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A New Approach for Clustering in Wireless Sensors Networks Based on LEACH

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Abstract

Wireless sensors networks (WSNs) are traditionally composed of large number of low-cost and tiny homogenous sensors nodes connected through a wireless network that gather data to be treated locally or relayed to the sink node through multi-hop wireless transmission. Moreover, such issues are very critical due servers resources constraints like efficient energy, stock limitation and lifetime of network. Several solutions were proposed to minimize the traffic into network. Clustering algorithms have been widely used to reduce energy consumption. In this context, the key point in such topology is to select a cluster. One of solutions is to select a cluster alternately. However, this choice does not consider the energy as important criteria in actual papers. In order to limit energy consumption, our new method is proposed in this paper to optimization Low Energy Adaptive Clustering Hierarchy (O-LEACH) to improve existing LEACH and LEACH-C by selecting cluster according to the residual energy of nodes dynamically. The simulation results show that proposed algorithm achieve longer stability by comparison to original LEACH and LEACH-C.

Selection and Peer-review under responsibility of the Program Chairs.

Keywords: wireless sensors network; clustering; energy thresh; network life time; optimization.

1. Introduction

Wireless sensor networks (WSNs) drew attention of researchers in different fields in the last decade. These networks are used for several applications such as traffic monitoring, surveillance, acoustic and seismic detection, environmental monitoring, etc [1]. The ultimate objective of clustering is to offer a solution that keeps stability between the sensors throughout the network operation. Energy consumption is ranked among the major problems of research in distributed system including sensor networks, the majority of research has been focused on the study protocol and algorithms that addresses these issues to resolve.
In sensor networks, the main reason for nodes failure is the discharge of batteries. Energy efficiency is a critical issue in wireless sensor networks [2], [3]; therefore, using energy efficient programs and algorithms on these nodes is of

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great significance [2]. One of the most important problems in computer networks, including wireless sensor networks, the organization nodes into the network. In view of the fact that wireless sensor networks are used for monitoring strategic environments, the accuracy of the information gathered is crucial. Information accuracy highly depends on the capability of nodes to do their tasks until the end; as a result, energy consumption plays an important role.
he selection of cluster head is the key issue in the clustering algorithm, which is also a multiple criteria in decision making procedure. In this paper, we propose a new technique for the selection of the sensors cluster-heads based on the amount of energy remaining after each round [(4), (5)]. As the minimum percentage of energy for the selected leader is determined in advance and consequently limiting its performance and nonstop coordination task, the new hierarchical routing protocol is based on an energy limit value threshold preventing the creation of a group leader, to ensure reliable performance of the whole network.
The remainder of this article is organized as follows: in the next section, we briefly review related work. Section 3 presents the details of our algorithm. Therefore in section 4, shows the performance of O-LEACH by simulations and compare it with LEACH and LEACH-C. Finally we conclude the paper in section 5.

2. Related Works

In hierarchical routing protocols whole network is divided into multiple clusters. one node in each cluster play leading rule. cluster-head is the only node that can communicate to Base station in clustering routing protocols. This significantly reduces the routing overhead of normal nodes because normal nodes have to transmit to cluster-head only. Description of some hierarchical routing protocols is discuss in next subsections.

2.1. LEACH (Low Energy Adaptive Clustering Hierarchy)

In [5], Heinzelman and al. have proposed a distributed clustering algorithm called Low-Energy Adaptive Clustering Hierarchy (LEACH), for routing in homogeneous sensor networks. LEACH selects randomly the nodes cluster-heads and assigns this role to different nodes according to round- robin management policy to ensure fair energy dissipation between nodes In order to reduce the amount of information transmitted to the base station, the cluster-heads aggregate the data captured by the member nodes belonging to their own cluster, and then sends an aggregated packet to the base station. The protocol consists of two phases: The first is the set-up phase, and the second is the steady-state

