Review of LEACH based Energy Efficient Protocols in Wireless Sensor Network

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***Abstract*—The application of wireless sensor network (WSN) is rapidly growing to become highly interested research area in all around the time in this era of trending Internet of things (IoT) technology. The energy-constrained WSNs are deployed in large-scale area and multi-hop data aggregation and transmission are required for energy efficiency. Clustering in one of the effective technique for organizing a network into connected hierarchy. In this review, we study and analyze the effectiveness of (LEACH) low-energy adaptive clustering hierarchy protocol and other LEACH-based protocols for enhancing the lifetime for energy-constrained WSNs.**

***Keywords*— WSN, Clustering, Energy Efficiency, Network Lifetime, LEACH.**

I. Introduction

Wireless Sensor Networks (WSNs) have been widely considered to be one of the most important technologies of the twenty-first century [1]. It has a wide range of ever-increasing important applications. The sensor nodes are tiny and cheap; they are battery-powered devices that are deployed in a physical area to collect useful information and transmit it through wireless links to sink nodes. These sensors can communicate either among each other or directly to the sink. However, nodes have limited energy resources that represent the biggest challenge for WSNs. The energy efficiency, robust self-organization, clustering, and routing protocols are very important aspects of conserving energy and prolonging network lifetime, while ensuring proper operations of the network. Moreover, WSNs present some weaknesses because of their limited buffering features and computational resources.

The main problem in WSNs is controlling energy consumption across the whole network. The limitation of energy resources is a major issue in every wireless device. This issue is particularly amplified in WSNs for the following reasons [2, 3].

- A WSN comprises many nodes. Therefore, recharging or replacing batteries is almost impossible.
- WSNs may be deployed to inaccessible places.
- The size of nodes is very small.
- Nodes are responsible for complex tasks such as sensing, processing, self-organizing, and communication.
- The failure of a few nodes leads to the manifestation of independent clusters.

For these reasons, network lifetime constitutes a crucial factor in WSNs, requiring more investigation before improvement. A new coherent clustering algorithm should fairly distribute energy consumption in the entire network by the following means.

- Develop a new clustering algorithm that dynamically distributes the operating tasks among sensor nodes (e.g., cluster head (CH), relay, regular). These nodes periodically change their operating modes to ensure equitable energy consumption and to improve the network lifetime.
- Regarding the low-energy adaptive clustering hierarchy (LEACH)-based clustering algorithm, a new multi-hop-based process between CHs can conserve their residual energies. A leveling phase should first be introduced to attribute different levels for all sensor nodes according to their distances from the sink node.
- The amounts of residual energies should be used to make the decision on how to control the energy distribution for the entire network. Thus, calculating the round time, based on energy consumption in the network, leads to fair energy distribution among all nodes, because CHs change in each round.

The main objective of this paper is present methodological review to improve the lifetime and reliability of the WSN. The rest of the paper is organized as follows. Section 2 presents multi-hop technique of wireless sensor network for energy efficiency, Section 3 presents several related works as enhanced and LEACH-based clustering protocols. Section 3 describes the technical processes of the proposed approach on LEACH-based algorithm for more energy efficiency. Section 4 concludes the achieved work.

II. Multi-hop Technique in WSN

In traditional LEACH protocol, data is transmitted from each cluster head to the base station and the transmission hopping technique is used to reduce energy consumption [4, 5]. In place of direct data transmission form each cluster head to base station, the nearest cluster head to the base station is selected and all the other cluster head will transmit their data to its cluster head and ultimately it transmits all data to the base station. The concept of multi-hop data flow technique in WSN in represented in Figure 1.

III. Literature Review

The LEACH [6] protocol is considered the first clustering-based routing protocol to achieve scalable solutions and extend network lifetime [6]. LEACH allows minimization of global energy usage by continuously distributing the network load

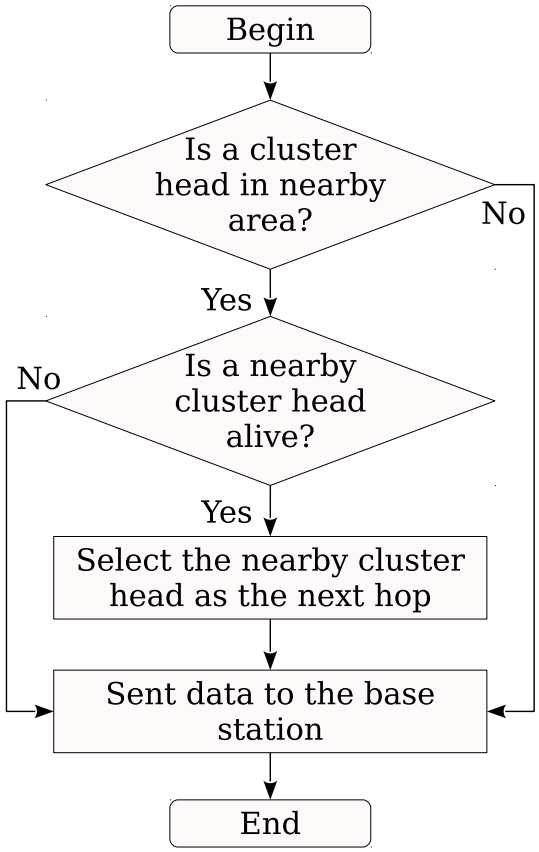

Fig. 1. Multi-hop Data Flow Technique in WSN

to all nodes at different points. Typically, sensor nodes are organized hierarchically in clusters, including a CH for each. The CH is responsible for gathering data from nodes of its group, aggregating data reports, and routing them to the sink node. Using LEACH, a node is elected to CH when its probability, defined by a random number chosen between 0 and 1, is less than a specific threshold, T(n) (Equation 1). The rest of the nodes join a certain cluster by choosing the CH that can be reached with the least communication energy. The role of CH rotates all the sensors to prevent draining the battery of a single sensor.

