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To cite this article: M. Mahmuddin *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **551** 012057

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WM-LEACH - An Improved Network Lifetime LEACH Protocol for Wireless Sensor Networks

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Abstract. Ad hoc network is divided into subcategories in which wireless sensor network (WSN) is one of them, which include several small devices known as sensor nodes (SNs) connected to base stations (BSs). The network lifetime is one of the most vital features as a trustworthy transmission. The low energy adaptive clustering hierarchy (LEACH) is one of the prominent protocols for deploying in the WSN that depends upon a procedure of clustering. Nevertheless, as cluster heads (CHs) share information with a BS openly irrespective of their interior distance, a maximum energy is utilized if the distance between them is too long, which alternatively minimizes the lifetime of the network. To cope with these challenges, various extensions of the LEACH protocol have been designed that send data in two ways, i.e., either in a single hop or multi hop. However, most of these extensions bring extra computational complexity for CHs due to the usage of residual energies. This study proposes an adaptive routing multi-hop LEACH (WM-LEACH) that would minimize the utilization of energy and augment the entire lifetime of the WSN. This rationale of the WM-LEACH is examined in the MATLAB simulator and the obtained outcomes are associated with other routing protocols in terms of network lifetime.

1. Introduction

Routing in the WSN is a quite difficult task because of various features which distinguish this network from other wireless networks, for example, mobile network or cellular communications. A few common characteristics of WSNs that are vital for forwarding techniques design comprise of many-to-one (M21) transmission, location familiarity, fixed devices, strongly restricted power, partial managing capabilities, caching spaces, and information gathering data merging

1.1. Low Energy Adaptive Clustering Hierarchy (LEACH)

LEACH is a procedure, which is the most appropriate for the WSN routing [1]. LEACH depends upon an adapted clustering procedure. The LEACH manipulates clusters and a single tier structure on the basis of a two-stage manoeuvre. A CH in the LEACH is arbitrarily shaped and the CH gathers the sensed information in all clusters. This also has several features associated with supplementary protocols. This may attain some stable energy utilization because of three features. Principally, a CH is interchanged on random basis. Next, sensors identify the beginning of every novel cycle on the basis of coordinated clocks for the whole system. Further, the remaining devices inside the network (in any of the cluster), which do not perform as CHs may switch off the radio till the allotted time slots of devices. Besides, features of the LEACH are such that all sensors may send and receive data from/to others without the



demand of earlier data regarding locations. Lastly, the LEACH is able to improve the gathered information in all clusters with the intention that the information sent to the BS may be reduced to the lowermost level.

The LEACH method is founded on the idea of cycles (rounds) where it scuttles in several cycles [2]. Every cycle includes two conditions/states, i.e., the steady one and the setup of a cluster [3]. In the former one, the information is forwarded from the source to other network devices whereas in the latter one the cluster is shaped in a way called self-adaptation. The concept of selecting a CH is such that the LEACH protocol selects a CH in every cycle [4-5]. Therefore, some of the sensors would utilize energy quite soon when they are chosen as CHs many times.

Likewise, a CH in the LEACH sends data to the source directly, thus, the energy consumption between the CH and the source is more than the energy consumed between two CHs. As a result, energy is drained rapidly by the CH. In the multi-hop LEACH process, the entire network nodes may not die soon and therefore the network lifetime is prolonged in comparison with the normal LEACH process. This is done via specifying stability in the energy utilization among the entire sensor network.

Also, as a CH is connected to the source directly irrespective of their distance, majority of the energy is utilized if the distance is long and therefore it minimizes the whole lifetime of the network [6]. To surmount this problem, various editions to the multi-hop LEACH are available, however, most of these editions (extensions) such as MR-LEACH, LEACH-E, LEACHME, LEACH-C, and LEACH-B, produce extra communication overhead for a CH as these all utilize a kind of energy known as residual energy.

Some more extensions of the multi-hop LEACH, e.g., M-LEACH and LEACH-W, also follow a random selection process for the CH that is not an effective method to improve the lifetime of the network and minimize the utilization of energy. Thus, a stout, accessible, and effective method is desirable for the enhancement of network lifetime and minimization of energy utilization in both large and small WSNs [7-12]. Hence, this study proposes a multi-hop LEACH extension, named WM-LEACH, which would minimize the utilization of energy and upsurge the lifetime of WSN

2. Setup Phase

The setup phase is not identical for all communication rounds. It differs based on whether the network has clusters or not. When the network has zero clusters, each alive node forwards a control message to the BS that consists of the ID, location and energy information.