In the first phase, cluster heads are selected and clusters are formed, and in the second phase, the data transfer to the base station is held. During the first phase, the process of electing cluster heads is triggered to select future cluster heads. Thus, a predetermined fraction of nodes connected as cluster heads according either 0 or 1. If the random number is less than a threshold T_s then the node becomes a cluster head in the current round, otherwise the node n is expected to join the nearest cluster head in its neighborhood. The threshold is set as:

$$T_n = \begin{cases} \frac{T}{1-p(r mod \frac{1}{p})} & if \quad n \in G \\ 0 & Otherwise \end{cases} . \tag{1}$$

Where r is the current round number (starting from round 0), p the probability for each node to become cluster heads (e.g. 0.05), and G the set of nodes that have not been cluster-head in the last 1/p round. The election probability of nodes G to become cluster heads increases in each round in the same epoch and becomes equal to 1 in the last round of the epoch. However, while LEACH can increase the lifetime of the network, it has some limitations. LEACH assumes that all nodes can transmit data with great power to reach the base station and each node has a computing power enabling it to withstand various MAC layers. Therefore, LEACH is not suitable for networks deployed in large areas. In addition, LEACH randomly selects a list of cluster heads and there are no restrictions on their distribution and on their energy level. Thus, the cluster heads can concentrate on one place and therefore there may be isolated nodes (without cluster head) that may occur. On the other hand, in LEACH, the aggregation of data is centralized and is performed periodically. However, in some cases, the periodic transmission of data may not be necessary, which exhausts rapidly the limited energy of sensors [7].

2.2. Multi-hop LEACH

An improved version of LEACH called Multi-hop LEACH (LEACH-M) [8], in which members of a cluster may be more of a leap from their corresponding cluster-head and communicates with it in multi-hop fashion. Thus, they illustrate the cases in which M-LEACH outperforms LEACH. However, this proposed version requires each sensor must be able to aggregate data, which increases the overhead for all sensors. To improve this strategy, in [9], the authors have focused on heterogeneous sensor networks, in which two types of sensors are deployed: high capacity sensors (Super Sensor) and simple sensors. The sensors have large capacity processing capabilities and communicate very intensively and act as cluster-heads, while others are simple sensors with limited power, affiliated to the closest cluster-head in their neighborhood and communicate with it directly or in multi hop.

2.3. Mobile LEACH

The LEACH considers all nodes are homogeneous with respect to energy, which is not realistic approach. In particular round uneven nodes are attached to multiple Cluster-head; in this case cluster-head with large number of member ode will drain its energy as compare to cluster-head with smaller number of associated member nodes. Furthermore mobility support is another issue with LEACH routing protocol, to mitigate these issues, M-LEACH is proposed in [9], [10].

2.4. LEACH-C

LEACH-Centralized (LEACH-C) [8] is similar to the LEACH Protocol as far as formatting clusters at the beginning of each round is designed to improve the performance of LEACH. However, instead of nodes randomly self-selecting as a CH, the sink in LEACH-C performs a centralized algorithm. The sink collects location data from the nodes, and then broadcasts its decision of which nodes are to act as CHs back to the nodes. The overall performance of LEACH-C is better than LEACH by dispersing the cluster heads throughout the network. However, LEACH-C is sensitive to the sink location. Once the energy cost of communicating with the sink becomes higher than the energy cost for cluster formation, LEACH-C no longer provides good performance. Sinks may be located far from the network in most WSN applications. So, the dependence on the sink location is a major disadvantage of LEACH-C.
In the second parts of this section we can compare the above-mentioned clustering protocols according to their performance depending on different parameters. For analytical comparison, it is crucial to be aware from Radio model assumption adopted by energy efficient clustering protocol. All energy efficient clustering protocols proposed in previous research provide different assumptions about the radio particularity. These dissimilar features cause significant variation in energy efficiency of routing protocols. These assumptions differentiate energy dissipation to run transceiver and receiver circuitry per bit. Radio wastes amp for transmit amplifier to attain suitable $Eb/N0$. These are also multiple assumptions in selection of suitable amp. Most acceptable value of these radio characteristics, which is assumed by extensive research work, is given in the table 1 [9].

