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A Comparative Study on Hoping Mechanism of LEACH Protocol in Wireless Sensor Networks: A Survey

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Abstract. Low Energy Adaptive Clustering Hierarchy (LEACH) is a procedure, which is the most appropriate for the WSN routing. LEACH depends upon an adapted clustering procedure. The LEACH manipulates clusters and a single tier structure on the basis of a two-stage manoeuvre. LEACH functions in a single hop in such a way that every cluster head (CH) in WSNs my transfer its data to the BS and therefore the CH accepts the responsibility of sending information to the entire network. LEACH with Multi-Hop This procedure is the extension of single hop method, which works in a way that maximum CHs could send data to the BS.in this paper discussed the two extensions of LEACH in full detail with regard to their proposed schemes in terms of contributions and limitations.

1. Introduction

It is observed in the last few years that Wireless Sensor Networks (WSNs) have been utilized in various applications wirelessly. These applications include industrial applications such as mining, smart cities, smart emergency systems, and smart virtual power plants. WSNs may be categorized into infrastructure-less and infrastructure-based networks [1, 2]. The former one includes base station (BS) for sending data inside the network. Data networks that normally send data wirelessly are deployed either multi-hop or single-hop between the BS and all wireless nodes. Nevertheless, this category is unable to fulfil the demands of end users, even though the progress in this class has obtained a prodigious growth [3].

2. Discussion on LEACH Protocol

LEACH protocol is measured as the best procedure for WSN routing [4]. The idea of LEACH is being contemplated as an inventiveness for several routing procedures. The goal of this protocol is to select sensor nodes being the CHs in various cycles so as the outcome of extreme power excess (in communication with sinks) is obtained and then dispersed in the entire WSN.

3. LEACH Improvement

For the improvement of LEACH, several extensions were proposed in the last decade [5, 6]. In this section, we elaborate the features of those extensions.

3.1. Single-Hop LEACH Protocol

LEACH functions in a single hop in such a way that every CH in WSNs my transfer its data to the BS and therefore the CH accepts the responsibility of sending information to the entire network. Furthermore, a CH in this mode of transmission may receive information from WSN nodes and send it to the receiver (i.e., BS). A range of protocols have been designed for this category of LEACH, some of which are elaborated here in this section.

LEACH-C

In centralized LEACH, shortly called LEACH-C, a CH is chosen by the entire participating nodes in the network and therefore shapes a cluster [7]. Moreover, in the selection process of CH, the BS should be earlier aware of the level of energy in line with nodes placement. As a result, the BS must choose the most suitable sensor to become the CH while other nodes are assigned to CHs for shaping different clusters. The advantage of this procedure is such that a greater number of rounds may be accomplished in a little network portion. Nonetheless, this leads to additional operating cost because of transmission in a single hop and thus is not suitable for a network encompassing huge area.

V-LEACH

Vice-LEACH (V-LEACH) presents an associate sensor within the network to function being a CH if the central CH expires [8]. This is considered as a single hop due to the fact that it consists of merely one CH for the entire WSN. While an associate CH is chosen that begins working when the main CH expires, merely one node functions as a CH at one time. When a vice CH promotes to become the main CH, a third sensor is chosen to become the vice CH, etc. With this phenomenon, the selection of a new CH is not necessary every time when the main CH expires and thus the entire lifetime of WSN can be augmented. On the other hand, the vice CH is chosen on random basis, thus, this could be faraway, or would have a little amount of energy as well as battery life. Hence, that could expire immediately due to elongated distance data transmission.

Enhanced-LEACH (E-LEACH)

Enhanced LEACH or E-LEACH, smooth's the energy utilization of sensor nodes [9]. In the categorized routing procedure, numerous CHs are contemplated as the key component persuading the performance of routing protocols. When the number of CHs is less, all of them may need to cover a large area. It may encounter several challenges that some of the sensors would be placed nearby the CH that may utilize maximum energy. Data transmission or information sharing between the BS and CHs utilize maximum energy as compared to sharing sensors. A maximum level of CH would increase energy utilization and may ultimately minimize the lifetime of WSNs. Thus, this is primarily important to select the best node as a CH so that assist in consuming a little amount of energy. This scheme may expand the course to choose CHs by controlling the obligatory number of CHs, which ultimately minimizes the utilization of energy. Nonetheless, for getting information, a CH should retain its receptionist nodes ON every time. This help to minimize lifetime of the network.

