Improvement on LEACH Protocol of Wireless Sensor Network (VLEACH)

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Abstract

This paper presents a new version of LEACH protocol called VLEACH which aims to reduce energy consumption within the wireless network. We evaluate both LEACH and V-LEACH through extensive simulations using OMNET++ simulator which shows that VLEACH performs better than LEACH protocol.

Keywords

Broadcasting, Clustering, LEACH protocol, V-LEACH.

1. Introduction

Wireless sensor network (WSN)[2,3] consists of hundreds and even thousands of small tiny devices called sensor nodes distributed autonomously to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure and motion at different locations. Energy plays an important role in wireless sensor networks because nodes are battery operated. Consequently many protocols have been proposed in order to minimize the energy consumption of these nodes.

Each node in a sensor network is typically equipped with one or more sensors, a radio transceiver or other wireless communications device, a small microcontroller, and an energy source, since in most Wireless sensor network applications the energy source is a battery [6], energy plays an important role in wireless sensor network, and preserving the consumed energy of each node is an important goal that must be considered when developing a routing protocol for wireless sensor networks.

Many routing protocols have been proposed in the literature such as LEACH[4,6],PAMAS[12].

Leach is considered as the most popular routing protocol that use cluster based routing in order to minimize the energy consumption; in this paper we propose an improvement on the Leach Protocol that further enhance the Power consumption, simulation results bring out that our protocol outperforms Leach protocol in term of energy consumption and overall throughput.

In section 2 we discuss the Leach protocol in details, Section 3 presents the related work, in section 4 we introduce our proposed protocol **VLEACH**, in section 5 we evaluate our protocol an present the simulation results, in section 6 we conclude the paper.

Broadcasting

Broadcasting is the process in which a source node sends a message to all other nodes in the network. Figure.1 shows the classifications of broadcasting methods. One of these methods is clustering which is used by LEACH protocol, and in which we are interested in.

2. Cluster-based Routing

The basic objective on any routing protocol is to make the network useful and efficient. A cluster based routing protocol groups sensor nodes where each group of nodes has a CH or a gateway [5,8]. Sensed data is sent to the CH rather than send it to the BS, CH performs some aggregation function on data it receives then send it to the BS where these data is needed.

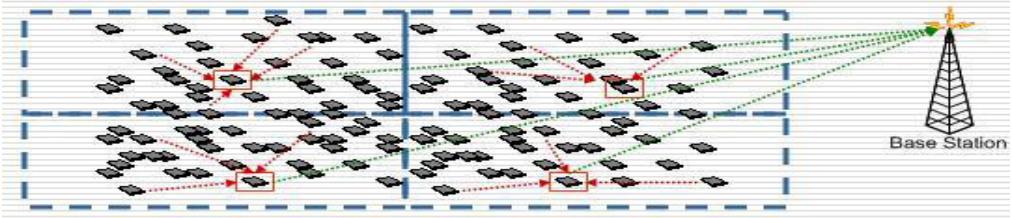

Fig. 1: Clustering

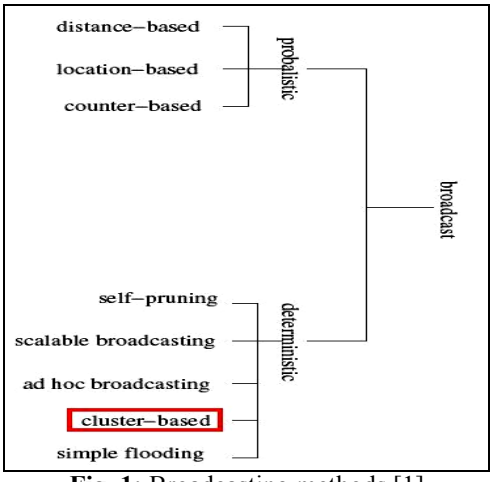

Fig. 1: Broadcasting methods [1]

A number of routing protocols have been proposed for WSN [2,3,4]. However, few of them are cluster based. Two of the most well known hierarchical protocols are LEACH, PAMAS and PEGASIS[]. Both of these show significant reduction in the overall network energy over other non-clustering protocol.

Hierarchical routing protocols designed to reduce energy consumption by localizing communication within the cluster and aggregate data to reduce transmissions to the BS.

