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Energy Efficient in Wireless Sensor Networks Using Cluster-Based Approach Routing

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Abstract: In wireless sensor networks, the energy consumed by each node of the network influences the lifetime of the networks, more than the consumption of energy increases more than the lifetime of the networks decreases, this is why the increase of the lifetime of the networks requires a strategy (protocol) which reduces the power consumption of the transmission or reception of data by the sensor nodes. In recent years much research has been done to maximize a life time of network sensor. To deal with this, the hierarchical protocols (Cluster based-approach, chain based-approach) have been developed in order to reduce the network traffic toward the sink and therefore prolong the network lifetime. In this paper, the focus is mainly driven over the survey of the energy-efficient using hierarchical cluster-based approach namely LEACH (Low Energy Adaptive Clustering Hierarchy Protocol), in order to propose a new method to maximize more the life time of network sensor. Our method is to conserve energy consumption when transmitting data to the Base Station (BS). We evaluated the performance of the LEACH protocol with our proposed method simulated, the results of our method are demonstrated by the simulation results using Matlab Simulink.

Keywords: Network Sensor, Hierarchical Protocols, *LEACH*, Energy-Efficient, Cluster Based-Approach, *Matlab*

1. Introduction

A wireless sensor network (WSN) consists of a large number of small-sensor nodes used to monitor areas, collect and report data to the base station (BS)[1], in the other, each node serves as transmitter and router, these sensors (node) are used to control an environment and transmit the captured data to the base stations [2].

In general Wireless Sensor Network (WSN) is a set of communicating sensors using wireless links [1, 2]. The nodes are usually powered by batteries with finite capacity and it is always impossible to replenish the power [3, 24], for that the failure of the energy sensor can significantly modify the topology of the network and impose an expensive reorganization of the network [4].

In order to extend the lifetime of the network, several routing approaches have been proposed. Among these protocols, the hierarchical routing in which the network is partitioned into small groups and each group is monitored and controlled by a node called (Cluster Head: CH). A CH is responsible for transmitting the information collected by the nodes of its cluster and it can compress the data before sending it to the BS [6].

In WSN power saving techniques can generally be classified in two categories [3]:

a) Scheduling the sensor nodes to alternate between active and sleep mode.
b) Adjusting the transmission or sensing radius of the wireless nodes.

In this paper we study the performances of the LEACH protocol and the existing improvement has been implemented and our approach to prolong the lifetime of the sensors.

In Section II we present the application and characteristics of wireless sensor network. Section III presents the cluster based approach protocols and the operation of LEACH protocol. Section IV detailed the existing method algorithm based on LEACH protocol, Section V and VI detailed our proposed

method approach, the results obtained and discuss result,Finally Section VII concludes a comparative between our approach and method existing and our perspective for future works.

2. Wireless Sensor Network: Application and Characeristics

Wireless Sensor network is most adaptive communication network that is used in many applications and organizations: military, medical, and environmental, for the monitoring of critical infrastructure in the affected areas and hostile[2], WSN has several Characteristics are as below [19, 23]:

a) Power consumation constrains for nodes using batteries or energy harvesting.
b) Ability to cope with node failures.
c) Mobility of nodes.
d) Dynamic network topology.
e) Communication failures.
f) Heterogeneity of nodes.
g) Scalability to large scale of deployment.
h) Ability to withstand harsh environmental conditions.
i) Ease of use.

3. Cluster Based Approach in WSN and LEACH Protocol Operation

3.1. Clustering Based Appraoch in WSN

The structuring of a network is one of the main tools to save energy in each network node [11].

In sensor networks there are two types of architecture for networks, flat architecture that constitutes a homogeneous network where all nodes have the same in terms energy resources,calculation and memory [8, 9, 10], and another hierarchical architecture where all nodes do not have the same roles and therefore the same resources [2]. Being given that the main purpose of a routing protocol for WSN is the proper and efficient development of routes between a pair of nodes so that messages can be routed, why multiple routing protocols (Hierarchical Protocols, Flat protocols) have been developed these last year's [2].

The comparison studied between the flat and hierarchical structure at the energy consumption level shows that the hierarchical architecture has more advantage than the flat architecture [2], namely: well-structured network, easy network management, less power consumption, high lifetime, unless the message circulating on networks and the flood problem is avoided [2].

