Energy Efficiency Improvement in LEACH Protocol for Wireless Sensor Network

Safiullah Noori, Nirav Raja

Abstract*: The most important reason for saving energy on wireless sensor networks is communication. Data transmission consumes about 70% of the energy of the sensor node. Effective use of energy on sensor nodes is a good way to increase the lifetime of WSN. In order to extend the life of the network, energy-saving routing protocols must be designed. In this article, I will discuss (LEACH), which is the first and most popular energy-saving hierarchical clustering algorithm for WSN and an improvement to Leach and VLeach that attempts to eliminate the shortcoming of V-LEACH and LEACH protocols, In this method, initially, the "sub-cluster head" and "cluster head" are selected according to the energy and distance parameters. The head of the cluster and the vice president of the cluster make decisions based on the distance and the remaining energy of the sensor nodes. Compared with standard leaching, this algorithm can provide better network life, efficiency and performance.

Keywords: DVLEACH, LEACH, VLEACH

I. INTRODUCTION

The wireless sensor network is combination of small devices called sensor nodes. These small devices are deployed in a geographical area and are used to monitor physical phenomena such as temperature, humidity, and vibration [23]. The sensor node are divided into three parts: a sensing unit for collecting data from the surrounding environment, a computing unit for data processing and storage, and a wireless communication unit for data transmission.

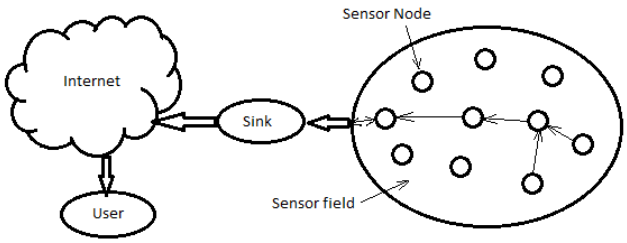

Figure 1: Basic Architecture of WSN

Sensor nodes also need power to complete their tasks. The energy used by the sensor node is a low-energy battery, and because the node can be deployed anywhere and in environments where it is difficult to replace the battery, energy has become the focus of our network.

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Wireless detection technology provides huge opportunities for research and development. .WSN wireless sensor network is one of the most important technologies in the 21st century, it can run in a wide range of environments, so it can be used for different applications. Wireless sensor networks have been powered by military applications, such as surveillance on the battlefield. Today, such networks have been used in many industrial and consumer applications, such as monitoring and control of industrial processes, monitoring of machine status, etc. Wireless sensor technology can also have a huge impact in the industrial and commercial fields, because the technology can monitor data such as pressure, humidity, flow rate, density, temperature, liquid level, viscosity and vibration intensity, which can be collected and transmitted to the sensor node system to Control for monitoring. Sometimes it is due to some reasons, such as the inability to install equipment in certain places, such as: unable to connect to the power or unable to establish a wired connection. Because of these problems, WSN is used. The benefits of using WSN are: no need for difficult wiring, short distance limitations, and high energy efficiency and cost efficiency. By detecting changes in environmental parameters (such as humidity, temperature, etc.), these WSN benefits can be used to monitor weather conditions at weather monitoring stations. As mentioned earlier, wireless sensor networks (WSN) involve multiple sensor nodes. These sensor nodes are distributed in an environment called sensor fields. The basic WSN communication architecture is shown in Figure 1.1. The detection node communicates with the sink through multi-hop. The receiver communicates with users via the Internet or satellite network [18]. The taxonomy of WSN routing protocols has been developed in several different ways. For example, protocols are classified as QoS-based, consistent, multi-path based, query-based, and negotiation-based protocols. WSN mobile ad hoc routing protocol can be divided into topology-based routing and location-based routing, the latter can be divided into active, passive and hybrid. In this document, when considering the network architecture, we divide the routing protocol into data-centric, hierarchical, and location-based routing. All nodes perform the same function in plane routing, and the nodes transmit data to all other nodes. Planar routing is effective on small networks, but it does not work effectively in networks with a large number of nodes On the other hand, in cluster routing protocols or hierarchical routing protocols, nodes are clustered. Usually, each team has a team leader and team members.

Generally, the node with the highest energy acts as a CH and performs the task of data aggregation, and then sends the information to the sink node, while the remaining nodes (that is, those nodes with the lowest energy) perform the detection task from the receiving node. surroundings. In recent years, many cluster routing protocols have been developed for WSN. In this article, we discussed the most outstanding LEACH cluster routing algorithm.

