A Modified Clustering Algorithm in WSN

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***Abstract*—Nowadays many applications use Wireless Sensor Networks (WSN) as their fulfill the purpose of collection of data from a particular phenomenon. Their data centric behavior as well as harsh restrictions on energy makes WSN different from many other networks known. During this work the energy management problem of WSN is studied, by using our proposed modified algorithm. It is a clustering algorithm, where nodes are organized in clusters and send their data to a shift selected cluster head. It will provide improvement on energy consumption in terms of member nodes, by making cluster heads static. LEACH already has a good energy saving strategy but our modification will provide an easier approach towards efficiency.**

***Keywords*—energy efficient; algorithm; WSN; clustering; Cluster Head; LEACH**

I. Introduction

New technologies and semiconductor elements usage have brought to an evolution in to the electronics world. By integrating systems development in chips has brought a significant change on the way we perceive the world around us. The development of microchips has led to the production of small sized devices used in many applications, there are called sensors. These nodes are still in development phase but many applications nowadays use them for their purposes. Sensor elements are not only capable of measuring a physical factor to which they are designed, but also to process and store the collected data [1].

Sensor nodes cooperate with each other to build an ad-hoc system, using wireless communication form to create a wireless sensor networks. A wireless sensor network consists of two main elements, nodes and sinks. A node represents an active point of the network where all data collection is done. A sink represents a fixed element that acts as a repository for the data gathered in the nodes. One common problem of wireless sensor networks is the communication nodes range of that is formatted based on energy consumption and obstacles in the network. A solution to this is by using multi-hop communication networks where nodes can transmit to other nodes rather than to the sink. This approach is only used if the network is big enough and in the case where nodes that are far away from the sink [2].

Usually sensor nodes are placed at random places within the study area. They perform signal processing, computation as well as self-configuration to achieve a strong, scalable and durable network. Therefore WSN provide cost-effective opportunities, practical and able to support many real-life applications. WSN consist of a large number of small sensor nodes. These sensor nodes have a great advantage in communicating their data. Unlike other wireless systems, they do not need necessarily to forward the collected information to the base station if there is a neighboring node that can further forward it. Sensors differ from one another based on type and magnitude of monitored phenomenon. WSN used for monitoring require sensor deployment in environments where it maybe is impossible to recover them again. These applications include toxic levels of a pond, temperature in a mountain and more. Therefore energy levels are very important for the sensors in these kinds of networks. Many protocols propose different ways to conserve efficiently energy in wireless nodes [3].

In this paper, we focus on LEACH, which is the foundation of a new algorithm proposed. LEACH is a clustering algorithm, which means the nodes of the network are organized within clusters and they communicate between themselves via sensor elements called Cluster Heads (CH). Energy saving is reached throughout rotation of the cluster head role among cluster nodes because CH spend much more energy than the normal nodes. Our proposal aims in modifying LEACH algorithm in order to reach more effectiveness in energy terms. In the following section we present the related work that is a general knowledge of WSN protocols, focusing on different implementations. Then section III briefly explained clustering as it is the main technique used in LEACH algorithm. Proceeding in this section with a detailed explanation of LEACH and the proposed algorithm. Section IV describes the simulation experiments and the results. Finally, section V concludes the paper.

II. Related Works

Having a limited power, sensor nodes are very much affected by the routing protocol used in transmission. To cooperate with this constrain direct transmission was firstly discussed [11]. In this kind of transmission a node senses data from the environment and sends it directly to the base station. This is a method which certainly ensures data security. However it is needed to do a compromise on power consumption due to the energy needed to transmit information in such long distances.

To solve this problem, multi-hop concept was introduced via Minimum Transmission Energy algorithm (MTE) [4]. Using this algorithm, the nodes distant from the base station save their energy by forwarding information to nodes near to them, rather than to the base station. Its drawback, unfortunately, is connected to the nodes near the base station.

