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Comparative Study of LEACH Protocol in Wireless Sensor Network

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Abstract-The latest innovations in the wireless sensor network (WSN) have resulted in many new protocols for sensor networks, which have considerable energy consciousness. At the same time, most of the attention is given to the routing protocols, since it may differ from software and network architecture differences. AnEnergy Efficient Routing Protocol is one of the key concerns of WSN. In this paper, we present a review on energy-efficient hierarchical routing protocols known as Low-energy adaptive clustering hierarchy (LEACH) routing protocols. The main focus of our study is to study the results obtained when LEACH is used with artificial intelligence technique.A comparative analysis of existing work is also been provided to show the effectiveness of LEACH in terms of energy consumption. It has been examined that LEACH with Artificial Neural Network (ANN) perform well with an energy consumption of upto 0.3 J.

Keywords-WSN, routing, LEACH, ANN, Fuzzy

1. Introduction

A WSN is a network of heterogeneous nodes called sensor nodes that are spatially distributed throughout the location and that are used to monitor physical or environmental conditions at these locations, such as temperature, pressure, sound, vibration [1].

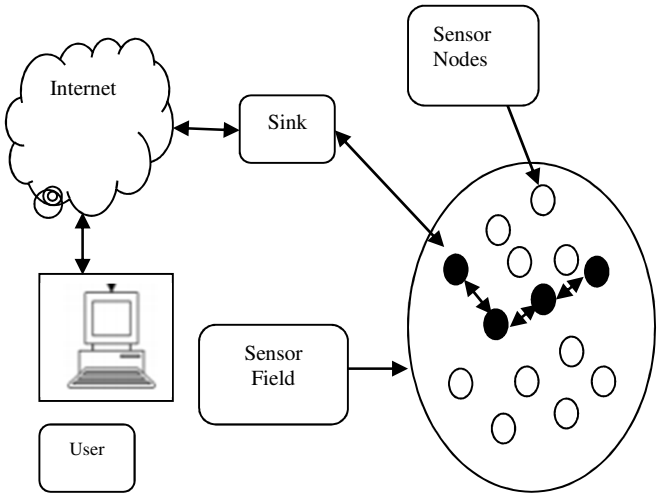

Fig. 1 WSN architecture

Wireless communication enables node collaboration to accomplish larger tasks that a single node cannot accomplish. Nodes in WSNs are densely deployed and more numerous than mobile ad hoc networks [2]. These nodes communicate with each other and pass data from each other so that data can be transmitted from the source to the receiver [3]. Traditional nodes basically bridge the gap between the physical world and the virtual world. Each node consists of processing power and can contain many processing units, such as multiple types of memory, with RF transceivers, power supplies such as batteries, and adapt to various sensors and actuators [4].

A sensor network is usually composed of several tiny sensor nodes and several powerful control nodes, named as base stations or receivers. Sensor nodes are typically densely placed over a wide range and communicate with each other over short distances by wireless communication [5]. Although specific sensor nodes have a limited amount of resources, they can perform a large number of valuable tasks when they work in a group[6]. The information collected and transmitted on the sensor network of the WSNillustrates the conditions under which the physical environment of the region of the sensor network is established [7].

Table 1: Issue in WSN

Issues	***Description***
Range & Connection	Sensor nodes used smaller bandwidth with less low power
Location & synchronization	The position of sensor nodes is very important as the user can know about the state of nodes such as

	active or sleep node
Power Management	It is very necessary as it decides the lifetime of the network
Low latency	As the network has to deal with the event occurred in the network urgently, therefore the network must have a process that event with less delay

2. Routing in WSN

Routing is the process to search route between the source and the destination node. Routing also helps for the transmission of data from one node to another node [8]. In WSN, routing is mainly categorized into three types as shown in the fig.2.

