Egyptian Informatics Journal (2014) xxx, xxx–xxx

Cairo University

Egyptian Informatics Journal

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# Innovative energy resourceful merged layer technique (MLT) of node deployment to enhance the lifetime of wireless sensor networks

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Received 20 February 2014; accepted 30 November 2014

**KEYWORDS**

Clustering concept;
Homogeneous system;
Heterogeneous system;
Merged Layer node deployment techniques (MLT);
Wireless sensor network

**Abstract** A wireless sensor network (WSN) is consisting of anthology of large number of small sensor nodes which are deployed in a defined area to observe the surroundings parameters. Since, energy consumption is significant challenge in WSN. As sensor nodes are equipped with battery which has limited energy. Energy efficient information processing is most importance for many routing protocols were proposed to increase the lifetime of WSN. In order to improve the lifetime of WSN, the proposed MLT routing protocol has implemented where the sensor nodes are randomly deployed in the field. The merged layer node deployment pattern of the sensor nodes system operation maximizes the working time of full coverage in a given WSN. MLT provides energy-balancing while selecting cluster head (CH) for each round. The cluster head selection mechanism is essential and has same procedure like Low Energy Adaptive Clustering Hierarchy (LEACH) in MLT protocol. The main idea of this paper is combine two layers of sensor nodes which are belonging to the same set but in different group to improve the lifetime of WSN. MATLAB simulations are performed to analyze and compare the performance of MLT with LEACH protocol. The obtained simulation output has enhanced results and superfluous lifetime compared to other protocols.



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Peer review under responsibility of Faculty of Computers and Information, Cairo University.

Production and hosting by Elsevier

## 1. Introduction

Wireless sensor networks (WSNs) are serene of many small sensor nodes with limited battery power. Routing techniques are the most important issue for networks to save the energy in [1,2]. Each sensor is limited in their energy level, by limit the processing power and sensing ability. Thus a network of these sensors gives rise to a more robust, reliable and accurate

http://dx.doi.org/10.1016/j.eij.2014.11.002

network. New applications have been introduced by many research scholars in various areas, like remote and hostile regions as seen in the military for battle field surveillance, monitoring the enemy land, detection of attacks and security propriety information delivery.

An extravagant use of the available energy leads to poor performance the network. To this end, energy in these sensors is a rare resource and must be managed in an efficient manner. In this chapter, we proposed algorithm is implemented in homogeneous and heterogeneous system where merged layer technique (MLT) node deployment system of network helps to improve the power economy in WSN. In this case random deployment of nodes is deployed in two layers with same energy and same probability of head selection procedure. Two layer sensor nodes are belonging to same set but in different group. According to the LEACH principle the sensor nodes are transmitting their sensed data to CH and CH transmits aggregated data to base station (BS). The merged layer concept network has better results compared with LEACH protocol.

The formations of these chapters are as follows. We briefly review the related work in Section 2. Section 3 describes heterogeneous sensor network system. A sensor network model is analyzed in Section 4. In Section 5, we present MLT protocol. Simulation results of the proposed protocol are discussed in terms of energy consumption, number of live nodes per round, separate base station location for two layer sensor nodes and comparative result graphs in Section 6. Finally, in Section 7 bring to an end of the proposed algorithm and future works.

## 2. Related works

Hierarchical routing technique in [3,4] is one of the effective techniques to maintain the energy saving of sensor nodes to improve the lifetime of the WSNs in [5,6]. It has multi-hop communication within a particular cluster and sensor nodes by performing data aggregation and transmits the data to the sink in [7,8].

### *2.1. Low-energy adaptive clustering hierarchy (LEACH) protocol*

LEACH (Heinemann et al., 2002) is the first hierarchical routing protocol for sensors networks. The idea proposed in LEACH has been an encouragement for many protocols in [9–11]. In LEACH, formation of clusters among the sensor nodes is based on the elected cluster heads for routers to the base station (BS) in [12]. The selection of cluster heads in [13,14] is followed by Eq. (1).

$$T(n) = \begin{cases} \frac{p}{1-p*\left(r \bmod \frac{1}{p}\right)} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

where '$P$' is desired percentage of cluster head nodes in the sensor network, '$r$' is current round number and '$G$' is the set of nodes that have not been cluster heads in the last $1/P$ rounds. The concept of LEACH is depicted in Fig. 1.

