on the basis of Hard Threshold (HT) and Soft threshold (ST).

[16] have discussed about a clustering protocol for the application of IOT named as Energy Efficient Centroid-based Routing Protocol (EECRP).The cluster formation includes three phases as: Initialization phase, First CH selection phase,Rotating phase.This method reduces number of long distance communications using protective mechanism.

Nodes heterogeneity is essential for better utilization of network resources. Therefore **[17]** have considered energy and data aggregation rate (traffic) awareness in WSN and proposed Traffic and Energy Aware Routing (TEAR) algorithm. This protocol considers nodes initial energy, residual energy average energy of the round and traffic load during the selection of CH. But this also increases the network energy consumption, therefore nodes with higher traffic loads are not considered for CH selection procedure.

In 2018 **[18]** has taken into account the IoT applications, which require high energy to process data, and proposed an extension to LEACH named as IoT-LEACH or I-LEACH. This protocol altered in terms of CH selection and simultaneously switching power levels. There are two power levels set in this, one is low power level for intra-cluster communication and other one is high power level for inter-cluster communication and long haul data transmission. Therefore this protocol is best suited for the applications in which network required to be scalable i.e. more no. of nodes can be added.

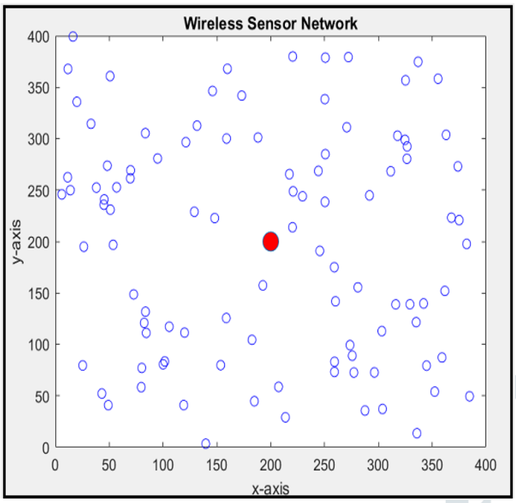


Fig. 2: Node deployment in WSN

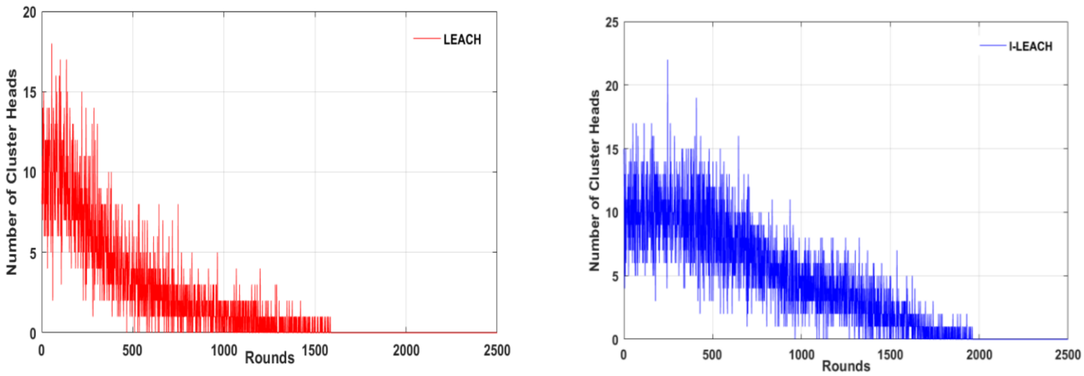
Table 1: Simulation Parameters

Symbol	Description	Value
x_m	Distance of x- axis	400m
y_m	Distance of y-axis	400m
n	Total no. of sensor nodes	100
p	Election probability of node to become CH	0.1
E_{TX},E_{RX}	Transmiter and receiver energy per node	50nJ/bit
$\mathcal{E}_{fs}$	Energy dissipation:free space model	10pJ/bit/ m^2
$\mathcal{E}_{mp}$	Energy dissipation: multipath fading model	0.0013pJ /bit/m^4
E_{DA}	Data aggregation energy	5nJ/bit

IV RESULTS AND SIMULATION

A sensor network is considered of dimensions 400×400 and sensor nodes are deployed randomly as shown in Fig. 2. The base station or the sink node is placed at center of the network. The normal sensor nodes are considered with limited energy. Table 1 consists of basic simulation parameters used for simulation in WSN. The simulation has been proposed for 2500 rounds with data packet size of 4000 bits. So, in this section a comparison has been taken out between I-LEACH and LEACH protocol.