Efficient Routing-LEACH (ER-LEACH)

In the Efficient Routing LEACH (ER-LEACH), the curiosity of a BS is pondered for gathering environmental information [10]. Therefore, sensors may collect information instead of forwarding to the sink. This protocol along with its process is presented. With this method, a notable execution is attained particularly when mobility is at the peak. On the other hand, since the selection of CH is done on the basis of sensor's life irrespective of distance, its energy could finish quickly because of data transfer in a void space.

3.2. Multi-Hop LEACH Protocol

This procedure is the extension of single hop method, which works in a way that maximum CHs could send data to the BS. In addition, a single CH in this scheme shares data with the remaining CHs and also

with the entire nodes lying in that particular cluster. Various amendments of LEACH with multi hop have been proposed, where a few of which are presented in this section.

Two-Level Hierarchy LEACH (TL-LEACH)

A TL-LEACH present a Two-Level Hierarchy LEACH [11], i.e., the basic CH is called the major CH and the second level signifies subordinate CHs. This method includes 4 main phases, i.e., setup, advertisement cluster formation, and information sharing. In the setup phase, all nodes decide that in case a basic CH is formed then a secondary CH would also work the same as the primary CH. In case a sensor is selected as the CH, this would have the responsibility of advertising the nature of the network to all other devices. In the next stage, all secondary CHs decide their status, i.e., it would lie in which cluster. In the 3rd stage, all basic CHs design an agenda on the basis of TDMA that employs time frame for information sending for all nodes in the cluster. All basic CHs choose the code of CDMA and notify it to all sensors for utilizing it. In the last phase, clusters are formed, and all sensors forward data with respect to the timeframe designed by the basic CH.

Mobile-LEACH (M-LEACH)

Mobile-LEACH (M-LEACH) [12] allows the mobility relevant to non-CHs and the basic CH when the first phase, i.e., setup, begins. This procedure reflects the energy of devices allotted during CH selections. Initially, all sensors are treated the same with respect to the performance of antenna, sensors having knowledge about the placement with the assistance of GPS whereby the BS is considered as stationary. In this scheme, a CH is selected based on diminution development. The best CH is selected to minimize the influence of diminution. This scheme provisions the nodes' mobility and therefore assures the collaboration of nodes and CHs albeit the nodes is not mobbing at all. Yet, this utilizes maximum energy because of a large ratio of data loss if the CH travels prior to the election of a CH in the upcoming stage.

LEACH-D

LEACH-Density Distribution of Node (LEACH-D) determines load balancing through adapting the function of levels [13]. The basic feature of levels is connectivity density that determines delivery denseness of sensor nodes. In this scheme the radius of a CH is decided by the CH itself, i.e., it is placed how far from the BS. Lastly, the CH applies multi-hop steady state in order to send information to the sink (i.e., BS). This is believed that LEACH-D is used to minimize energy utilization of the whole network, however, the election of CH is done on the basis of distance wherein the closer sensor to the BS is selected as the CH that would have lower battery-life and therefore may expire quite early.

W-LEACH (Weighted Low Energy Adaptive Clustering Hierarchy Aggregation)

W-LEACH [14], is a decentralized form of LEACH designed to augment the entire lifetime of WSNs. The general procedure of this protocol is similar to the basic LEACH scheme, but W-LEACH includes rounds which are absent in the basic LEACH. Every round in W-LEACH begins by setting up the cluster formation and CH selection. The next phase is the steady state wherein it is utilized for data transmission between the BS and all network nodes. Before the information sharing begins, all nodes identify their adjacent nodes on the basis of a fixed distance that supervises the denseness of sensors in order to avoid adjacent nodes to send similar data. On the basis of various adjacent nodes, sensors make decision so that to be dynamic or persist in asleep phase in this round. Thus, a node that has various adjacent nodes works in the active status for as much time as required. This way, all sensors send their data to the CH and thus reduce redundancy of information for a particular CH. W-LEACH works efficiently as it consumes little energy.