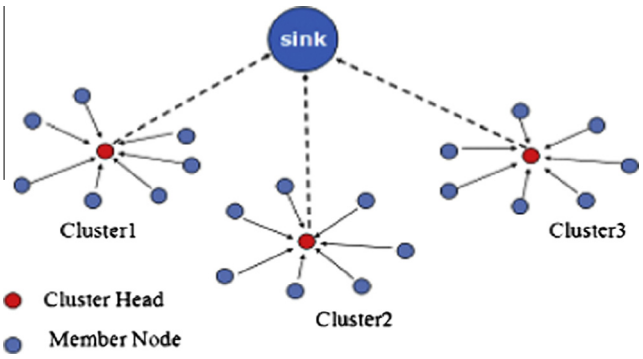


**Figure 1** LEACH protocol.

### *2.2. Stable Election Protocol (SEP)*

A Stable Election Protocol (SEP) is improved version of LEACH protocol in [15]. In this protocol heterogeneous sensor nodes are used in wireless sensor networks. This protocol has operation like LEACH but in two different energy nodes. SEP based on weighted election probabilities of each node to become cluster head according to their respective energy. This approach ensures that the cluster head election is randomly selected and distributed based on the fraction of energy of each node assuring a uniform use of the nodes energy. In SEP, two types of nodes (normal and advanced) are considered [16]. It is based on weighted election probabilities of each node to become cluster head. This prolongs the stability period i.e. the time interval before the death of the first node.

### *2.3. Cluster head relay routing protocol for heterogeneous sensor networks*

A cluster head relay (CHR) routing protocol for heterogeneous sensor networks in [17]. This protocol uses two types of sensors to form a heterogeneous network with a single sink: a large number of lower-energy sensors and a small number of higher-energy sensors. Both types of sensors are static and aware of their locations using some location service. Moreover, both types are uniformly and randomly distributed in a defined area. The CHR protocol partitions the heterogeneous network into clusters, each being composed of both lower and higher energy sensors. Within a cluster, the lower energy sensors are in charge of sensing the environment and forwarding data packets originated by other lower energy sensors toward their cluster head in a multi-hop transmission. The higher energy sensors, on the other hand, are responsible for data fusion within their own clusters and forwarding aggregated data packets from other cluster heads toward the sink in a multi-hop transmission by only cluster heads.

## 3. Performance measures of heterogeneity

Some performance measures that are used to evaluate the performance of clustering protocols are listed below for heterogeneity of WSNs in [18]. Network lifetime (stability period): It is the time interval from the start of operation (of the sensor network) until the death of the first alive node. Number of cluster heads per round: Instantaneous measure reflects the number of

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nodes which would send directly to the base station, information aggregated from their cluster members. Energy Efficiency: The Innovative ways for Smart Energy consumption. Number of live nodes per round: This instantaneous measure reflects the total number of nodes and that of each type that has not yet expended all of their energy. Throughput: This includes the total rate of data sent over the network, the rate of data sent from cluster heads to the base station as well as the rate of data sent from the nodes to their cluster heads

## 4. Energy model of sensor network

### 4.1. Network model

The following properties are assumed for the sensor nodes in the network energy model in Fig. 2.

- The sink node locates at the center of field area and has enough memory and computing capability.
- The WSNs consist of the heterogeneous sensor nodes. Percentage of sensor nodes are equipped with more energy resources than the rest of the nodes. Let '*m*' be the fraction of the total number of nodes '*n*' which are equipped with alpha times more energy than the others.
- The distance can be measured based on the wireless radio signal power.
- All sensor nodes are immobile and have a limited energy.
- All nodes are equipped with power control capabilities to vary their transmitting power.

Radio energy dissipation model adopted wireless channel models in the reference. Thus, to transmit a 1-bit message a distance '*d*', the radio expends:

$$E_{TX}(k,d) = \begin{cases} kE_{elec} + k\varepsilon_{fs}d^2 & d < d_0 \\ kE_{elec} + k\varepsilon_{amp}d^4 & d \geqslant d_0 \end{cases} \quad (2)$$

The electronics energy $E_{elec}$ depends on factors such as the digital coding, filtering and reading of the signal, whereas the amplifier energy, $\varepsilon_{fs}$, $d^2$, $\varepsilon_{mp}$, $d^4$, depends on the distance to the receiver and the acceptable bit error rate and do is a distance constant.

To receive this message, the radio expends:

$$E_{Rx}(d) = kE_{elec} \quad (3)$$

## 5. Proposed merged layer node deployment technique (MLT) routing algorithm to enhance lifetime of WSN

The proposed algorithm is for homogeneous and heterogeneous system of merged layer node deployment leach technique (MLT). In these random deployments of sensor nodes are deployed in two layers with same energy and same probability of head selection procedure. These two layers are sandwiched and belonging to same set, but in different group. According to the LEACH formula the nodes are transmitting their data to the CH and CH transmits aggregated data to the BS. The merged layer concept network has better results compared with LEACH Protocol which is followed the same procedure.