They spend more energy by routing all that data traffic to the base station. The third algorithm discussed deals with clustering. Literature [5] described a cluster based routing protocol where all nodes are distributed within a 2-hop based cluster algorithm (CBRP). Using this algorithm, when a sensor network is deployed, nodes establish the clusters and nominate one sensor as their cluster head. Cluster heads are given more energy to ensure a longer network lifetime. Considering cluster based algorithms, many approaches are taken through years. LEACH, TEEN and SEEP are the representatives cluster routing techniques focusing on cluster head election [3], [6], [7]. Main procedure of cluster head election is introduced by LEACH and further enhanced by SEEP and TEEN. Q-LEACH is another algorithm based on LEACH which optimizes network lifetime of homogenous WSN, [8]. Other variants of LEACH proposed are: A-LEACH, S-LEACH and M-LEACH [9]. They also focus on energy efficiency and applications.

III. CLUSTERING IN WSN

Clustering essentially means grouping of the sensor nodes into formations to satisfy scalability and achieve energy efficiency in WSN. Cluster formation implies two logic levels of architecture. The upper level is formed by the Cluster Heads, which are responsible of forwarding data gathered by sensors to the sink node. The lower level is formed by all the other simple sensor nodes. Usage of the different ways a CH is first elected and then the nodes in the system are invited to join a cluster by linking to a specific Cluster Head. CH may connect directly to the sink or they may connect to other CH in other clusters, Fig.1. The sink, also called base station, is the main data processing point where is brought all information gathered by sensor nodes. The sink is also the closest element accessible by the end users. CH elements act as gateways between nodes and sink. Their duty is to perform some functions for all the nodes of the cluster [7]. In addition to supporting scalability and decreasing energy consumption, Cluster technique has many other advantages and benefits. By limiting the communication between the nodes within a cluster it can maintain in a stable state communication bandwidth. It can also localize the route within the cluster by limiting routing tables to small sizes. Moreover clustering can fix network topology at the sensor level, resulting in smaller maintenance overhead [10].

A. *LEACH algorithm*

LEACH is a representative of clustering and energy efficient protocols, [11]. It is a self-adaptive and self-organized algorithm. In LEACH nodes get organized themselves into clusters where every cluster has one special node called Cluster Head. If CH would be kept fixed we would see that they would die quickly. So a rotation technique is used by LEACH to move the CH role between all the members of the cluster. Before joining any particular cluster, nodes can elect themselves to be cluster heads with a certain probability.

These cluster heads broadcast their position to the system. The other nodes in the network can join a cluster by linking to the CH and it is more convenient to them. Convenience implies with the minimum energy needed for communication between node and CH. After cluster formation, CH schedule transmission times for each and every node depending on their responsibility in the network. This is done in order to save nodes energy and activate them just in case they need to transmit data. Once CH has all the data gathered from nodes in the cluster, it aggregates the information and sends it to the base station [12]. As we stated earlier, LEACH algorithm implies nodes rotation to ensure energy efficiency. If a group

