An Energy-Efficient Clustering Algorithm for WSN Based on Cluster Head Selection Optimization to Prolong Network Lifetime

Rania Khadim, Abdelhakim Maaden, Ansam Ennaciri, and Mohammed Erritali

Abstract—**The use of wireless sensor networks continue to increase in many fields (scientific, logistic, military or health, etc).The size of the sensors constitutes, however, an important limitation, mainly in term of energetic autonomy and therefore lifetime because the battery must be very small. For this reason, the improvement of energy efficiency is a critical issue for WSN protocols. Clustering in wireless sensor networks is an effective way of structuring the network. Its purpose is to identify a subset of nodes in the network and to assign a cluster head to it.**

Hierarchical routing or clustering routing is considered to be the most favorable approach in terms of energy efficiency. It is based on the concept (child node - parent node) where the child nodes forward their messages to their parent, who then routes them in the entire network via other parent nodes to the base station (sink).Two major approaches are derived from this type of protocol: chain-based approach and cluster-based approach.

Low Energy Adaptive Clustering Hierarchy (LEACH) is considered as the first hierarchical routing protocol based on the second approach. It is also one of the most popular hierarchical routing algorithms for sensor networks. Another variant of LEACH, called Low-Energy Adaptive Clustering Hierarchy centralized (LEACH-C), is also presented.

This paper presents an improvement of LEACH and LEACH-C protocol based on two modifications one on balancing energy distribution of network by means of changing range of nodes being cluster head and other by load balancing the number of nodes equally by fixing the average value N, so the lifetime of the network is increased. Simulation results show that Improved LEACH-C can improve system lifetime over its comparatives.

***Index Terms*—Wireless sensor network (WSN), leach, LEACH-C, clustering algorithm.**

I. Introduction

Recent advances in micro-manufacturing and wireless communication technologies have spawned a new generation of networks called Wireless Sensor Networks (WSN) [1]. They consist of a multitude of sensors distributed randomly in areas often hostile and / or inaccessible to humans. These sensors collect various information about the physical or environmental environment and transmit them to a remote base station via wireless communications. Sensor networks find applications in monitoring (forest fire, meteorological measurements, air quality control), connected objects etc.

Sensors, also known as nodes in the remainder of the paper are characterized by their small size, limited energy and low calculation capacity. Depletion of the battery causes the sensor to "die". Therefore one of the big challenges in WSN is to save the battery at best to extend the life of the network [2].

For example, in recent years research has focused on routing protocols to convey captured information to the BS (Base Station) using the least energy and thus extend the lifetime of WSN. These include LEACH, PEGASIS, TEEN, [3]. Proposed by Heinzelman *et al*. LEACH is considered to be the first hierarchical routing protocol based on cluster formation .This paper proposes an improved version of LEACH-C that minimize the energy consumption and prolong the lifetime of sensor networks. Section II presents related works on routing protocols in sensor networks. Section III shows the Network model of energy consumption in sensor networks. Section IV explains our Improved LEACH-C protocol .Section V presents the results of the simulations. Finally, Section VI gives a define conclusion to this work.

II. Related Works

A. Hierarchical Routing Protocols in WSN

Hierarchical routing or cluster-based routing, initially proposed in wired networks, is a well-known technique with features that solve problems related to base station overhead due to network density [4].

Hierarchical routing protocols are typically responsible for assigning roles to nodes in the network, establishing clusters, and defining how nodes decide which cluster-head to join (Fig. 1).

Nodes chosen as cluster-head are high energy nodes. They can be used to process and send information. Low energy nodes can be used to perform the task of capturing near the target.

The advantage of this type of protocol is that they route data faster, thus reducing the latency time compared to a multi-hop approach.

B. LEACH and Its Derived Protocols

1) LEACH protocol

Initially, LEACH randomly selects a few sensor nodes as cluster-heads and performs this role in a uniform manner to distribute the load between the sensors and extend the life of network. In [5], the percentage of sensor nodes that must act as cluster-head is equal to 5%, these clusters aggregate the data transmitted by its members and send this data to the base

Manuscript received June 11, 2018; revised August 7, 2018.

The authors are with LMA Laboratory, Mathematics Department, Faculty of Sciences and Technics, Sultan Moulay Slimane University, Beni Mellal, Morocco (e-mail: khadimrania@gmail.com, m.erritali@usms.ma).

station, for this reason, the cluster-heads need more energy than other nodes. LEACH's operation is divided in two main phases: the set-up phase, and the steady-phase.

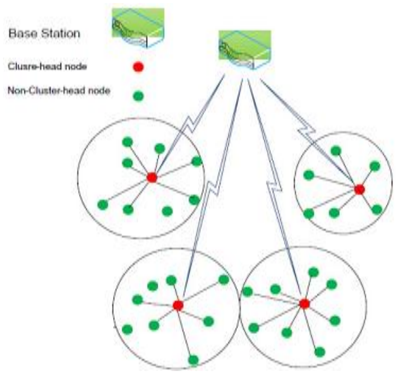

Fig. 1. Hierarchical routing protocols.