### 5.1. Homogeneous merged layer LEACH system

In proposed HHMTL algorithm, Homogeneous Merged Layer LEACH system of sensor node deployment has 50 sensor nodes are in blue color and other 50 sensor nodes are in red color. These two layer sensor nodes are deployed and merged in the same set but in different group. As like the LEACH operation, after certain rounds the sensor nodes are lose their energy and going to be a dead node. Dead nodes are indicated as red dot after drain out its energy at certain rounds. The sensor node deployment for two layers with its base station located at (45 m, 45 m) and (55 m, 55 m) indicated in Fig. 3.

The data transmission from each sensor node to its CH and CH to BS could consume large amount of energy in separate BS of two layers. The two base-stations are located at (45 m, 45 m) and (55 m, 55 m). As a result, by providing common base station at center (50 m, 50 m) for each layer sensor nodes to have less consumption of energy for data communication than the separate base station for both layers is shown in Fig. 4. From the graph the homogeneous merged layer LEACH with common BS system yield better result of energy consumption with lifetime improvement.

### 5.2. Heterogeneous sensor networks

Two different energy level sensor nodes are forming heterogeneous system of network, such as fewer nodes are having higher energy than the other nodes in the same random deployment of defined area. Energy efficient cluster head election protocol for heterogeneous wireless sensor network is proposed by LI Han 2010. One of the improved algorithms to construct an inter cluster routing in wireless sensor networks. It considered three types of sensor nodes.

1. Normal nodes which are lower energy.
2. Some fraction of the sensor nodes is assign higher energy than that of nodes called advanced nodes.
3. Cluster head nodes, sets up a TDMA schedule and transmits this schedule to the nodes in the cluster.

It assumed that all the sensor nodes are uniformly distributed. In this protocol, the cluster head node and also allows the radio components of each non-cluster head node to be

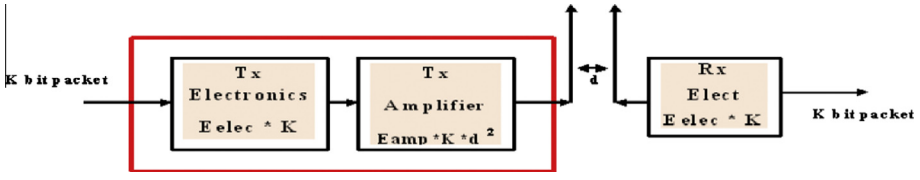


**Figure 2** Radio energy model.

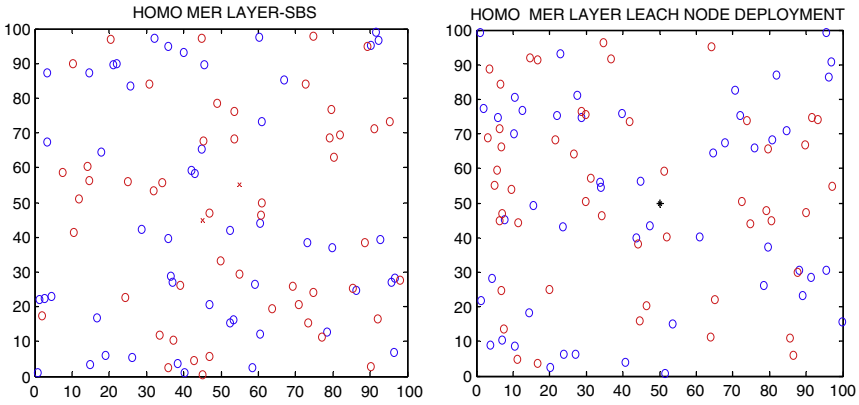


**Figure 3** Homogeneous merged layer node deployment with two and single BS.

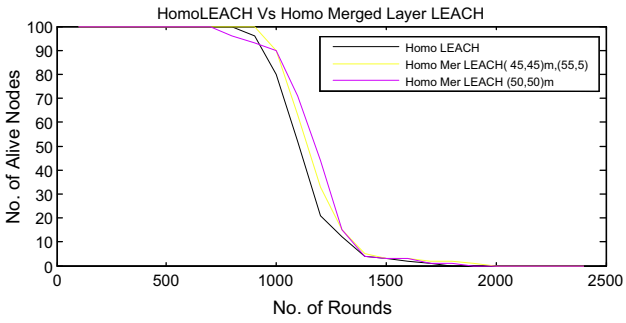


**Figure 4** Comparison of homogeneous merged layer LEACH with separate BS and common BS with homogeneous LEACH protocol.

turned off at all times except during their transmit time, thus minimizing the energy dissipated by the individual sensors.