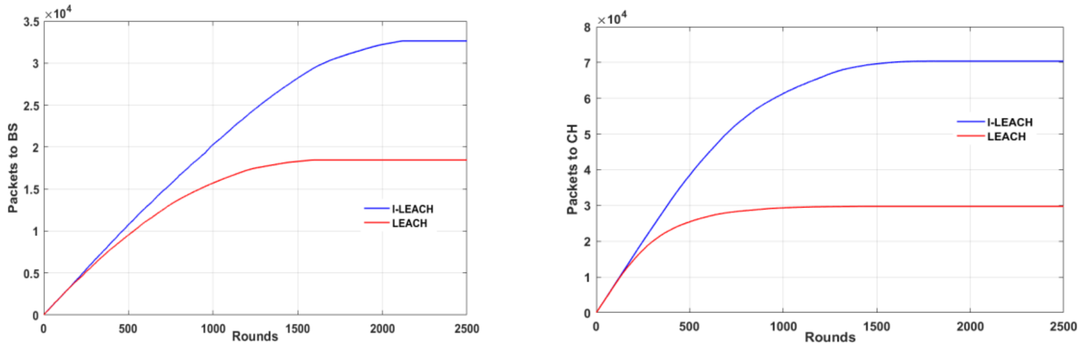
Network lifetime, stability, dead nodes, alive nodes, packets communicated to BS and CH, Residual energy and Throughput of the network are the lifetime metrics which are considered for the comparison of I-LEACH and LECAH.



(a) (b)