During the setup phase, the cluster-heads nodes are elected and the clusters are formed.

The cluster-heads are elected as follows: Each sensor chooses itself to be a cluster-head with a probability *P* which is chosen according to the number of clusters *K* and the number of *N* sensor nodes in the network. This protocol checks if the node was not a cluster-head in the most recent rounds. Then each sensor chooses a random number, *r*, between 0 and 1. If this random number is less than the set threshold value *T* (*n*), the node becomes a cluster-head for the current cycle. The threshold is calculated as follows.

$$T(n)=\begin{cases}\dfrac{P}{1-p*\left(r \bmod \dfrac{1}{p}\right)}, n\in G \\ O, \text{otherwise}\end{cases} \tag{1}$$

where

p : is the desired cluster head's percentage in all sensor nodes

r : is the current round number

G : is the collection of nodes that have not been cluster head node in last $\dfrac{1}{p}$ rounds.

Once the cluster heads are elected and the clusters are formed, we go to the transmission phase.

During the transmission phase, nodes send their data to cluster-head of the cluster to which they belong, and then cluster-head broadcasts a packet which includes information of cluster head to base station.

At the beginning of the "steady phase", a TDMA (Time Division Multiple Access) scheduling allows to assign to each node a slot time for the transmission of its data. In order to save energy, simple nodes that are not cluster-head are active only during their transmission time, the rest of the time they put their radio on standby mode. The cluster-head, however, is active all the time to receive data from other cluster members. At the end of the round, another round is started with a new "set-up phase". Nodes that were cluster-head during the previous round cannot be re-elected again.

LEACH advantages:

- The self-cluster configuration is done independently of the base station (distributed algorithm).
- The data is aggregated to reduce the amount of information transmitted to the base station.
- Energy consumption is shared across all nodes, thus extending the lifetime of the network.
- The use of TDMA / CDMA techniques makes it possible to have a hierarchy and to carry out clustering on several levels. The latter saves more energy.

On the other hand, LEACH has the following disadvantages:

- Without justifying their choice, the authors fix the optimal percentage of CHs (Cluster-Heads) for the network to 5% of the total number of nodes. However, the topology, the density and the number of nodes may be different in other networks.
- No suggestion is made about the re-election time of the CHs (time of the iterations).
- The CHs farthest away from the base station die more quickly than those that are close to the base station.
- The use of probabilistic model to select CHs can generate CHs too close in an area of the network
- The remaining energy and distance of nodes are not taken into account when electing CHs; it can give the CH role to node with discharged battery.

C. LEACH-C Protocol

LEACH-C is a variant of LEACH, designed to avoid the problem of random selection of cluster-heads in LEACH. It has been proposed by the same authors of LEACH in [6]. It is also divided into two phases, setup phase and transmission phase. During the setup phase of LEACH-C, each node sends their information, including its location and residual energy to the base station. Then the BS calculates the average energy of the nodes. The base station designates the Cluster Head based on the average of the energy levels, only the nodes with more energy than the average energy level can be Cluster Head in the current iteration. It is an iterative algorithm, in which the cluster structure is computed at the base station using the optimization method of "annealing algorithm" [7]. However, the base station assigns roles for the different network nodes (CH or single sensor) in each iteration. Then, the operation continues in the same way as for LEACH.

Several improvements and extended versions of LEACH protocol have been emerged. LEACH-B (Balanced) by Depedri. A. *et al.*, [8], LEACH-E (Energy Low Energy Adaptive Clustering Hierarchy) by Fan. X. N. *et al.* [9], LEACH-F (Fixed number of cluster Low Energy Adaptive Clustering Hierarchy) by Manimala. P. *et al.* [10], I-LEACH (Improved Low Energy Adaptive Clustering Hierarchy) by Dembla. D. *et al.* [11], K-LEACH (Kmedoids-Low Energy Adaptive Clustering Hierarchy) by Bakaraniya. P,. et al. [12], L-LEACH (Energy Balanced Clustering Algorithm Based on LEACH Protocol) by Qian. L,. *et al.* [13], LEACH-M (Mobile) by Kim. D. S. *et al.* [14], LEACH-ME (Mobile Enhanced) by Kumar G. S. *et al.* [15], LEACH-P (Performance) by Zhu. D. *et al.* [16], LEACH-S (Solar aware Centralized & Distributed Low Energy Adaptive Clustering Hierarchy) by Thiemo. V. *et al.* [17], T-LEACH (Threshold-based LEACH) by Jiman. H. *et al.* [18], V-LEACH (Vice) by Bani Y. M. *et al.* [19][20], W-LEACH (Weighted Low Energy Adaptive Clustering Hierarchy Aggregation) by Hanady. M. *et al.* [21] and LEACH-WD (Decentralized Algorithm) by Abdelhalim. H. *et al.* [22].

To overcome the various drawbacks, several more efficient LEACH descendants are developed which are presented on various hypotheses in Table I.

