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ABSTRACT

Wireless Sensor Networks (WSNs) has emerged as a powerful technology, which has multiple applications such as health, military surveillance, home applications, and many more. WSN consists of multiple numbers of nodes deployed randomly in a remote environment. Each node has a sensing device to capture data from the environment. Processing units are attached to the sensing devices to operate on the collected data. Each node performs three activities: sensing, processing, and communication, most of the energy is spent on communication purposes. The design of the sensor network is affected by many factors such as scalability, energy consumption, environment, etc. Due to battery charging or replacement is not considered practical. Energy conservation is thus a dominant factor in WSNs. This research focuses on the energy consumption problem in WSN. The Clustering techniques have been proven as one of the most effective for reducing energy consumption. Also, routing strategy selection is very important for the proper delivery of packets. This paper provides a comparative study between MODLEACH and MIEEPB routing protocols in WSN.

KEYWORDS

Routing Protocols, Energy Efficiency, Wireless Sensor Networks, Cluster-based Routing, MODLEACH, MIEEPB

1. INTRODUCTION

Wireless sensor network consisting of sensor nodes to form a network. Environmental conditions, such as sounds, temperature, and pressure, are measured by wireless sensor networks [1]. These sensor nodes capture the data from the environment and communicate with each other or an external base station. The size and weight of these sensor nodes are small and light. The progression of WSN [1, 2] initially motivated by military applications. Today, WSNs are also used in civilian applications. Figure 1 shows the main components of a sensor node. They include a processing unit, sensing unit, a battery, transceiver, and microprocessor to communicate with the network.

The sensing unit is further divided into two subunits, i.e., sensors and Analog to Digital Converter (ADC). Sensors capture the data from the surrounding environment while the ADC converts the collected analog data to a digital output and passes it to the processing unit. The processing unit has storage, which is used for storing data temporarily and then passes the data to other nodes to perform sensing tasks. Then, the transceiver passes data to the other nodes present in the network from the current node. The power unit consists of energy sources, such as batteries or solar cells [4]. To make nodes mobile; a mobilize device is used to make the node suitable for the environment.

Due to the random distribution of sensor nodes in a remote environment, limited battery power, and the remote possibility of battery replacement, the energy efficiency of a routing protocol for WSN is considered the most crucial for the lifetime of a sensor network. Clustering is the main technique used in WSNs to save energy. In clustering, the entire network is partitioned into several clusters. Each cluster contains multiple nodes; however, one node out of them converts as a cluster head (CH). The cluster head is responsible for the communication with the nodes outside the cluster. The most outstanding method to partition the nodes of a WSN into clusters is LEACH (Low Energy Adaptive Clustering Hierarchy) [1]. Many variations of LEACH protocol were proposed such as LEACH-B [28], LEACH-C [29, 30], LEACH-P [31] LEACH-M [32], LEACH-V [33], MODLEACH [13], and PEGASIS [24].

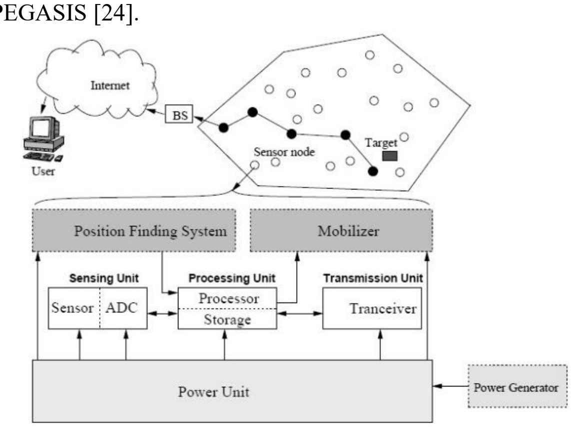

Figure 1. Sensor node components [3].

The network layer deals with routing issues in sensor networks. Since radio transmission and reception consumes a large amount of energy, power is an important factor to be investigated on. Energy conservation is thus a key issue in wireless sensor networks. Ongoing research involves designing routing protocols that require less energy during communication, thereby extending the network's lifetime. For most of the applications, a replacement of energy is too expensive. An energy harvesting wireless sensor networks make use of nodes that can harvest energy from the environment. This paper provides a survey of energy-efficient routing. This paper provides an overview of WSNs and is organized as follows: Section 2 explains some energy-efficient hierarchical based routing LEACH, PEGASIS, and its variants. Section 3 shows the simulation results of two routing protocols MODLEACH and MIEEPB. Finally, Section 4 concludes which one is best for saving the energy based on the experimental results.