Multi-Hop LEACH (MH-LEACH)

In this kind of procedure, data transmission between the BS and all sensors is achieved in such a fashion that requires little transmission cost. This is due to the fact that maximum data transfer cost is required for when it is sent form the CH to the BS MH-LEACH protocol [9, 15] ,which provides solutions to the mentioned problems in which sensors send information to the CH. The CH then collects and share this

information with the BS either directly or via the BS. Similar to the basic LEACH, this procedure chooses a CH on random basis. A path, i.e., route best known for energy efficiency, is chosen for a CH placed quite data a distance from the BS. The distance is measured as the way for the selection of the middle CH.

A CH that is placed closer to the BS, obtains information from other CHs which is located at a distance from the BS. Through this way it assists to save CH's energy, which is portion of the cluster. Nevertheless, the election of CHs is done randomly, thus, a node which is chosen randomly would not essentially have high energy or power. Hence, the overall lifetime of WSN is minimized in this scheme, which is its main drawback.

The timeline of LEACH, their comparison, and its summary are given in table 1

Table 1. Timeline of LEACH and its Descendants

No	Type	CH Selection	Contributions	Limitations
1	**LEACH**	Random	Increases the network lifetime and achieves better energy efficiency	Does not guarantee good CH distribution , assumes uniform energy distribution
2	**LEACH-C**	Based on residual energy	A higher number of rounds is achieved in a small network area	Introduces extra overhead due to single-hop communication
3	**TL-LEACH**	Random	Brings better energy load distribution across the network.	Increases overhead during alternative CH selection and cluster formation.
4	**M-LEACH**	Based on residual energy	Supports the mobility of nodes and hence guarantees the CH and node's interaction even if node is static.	Consumes more energy due to huge packet loss ratio when the CH moves before the selection of a new CH for the next round.
5	**LEACH-E**	Based on residual energy	Enhances network lifetime by balancing energy consumption among all network nodes.	Selects CH based on energy which may have low battery and far from the sink, therefore could die soon.
6	**MH-LEACH**	Random	Helps in saving CHs' energy	Selects CH on random basis that may not necessarily be high in power and energy and hence decrease the network lifetime.
7	**LEACH-V**	Random	Prolongs the network lifetime .	The CH may die soon due to long distance communication.
8	**ER-LEACH**	Based on residual energy	Good performance is achieved at the time of high mobility.	The CH is selected based on the node's energy regardless of the distance; therefore, its energy may vanish very soon due to long distance communication.
9	**LEACH-D**	Based on distance	Reduces the entire network energy consumption.	Selects CH based on distance, which may have low ba;ttery and thus could die soon.
10	**E-LEACH**	Based on residual energy	Improves the process of CH selection by determining the required number of CHs that may reduce the energy consumption.	For receiving data, the CHs keep their receivers turned on all the time, which reduces the battery lifetime.
11	**LEACH-W**	Random	Saves energy consumption.	Selects CH on random basis, therefore it is difficult to know which node has higher energy to be chosen as CH. Thus the overall network lifetime may be reduced.

4. Conclusions

In this research we surveyed deeply the comprehension of wireless networks in line with their applicability and next we elaborated the method that packets are forwarded in the wireless environment. In addition, we also presented the basic procedures of WSN routing, known as LEACH, in terms of its working and features. Additionally, we also put light on the two main extensions this scheme, called multi-hop and single-hop, in terms of their suggested procedures with regards to its advantage and disadvantage. Besides the presented protocols and procedures, LEACH has various extensions, but its comprehensive elaboration is required for discovering an accessible, vigorous and effective clustering mechanism so that to reduce the usage of energy and augment the lifetime of WSN in both large-scale and small network zones.

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