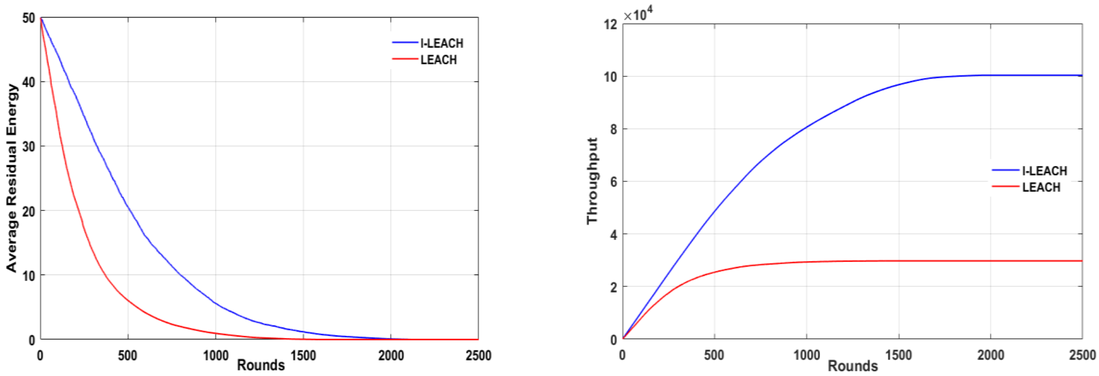
Fig. 3:Cluster count

Cluster count for LEACH , (b)Cluster count for ILEACH



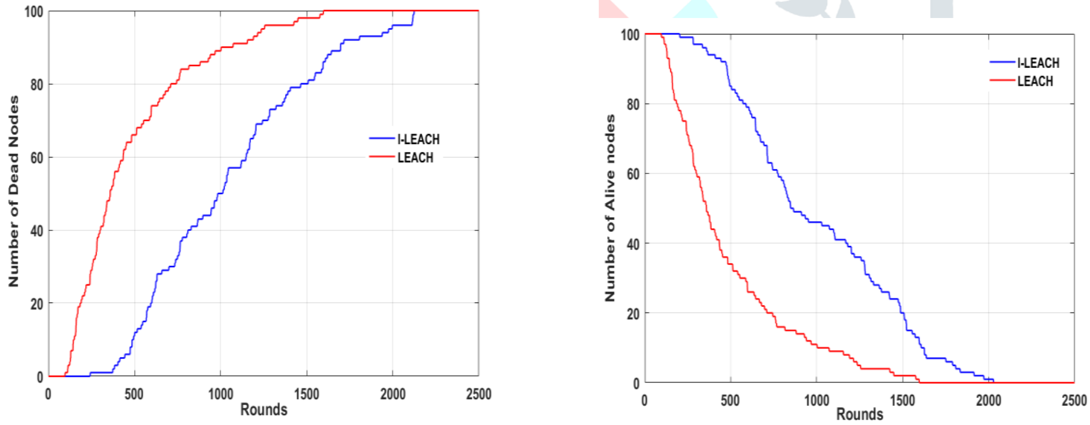
(a) (b)

Fig. 4: Packets Communicated
(a) to BS, (b) to CH



(a) (b)

Fig. 5: Network Performance
(a) Average residual energy , (b)Throughput



(a) (b)

Fig. 6: Lifetime Metrics
(a) Dead Nodes, (b) Alive nodes

From Fig. 3(a) and (b), it is clear that in LEACH the CHs count lasts upto 1790 round only, where as in I-LEACH this no. increases to 2360 rounds respectively. The number of packets communicated to CH and BS is one of the main factor for an energy efficient network. In LEACH the number of packets sent to BS is 1.8×10^4 and in I-LEACH this rises to 2.8×10^4 as indicated in Fig. 4(a).In the same way number of packets to CH also rises in I-LEACH as shown in Fig. 4(b).
Also network performance of I-LEACH is elevated in comparison to LEACH as Fig.5(a)and (b) indicating. In LEACH after 1250 rounds the average energy of nodes become zero and in I-LEACH it continues upto 2000 rounds. And the throughput of the network in I-LEACH is more and it is 9.8×10^4.
When network is performing, then its energy depletes regularly with the rounds and that is given in the terms of number of dead and alive nodes as indicated in Fig.6(a) and (b). In LEACH the number of alive nodes becomes zero after completion of approximate 1500 rounds and in I-LEACH the number of rounds increases to 2000.Thus I-LEACH is having more network lifetime which is fairly due to consideration of hard-threshold and soft-threshold values.
To study the behaviour of the algorithm of any protocol in different fields of applications it is necessary to study its lifetime and stability. The stability of the network is calculated from the First Node Dead (FND) and lifetime is calculated as the interval between the start of the network operation and till last node dies *i.e.* Last Node Dead (LND) .But in this paper we are considering network lifetime as a function of Half Nodes Dead (HND). Hence Table 2 depicts the FND, HND and LND for different areas with different density of the network. Three different areas (100,200 and 400 sq. unit) are considered for different number of nodes.

Table 2: Lifetime metrics comparison

Nodes	Energy	Area	LEACH			I-LEACH		
			FND	HND	LND	FND	HND	LND
100	0.5	100	1085	1255	1579	1364	1608	2246
		200	773	1048	1538	1181	1481	2161
		400	87	381	1565	232	973	2167
400	0.5	100	1000	1214	1665	1154	1465	2142
		200	901	1126	1701	1101	1419	2262
		400	154	625	1725	217	895	2191

Considering area of 200 m^2 and number of nodes of 100, the percentage increase in FND in I-LEACH is 52.7% as compare to LEACH and that increase in HND is 41.3%. In the same way, with area of 200m^2 and no. of nodes of 400, the percentage increase in FND in I-LEACH is 22.2% as compare to LEACH and that increase in HND is 26.02%.
Hence stability and network lifetime of I-LEACH is clearly more than LEACH.

V CONCLUSION

This paper presented the comparison between I-LEACH and LEACH protocol in terms of various lifetime metrics in different scenarios. Through simulation results we found that I-LEACH surmount the LEACH protocol in terms of lifetime and stability.
Hence it can be used for wide range of applications having higher data traffic rates. In future this protocol can be extended to heterogenous networks containing nodes with different levels of energy.

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