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An improvement of Energy-Efficient for Hierarchical Routing Protocol for Wireless Sensor Networks

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ABSTRACT
The advances and many new works have been made in sensor technologies and communication in Wireless Sensor Networks (WSN). Almost hierarchical routing protocols are based in the separated area zone and clustering. In this work, we propose an improvement of energy aware of nodes in wireless sensor networks for a hierarchical routing protocol. The proposed improvement is based on taking into account the number of nodes that are dead which can create an empty space with any functional nodes. Here we proposed the simulation results with some different parameters. We have simulated and analyzed LEACH, and then we have compared a performance concerning a network lifetime. We noticed a gain of around 16%.

Keywords
WSN; LEACH; Simulation; network lifetime.

1. INTRODUCTION
Very important applications of WSN networks are the early establishment of a communication network in case of a major disaster and in the case of an free areas infrastructure. The most realistic examples are from areas subject to natural disasters such as fires, floods and earthquakes.

Many advanced work have been done in WSN which is used in many applications as home security, healthcare applications, intrusion detection, sensing ambient conditions such as sound, pressure, gas concentration and temperature [1, 2]. A wireless sensor network has characteristics of self-organization and energy constraints [3, 4].

The special characteristics of WSNs modify the classical performance than traditional wireless networks. In the local wireless networks or cellular networks, the most relevant criteria are throughput, latency and quality of service for new activities such as images and videos transfer and browsing the Internet require a high throughput, low latency, and good quality service.

However, in sensor networks designed to monitor an area of interest, the longevity of the network is important and fundamental. Therefore, the conservation of energy has become a major performance and compared to throughput or the use of bandwidth.

In WSN, all sensor devices should collaborate with each other in order to report the data to the sink node and finally accomplish the sensing and communication task. The most protocols have focused on a maximizing the lifetime of the network and on the resources control in particularly the energy saving in WSN.

Energy consumption is more studied and modeled [5] to generate protocols and models for improvement of the performance as particularly a lifetime of WSN which is extremely important [6] . There are still a number of issues and topics about the assumptions used in WSN.

In this work, the well-know protocol for wireless sensor network, Low Energy Adaptative Clustering Hierarchy (LEACH) [7] is evaluated. The good idea of this protocol has allowed several researchers to do an improvement and even draw inspiration for new algorithm for better control and energy conservation in WSN as the protocols: PEGASIS, HEED and EEUC [8 - 10].

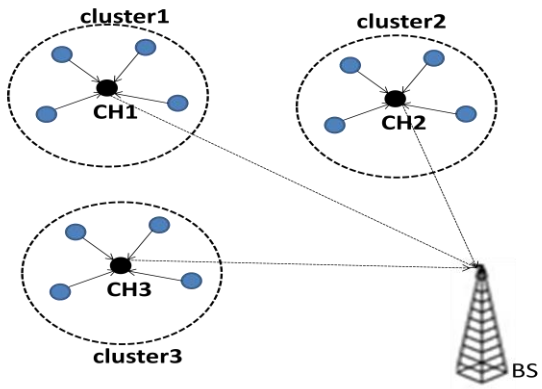

Fig 1: The LEACH clustering communication hierarchy for WSNs.

This paper is organized as follow, after introduction, the next section is related work, then the simulation results and discussion and the final part concludes the paper.

2. RELATED WORK, RESULTS AND DISCUSSION
LEACH is the first adaptive hierarchical clustering routing protocol that takes energy saving in the consideration [7].

As mentioned above, the idea of LEACH protocol has allowed several researchers to do an improvement and even draw inspiration for new algorithm for better control and energy conservation in WSN (Figure 1).

The node becomes a cluster head for the current round if the number is less than the threshold defined by T(s) [7]:

$$\begin{cases} T(s) = \dfrac{p}{1 - p*(r \bmod \frac{1}{p})} & \text{if } s \in G \\ T(s) = 0 & \text{otherwise} \end{cases} \quad (1)$$

Here, p is the desired percentage of cluster heads, G is the set of nodes that have not been cluster heads in the last 1/p rounds and r is the current round. We have used a simple radio hardware energy dissipation model shown in Ref. [7]

It is important to be noted that void area in WSN is considered as a set of nodes with sustainable congestion which will cause a high packet loss and then high power dissipation. So, at first, it is based on improvement LEACH in order to implement in the future another protocol of WSN with control of the empty area caused by dissipation of energy of nodes.

Only the first step called a preparation phase of the proposed protocol based on LEACH modification is presented below.

In any case, a node must belong to one class of nodes. So the nodes should be classified in four class types:

- Normal and candidate to CH nodes,
- Cluster Head (CH) nodes,
- Sleep nodes for a fixed moment,
- Dead nodes forever.