2. HIERARCHICAL ROUTING PROTOCOL

Routing protocols are responsible for communication between routers. Each router has prior knowledge of only directly attached networks. A routing protocol shares this information among the immediate neighbors at first and later throughout the network. In this way, routers gain knowledge regarding network topology.

In WSN, the network layer aims to maximize the lifetime by finding ways for energy-efficient route setup and reliable relaying of data from sensor nodes to sink. Many routing protocols have been proposed to solve the routing problem in WSNs [25,26,27].

The designs of routing protocols are also affected by various factors such as deployment, energy consumption, security, etc. Researchers thus focus more on designing energy-efficient nodes and protocols that could support various operations.

The routing protocols based on network structure are classified into three types: Location-based routing, hierarchical based routing, and Flat based routing.

In ***Flat based,*** each node has its functionality or role. Sink sends queries to some regions and then waits for data from the sensors located in the selected regions to facilitate data-centric characteristics.

In ***Hierarchical based,*** each node plays a different role in the network. Hierarchical routing generally works in two layers. In the first layer, cluster-head is chosen, and in the second layer, routing is done. These clusters perform data aggregation and fusion tasks to make WSNs more scalable and energy-efficient.

In ***location-based,*** the tracking of node location is performed by the sensor node. Two techniques are used to calculate the nearest neighboring node distance. i.e., finding the coordinate of the neighboring node, and the other is to use GPS (Global Positioning System). Figure 2. shows the types of energy-efficient routing protocol [5].

In this paper, we focus on only the hierarchical based routing protocols. Many hierarchical protocols are proposed, such as LEACH, PEGASIS, MODLEACH, MIEEPB. [6,7,8,9]. In this study, we compare the variants of LEACH and PEGASIS protocols.

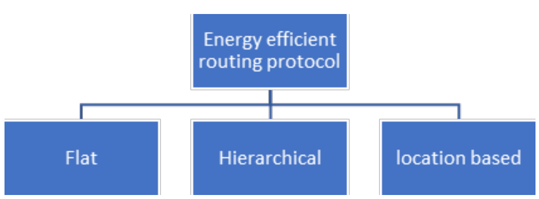

Figure 2. Routing protocol types.

2.1 Low Energy Adaptive Clustering Hierarchy (LEACH)

LEACH is the first network protocol that uses hierarchical routing for wireless sensor networks to increase the lifetime of the network. All the nodes in a network divide themselves into several local clusters, with one node acting as the cluster-heads. Figure 3 shows the architecture of the cluster head and cluster nodes.

All nodes that non-cluster-head transmit their data to the cluster-head, while the cluster-head node receives data from all the cluster nodes. The cluster-head node performs signal processing functions on the data such as data aggregation and data transmission to the remote base station. Therefore, being a cluster-head node is much more energy-consumer than being a non-cluster-head node. Thus, when a cluster-head node dies, all the nodes that belong to the cluster lose communication ability [20, 21].

LEACH rotates the cluster-head position among the sensors to avoid draining the battery of anyone sensor in the network [22]. In this way, the energy load associated with being a cluster-head is evenly distributed among the nodes. When the cluster-head node knows all the cluster members, it creates a Time Division Multiple Access (TDMA) schedule that tells each node exactly when to transmit its data. Also, using a TDMA schedule for data transfer prevents intra-cluster collisions. The operation of LEACH is divided into rounds. Each round begins with a set-up phase when the clusters are organized, followed by a steady-state phase where several frames of data are transferred from the nodes to the cluster-head that aggregates the data and sends it to the base station [23].

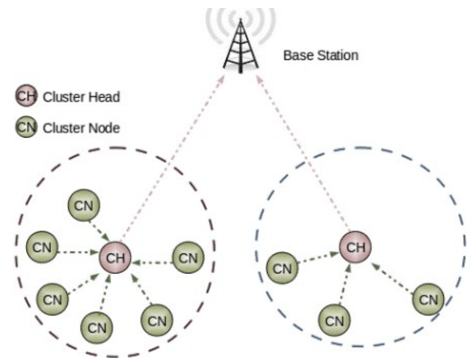

Figure 3. The architecture of cluster head and cluster nodes.