Low Energy Adaptive Cluster Hierarchy (LEACH) is one of the earliest WSN cluster-based protocols. If the LEACH comes from the cluster head used to communicate with the receiver node or base station, direct communication with the receiver node can be avoided, thereby reducing power consumption in the LEACH protocol. LEACH operation is divided into several rounds, similar to the beacon interval concept in the MAC layer, each round has two stages:

$$T(n) = \begin{cases} \dfrac{p}{1-p*(r \bmod \frac{1}{p})} & \text{if } n \in G \\ \text{othrwise} \end{cases}$$

The configuration phase is used to form a group, and during the steady-state phase of data aggregation and data transmission to the sink node. In the configuration phase, the cluster head will be selected before the cluster is formed, and the cluster will be selected according to a threshold between 0 and 1. If this random number is less than this value, the node will become the cluster head of the node. This round. The threshold is defined as:

In the above equation, P is the percentage of the required group head, r is the count of the current round, and G is the set of sensor nodes that were not selected as the group head in the most recent round of 1/P. Define the cluster head, and send the advertisement message to all the remaining sensor nodes with the same transmission power. The remaining sensor nodes decide to join the cluster head according to the maximum signal strength received from this round of announcements.

After completing the setup phase, the stabilization phase will last longer than the setup phase to avoid unnecessary burden on group formation. In the stabilization phase, the sensor node will perform the detection and send the data to the cluster head, which will add the message and send it to the base station. The sensor node radio can be turned off to save power until a predetermined transmission time is reached. Instead, the cluster head must always keep the radio on to receive data. Before sending data to the coordinator, the cluster manager performs the necessary data processing, namely aggregation and compression. Once this phase is completed, WSN will enter the next round of LEACH protocol and repeat the same configuration and steady-state phases described above.

Facts have proved that LEACH can significantly extend the life cycle of WSN. In LEACH routing, data is only propagated from the sensor node to the coordinator through the cluster head. Due to the limited radio power and transmission distance of each sensor node, the 2-hop transmission path limits the WSN deployed on a large area. LEACH assumes that all nodes start with the same energy, and the leader consumes about the same energy in each round as the ungrouped nodes. In fact, this assumption may not be the case. In addition, the dynamic pool technology specified in LEACH periodically changes the topology, which requires a lot of network reorganization and synchronization overhead.

II. RELATED WORK

Rathi and Viswanathan [1] proposed a two-stage grouping method for group head selection to improve the LEACH protocol [1]. This article focuses on a two-stage packet protocol based on self-organizing graph neutral network (SOM) and improved fuzzy probability grouping algorithm (MFPCM), which aims to balance power consumption. The grouping is based on two important conditions, namely the coordinates and energy levels of the sensor nodes. Therefore, this two-stage grouping method can prevent nodes from dying prematurely and allow them to die randomly.

Md Arif Ali and Abha Kiran Rajpoot [3] proposed the Hop PEGASIS method, which is more effective than LEACH and PEGASIS. If there is direct transmission between the CH and the base station, the cluster head far from the base station will use a strong signal when transmitting to the base station, resulting in higher power consumption, so in this protocol, the network life is improved.

Dr. Neeraj Bhargava, Dr. Ritu Bhargava, Shilpi Gupta, K. Kumar Jyotiyana [4] discussed various algorithms to avoid network congestion. This algorithm is usually used to quickly relay data after a collision. Reduce the waiting time of the sender before retransmitting the lost segment. The fast recovery algorithm is an improvement that can achieve high performance in the case of moderate congestion through fast data recovery.

S. Meeting in the sensor information system (PEGASIS).

S. Karthikeyan and S. Jayashrion [9] describe different levels of networks and introduce grouping methods. The proposed system will make the protocol more energy efficient, which is achieved by using the concept of auxiliary group head formation and the first shorter path opening algorithm.

Vikash Kumar Singh, Sujata Ghatak, Lekhika Chettri and Biswaraj Sen [10] describe the binary exponential rollback method, which can tell the operator how long to wait after a collision or packet loss when the bus is busy. The MAC algorithm has also been used to overcome these problems. This is the most widely used algorithm for selecting a random number during network timeout.

Swati Bhagoria and W.U Khan [11] discussed the Sensing Backoff algorithm that has been integrated with the MAC protocol. This algorithm greatly reduces the end-to-end delay and collision rate.

Bhawnesh Kumar and Vinit Kumar Sharma [12] proposed a distance-based clustering hybrid selection algorithm to improve the lifetime of sensor networks. By balancing the power load on all nodes, this protocol achieves good performance in terms of life cycle. This clustering technology helps to extend the life of wireless sensor networks, especially in harsh environments. After a single sensor node is deployed in a given target area, the battery cannot be replaced in a harsh environment. Therefore, the proposed technique of distributing the role of cluster head (CH) between wireless sensor nodes in the same cluster is crucial for extending the life of the network. The algorithm uses distance-based methods to provide cluster head selection. Pool technology can also provide good load balancing and data aggregation within the network.