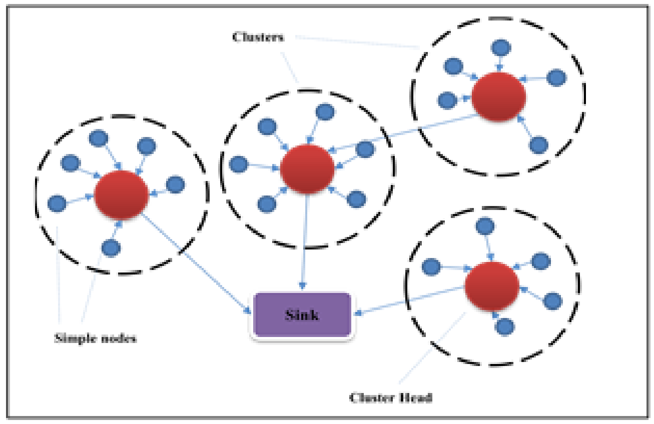

Fig. 1. Simple cluster WSN

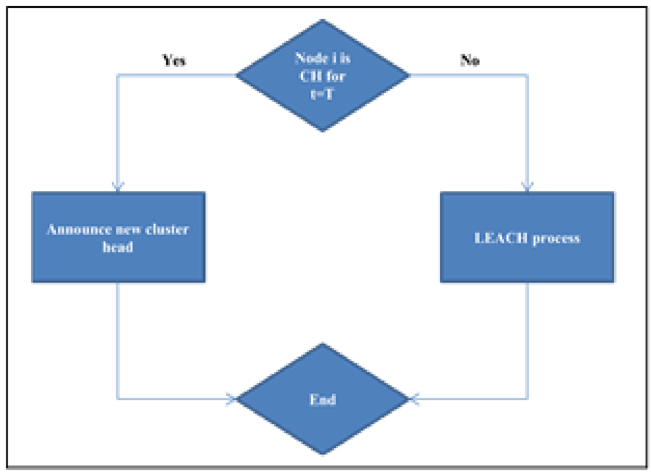

Fig. 2. Block-scheme for LEACH algorithm

of nodes are elected as cluster heads within interval T, another group will be elected CH within interval $T + b$, where b is the CH round time. The decision of the nodes to become CH is a probabilistic function depending primarily in the energy left at that specific node [13]. The diagram shown in Fig.2 explains LEACH algorithm behavior. The algorithm starts with a node being selected previously as a CH. The first condition evaluates the amount of time for a CH to have its position. If that amount of time is not equal to the maximum value, the CH can continue its activities imposed by the algorithm. If this amount of time is equal to the limit, CH must delegate its position to another node.

B. *Modified LEACH*

According to LEACH protocol, in every round, a new cluster head must be elected and therefore new cluster formation is needed. This leads to unnecessary routing overhead resulting in excessive use of energy. If we want to overcome this problem, there is a need to stabilize the process of cluster head selection by making them static. It is proposed a modified version of LEACH algorithm which focuses on energy efficiency.

The purpose is to prove that our modification will somehow improve lifetime of a wireless sensor node by lowering energy consumption. The idea is very simple and is clearly understandable in Fig. 3. We have modified LEACH algorithm by choosing CH preliminarily with the same energy

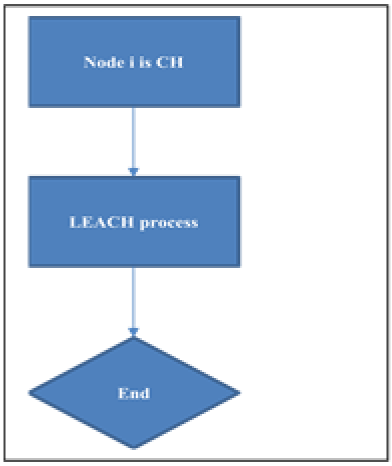

Fig. 3. Block-scheme for Modified LEACH algorithm

as before. Focusing on the algorithm scheme, node *i* is Cluster Head on all iteration until its battery it's completely drained. Other nodes thereby maintain stable energetic values given that they are never turned into CH. We believe that, given a certain network with many nodes, even if CH is static the overall energy of the network saved will be slightly greater if we give CH more energy than non CH nodes.

IV. SIMULATION AND RESULTS

We have used for our simulations Castalia, a simulator build on Omnet++ which works well for wireless network simulations and can be used for free by all developers who want to test their algorithms in a realistic wireless channel. The network model for the Modified LEACH is shown in Fig.4, while the network parameters are present in Table I for both algorithms used. Construction for our simulation purposes of different sizes of network respectively 18, 81 and 162 nodes where each group of 9 nodes forms a cluster with one cluster head. The round of being CH node in LEACH algorithm will be kept even if CH will be static in our algorithm. That means that we are modifying the CH-s rotation but not rounds in LEACH.

TABLE I. NETWORK'S PARAMETERS

Network's parameters	***LEACH***	***Modified LEACH***
Number of total nodes	18, 81, 162	18, 81, 162
Number of cluster heads	dinamic	static
Simulation time	300 sec	300 sec
Packet size	9 byte	9 byte
Rotation	YES	NO
Number of rounds	30	30

A. Experiment 1

Two experiments are performed to compare two algorithms: LEACH and Modified LEACH based on energy consumption and therefore lifetime of the network.