Table 1. Performance Comparison of Hierarchical Routing Protocol

Algorithm	classification	Mobility	Scalability	Self-organization	Distributed	Centralized	Homogenous
LEACH	Hierarchical	Fixed BS	limited	Yes	Yes	No	Yes
LEACH-C	Hierarchical	Fixed BS	Good	Yes	Yes	Yes	Yes
LEACH	Hierarchical	Fixed BS	Very Good	Yes	Yes	No	Yes
M-LEACH	Hierarchical	Fixed BS	Very Good	Yes	Yes	No	Yes

2.5. Energy Model

The energy consumption rate in the sensors networks represents the most important metric in the performance evaluation phase. This parameter depends on the used nodes characteristics (standby mode, nature of data processing,

transmitted power, etc), and nodes behavior during the communication (retransmission, congestion, diffusion of the messages,.) [13].
The consumed power by sensor is that the consumed power by these captures units, treatment units and communication units. So the energy consumption formula is defined follows:

$$E_c = E_c/Capture + E_c/Treatment + E_c/Communication. \tag{2}$$

Where:

- $E_c/Capture$: is the energy consumed by sensor during the capture unit activation. This energy depends primarily on the type of detected event (image..) and of the tasks to be realized by this unit.
- $E_c/Treatment$: is the energy consumed by the sensor during the activation of its treatment unit.
- $E_c/Communication$: is the energy consumed by the sensor the activation of its communication unit.

The consumed energy by sensors during communication is larger those consumed by treatment unit and capture unit. Indeed, the transmission of a bit of information can consume as much as the execution of a few thousands instructions. For that, we can neglect the energy of the capture unit, and the treatment unit compared to the energy consumed by the communication unit. In this, case the equation (2) will be thus

$$E_c = E_c/Communication. \tag{3}$$

The communication energy breaks up into emission energy and reception energy:

$$E_c/Communication = E_{TX} + E_{RX}. \tag{4}$$

Referring to [14], the transmission energy and reception energy are defined as follows:

$$E_{TX} = E_{elec} * K + \varepsilon_{mp} * K * d\lambda \tag{5}$$

Where:

- K=message length(bits).
- D=distance between transmitting node and receiving node
- λ= of way loss exhibitor, $\lambda > 2$
- E_{elec} =emission/reception energy, E_{elec}=50 nJ/bit.

2.6. The O-LEACH protocol

In this section, we describe the network model. Assume that are N sensors nodes, which are uniformly dispersed within a MxM square region (see Fig.2). The nodes always have data to transmit to a base station, which is often far from the sensing area. This kind of sensors network can be used to track the medical object or seism detection. Without loss of generality, we assume in first simulation that the base station is located at the center of square region, and in the second simulation we assume that the base station is in the top or square region (99m X 99m). The network is organized into a clustering hierarchy, and the cluster-heads execute fusion function to reduce correlated data produced by the sensor node within the clusters. The cluster heads transmit the aggregated data to the base station directly. To avoid the frequent change of topology, we assume that the nodes are in static mode [5].

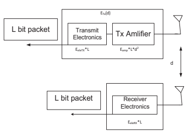

Fig. 1. Energy model [13].

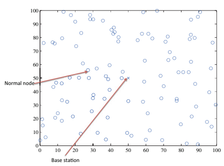

Fig. 2. Random deployment of sensors

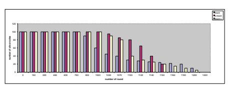
Fig. 3. Number of alive nodes (100 nodes).

2.6.1. Assumption

Some of the assumptions made in clustered for communicating in wireless sensor network are as following:

- The network is shaped by N sensors nodes deployed in square field and has designed cluster hierarchical topology.
- The base station is located outside the sensing field.
- Nodes are deployed randomly.
- The base station location is pre-determined.
- The cluster head nodes are cognizant of its members and can communicate directly with them.
- The cluster-head nodes communicate with their parent cluster-head, and finally every cluster-head node is communicate with base station.