TABLE I: SURVEY ON LEACH AND ITS DESCENDANT PROTOCOLS BASED ON SELECTED FEATURES

LEACH Descendent	Clustering method	Data Aggregation	Mobility Type	Scalability	Advantages	Disadvantage
LEACH[5]	Distributed	Yes	Static	Limited	Load distribution in network	CH are not uniformly
LEACH-B[8]	Distributed	Yes	Static	Good	Network lifetime increase	Overhead increase
LEACH-C[6]	Centralized	Yes	Static	Good	Achieves more rounds in n/w	Overhead on the BS
LEACH-E[9]	Distributed	Yes	Static	Very Good	Improves CH selection	CH is always in active
LEACH-F[10]	Centralized	Yes	Static	Limited	Delay is small	Cover larger region
LEACH-I[11]	Distributed	Yes	Static	Very Good	Equally divide field	Periodically updates
LEACH-K[12]	Distributed	Yes	Static	Good	Prolonged stability period	Needs load balancing
LEACH-L[13]	Distributed	Yes	Static	Very Good	Balanced network load	Needs storage capacity more
LEACH-M[14]	Distributed	Yes	Mobile	Good	Mobility of CH node	Overhead increase
LEACH-ME[15]	Distributed	Yes	Mobile	Limited	Supports nodes mobility	Extra overhead
LEACH-P[16]	Centralized	Yes	Static	Good	Increase network lifetime	Introduced extra overhead
LEACH-S[17]	Distributed	Yes	Static	Very Good	Power gain from solar	Centrally controlled
LEACH-T[18]	Distributed	Yes	Static	Good	Reducing the CH selection	CH based on threshold
LEACH-V[19], [20]	Distributed	Yes	Static	Very Good	Introduce vice CH	Extra processing for vice CH
LEACH-W[21]	Centralized	Yes	Static	Good	Increase lifetime of network	CH selection is random

III. NETWORK MODEL OF ENERGY CONSUMPTION

A sensor uses its energy to perform three main actions: acquisition, communication and data processing.

- **Acquisition:** The energy consumed to make the acquisition is not very important. Nevertheless, it varies depending on the phenomenon and the type of surveillance performed.
- **Communication:** Communications consume much more energy than other tasks. They cover communications in transmission and reception. Fig. 2 shows an antenna model and associated energy consumption rules [23].

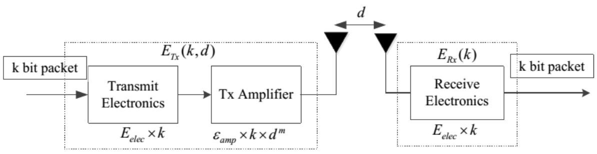

Fig. 2. Radio energy dissipation model.

To transmit a message of k bits over a distance of d meters, the transmitter consumes:

$$E_{Tx}(k,d) = E_{elec} \times k + \varepsilon_{amp} \times k \times d^n \quad (2)$$

To receive a message of *k* bits, the receiver consumes:

$$E_{Rx} = E_{elec} \times k \quad (3)$$

where E_{elec} is electronics energy of transmission/reception, k size of a message, ε_{amp} is magnification times of amplifier. Consumption of amplifier, and distance d^m is in a scale. If transmission distance is short, $d < d_0$ and $m = 0$, otherwise $d \geq d_0$ and $m = 4$. Hence the energy consumption of sending k bit data is:

$$E_{Tx}(k,d) = \begin{cases} E_{elec} \times k + \varepsilon_{amp} \times k \times d^2, d < d_0 \\ E_{elec} \times k + \varepsilon_{amp} \times k \times d^4, d \geq d_0 \end{cases} \quad (4)$$

- **Data processing:** The energy consumed for the calculation operations is much lower than the energy of communication.

IV. PROBLEM STATEMENT AND PROPOSED SOLUTION

LEACH protocol selects randomly a few sensor nodes as cluster leaders and performs this role in a consistent manner to distribute load across sensors and extend network life. And LEACH-C adds a simple restriction which is all the nodes with energy greater than the average are selected as cluster head. However the impact of this method is still limited. Especially when the average energy of nodes is low, even if the residual energy of nodes is higher than the average energy, it is possible that the node would die faster after this round.

LEACH could produce clusters of large size in dense networks and small size clusters in small networks. In both cases, the cluster heads of a large number of nodes could quickly exhaust their battery power and die faster. In dense networks, cluster-heads coordinate between several cluster members, whereas in small networks, cluster heads are placed away from the base station, which requires high-power transmissions. This phenomenon affects the efficiency of the network. LEACH and LEACH-C fail to solve this problem

To overcome this problems, we propose two improvements one in the cluster-head selection and other in the allocation of nodes.

In this work to improve the cluster head selection scheme, we choose according to the energy level of nodes to redefine the election range of cluster heads in order to balance the energy distribution.