In [7], Loscri et al. proposed the two-level LEACH (TL-LEACH) algorithm as an extended version of LEACH, utilizing two levels of CHs (i.e., primary and secondary). The primary CH in each cluster communicates with the secondaries, and corresponding secondaries communicate with the nodes in their sub-clusters. The two-level structure of TL-LEACH reduces the number of nodes that need to transmit to the sink. Thus, it effectively reduces the total energy usage. If using TL-LEACH, the number of rounds consumed when the first node dies (FND) is about 200 more than when using LEACH. The number consumed is near 500 rounds more when the last node dies (LND).

Multi-hop routing with LEACH (MR-LEACH) was proposed by Farooq *et al.* [8, 9] to partition the network into different cluster layers. The CHs in each layer collaborate with the adjacent layers to transmit data to the sink. Other nodes join CHs, based on the RSS indicator (RSSI). The sink selects the upper layer CHs to act as super CHs for the lower layer CHs. The sink is also responsible of defining the TDMA schedule for each cluster-head to transmit data. Thus, MR-LEACH uses multi-hop routing starting from cluster-heads to the sink to save energy and increase network life.

Cell-LEACH, proposed by Yektaparast *et al.* [10], is an improvement to the LEACH protocol, where every cluster is divided into seven subsections called cells. Additionally, every cell has a cell-head that communicates directly with cluster-heads. They aggregate their cell information and prevent sensors from communicating.

Wang *et al.* [11] proposed a hybrid cluster-head selection LEACH (LEACH-H) as an improved version of the LEACH protocol. In the first round of LEACH-H, the sink deploys a simulated annealing algorithm to select the CH set. In the next rounds, each CH selects a new CH for its own cluster. Using this approach, the authors attempted to maintain the characteristics of cluster-head distribution, which caused the CHs to be evenly distributed in the network. This saved energy consumption and extended the network lifetime.

Guo *et al.* [12], proposed an adaptive CH election and two-hop LEACH (ACHTH-LEACH) protocol to increase the network lifetime. ACHTH-LEACH is an extended LEACH protocol, using an adaptive algorithm of CH election and multi-hop communication among CHs. Each node in the network is tagged as a “near” or “far” node, based on its distance from the sink. All near nodes are included in one cluster, whereas far nodes are divided into different clusters using the greedy K-means algorithm. Each round, the CH-shifting process elects the node with the maximal residual energy in each cluster. During the data transmission phase, the far CHs may select the CH in the near area as the next hop, or they may communicate directly to the sink. ACHTH-LEACH effectively prolongs the life span of the network more than two-times over LEACH and build a more stable routing environment.

LEACH-balanced (LEACH-B) is another improved LEACH protocol. At each LEACH-B round, the first CH is selected using the same LEACH concept. Afterwards, a second selection is introduced to modify the number of CHs, considering the node’s residual energy [13]. Thus, the number of CHs is constant and nearly optimal every round.

IV. Proposed Approach

Due to battery power limitations, researchers are now working on the structures and methods of energy aware protocols for wireless sensor network. Because, generally, the battery of sensor node in WSNs are equipped as one time limited power source. There are some limitations in each specific routing protocol, and they use their own strategies for efficient routing to overcome limitations.

For improvement and enhancement of the network lifetime, clustering provides an efficient and effective way [14]. The

clustering protocols discussed as path, network, operation and next-hop selection based protocols usually apply two techniques, selection of cluster heads with more residual energy and rotation of cluster heads (CHs). These works on the probability basis periodically, for fairly even distribution of energy consumption among sensor nodes in each cluster and enhance the network lifetime. When cluster heads cooperate with other cluster heads for forwarding their data packets to the base station, then the cluster heads nearer to the base station are loaded with high data packet transmission traffic and it tend to die early, leaving areas of the network uncovered and produce network partition.

For solving limitations, soft computing techniques and unequal clustering mechanism can be proposed for periodical gathering of data packets in wireless sensor networks. It groups the sensor nodes into the clusters of unequal size, and clusters closer to the base station (sink) have smaller in size than those farther away from the base station. Thus cluster heads nearer to the base station can preserve some energy for the inter-cluster data packet forwarding. Soft computing techniques are helpful for efficient cluster head selection and routing.

V. Conclusion

This survey presents categories as path, network, operation and next-hop selection based routing protocols in wireless sensor network. The general and comprehensive analysis of these energy efficient methods in WSN have been presented, by which network lifetime can be enhanced. Researchers mainly focused on hierarchical routing protocols which provide energy efficiency and enhanced the network lifetime. The soft computing techniques and unequal clustering mechanism is presented as an improvement over existing hierarchical routing protocols. Hierarchical routing protocols are effective, but still major future challenging issues are needed to be developed in the sensor networks.

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