At the first experiment we have preloaded CH nodes in our modified algorithm with exactly the same energy as other

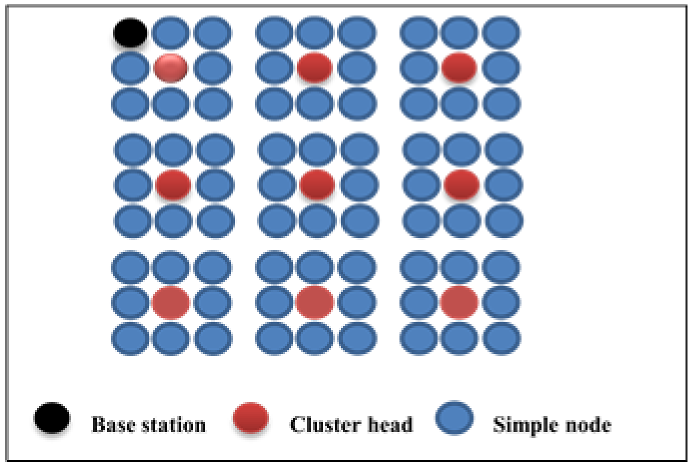

Fig. 4. The network model

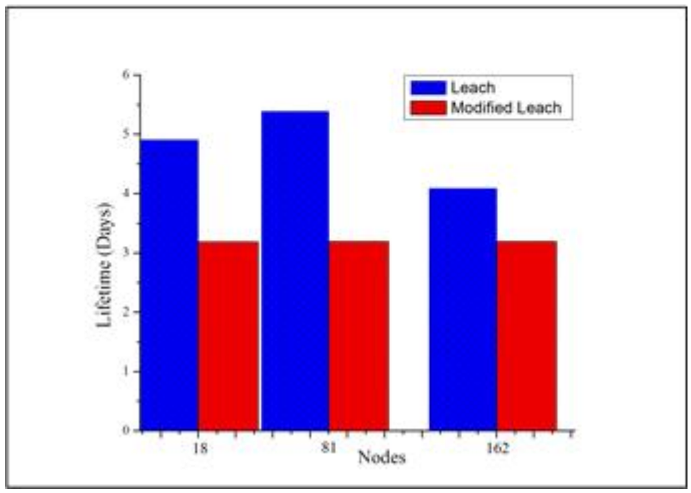

Fig. 5. Network Lifetime at the first experiment

nodes. This node's initial energy is the same as it used in LEACH algorithm with value 18720J. We have simulated 300 seconds. Having specified the round length time we can calculate rounds in this simulation as 300/10sec (per round). Based on the remaining energy of CH, the one that has spent more, it counts to calculate the lifetime of the network for both algorithms. As we can see from the Fig.5, Modified Leach has no improvement compared with LEACH. This was expected. CH in our modified algorithm spends much more energy compared with CH from the traditional LEACH and that is because our CH does not use rotation and therefore spend much more energy given an amount of rounds simulated.

Table II reveals the benefits of our modified version of LEACH, to where the energy is divided based on roles. Based on the same cost we could give more energy to CH and less to non CH nodes. The results of the first experiment and based on calculations shows that CH nodes spend 2.7 times more energy than non CH nodes. So, CH nodes will have no more energy, while non CH will remain with a great amount of energy that will never be used. Our idea is to take this energy from non CH nodes and give it to CH ones. From calculations we estimated the total initial energy of non CH nodes in our algorithm by setting it different from CH nodes. We are using this result for our second experiment where member nodes and CH nodes are now given different energy levels.

TABLE II. THE RESULTS OF EXPERIMENT 1 AND THE MODERATE ENERGY

	LEACH	*Modified LEACH*
Lifetime	4.06 days	3.2 days
Simple node energy	18720	18720
CH node energy	18720J	18720J
node/CH energy factor	NO	2.7
Moderate energy (node)	18720J	15745.79J
Moderate energy (CH)	18720J	42513.68J

B. *Experiment2*

Our second experiment takes in consideration the results at the first experiment for the calculation of lifetime and packets dropped.

During simulations of the second experiment the initial energy of the CH nodes will be greater than other nodes. CH's added energy will be subtracted from the other nodes so the total energy of the network will not change. In our second experiment we are giving CH nodes more energy than member nodes based on the equation:

$$18720\,J * N = A * 2.7 * X + B * X \quad (1)$$

Where: $N$is the total number of nodes; A is the number of CH nodes; B is the number of member nodes; X is the new energy of member nodes.