2.6.2. Proposed Algorithm

- The base station (BS) initiates the routing process.
- Election a cluster-head in each round with an energy value greater than ten percent of the residual value at each sensor.
- After selection of the head. Wait for member nodes.
- Create the table TDMA and sent it to members.
- Launch of the transmission phase.
- If the energy is less than its value in second steps, the process of LEACH will be launched.

3. SIMULATION AND ANALYSIS

3.1. simulation Environment

In this section, we evaluate the performance of O-LEACH protocol using MATLAB, and compare it's performance with LEACH, using the same initial values and following the same scenario and energy model. The algorithm is tested in Matlab (version 7.0). The experiments are performed with diverse number of nodes placed in a 100m x 100m field (see fig.2). Each sensor node is assumed to have an initial energy of 0.5 joules. Anode is considered dead if its energy level reaches 20 to 0 joules. The general simulation parameters are:

Table 2. Simulation Parameters

Parameters	Value
Simulation Area	100*100
Initial energy	0.5J
Base station	50m∗50m and 99m*99m
Transmitter/Receiver Electronics	50 nJ /bit
Number of nodes	100 and 300
ε_{fs}	10pJ/ bit/m
ε_{mp}	0.0013 pJ/bit/m

3.2. Results

The results about system lifetime are described in Figure.3. We deduct that the proposed algorithm improve lifetime and stability of nodes. This plot shows the number of nodes that remain alive over the number of rounds of activity of the 100m x 100m network scenario. With our approach, all the nodes remain alive for 1060 round, while the corresponding numbers for LEACH are 850. This is because LEACH treats all the nodes without discrimination. O-LEACH has longer stability period than LEACH and LEACH-C just because of discriminating nodes according to their initial energy. Also we can see the intersection of the two curves (red and yellow) in fig.3 at the round 1140 after this round our scheme falling freely because the messages delivered by O-LEACH is more than LEACH-C and

LEACH. This means that O-LEACH is more efficient than LEACH and LEACH-C. In addition after this intersection there is no guarantee that the alive nodes with leach works well (to send and receive data inter and intra cluster).

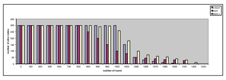

Fig. 4. Number of alive nodes (300 nodes).

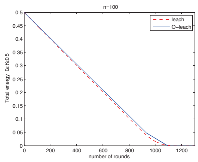

Fig. 5. The energy dissipation (100 nodes)

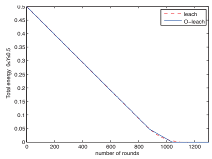

Fig. 6. The energy dissipation (300 nodes)

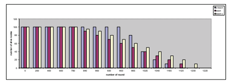

Fig. 7. Number of alive nodes (base station in 99m X99 m)

Fig.4 shows although the number of nodes increases the stability of O-LEACH are longer than LEACH and LEACH-C. From Fig 7 we can conclude that the position of base station plays a crucial role for the stability and energy consumption of nodes. If the base station is misplaced the quality and energy consumption become more defective. Besides among the two approaches with density of 100 and 300 fig.5 and fig.6, this latter just has a little longer network lifetime than the network with only 100 nodes. This is because more nodes deployed can be regarded as increasing the total energy of the network.

4. Conclusion

The past few years have attracted a lot of attention on clustering method for wireless sensor networks and introduced unique challenges compared to traditional method in wired networks. In this paper, the energy efficient clustering algorithm for wireless sensors network has been introduced. Detailed simulations of wireless sensors network environment demonstrate that our approach is a good candidate to increase the period of stability of network, and has the ability of extending the life span of the whole network. From our point of view O-LEACH will work in dynamic networks as well as in static networks. In this paper we evaluated O-LEACH only on static networks. This protocol should be tested on dynamic networks as well.

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