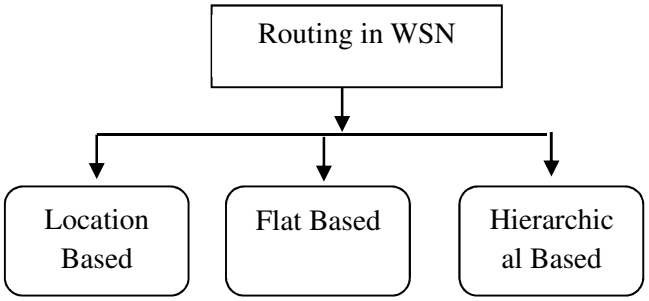

Fig. 2 Types of Routing

2.1Location Based

In location-based routing protocol, it is assumed that all nodes know along with source node knows its location as well as the neighbors' location. In this scheme, the data is forwarded as per the greedy forwarding approach. In this approach, the node forwards data all the time to the node whose Euclidean distance is smaller [9]. An example of location-based routing is shown in fig. 3.

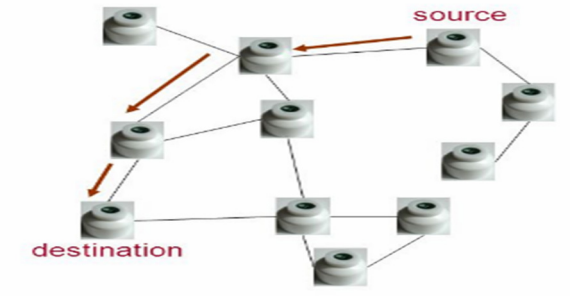

Fig. 3 Location-based routing

2.2 Flat Routing

It is a network communication protocol which is implemented by a router, in which all routers are interconnected to each other. Also, the information is provided by these routers without following any organization structure [10].

2.3 Hierarchical Routing protocol

Hierarchal routing protocol effectively utilizes data aggregation to reduce the amount of network data streams. With hierarchical multi-hop routing algorithms, the sensor node accepts different roles that can be changed over time. It is also known as cluster-based routing that can be utilized to reduce the energy consumed by sensor nodes. During this process, the nodes having higher energy are used for the data transmission whereas the nodes with low energy are used to sense the data only. The LEACH is the example of Hierarchical routing algorithm [11].

2.3.1 LEACH

It is the first energy efficient protocol that is used to create a route on the basis of energy consumed by the node.

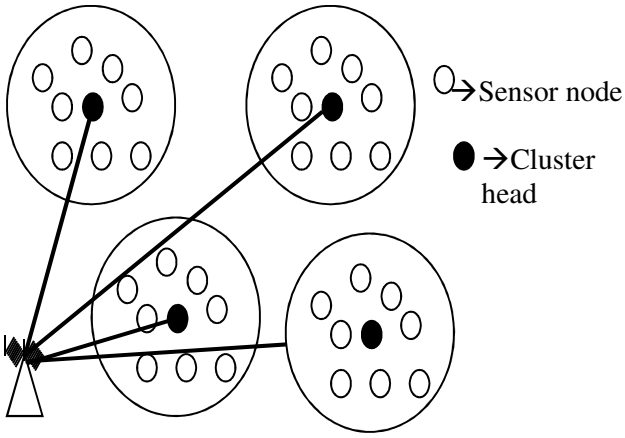

Fig. 4 LEACH architecture

In LEACH, the network is divided into clusters as shown in fig. 4. The entire network comprises of four different clusters each includes sensor nodes with cluster head (CH). CH is the heart of the route formation, through which the data transmission is possible, the remaining nodes are known as cluster members. The route is formed through two phases: Set up phase and Steady-state phase [12].

i. Setup phase

In this phase, the selection of CH is performed. Initially, the entire network nodes choose a number between 0 &

1. The selected number is then compared with the formula written below.

$$T(m) = \frac{Prob}{1 - prob(qmodprob^{-1})} \forall m \epsilon Grp$$

$$T(m) = 0 \forall m \not\in Grp$$

Here, m is a random number lies between 0 and 1

Prob- is the probability of cluster head

Grp is the group of nodes that were not clustered heads in the previous rounds

$T(m) -$ is the threshold value

The node whose value is less than the threshold number is defined as CH for that particular round.

ii. Steady State Phase

In this phase, the data is transmitted to the base station with the minimization of overlead. Also, the time required in the set-up phase is more than the time required in the steady state phase [13].