III. PROPOSED WORK

In LEACH or other cluster-based wireless sensor network routing protocols, when a node is far from the cluster head, it consumes more power to send data to the cluster head, and the cluster head transmits data to the sink based on single-hop transmission Nodes, then, cluster heads farther away consume more energy than nearby cluster heads. This can reduce load balancing in the network. If the cluster heads cooperate with each other and transmit data based on multi-hop transmission, the cluster head closer to the sink node will take a lot of relay traffic and consume energy faster, which will cause network coverage problems, also known as hot spots. In order to avoid the above problems, we proposed DV-LEACH, which can extend the life of the network, increase the number of data packets received by the base station, have higher energy efficiency, and have higher scalability when evaluated with other existing routing protocols.

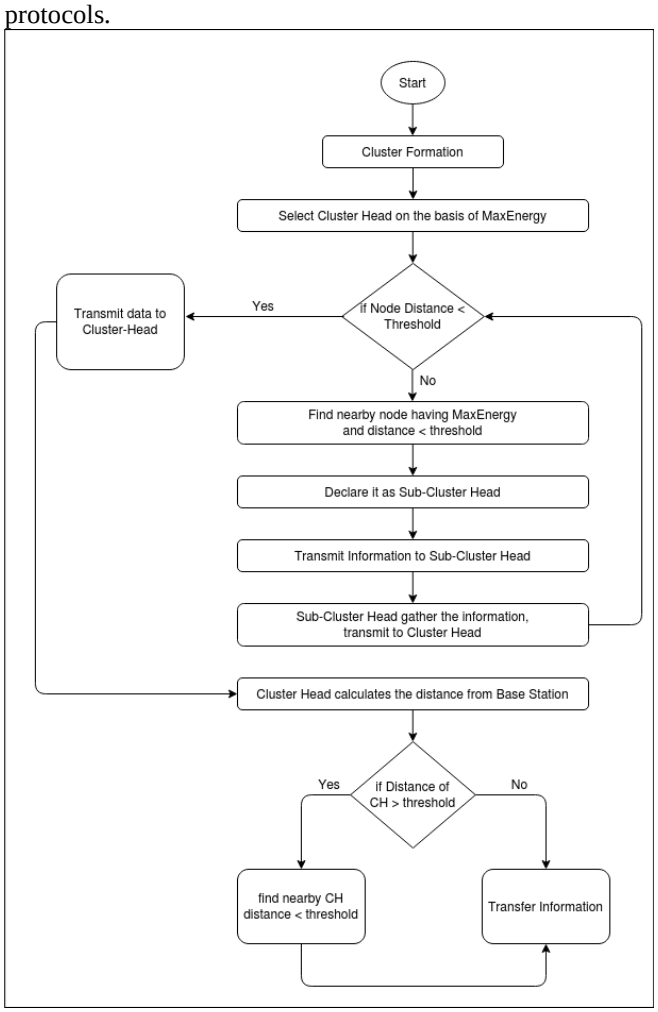

Figure 2: flow chart of DV-LEACH

Proposed model divides the network into clusters and elects the cluster heads on the basis of maximum energy. Path formation module decides the transmission of data from node to node, if the node distance is less than the threshold value. This means that the node is in range of Base Station and can transmit the data directly to it via Cluster Head. Otherwise, it will find the nearby node that has maximum energy and distance less than predefined threshold value. Further, it will send the data to Sub-Cluster Head in a cluster. Sub-Cluster Head has the responsibility to gather the information and transmit it to nearby Cluster-head. After this, it again compares the nodes' distance from threshold. If the distance is less then it will transmit the data, or repeat the process.

In the proposed protocol after formation of clusters and electing of cluster head in setup phase while the information or data sensed by sensor nodes are transmitted to cluster heads (CHS) the sensor node will decide based on distance to the cluster head.

If the distance is > threshold value (d0)
Where d0= sqrt(Efs/Emp)

it will find the nearby node that has maximum energy and distance less than predefined threshold value and select that node as sub cluster head. Further, the node will send the data to Sub-Cluster Head in a cluster. Sub-Cluster Head has the responsibility to gather the information and transmit it to nearby Cluster-head.

If the distance is < threshold value (d0)

The node will transmit the data to the cluster head and again the cluster head will decide based on the distance to the base station, cluster head will calculate the distance from base station ***if the distance is < threshold*** value it will send the data to base station otherwise it will find a nearby cluster head and transmit the data.