The other strategy is the allocation of nodes to the nearest cluster head only if the nodes already allocated to that cluster head is less than a number *N*. If the number of nodes is greater than *N*, a node is allocated to the second-nearest cluster head. We obtain the value N by dividing the number of nodes of the network on the number of cluster-heads.

Improved LEACH-C procedure

Step 1: Initialization of simulation parameters as shown in the Table II.

TABLE II: SIMULATION PARAMETERS SETTINGS

Simulation parameters	Value
Node Deployment Area	$100m \times 100m$
sink.x	$0.5 \times x_m$
sink.y	$0.5 \times y_m$
Total number of nodes (N)	100
Initial energy (E_0)	0.5 J
T_x and R_x energy for each node	$50 \times 10^{-9} J$
Data aggregation energy (EDA)	$50 \times 10^{-9} J / bit / message$
Total number of rounds r_{max}	5000
Packet size	4000 bits
Amplifier coefficient of sending node(d<d0) (Efs)	$10 pJ / bit / m^2$
Amplifier coefficient of sending node(d≥d0) (Emp)	$0.0013 pJ/bit/m^4$

Step 2: Distribution of nodes randomly and evenly to the total area

Step 3: Assume all the nodes are initially normal.

Cluster forming: Initialize number of cluster heads to zero

Step 4: Cluster head selection

Step 5: The BS computes average energy level of all nodes in the network

Step 6: The BS chooses the nodes which can participate in cluster head election based on formula (5)

$$E_{\text{node\_eng}} - E_{\text{node\_avg\_eng}} \geq n \times E_{\text{each\_round}}, n = 1;2;3 \tag{5}$$

Step 7: Count the number k of nodes that satisfy the above requirement. If $k < k_{op}$, the base station will redefine the set G as LEACH-C. For the rest of the experiments, we set k to 5 as indicated in the work of the LEACH protocol.

Step 8: After set confirmed, BS selects cluster heads according to formula (1), and then finds clusters.

Step 9: Setup phase

Find the number of nodes for each cluster

$$N_{\text{nodes}} = \left((\text{Nodes - cluster} + 1)/(\text{cluster} - 1)\right) \tag{6}$$

The total number of non-CH nodes is divided equally among the CH nodes.

If $d < d_{\min}$ and $N_{\text{nodes\_allocated}} < N_{\text{nodes}}$

$$d_{\min} = d \quad \textit{and} \quad d_{\min\_CH} = \text{Current}_{CH} \tag{7}$$

else

Nodes to nearest CH, if it has less than the allotted number of nodes

If there are any remaining nodes, it will choose its neighbor CH.

Step 10: Cluster heads create TDMA sequence for each node within clusters.

Step 11: In the communication phase non-cluster-head nodes send their collected data to cluster head during their own TDMA sequences. In other time, nodes stay in sleeping state to save energy. Cluster heads processes data fusion and send them to BS.

After a certain time, the network will enter into next round.

The flow chart of Improved LEACH-C algorithm is presented in Fig. 3.

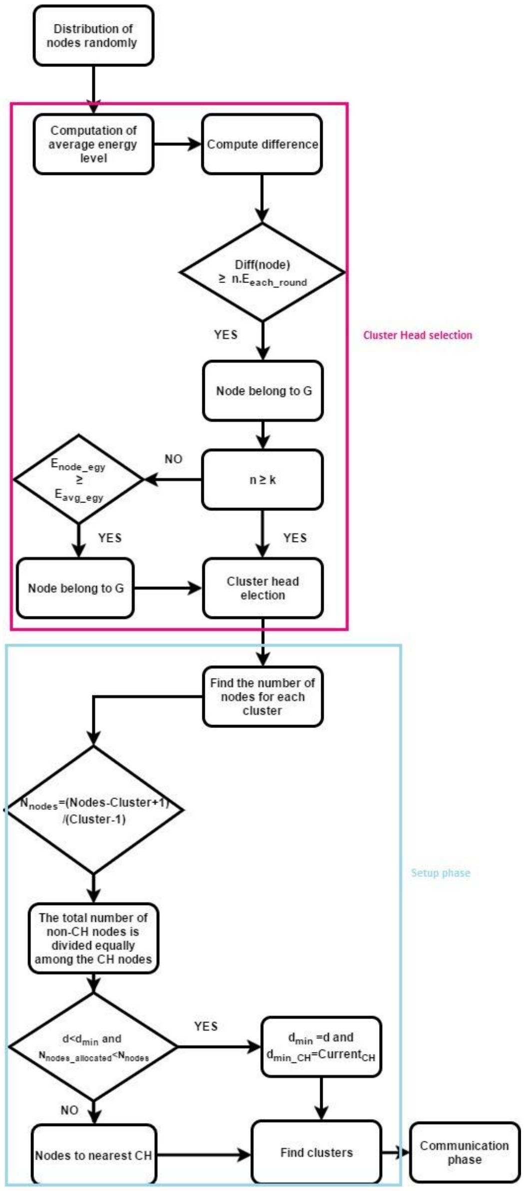

Fig. 3. Flow chart of improved LEACH-C protocol.