In the other hierarchical structure there are two main approaches are derived from these protocols: cluster-based approach and chain–based approach [12, 13, 21]:

a) Cluster-based approach: The node is organized in cluster, each cluster have his leader to transmit a data to the base station.
b) Chain–based approach: The node is organized in a chain to send the data to the base station.

Many research activities have been carried out on the area of energy-efficient data gathering in WSN, since the basic task of the WSN is to effectively collect the data with lesser resource consumption. Most of the data gathering algorithms are aimed to minimize the energy consumption problem like this LEACH Protocols [14, 15].

LEACH is one of the protocols based on the concept of classification (clustering) shown in Figure 1, which consists of to partition the network into clusters. The nodes send their data to the CHs who send these Data to the SB. CHs make simple treatments (Aggregation for example) on the data before the to transmit[14, 15].

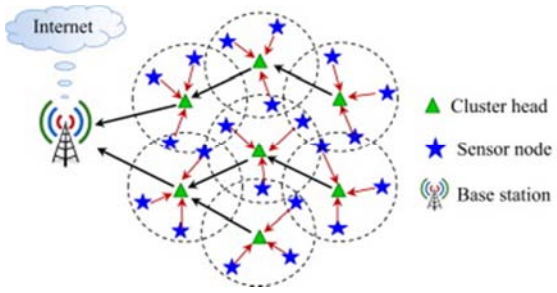

Figure 1. *Clustering based appraoch Protocol.*

In this section, we present a brief overview of some related research work developed like this LEACH protocols.

3.2. Leach Protocol Operation

Low-Energy Adaptive Clustering Hierarchy (LEACH), which is a popular cluster based routing technique, is an energy-efficient communication protocol [16].

In LEACH, the sensor nodes are divided periodically into several clusters. For each cluster, a sensor node is selected as a CH. Thus, LEACH performs a periodic randomized rotation of the CH nodes.

The operations of LEACH are generally separated into two phases: the setup phase and the steady-state phase. In the setup phase, CHs are selected and clusters are organized. In the steady-state phase, the data transmissions to the BS take place. The role of the CH is assigned by the node getting a random number between 0 and 1. If the number is less than the threshold values T(n), the node becomes a CH for the current round [17], the following equation (1) bellow shows how to compute T(n):

$$T(n)= \begin{cases} p/(1-p*(r*\mathrm{mod}(1/p)) & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

Where n is the given node, P is the predetermined percentage of CHs (P = 5%), r is the current round, and G is the set of nodes that have not been selected as CHs in the last 1/P rounds.

Using this threshold, each node will be a CH at some round with in 1/p. After the election of CH nodes, each ordinary node will determine the optimal CH to join in terms of minimum energy required for transmission.

After the election of CH nodes, each ordinary node will

determine the optimal CH to join in terms of minimum energy required for transmission.

In the other, after the formation of the clusters, the CHs construct Time Division Multiple Access (TDMA) tables based on the number of nodes in their clusters. In these tables each node is associated with a time slot which it can transmit these messages (the transmission is Over the entire bandwidth allocated for the transmission of Data), that is to say that each node that tries to make a Transmission during its time-slot it is sure that the channel is clean.

Finally to prevent interference between cluster messages which are close, each CH randomly selects a code in a list of CDMA codes (Code Division Multiple Access) and transmits it to the nodes belonging to its group to use it during transmission, so all nodes use the same bandwidth but with Frequency modulations that are specified in the code Sent by the CH [22].

4. Existing Method Algorithm Based on LEACH Protocol

4.1. Detail Method Existing Using LEACH Protocol

In WSN several method are developing to increase the lifetime of Nodes using the CH selection method, one of this method consists in favoring the nodes which have more energy to become CH [18].To achieve this, authors use the formula for calculating the energy ratio (Energy present in node /Initialed energy) $E_{prés}$ / E_{ini}, and introduce it in the classification formula, the new threshold the energy [18]:

$$T_1(n)=T(n)*(E_{prés}/E_{ini}) \quad (2)$$

4.2. Simulation and Descuss Existing Method Using LEACH Protocol

4.2.1. Parameters of Simulation Protocol

To simulate the improved algorithm we will use Matlab as a simulator with change of position of the base station to show the influence of the distance between BS and the nodes cluster head on the consumption of energy, for this we will choose two locations for BS as shown in table 1 bellow:

Table 1. *Parameters position of base station.*

Location	Position of Base Station
First location(L1)	L1=(150m,50m)
Second Location (L2)	L2=(175m,50m)

The following table 2 bellow shows the simulation parameters for the two locations L1 and L2 with other parameters for existing method:

Table 2. *Simulation parameters of LEACH existing method.*

Parameters	values
Number of nodes	100
Simulation Surface	(100m,100m)
Position of the BS	L1=(150m,50m), L2=(175m,50m)
Initial Energy	0,1 J
Simulator	Matlab
maximum number of rounds	100

4.2.2. Simulation Results Existing Method

Before the simulation, we represented in the figure 2 bellow the distribution of the nodes using LEACH Protocols simulate in Matlab [20].

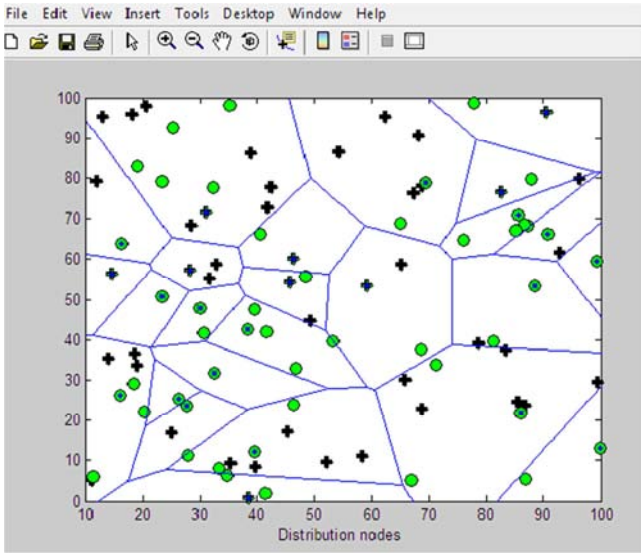

Figure 2. *Distribution nodes and cluster format using LEACH Protocol.*

To make a comparison of both location BS for hierarchical architecture using LEACH protocol, several parameters are to be tested, for that we chose in our simulation the parameters how presented in table 1 for each location BS,then we will take the results of simulation in Matlab [20].with change the location BS.

4.2.3. Results Simulation with BS in L1 (150m, 50m)

The both figures(Figure 3 and figure 4) bellow shows the simulation results representing respectively the state of the nodes after simulation and the number of node dead after number of rounds with BS in location (150m, 50m).

The yellow triangle in figure 3 represents the dead node after finally simulation with BS in location (150m, 50m).

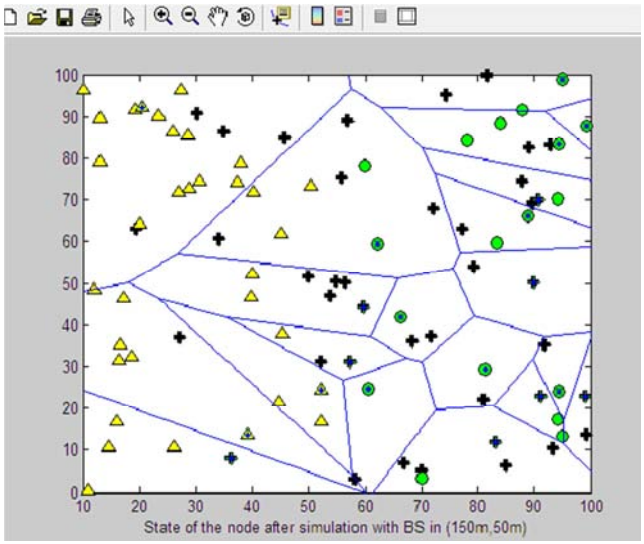

Figure 3. *State of the nodes after 100 rounds with BS in location (150m, 50m).*

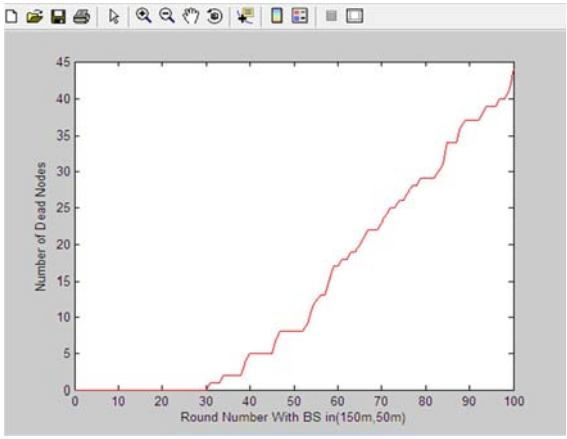

Figure 4. *Number of node dead after 100 rounds with BS in location (150m, 50m).*