IV. SIMULATION AND RESULT

The Figure 3 showing alive nodes versus number of rounds plot for original LEACH, VICE LEACH and DV-LEACH protocol. The FND (First Node Dead) also known as stability period for LEACH protocol is at 390th round means that the network is stable up to 390 rounds in LEACH protocol, the number of round increases in VLEACH and DV-LEACH than LEACH protocol, figure 4 illustrate that in VLEACH the first node dead in 790th round and in DV-LEACH the first node dead in 1079th round, that mean DV-LEACH work three times better than the original LEACH protocol and our network will be stable till 1070th round and all the nodes are alive which shows improvement in LEACH protocol.

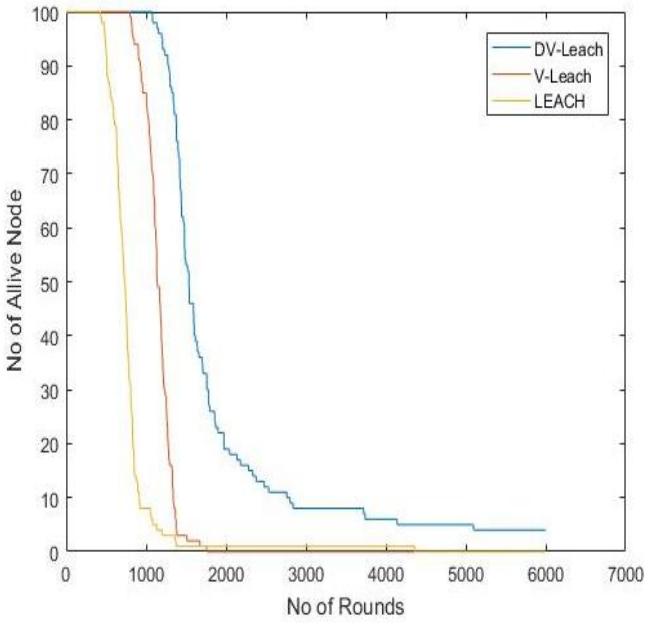

Figure 3: Alive nodes v/s. number of rounds plot

The Figure 4 showing that nodes in V-LEACH and LEACH die earlier than the DV-LEACH, in LEACH and VLEACH almost all the nodes have died before we reach to the last round but in DV-LEACH
we have some nodes that are alive.

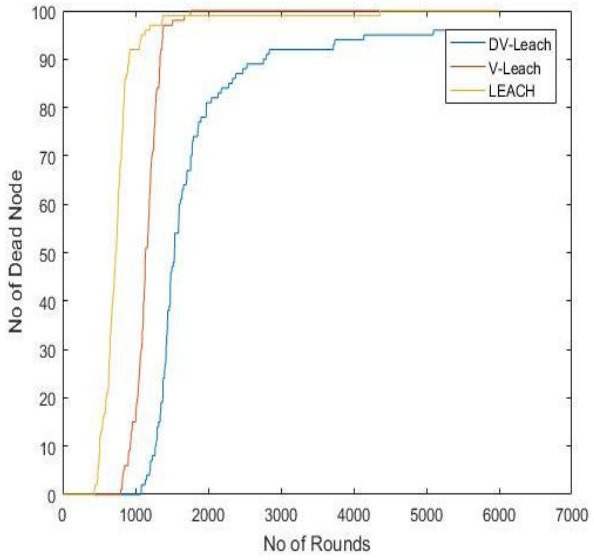

Figure 4: dead nodes v/s. number of rounds plot

V. CONCLUSION

Recently, the use of wireless sensor networks for monitoring environmental information (temperature, sound level, humidity, etc.) in the entire physical space has increased. In sensor networks, sensor nodes are used to collect local data and communicate with other nodes. A wireless sensor network (WSN) is constructed from several nodes (from a few to a few hundred, or even thousands), where each node is connected to one (sometimes several) sensors. The main challenging task in this network is the life cycle. Different types of protocols are used in WSN to extend the life of the network. The Low Energy Adaptive Clustering Layered Protocol (LEACH) protocol is one of the best layered protocols that uses probabilistic models to manage WSN energy consumption. However, LEACH provides an unguaranteed choice of cluster heads, and there is no guarantee that the selection is optimal. The proposed method has better lifetime and better throughput than existing protocols, and it sends more data to the sink node. The main problem in WSN is the energy of the nodes. We cannot directly provide energy to the nodes. Therefore, we must apply energy-efficient routing protocols in the network. Therefore, this protocol consumes less power than the LEACH and VLEACH protocols. Simulate by using MATLAB. Simulation results show that the proposed LEACH (DV-LEACH) protocol has better performance than the existing LEACH and VLEACH protocols.

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