2.2 Modified LEACH (MODLEACH)

In LEACH, new cluster-heads nodes CHs are elected in every round resulting in unnecessary routing overheads. An efficient cluster head replacement algorithm is required to reduce this excessive use of limited energy resources. MODLEACH incorporates such a mechanism along with a dual transmission power level mechanism. The latter allows the farthest and nearest nodes from BS to transmit their data with different power levels providing a balance of energy in the network [13].

2.3 Power Efficient Gathering in Sensor Information Systems (PEGASIS)

Power Efficient Gathering in Sensor Information Systems (PEGASIS) is an improvement of the LEACH protocol [24]. PEGASIS is a chain-based protocol where each node communicates only with its immediate neighbors, which requires information of chain, which is achieved in two steps: 1) Chain construction and 2) Gathering data.

Chain Construction: PEGASIS forms chains of sensor nodes, which transmit and receive data from its neighbor and by randomly selecting one node among them to transmit data to the base station (sink). Constructing of the chain is performed in a greedy method, by taking the farthest node from the sink. The nearest node to this node is selected as the next node in the chain of nodes. Until all the nodes are included in the chain. The node can be placed in the chain only at a single position and selected randomly to be the leader of the chain at every round.

Gathering Data: Send data to the next node after collecting it, this gathered data which is in the aggregated form sent to the Base Station (BS). Unlike the LEACH, PEGASIS avoids cluster formation and selects only one node from the chain to transmit network information to the BS (or sink). The method of data transmission and reception using PEGASIS protocol is shown in Figure 4. If node C2 is the leader, it passes the token along the chain to node C0 at the left side. Then, node C0 will pass its data toward its right to node C2 through C1. After node C2 receives data from node C1, it will pass the token to node C4; next, it will pass its data towards node C2 through node C3. The data fusion takes place in this process.

Token passing is adopted to start data transmission, and data fusion is performed at each node except at end nodes. The average energy spent by each node per round is reduced and improves network lifetime up to 300% as compared to LEACH [15].

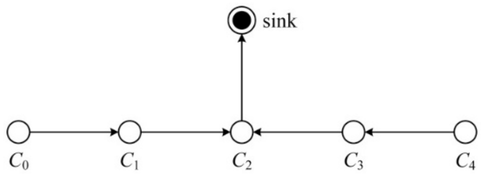

Figure 4. Data transmitting Scheme in PEGASIS.

2.4 Mobile Sink Improved Energy-Efficient PEGASIS-based Routing Protocol (MIEEPB)

MIEEPB is a multi-chain model incorporating sink mobility thereby achieving smaller chains and reduced loads on leader nodes. A mobile sink minimizes the energy usage of sensor nodes and helps in reducing data delivery delay for all the nodes. The multi-chain concept reduces the distance between connected nodes. It decreases network overhead since there are only fewer nodes in the chains [18].

3. SIMULATION AND RESULTS

3.1 Simulation

The performance of MODLEACH and MIEEPB routing protocols was simulated using MATLABR2016b by considering the following parameters: number of nodes alive per rounds (network lifetime), number of dead nodes per rounds, and residual energy. The simulation parameters are given in Table 1.

Table 1. Network parameters

Network parameters	Value
Network Size	100 x 100 m^2
The initial energy of nodes	0.5 J
Packet Size	3000 bits
Number of nodes considered for simulation	100 nodes
Number of rounds taken for simulation	2500 rounds

3.2 Results

The results obtained from the simulation are depicted in Figures 5, 6, 7, and 8. The comparison showed that MIEEPB performs better than MODLEACH.

Figure 5 shows the network's lifetime. X-axes represent the number of rounds, while Y-axes represents number of live nodes. For the MODLEACH the range is between 10 and 100 nodes and died at round 1711 while MIEEPB begins to die at round 1560.

Figure 6 shows a comparison of the number of dead nodes over rounds. In the MODLEACH, all nodes died at round 1711 while in the MIEEPB only 84 nodes died at round 2500.