The main shortcoming of LEACH is the random selection of CH that is applied to all sensor nodes without taking into account any factor. In reality, to increase the lifetime of network and energy efficiency, we need to change the threshold of selecting CH. In other words, we must consider four essential factors: the distance between the nodes and the BS, the residual energy, RSSI and nodes degrees within the transmission range, to calculate the threshold, which are calculated presented in (1):

$$\text{cost}(i) = \frac{\alpha E_{res}(i) + \beta N_{nbr}(i) + \delta RSSI(i)}{\mathcal{D}(i, bs)} \quad (1)$$

where, E_{res} is the initial energy, $N_{nbr}(i)$ is the number of neighbours of node i , N_{alive} is the number of alive nodes, $d(i, bs)$ is the distance between the node i and the bs . Then the threshold can be written as follows:

$$T(i) = \begin{cases} \text{cost}(i) & ; \text{if } i \in G \\ 0 & ; \text{otherwise} \end{cases} \quad (2)$$

3. Results and Discussion

3.1 Network Lifetime

The network lifetime of a sensing device means that a node may consume its energy in how much time that it dies after that. Thus, the device is counted as a dead node and is unable to function further in terms of information transmission. To elaborate it more, this is counted as in which round the first sensing device will lose its energy (i.e., die). Hence, it is considered as one of the most vital metrics to evaluate the capabilities of the network for prolonging sensing rounds of the network. A sensing device that dies after some time denotes that the system drops a routing choice and creates the lower and upper devices distressing from long-distance connections and thus misses some exposure of sensing.