V. SIMULATION RESULTS AND DISCUSSIONS

The simulation is executed using MATLAB. To test the performance of the proposed approach Improved LEACH-C against LEACH-C and LEACH, a network is created with 100 random nodes. These nodes are deployed in an area of $100m \times 100m$. Each node has $0.5J$ of initial energy. The coordinates of sink node were also determined. The maximum number of rounds was assumed as 5000. The size of packages was considered 4000. The various network simulation parameters and their values are defined in the Table II.

To calculate the energy consumption of each cluster head $Energy_{CH}$, the distance was compared to do value, that do value was obtained using the following equation:

$$do = sqrt(Efs/Emp) \tag{8}$$

where, Efs and Emp were transmission reinforcers. In case that $distance > do$, $Energy_{CH}$ will be calculated by the following equation:

$$\text{Energy}_{CH} = (ETX + EDA) \times (\text{Packet}) + Emp \times \text{Packet} \times (\text{distance} \times \text{distance} \times \text{distance} \times \text{distance}) \quad (9)$$

Otherwise, if $\text{distance} \le \text{do}$

$$\text{Energy}_{CH} = (ETX + EDA) \times (\text{Packet}) + Emp \times \text{Packet} \times (\text{distance} \times \text{distance}) \quad (10)$$

where, the Emp is transmission reinforcer and EDA is energy aggregation data. However, consumed energy of each node was calculated by comparing the shortest distance to do, as follows:

If $\min_{dist} > do$ then:

$$\text{Energy}_{\text{Mumber}} = ETX \times (\text{Packet}) + Emp \times (\text{Packet}) \times (\min_{dist} \times \min_{dist} \times \min_{dist} \times \min_{dist}) - (1/4000) \times \left(\left(Emp \times \text{Packet} \times (\min_{dist}) \right)^{(0.01)} \right) \quad (11)$$

That attains the optimum results much better and faster than previous methods.

The following performance metrics are used for evaluating the protocol.

Network Lifetime: This is the time interval between network operation start until the death of the last node Network lifetime is measured using three metrics: First Node Dies (FND), Half of the Nodes Alive (HNA) and Last Node Dies (LND). The result for FND, HND and LND is shown in the Fig 6.

Number of Alive Nodes per round: This will measure the number of live nodes in each round (Fig. 7).

Number of packets sends to base station: This will measure the total number of packets which are sent to base station (Fig. 9).

Energy consumption node: It indicates energy consumption per node. Lower the value of energy consumption per node better is the network lifetime. It is a very important parameter to prolong the network lifetime. Energy consumption per node is shown in the Fig. 10.

Number of cluster heads per round: This will measure the number of cluster heads formed in every round (Fig. 11).

Number of Dead Nodes per round: This will measure the number of dead nodes in each round (Fig. 13).

Number of packets sends to Cluster head: This will measure the total number of packets which are sent to cluster head (Fig. 14).

In formula (5), E_{each_round} is a key factor in our new scheme. How to decide its value will have a direct effect on the performance of protocol. Energy consumption of each round should be equal to that of LEACH-C. We use the experiments data of LEACH-C to decide the value of E_{each_round}.

According to the Fig. 4 energy consumption is approximately linear; it is stable before first node death, the linearity R^2, is up to 0.9888. The slope is directly related to the energy consumption of each round. Therefore, according to this line, we set E_{each_round} to 0.03676.

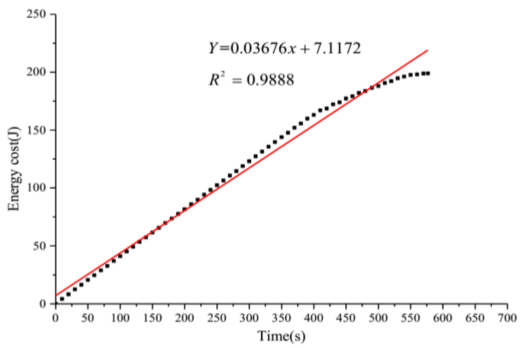

Fig. 4. Energy dissipation of LEACH-C.

Another constraint is how to choose the value of n. If n is too small, the quality of nodes that will satisfy the formula 5 is too large that the effect of new scheme is not obvious, on the contrary if n is too large, it will not have enough nodes and the new scheme will be similar to LEACH-C. In this work we choose n through a simulation. The Fig. 5 shows the round of first node death when initial energy is 0.5 J. According to this figure that simulation agrees with the analysis. This graph shows that the optimal value of n is between 2 and 18 for this network. Therefore we choose to set n to 8 for the rest of the experiments.

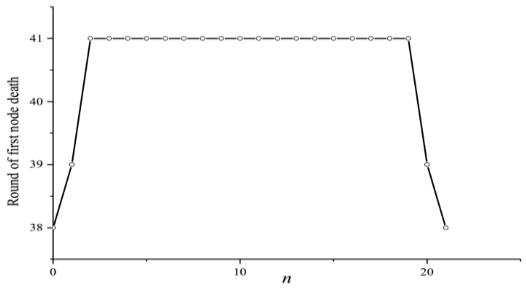

Fig. 5. Round of first node death as the value of *n*.