Figure 7 and Figure 8 show the residual energy of networks over rounds. At round 1500, the residual energy of the MODLEACH reduced to 0J while the residual energy of MIEEPB reduced to 1.62 J at round 2500.

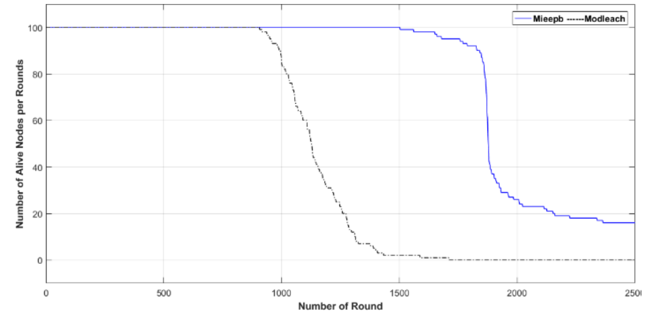

Figure 5. Comparison of network lifetime.

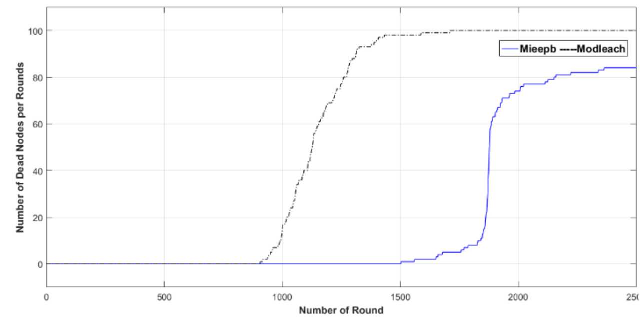

Figure 6. Comparison of number of dead nodes.

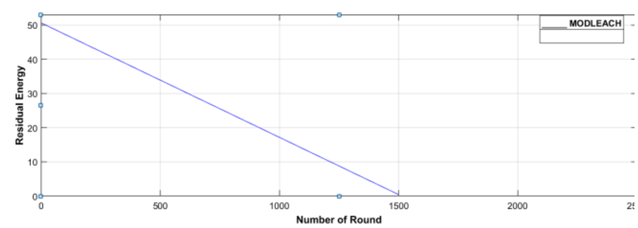

Figure 7. Residual energy in MODLEACH.

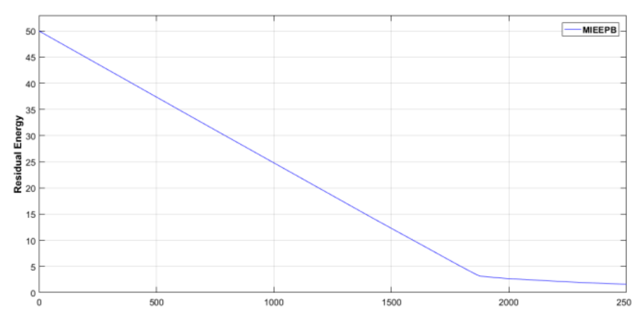

Figure 8. Residual energy in MIEEPB.

4. CONCLUSION

One of the major challenges in the design of routing protocols for WSNs is how to reduce energy consumption efficiently because energy resources are very limited. The main objective behind the routing protocol design is to keep the sensors in operation as long as possible, subsequently extending the lifetime of WSN. The energy consumption of the sensors is governed by data transmission and reception. Therefore, Designing routing protocols for WSNs should be as energy-efficient as possible to extend the lifetime of individual sensors, and hence the network's lifetime. This paper surveyed about wireless sensor networks, routing techniques, the hierarchical architecture sensor networks. Protocols designed should aim in keeping sensors alive for a long period to fulfill the application requirements and should meet the scalability issues. The hierarchical architecture approach is the best to provide scalability along with extended network lifetime. Simulated two protocols MODLEACH and MIEEPB, using MATLAB and on comparison showed that MIEEPB performs better than MODLEACH. Energy is the greatest problem faced by WSNs. Sensors depleted of energy can no longer fulfill its role unless source of energy is replenished. Wireless sensors that are powered by ambient energy are a promising technology for many wireless sensor applications. However, more work is still required to be done to find more efficient, scalable and robust clustering scheme to enhance energy consumption and prolonging network lifetime in small and large WSNs.

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