The importance of our proposed modification and improvement is in the choice of these classes. The protocol must choose based on the remaining energy every moment. Depending therefrom, the node must belong to one of these four categories of nodes.

The part of the pseudo-code of the proposed and modified LEACH Protocol is presented below.

```
p is the Specified probability (see (1)), n is number
of nodes;
E_init = E_0 ;
Ni=1,2, …, n;
E_v=F * E_0 ;
F ← 10% ;
if (E_init(s)>0 & rmod(1/p)≠0)
 r ← random(0,1) and compute T(s) %see  (1 )

 if (r < T(s)) then
           S_i.type ← normal ;
            if ((E_i <Es) & (Ei>E_v)
      % Node i can be candidate to CH position
                S_i.type ← Normal or S_i.type = CH ;
                   S_i.type ← sleep ;
                   Sleep ← sleep+1;
           end if

           if ((E_i <Es) & (Ei<E_v)
     % Node can't be candidate to CH
         S_i.type ← dead;
         Dead ← dead+1;
        S_i.group ← void_ji (node_i in void_j)
     % S_i will never be candidate to CH position
        end if
    end if
end if
```

Sensor network is composed of 80 sensor nodes. All nodes are deployed randomly with different distribution patterns in sensor field of 100m ×100m.

The energy required by the transmit amplifier $E_T(l,d)$ to transmit l bit message between a transmitter and receiver (over a distance d) is [12] :

$$E_T(l,d) = \begin{cases} l * Eelec + l * \varepsilon_{fs} * d^2 & if\ d \le d0 \\ l * Eelec + l * \varepsilon_{mp} * d^4 & if\ d > d0 \end{cases} \quad (2)$$

Here, $d_0 = \sqrt{\varepsilon_{fs}/\varepsilon_{mp}}$ is the threshold distance, E_{elec} represents the energy consumption in the electronics for sending or receiving one bit. The terms $\varepsilon_{fs} \times d^2$ and $\varepsilon_{mp} \times d^4$ are respectively the amplifier energy consumptions for a short- and long-distance transmissions [11].

The figure1 shows a WSN with 80-node sensor and the BS localization in the field of size 100m x 100m.

The BS located at coordinate (50,100). The simulation parameters used are listed in Table1 according to the radio basic energy dissipation model [7].

Table 1. Simulation parameters

Parameters	Values
Number of nodes	80
Field simulation	100m x 100m
Base station position	(50,100)
Initial energy (E0)	0.5 or 0.4 J/node
Transmitter Electronics (Eelec)	50 nJ/bit
Receiver Electronics (Eelec)	50 nJ/bit
Length of data packet (Bytes)	3000
Transmitter Amplifier (ε_{fs}) (If $d < d_0$)	10 pJ/bit/m^2 or 150 pJ/bit/m^2
Transmitter Amplifier (ε_{mp}) (If $d > d_0$)	0.0013 pJ/bit/m^4 or 0.0050 pJ/bit/m^4
Probability of CH	0.1
Maximum Sleep nodes	8

In figures 2, 3 and 4 we present the simulation results and the evolution of the wireless sensor network lifetime. In these studies, we are interested in the number of rounds when the first node dies and the time when the last node dies.

Here in this simulation the base station is not as far as possible to cause high energy consumption. It can be seen from all presented simulation results that the network lifetime is prolonged in modified LEACH compared with original LEACH. The gains achieved are as high as 54% compared to LEACH.

Indeed, the simulation1 (Figure 3) show that with the proposed approach all the nodes remain alive for 1550 round, while the corresponding numbers for LEACH are 1040.

For simulation2 (Figure 4), the threshold round at which the lifetime of the network begins to deteriorate were the rounds 700 and 1600 for LEACH and our approach, respectively. We can explain this by the given that the value of Transmitter Amplifier ε_{mp} and ε_{fs} is great in the case of simulation1 with an initial energy E_0 equal to 0.4 J. In simulations 1 and 3, the only difference in the simulation parameters is the energy value E_0.

If we now interested to the last nodes that are alive, we note that the network goes and becomes completely off after the round 1500 and 2000 for both protocols LEACH and modified LEACH.

Table 1 lists the simulation results obtained using LEACH and presented modified LEACH protocols for simulation1 and simulation2. The initial energy for all nodes was 0.4 J and the probability p used is 10%. The number of rounds required when the number live of nodes is 99%, 90%, 50%, and 1% are recorded during simulations. This results shows that the proposed modified LEACH outperforms LEACH in terms of lifetime of network.