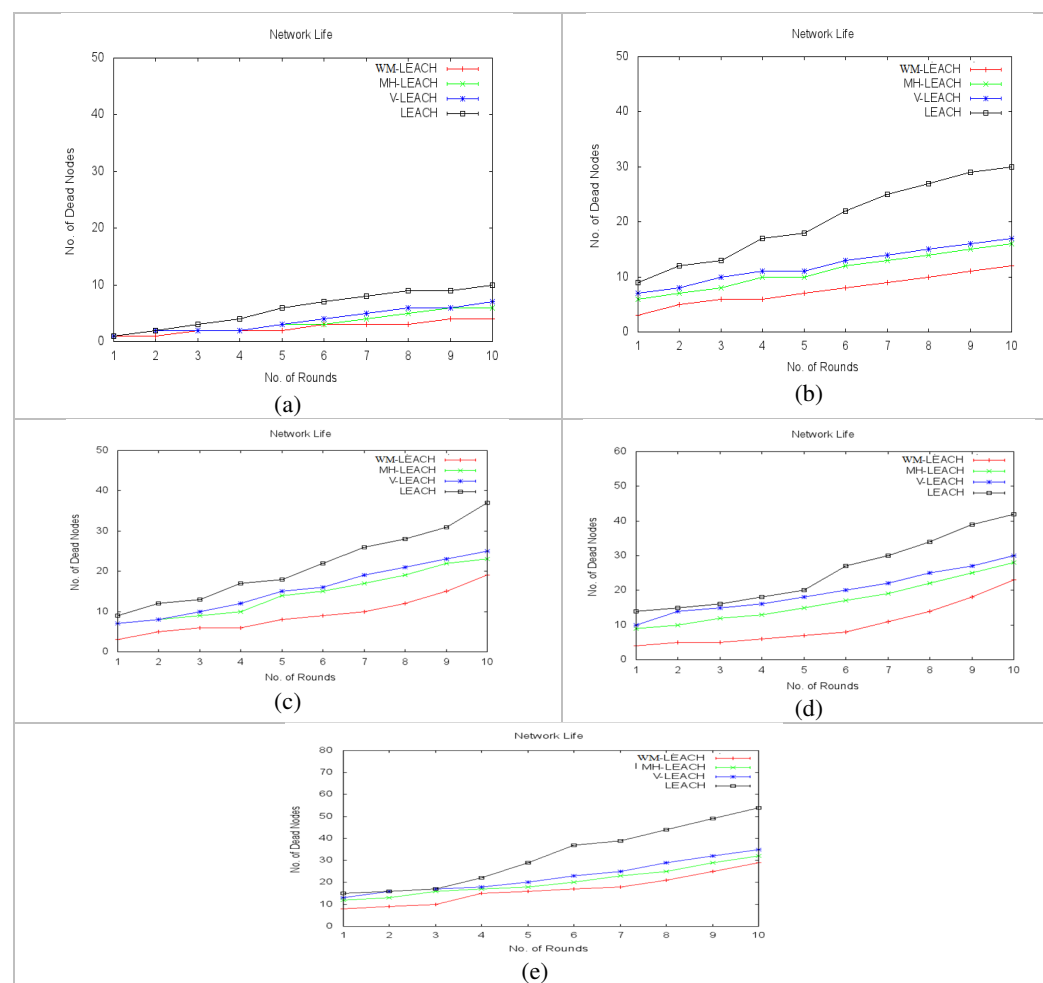


Figure 1. Network Lifetime with (a) 50, (b) 100, (c) 200, (d) 500 and (e) 1000 Nodes

The presented figure 1 demonstrates the lifetime the network for our proposed protocol in comparison with the basic LEACH, MH-LEACH, and V-LEACH having different number of nodes, i.e., 50 to 1,000 respectively, in 10 different rounds. The first figure, i.e., 1(a) shows that the number of nodes that have been died, (in a 50 nodes network) in the basic LEACH is one in the 1st round and 10

in the last round. In the MH-LEACH, dead nodes reached six from one in the 1st and last rounds, respectively. In the V-LEACH, the number of dead nodes reached seven in the 10th round as compared to one node in the 1st round. Whereas, in our proposed protocol, the number was recorded in such a fashion that it reached maxim four in the last round in comparison to one node in the 1st round.

Likewise, in the 100 nodes network, as shown in figure 1(b), the dead nodes were such that in the basic LEACH these were nine in the first round and then reached 30 in last round. In the MH-LEACH, dead nodes were six in the first and 16 in the last round, respectively. In the V-LEACH, the number reached 17 in the 10th round as compared to only seven nodes in the first round. Whereas, in the WM-LEACH, the numbers were such that in the first round these were only three and then reached 12 in the 10th one. Furthermore, when the network was extended to 200 sensing devices (nodes), the lifetime of the entire network was such that the basic LEACH lost nine nodes in the first round and 37 nodes in the final round (see figure 1(c)). The MH-LEACH lost 7 nodes in the first round as compared to 23 nodes in the last one. The V-LEACH was recorded such as it lost seven and 25 nodes in the first and 10th round, respectively. On the other hand, WM-LEACH lost only three nodes in the first round, which reached maxim 19 nodes in the 10th one. Moreover, when the network was deployed with a number of 500 nodes, LEACH got a number of dead nodes as 14 in the first round and 42 in the last one (see figure 1(d)). In the MH-LEACH, the number reached 28 in the final round, which was only nine in the first round. The V-LEACH lost 30 nodes in the final round, which was only 10 in the initial round. Whereas, in the WM-LEACH, the lost nodes were such that these it reached 23 in the last round, which were only four in the first round. In addition, these protocols were also tested with 1000 nodes in 10 different rounds.

This result was as follows: The basic LEACH lost 54 nodes in the last round, which were only 15 nodes in the first one. The MH-LEACH reached 32 lost nodes in the last round in comparison with 12 nodes in the first one. In the V-LEACH, the nodes reached 35 from 13 in the last round and first one, respectively. While our proposed protocol reached 29 nodes in the last round from eight nodes in the first one. Investigating the showing figures, this may be observed that the number of lost nodes is rationally minimized to a satisfactory degree in the proposed WM-LEACH protocol in comparison with other three protocols. Looking at all figures, i.e., (a) to (e), this can be seen that if the number of nodes is less or more, WM-LEACH works the best in comparison with basic LEACH, MH-LEACH, and V-LEACH. Therefore, this would have an appropriateness for deploying in the WSN so that to increase the entire lifetime of the network.

4. Conclusions

This rationale of the WM-LEACH is examined in the MATLAB simulator and the obtained outcomes are associated with three other routing schemes, i.e., basic LEACH, MH-LEACH, and V-LEACH in terms of network lifetime, energy consumptions, and network throughput. The obtained results are predicted to be momentous with regards to create the proposed WM-LEACH protocol satisfactory for subscribers where they may validate the rationale of WSNs afore choosing an appropriate scheme for routing.

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