3. Leach Protocol

Low Energy Adaptive Clustering Hierarchy (LEACH) is the first hierarchical cluster-based routing protocol for wireless sensor network which partitions the nodes into clusters, in each cluster a dedicated node with extra privileges called Cluster Head (CH) is responsible for creating and manipulating a TDMA (**Time division multiple access**) schedule and sending aggregated data from nodes to the BS where these data is needed using CDMA (**Code division multiple access**). Remaining nodes are cluster members.

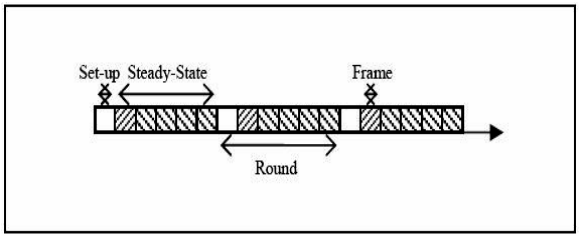

Fig.4: LEACH protocol phases **[4]**

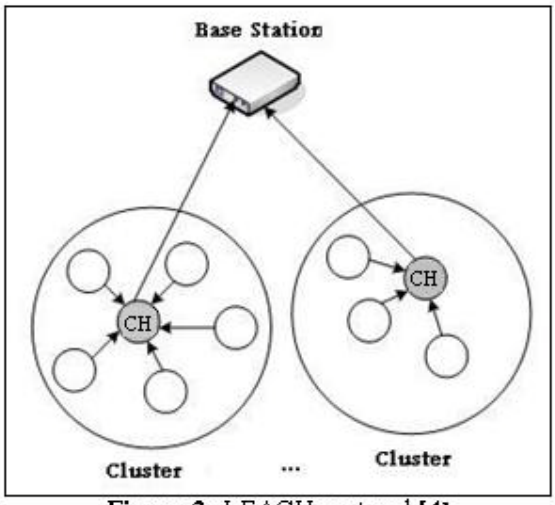

Figure.3: LEACH protocol **[4]**

This protocol is divided into rounds; each round consists of two phases;

Set-up Phase

(1) Advertisement Phase
(2) Cluster Set-up Phase

Steady Phase

(1) Schedule Creation
(2) Data Transmission

3.1 Setup Phase

Each node decides independent of other nodes if it will become a CH or not. This decision takes into account when the node served as a CH for the last time (the node that hasn't been a CH for long time is more likely to elect itself than nodes that have been a CH recently).

In the following advertisement phase, the CHs inform their neighborhood with an advertisement packet that they become CHs. Non-CH nodes pick the advertisement packet with the strongest received signal strength.

In the next cluster setup phase, the member nodes inform the CH that they become a member to that cluster with "join packet" contains their IDs using CSMA. After the cluster-setup sub phase, the CH knows the number of member nodes and their IDs. Based on all messages received within the cluster, the CH creates a TDMA schedule, pick a CSMA code randomly, and broadcast the TDMA table to cluster members. After that steady-state phase begins.

3.2 Steady-state phase:

Data transmission begins; Nodes send their data during their allocated TDMA slot to the CH. This transmission uses a minimal amount of energy (chosen based on the received strength of the CH advertisement). The radio of each non-CH node can be turned off until the nodes allocated TDMA slot, thus minimizing energy dissipation in these nodes.

When all the data has been received, the CH aggregate these data and send it to the BS.

LEACH is able to perform local aggregation of data in each cluster to reduce the amount of data that transmitted to the base station.

Although LEACH protocol acts in a good manner, it suffers from many drawbacks such like;

- CH selection is randomly, that does not take into account energy consumption.
- It can't cover a large area.
- CHs are not uniformly distributed; where CHs can be located at the edges of the cluster.

Since LEACH has many drawbacks, many researches have been done to make this protocol performs better.

4. Related Work

4.1 E-LEACH protocol

Energy-LEACH protocol improves the CH selection procedure. It makes residual energy of node as the main metric which decides whether the nodes turn into CH or not after the first round [9]. Same as LEACH protocol, E-LEACH is divided into rounds, in the first round, every node has the same probability to turn into CH, that mean nodes are randomly selected as CHs, in the next rounds, the residual energy of each node is different after one round communication and taken into account for the selection of the CHs. That mean nodes have more energy will become a CHs rather than nodes with less energy.