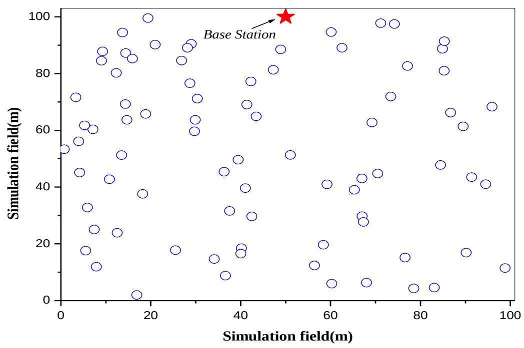

Fig 2: Wireless Sensor Network with 80 nodes

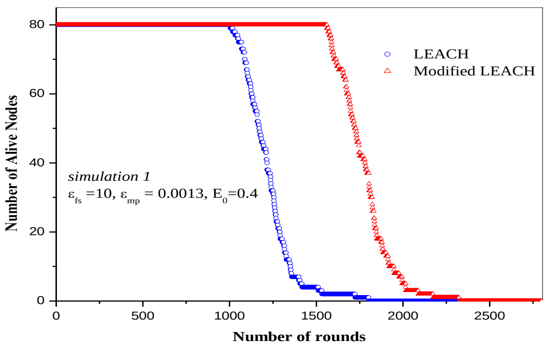

Fig 3: Wireless Sensor Network lifetime (simulation1)

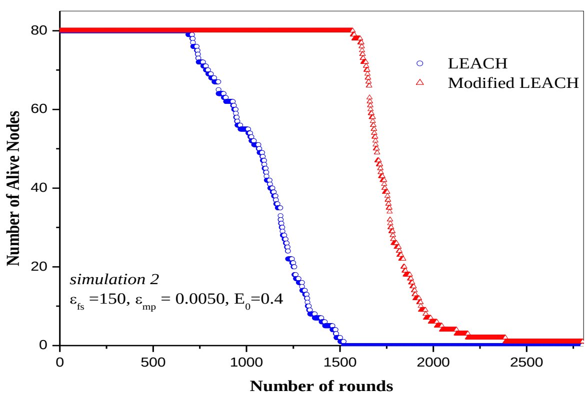

Fig 4: Wireless Sensor Network lifetime (simulation2)

Table 2. Comparison of network lifetimes (number of rounds) between LEACH and proposed modified LEACH protocols

ε_{fs} (pJ/bit/m^2)	ε_{mp} (pJ/bit/m^4)	Protocol	A live nodes			
			99%	90%	50%	1%
10	0.0013	LEACH	1041	1100	1200	1750
		Modified LEACH	1551	1625	1780	2200
150	0.0050	LEACH	701	770	1100	1500
		Modified LEACH	1546	1600	1750	2250

We note that in Simulation 3 the life of the sensors is increased and nodes alive die after 2000 and 3000 rounds for both protocols LEACH and modified LEACH. This is due to the optimal simulation conditions. In general, we note that the lifetime of the network has been increased

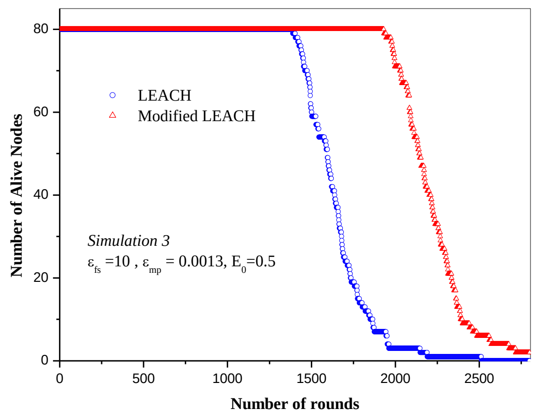

Fig 5: Wireless Sensor Network lifetime (simulation3)

To improve this work, it is necessary to take in consideration the number of dead nodes and sleeping nodes which can be random in reality. This complicates the situation if the size of data to be transmitted is not known in advance. Because the energy model dissipation which is based on the LEACH and the modified LEACH depend on the number of bits to be transmitted. This assumes that the size of the broadcast message may be fixed.

3. CONCLUSION

As conclusion, it should be noted that the Low Energy Adaptative Clustering Hierarchy (LEACH) protocol can increase the network lifetime if we change and improve the algorithm. The manner in which the cluster head is selected should be improved because the cluster heads can be concentrated in one limited space of the network with the limited energy resources. The result of the simulation is given on the flow rate, lifetime and the number of packets transmitted. The improvement of the network lifetime in this case is estimated to about 16%.

This modification can be improved and it is not enough if we want to improve the performance of WSN. So, our future work will be oriented to detect voids in the networks and even draw borders of that void.

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