3. Related work

This section describes the work performed by various authors to save energy in WSN.

Table 2: Comparison analysis of existing techniques in WSN

References	***Proposed work***	***Technique used***	***Findings***
Xu et al. (14, 2012)	The remaining power of the sensor nodes has been utilized for the network load balancing.	E-LEACH	The network lifetime upto 40 % has been increased.
Manjeshwar, A., & Agrawal, D. P. (15, 2001)	The network has been divided as per the nodes' functioning such as active and passive. The performance of TEEN algorithm has been measured in the re-active network.	Threshold sensitive Energy Efficient sensor Network protocol (TEEN)	The outcome in terms of energy dissipation, a number of the alive nodes, number of dead nodes with respect to time has been measured. From the experiment, it has been analyzed that the TEEN protocol performs well in terms of response time as well as energy consumption.
Wang et al. (16, 2018)	The main aim of this paper is to divide the entire network into a number of the grid. The coverage area of each grid is decided as per the energy consumed by each grid.	Particle Swarm Optimization (PSO)	The average energy consumed by the nodes of about 1 J has been achieved
Sarkar, A., & Murugan, T. S. (17, 2019)	In this paper, the CH selection approach is used, which helps in the reduction of energy utilization.	CH selection with Firefly algorithm	Using the firefly algorithm the distance among the nodes becomes small and hence the possibility of the number of alive nodes has increased.
Karaboga, D., Okdem, S., & Ozturk, C. (18, 2012)	In this research, the information is collected from the network in a particular time slot.	LEACH with ABC	The energy with ABC and LEACH upto 0.6 J has been normalized.
Kovendan et al. (19, 2018)	ANN is used to select the route which consumes minimum energy	LEACH with ANN	The performance in terms of throughput, energy and Packet delivery ratio has been determined. The Average of energy, throughput and PDR are about 300mJ, 50 and 0.55 has been achieved.
Arjunan, S., & Sujatha, P. (20, 2018)	In this research, Fuzzy logic has been used to divide the network as per the residual energy. For efficient routing, ACO technique has been used.	Fuzzy with ACO	The average energy upto 500 pJ has been achieved.

4. Comparison Of Existing Techniques

The energy consumption measured by different researchers in WSN is shown in table 3.

Table 3: Comparison of energy consumption in WSN

References	***Technique used***	***Energy consumed***
[16]	PSO	1J
[18]	LEACH with ABC	0.6J
[19]	Leach with ANN	0.3J
[20]	Fuzzy with ACO	0.5 J

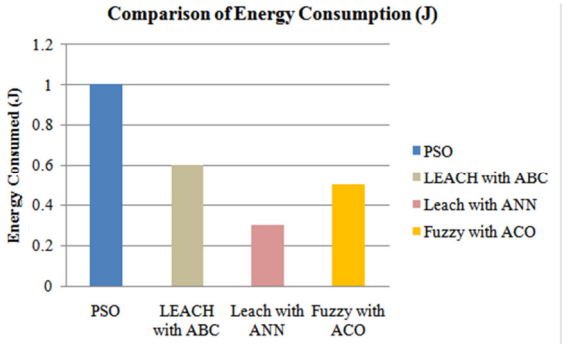

Fig. 5 Comparison of energy consumption in WSN

Fig. 5 represents the energy consumed by sensor nodes in the WSN field by utilizing various algorithms. From the figure, it is clear that when ANN is used with LEACH as an energy efficient routing protocol the energy consumed by nodes is small compared to other techniques.

5. Conclusion

In this paper, the survey from 2001 to 2019 in the field of WSN with the utilization of LEACH protocol has been conducted. LEACH has attracted the attention of the research community in the field of WSN. This in itself illustrates the importance of this agreement. Researchers have made various modifications to the LEACH protocol. The successor to the LEACH protocol is now available from single-hop to multi-hop scenarios. A wide range of work related to LEACH has been completed, and for many years new research on the WSN field has been a good idea through LEACH and its variants. This paper investigates the variants of the LEACH routing protocol proposed so far and discusses their enhancements and work. From the existing work, it has been examined that LEACH with ANN performs well with reduced energy consumption upto 0.3 J.

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