From the result of Eq. (1) which is purely based on simulations from the first experiment, it is concluded that the initialization value of energy of the nodes in the second experiment can be 15745.79J for member nodes and 42513.68J for CH nodes. From the results of the second experiment we derived the Fig.6.

It is possible to see the difference between lifetimes of LEACH and our modified version. The simulation results showed the lifetime of a network using a modified version of LEACH as we modeled to be 7.23 days compared to lifetime of the preview experiment where it was 3.18 days. We conclude that our modified version really is an improvement for a network even if network size grows. The fact that lifetime is constant even if we expand our networks because total network energy has a linear dependence with number of network nodes.

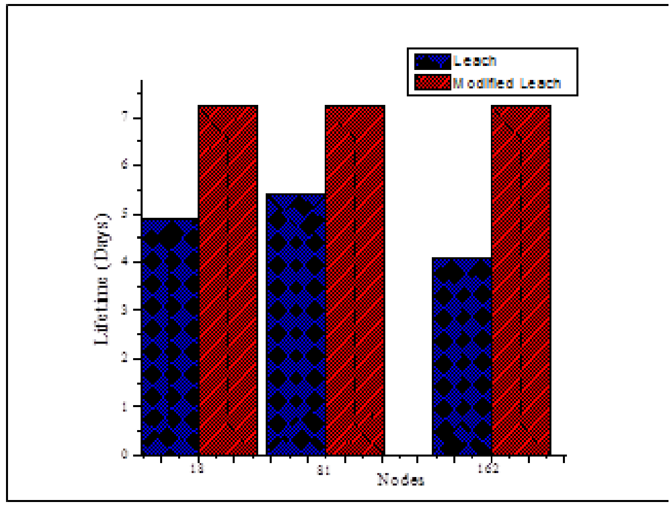

Fig. 6. Network Lifetime at the second experiment

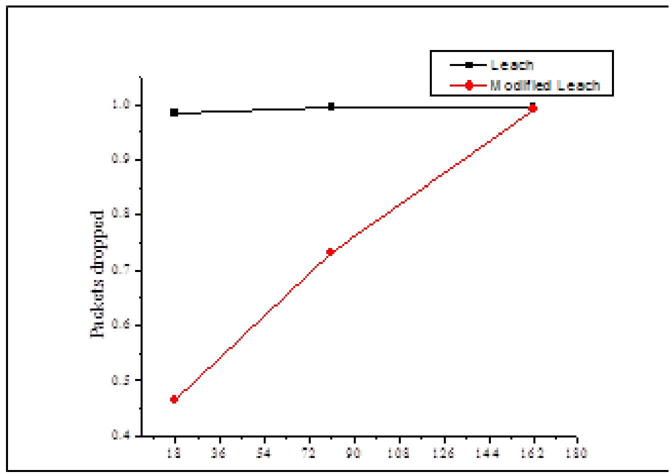

Fig. 7. Packets dropped results

The last results to compare are focused on calculating packets dropped in three different sizes of the networks. Our modification affected positively the overall packets dropped in the network as is show in Fig.7. Having more CHs, the distance of communication with the sink decreases and if the distance is shorter more packets are successfully sent to the destination. A second annotation based on the results, is the growing tendency of packets dropped related to the network size. If network size grows, more clusters are formed and more CH's are distant from the sink nodes. Therefore more packets will be dropped. In the large networks both algorithms have a big quantity of overhead that are difficult to manage.

V. THE CONCLUSIONS

The lifetime calculated during our simulations shows that if we use different levels of initial energy for two types of nodes, our proposal outperforms traditional LEACH.

The modified LEACH also improved packets dropped. That because nodes can transmit in smaller distances having more CHs and so has less packets dropped as in our modified version.

Our work concluded to be really a pleasant improvement. Being a cost effective algorithm and having static nodes as CH we believe that our next challenge will be the proposal of new hybrid algorithms that use modified LEACH as part of their logic. Further, as a future work connecting with the routing method of CH with another known routing algorithm would be worth studying.

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