In order to reduce the energy consumption of the cluster heads which are far away from the base station and balance the energy consumption of the cluster heads which are close to the base station, a multi-hop routing algorithm of cluster head has been presented, which introduces into the restriction factor of remainder energy when selects the short-term nodes between cluster heads and base station, and also the minimum spanning tree algorithm has been included. The protocol can not only reduce the consumption of transmit energy of cluster head, but also the consumption of communication energy between non-cluster head and cluster head nodes. Simulation results show that this protocol performs better than LEACH in terms of network lifetime. For that our proposed algorithm also implements the heterogeneity properties to improve the lifetime of WSN. Such as in merged layer 10% of nodes are higher energy advanced nodes than the normal nodes deployment in (100 m, 100 m) field. This made better performance than that of normal LEACH heterogeneity.

In proposed HHTML algorithm, Heterogeneous Merged Layer LEACH node deployment has 50 nodes are in blue color and other 50 nodes are in red color. These two layer nodes are deployed and merged in the same set but in different group. In this heterogeneity 10% of nodes have higher energy from each layer. Those nodes are indicated by green (+) and red (+) colors. As like the LEACH operation, after certain rounds the sensor nodes are lose their energy and going to be a dead node. Dead nodes are indicated as red dot after drain out its energy at certain rounds. The sensor node deployment for two layers with its base station located at (45 m, 45 m) and (55 m, 55 m) indicated in Fig. 5. The data transmission from each sensor node to its CH and CH to BS could consume large amount of energy in separate BS of two layers. The two base-stations are located at (45 m, 45 m) and (55 m, 55 m). As a result, by providing common base station at center (50 m, 50 m) for each layer sensor nodes to have less consumption of energy for data communication than the separate base station for both layers is shown in Fig. 6. From the graph the heterogeneous merged layer LEACH with common BS for two layers yield better result of energy consumption with lifetime improvement.

## 6. Analysis of simulation results

### 6.1. Energy consumption analysis

The performance of HHMLT is compared with the original LEACH in terms of energy is shown in Fig. 7. The energy consumption of the network is decreased while using merged layer technique of sensor node deployment for data transmission from CHs to the BS. This is due to the gain of the energy dissipated by cluster heads to the base station. From the graph it is clear that HHMLT can achieve better energy savings than LEACH protocol. The used simulation parameters are shown in Table 1.

### 6.2. Network lifetime

The number of nodes alive for each round of data transmission is observed for HHMLT algorithm to evaluate the lifetime of the network. The overall homogeneous and heterogeneous merged layer concept of separate BS and single BS is evidently compared with homogeneous and heterogeneous LEACH protocol. The foremost observation is heterogeneous merged layer single BS for both layer LEACH concept is produced the best result of energy consumption and lifetime improvement. It is clearly depicted in Fig. 7.

### 6.3. Result analysis

From our simulation, we observed the followings from Fig. 7.

- HHMLT achieves better energy savings than LEACH protocol.