4.2 TL-LEACH

In LEACH protocol, the CH collects and aggregates data from sensors in its own cluster and passes the information to the BS directly. CH might be located far away from the BS, so it uses most of its energy for transmitting and because it is always on it will die faster than other nodes.

A new version of LEACH called Two-level Leach was proposed. In this protocol; CH collects data from other cluster members as original LEACH, but rather than transfer data to the BS directly, it uses one of the CHs that lies between the CH and the BS as a relay station [7].

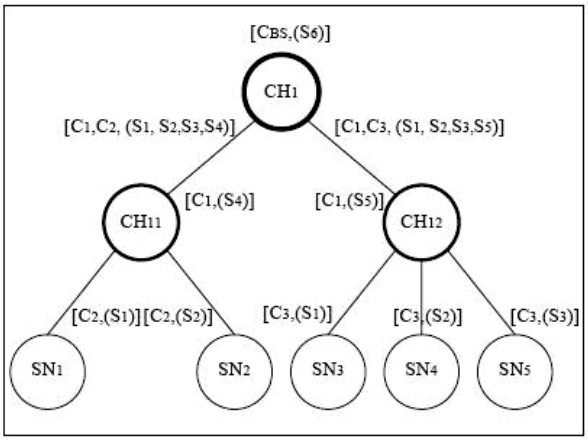

Fig. 5: TL-LEACH **[7]**

4.3 M-LEACH protocol

In LEACH, Each CH directly communicates with BS no matter the distance between CH and BS. It will consume lot of its energy if the distance is far. On the other hand, Multihop-LEACH protocol selects optimal path between the CH and the BS through other CHs and use these CHs as a relay station to transmit data over through them [8].

First, multi-hop communication is adopted among CHs. Then, according to the selected optimal path, these CHs transmit data to the corresponding CH which is nearest to BS. Finally, this CH sends data to BS.

M-LEACH protocol is almost the same as LEACH protocol, only makes communication mode from single hop to multi-hop between CHs and BS.

4.4 LEACH-C protocol

LEACH offers no guarantee about the placement and/or number of cluster heads. In [13], an enhancement over the LEACH protocol was proposed. The protocol, called LEACH-C, uses a centralized clustering algorithm and the same steady-state phase as LEACH. LEACH-C protocol can produce better performance by dispersing the cluster heads throughout the network. During the set-up phase of LEACH-C, each node sends information about its current location (possibly determined using GPS) and

residual energy level to the sink. In addition to determining good clusters, the sink needs to ensure that the energy load is evenly distributed among all the nodes. To do this, sink computes the average node energy, and determines which nodes have energy below this average.

Once the cluster heads and associated clusters are found, the sink broadcasts a message that obtains the cluster head ID for each node. If a cluster head ID matches its own ID, the node is a cluster head; otherwise the node determines its TDMA slot for data transmission and goes sleep until its time to transmit data. The steady-state phase of LEACH-C is identical to that of the LEACH protocol.

5. V-LEACH

In our new version of LEACH protocol, the cluster contains; CH (responsible only for sending data that is received from the cluster members to the BS), vice-CH (the node that will become a CH of the cluster in case of CH dies), cluster nodes (gathering data from environment and send it to the CH).

In the original leach, the CH is always on receiving data from cluster members, aggregate these data and then send it to the BS that might be located far away from it. The CH will die earlier than the other nodes in the cluster because of its operation of receiving, sending and overhearing. When the CH die, the cluster will become useless because the data gathered by cluster nodes will never reach the base station.

In our V-LEACH protocol, besides having a CH in the cluster, there is a vice-CH that takes the role of the CH when the CH dies because the reasons we mentioned above.

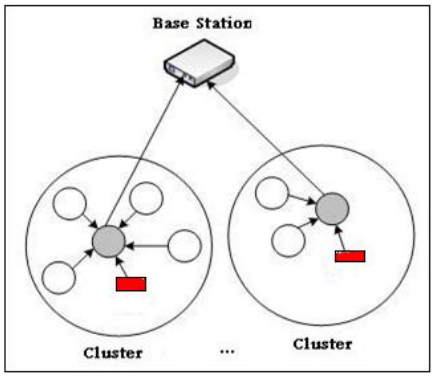

Fig. 6: VLEACH

By doing this, cluster nodes data will always reach the BS; no need to elect a new CH each time the CH dies. This will extend the overall network life time.