It can be seen from the Fig. 6 that the proposed approach improves the network lifetime, including stability period.

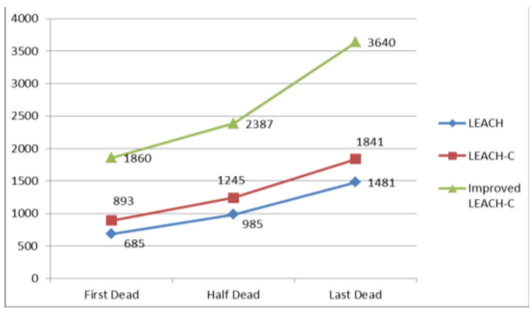

Fig. 6. Rounds for 1st, half and last node dead in LEACH, LEACH-C and improved LEACH-C.

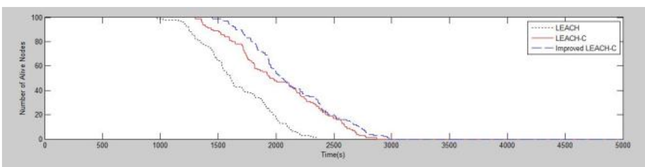

Fig. 7. Node alive of different protocols.

Fig. 7 plots the number of alive nodes per round and they are more in improved LEACH-C as compared to LEACH-C and LEACH. According to this figure, death time of first node in Improved LEACH-C algorithm is later than LEACH and LEACH-C protocol. The first node dies at the time of 956s, 1262s and 1528s in LEACH, LEACH-C and Improved LEACH-C respectively.

This is because, like LEACH-C protocol the base station knows the location and energy level of all nodes in the network, which makes it possible to establish more efficient clusters requiring less energy to transmit data. And the Improved LEACH-C has used new algorithm to choose the range of nodes that will participate in cluster heads selection .This can avoid an early condition that the node exhausts its energy after being cluster head, especially when average energy is low in the network. So this method can force the node that has more energy to consume energy through being cluster head and distribute energy more evenly in WSN.

In order to verify and validate the correctness of our analysis we calculate variance of residual energy before the 1000s of the first node death. Fig. 8 shows that in our Improved LEACH-C energy variance is always less than in LEACH-C and the energy distribution is more even in the Improved LEACH-C. The new algorithm prolong the network lifetime by eliminating nodes with low energy being cluster heads.

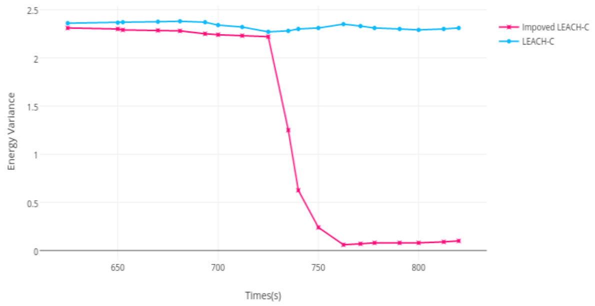

Fig. 8. Energy variance of different protocols.

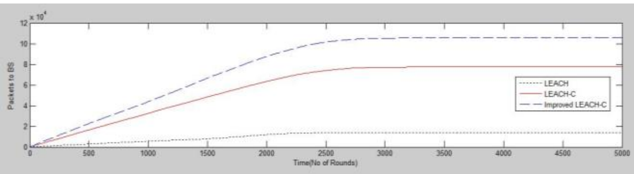

Fig. 9. Packets sent to BS for different protocols.

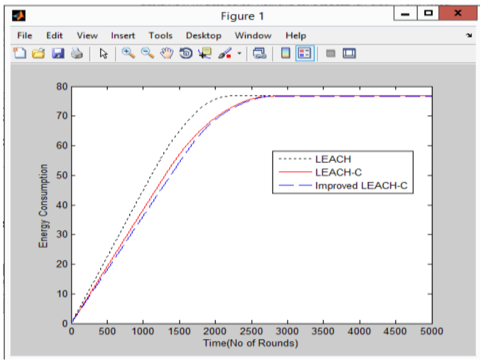

Fig. 10. Energy consumption of different protocols.

Fig. 9 shows the number of packets received by the BS from the network. It confirms that higher numbers of packets are received by the BS for Improved LEACH-C protocol as compared to LEACH-C and LEACH protocol. Higher the number of packets received indicates lower die rate of the nodes and energy consumption.

Fig. 10 plots the total energy consumption per round of Improved LEACH-C, LEACH-C and LEACH. From the figure it is crystal clear that total energy consumption of Improved LEACH-C is less than LEACH-C and LEACH. Improved LEACH- C outperforms better in this regard.