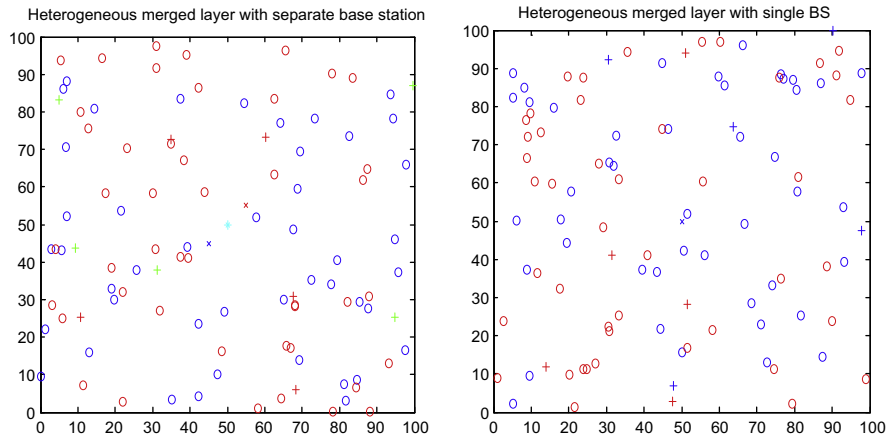


**Figure 5** Heterogeneous merged layer with separate BS and single BS.

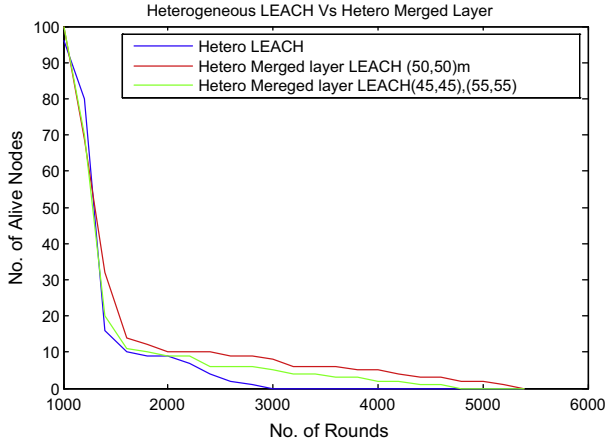


**Figure 6** Comparison of heterogeneous merged layer of separate BS and single BS with LEACH.

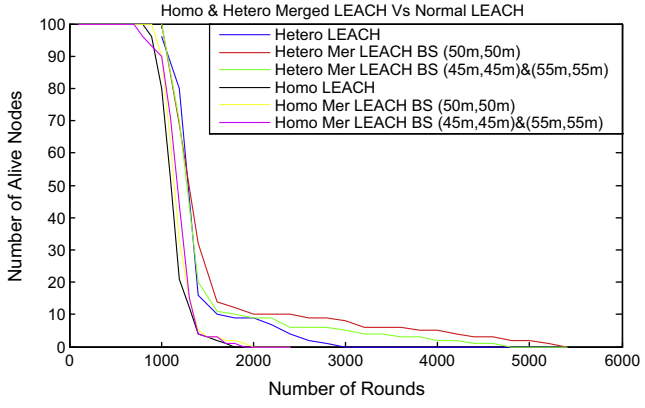


**Figure 7** Comparison between homogeneous and heterogeneous merged layer system with homogeneous and heterogeneous LEACH protocol.

- HHMLT with two layer merged technique to balanced energy dissipation of each nodes in WSN, which helps to extend the network lifetime.

**Table 1** Simulation parameters.

| Name of the parameter | Parameter values |
|---|---|
| Network area (variable) | 100 m × 100 m |
| Number of sensor nodes (variable) | 100 |
| Initial energy for homogeneous nodes (variable) | 0.5 J |
| $E_{elec}$ | 50 nJ/bit |
| $E_{tx} = E_{rx}$ | 50 nJ/bit |
| $\varepsilon_{fs}$ (Friss-amp) | 10 pJ/bits/m$^2$ |
| $\varepsilon_{amp}$ | 0.0013 pJ/bit/m$^4$ |
| Distance *do* | sqrt($\varepsilon_{fs}/\varepsilon_{mp}$) |
| $E_{DA}$ | 50 nJ/bit/signal |
| Packet size (variable) | 4000 bits |
| Initial energy for heterogeneous nodes (variable) | 1 J |

- For two separate base stations, the energy efficiency performance of HHMLT improves when compared to LEACH.
- In heterogeneous WSNs, HHMLT provides an extended lifetime of LEACH protocol and the stability period of the HHMLT was prolonged than LEACH.

## 7. Conclusion with future works

We have proposed Homogeneous and Heterogeneous Merged Layer Technique (HHMLT) energy efficient routing protocol for wireless sensor networks. The energy efficiency and alleviate of node deployment make HHMLT routing protocol is enviable and robust protocol for wireless sensor networks. In order to improve the lifetime and performance of the network HHMLT routing is proposed.

Simulation consequences show that the HHMLT improves the stable region of the clustering hierarchy, decrease probability of failure nodes and increase the lifetime of the network due to MERGED layer node deployment concept with balanced energy dissipation of individual node throughout the network and extends network lifetime. Balancing the energy consumption, reducing the occurrence of fast death node in single BS locations has better energy efficiency than two BS of merged layer node deployment concept. As the base station moves further away from the network, the energy proficient performance may improves than LEACH. Finally, HHMLT is scalable and

achieves better performance compared to LEACH in both heterogeneous and homogenous environments.

Plan to implement node scheduling in merged layer technique for both homogeneous and heterogeneous system of LEACH protocol.

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