6. Simulation and Result:

6.1 Simulator

OMNeT++ is used as a simulation platform. OMNeT++ is an object-oriented modular discrete event network simulator, it has been developed by András Varga [10].

6.2 Simulation parameters:

Table.1: Summery of the parameters used in the simulation experiments**.**

Parameter	Value
Simulation time	900 sec
Topology size	900 x 900 m^2
Number of node	25, 50,100, 115 nodes
CH probability	0.2, 0.5, 0.1
Number of trials	20 trial
Initial node power	1 Joule
Nodes distribution	Nodes are randomly distributed
BS position	Located at 1000 x 450

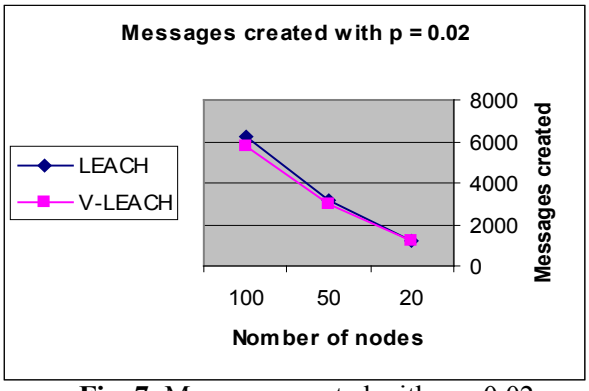

Fig. 7: Messages created with p = 0.02

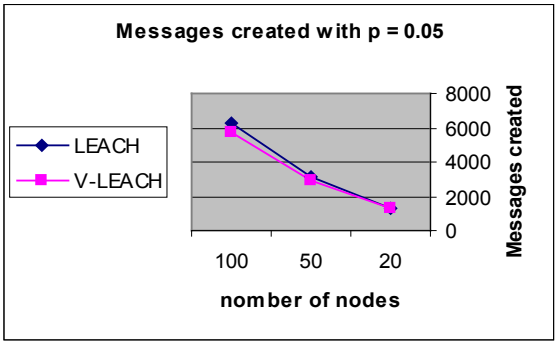

Fig. 8: Messages created with p = 0.05

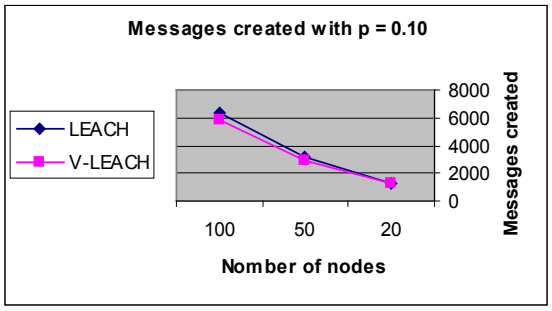

Fig. 9: Messages created with p = 0.10

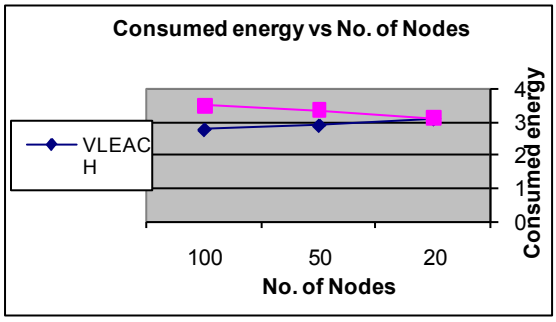

Fig. 10: consumed Network energy

7. Conclusion

In this paper we considered a well known protocol for wireless sensor networks called LEAH protocol which is the first and the most important protocol in wireless sensor network which uses cluster based broadcasting technique.

Followed by an overview of LEACH protocol implementations, then we proposed a new version of LEACH protocol called V-LEACH protocol.

From the simulation results, we can draw a number of conclusions. The first: number of messages created by the V-LEACH is less than the messages created by the original LEACH. The second: if messages created by the new version are less that mean the network energy remaining using V-LEACH is more than the remaining network energy using the original LEACH. We prove that in table1.That mean the new version of LEACH outperforms the original version of LEACH protocol.

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