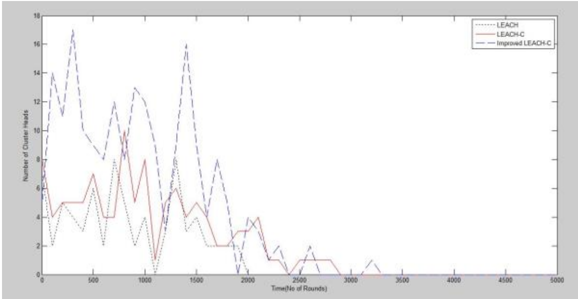
Fig. 11. Number of cluster-head.

Fig. 11 shows that total number of cluster-head per round is more in Improved LEACH-C than LEACH and LEACH-C. It demonstrates that the proposed protocol delivers a greater number of CH compared to LEACH.

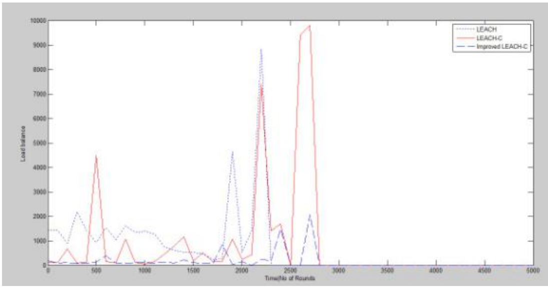
Fig. 12. Load balance.

Fig. 12 relates to balance of the load, that LEACH- C makes so much overload when operating cluster head and it is a weakness for this protocol. The new Improved LEACH-C protocol has succeeded in reducing the load balance up to more than 75% in comparison with LEACH and LEACH-C protocols.

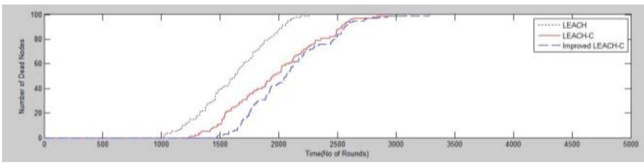
Fig. 13. Dead nodes of different protocols.

Fig. 13 presents the number of dead nodes per rounds, showing that the number of dead nodes is smaller for improved LEACH-C than for LEACH-C and LEACH. At 2320s, all LEACH nodes are dead, but some of the nodes remain live at 3000s in improved LEACH-C. The lifetime of the network is increased in Improved LEACH-C.

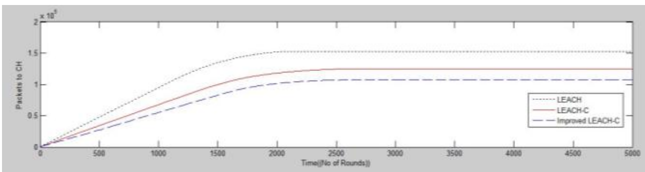
Fig. 14. Packets to CH.

Fig. 14 shows that total number of packets send to cluster-head per round is less in Improved LEACH-C than LEACH and LEACH-C.

VI. CONCLUSION

In this paper we propose an optimized LEACH-C protocol by adding two modifications. The first modification determines the scope of cluster head selection according to energy level of nodes, and the second one is the allocation of nodes to the nearest cluster head, only if the nodes already allocated to that cluster head is less than a number N. In the first approach the cluster heads are not selected randomly, and the second approach helps that every cluster has equal number of nodes which improves the network lifetime, stable region and throughput of sensor network. Proposed scheme balances the distribution of energy in the network. In comparison with LEACH-C and LEACH algorithm, simulation results show that new algorithm can improve energy efficiency and prolong the network lifetime. Our research is also focused on improving LEACH and LEACH-C performance to minimize the number of nodes stranded as the cluster heads die and on increasing network lifetime and throughput via load balancing.

REFERENCES

[1] R. Khadim, M. Erritali, and A. Maaden, "Range-free localization schemes for wireless sensor networks," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 16, no. 2, pp. 323-332, 2015.

[2] A. M. lal Parmar and A. Thakkar, "An improved modified LEACH-C algorithm for energy efficient routing in wireless sensor networks," *Nirma University Journal of Engineering and Technology*, vol. 4, no. 2, pp. 1-5, 2016.

[3] S. K. Singh, M. P. Singh, and D. K. Singh, "A survay of energy-efficient hierarchical cluster based routing in wireless sensor networks," *Int. J. of Advanced Networking and Applications*, vol. 2, pp. 570-580, 2010.

[4] R. P. Mahapatra and R. K. Yadav, "Descendant of LEACH based routing protocols in wireless sensor networks," *Procedia Computer Science*, vol. 57, pp. 1005-1014, 2015.

[5] W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy-efficient communication protocol for wireless microsensor networks," in *Proc. 33rd Annual Hawaii Internatio,al Conference on Syste Sciences*, 2000, pp.1-10.

[6] W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "An application specific protocol architecture for wireless mincrosensor networks," *IEEE Transactions on Wireless Communication*, vol. 1, no. 4, pp. 660-670, 2002.

[7] T. Murata and H. Ishibuchi, "Performance evaluation of genetic algorithms for flowshop scheduling problems," in *Proc. the 1st IEEE Conference Evolutionary Computation*, vol. 2, pp. 812-817, 1994.

[8] A. Depedri, A. Zanella *et al.*, "An energy efficient protocol for wireless sensor networks," in *Proc. AINS*, pp. 1-6, 2003

[9] X. N. Fan and Y. L. Song, "Improvement on LEACH protocol of wireless sensor network," in *Proc. International Conference on Sensor Technologies and Applications*, pp. 260-264, 2007.

[10] P. Manimala, R. Senthamil, "A survey on leach-energy based routing protocol," *International Journal of Emerging Technology and Advanced Engineering (IJETAE)*, vol. 3, issue 12, pp. 657-660, December 2013.

[11] D. Dembla and H. Shivam, "Analysis and implementation of improved-LEACH protocol for Wireless Sensor Network (I-LEACH)," *IJCSC*, vol. 4, no. 2, pp. 8-12, September 2013.

[12] P. Bakaraniya and M. Sheetal., "K-LEACH: An improved LEACH protocol for lifetime improvement in WSN," *International Journal of Engineering Trends and Technology*, vol. 4, issue 5, pp1521-1526, May, 2013.

[13] L. Qian and H. Zhu, "An energy balanced clustering algorithm based on LEACH protocol," in *Proc. the 2nd International Conference on Systems Engineering and Modeling*, Paris, France, pp. 72-73, 2013.

[14] D. S. Kim and Y. J. Chung, "Self-organization routing protocol supporting mobile nodes for wireless sensor network," in *Proc. First International Multi-Symposiums on Computer and Computational Sciences*, Hangzhou, China, 2006.

[15] G. S. Kumar, M. V Paul, and K. P. Jacob, "Mobility metric based leach-mobile protocol," in *Proc. 16th International Conference on Advanced Computing and Communications*, ADCOM, 2008.

[16] D. Zhu and D. Cai, "Research and simulation of energy efficient protocol for wireless sensor network," in *Proc. 2nd International Conference on Computer Engineering and Technology*, Quanzhou, China, 2010.

[17] V. Thiemo, R. Hartmut *et al*., "Solar-aware clustering in wireless sensor networks," in *Proc. the Ninth IEEE Symposium on Computers and Communications*, June 2004.

[18] H. Jiman and K. Joongjin, "T-LEACH: The method of threshold-based cluster head replacement for wireless sensor networks," *Springer Inf Syst Front*.

[19] Y. M. Bani, A. Al-zou'bi, Y. Khamayseh, and W. Mardini, "Improvement on LEACH protocol of wireless sensor network (VLEACH)," *International Journal of Digital Content Technology and its Applications*, vol. 3, no. 2, pp. 132-136, 2009.

[20] R. M. Bani and A. Abdalraheem, "A survey on LEACH-based energy aware protocols for wireless sensor networks," *Journal of Communications*, vol. 8, no. 3, pp. 192-206, March 2013.

[21] M. Hanady and A. Bader, "W-LEACH based dynamic adaptive data aggregation algorithm for wireless sensor networks," *Hindawi Publishing Corporation International Journal of Distributed Sensor Networks*, Article ID 289527, pp. 1-11, 2013.

[22] H. Abdelhalim, E. Abdellah, F. Mohammed, and H. Abdelmajid, "W-LEACH: Decentralized: Weighted LEACH with a decentralized way," *IOSR Journal of Computer Engineering (IOSR-JCE)*, vol. 16, issue 2, Ver -VII, pp. 32-33, April 2014.

[23] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A survey on sensor networks," *IEEE Communications Magazine*, vol. 40, no. 8, pp. 102-114, 2002.

Khadim Rania was born in BeniMellal, Morroco in September 1991. She received the fundamental license inphysics(option electronics and industrial systems), and master of Business Intelligence degrees from Sultan Moulay Sliman's University, Beni-Mellal, Morrocoin 2012 and 2014 respectively. Her general interests span the areas of Localization and mobility of ad-hoc sensor networks.

Ansam Ennaciri was born in Mohammadia, Morroco , on September 1991. She received the fundamental license in electronics and industrial systems, and master of business intelligence degrees from Soltan Moulay Sliman's University, Beni-Mellal, Morroco in 2012 and 2014 respectively. Her main areas of research interest are contribution to the improvement of video transmission in vehicular adhoc networks.

M. Erritali obtained a master's degree in business intelligence from the faculty of science and technology, Beni-Mellal at Morocco in 2010 and a Ph.D. degree in computer sciences from the faculty of sciences, Mohamed V Agdal University, Rabat, Morocco in 2013. His current interests include developing specification and design techniques for use within Intelligent Network, data mining, information Retrieval, image processing and cryptography. He is currently a professor at the Faculty of Science and Techniques, University Sultan MoulaySlimane, and also a member of the TIAD laboratory.