4.2.4. Results Simulation with BS in L2 (175m, 50m)

The both figure bellow(Figure 5 and figure 6) shows the simulation results representing respectively the state of the nodes and the number of node dead after number of rounds with BS in location (175m, 50m).

The yellow triangle in figure 5 represents the dead node after finally simulation with BS in Location (175m, 50m).

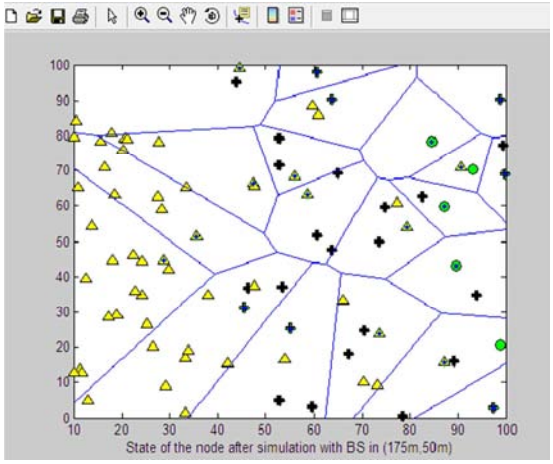

Figure 5. *State of the nodes after 100 rounds with BS in location (175m, 50m).*

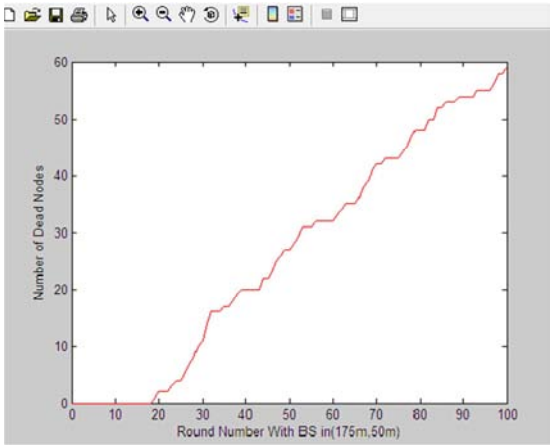

Figure 6. *Number of node dead after 100 rounds with BS in location (175m, 50m).*

4.2.5. Discuss Results Existing Approach LEACH Protocols

According to the result of the simulation obtained for each base station location C1 and C2, relative to the cluster head node, we notice that:

a) The distance that separates the base station and the nodes cluster head influenced over the lifetime of networks.
b) Decrease a distance that separates the base station with the cluster head node decrease a number of dead nodes during 100 rounds.
c) With BS in location (150m, 50m) we see that the number of dead nod during 100 round is about 40 nods.
d) With BS in location (175m, 50m) we see that the number of dead nod during 100 rounds is about 58 nods.

So to minimize the number of dead nodes and increase the lifetime of WSN, several improvements have been introduced, for us, in this article we will improve the constraint distance separating the base station with node (Cluster head) responsible for capturing the data to base station BS.

5. Proposed Method

Energy conservation is a key issue in the design of systems based on wireless sensor networks. Clustering routing protocols have been developed in order to reduce the network traffic toward the sink and therefore prolong the network lifetime [21, 24]. So several researches treats the problem of energy consumption by the nodes of the networks, also several research deals with the problem of the distance between the nodes that is why the researcher proposes the hierarchical architecture to solve the problem existing in the flat architecture such as the lifetime of the networks.

There are already several methods that deal with the problem of distance, but the existing method serves to minimize the distance with a selection of the cluster head next to base station, this brings back the death of the node which is far from CH, which we notice in the simulation done in the previous part.

In formula (1), it has been seen that the nodes self-elect and randomly select a number between 0 and 1 and that this value must be less than a threshold for the nodes to be CHs, then, it is necessary to increase the threshold value to increase the probability of having nodes CHs.

The figure 7 Bellow show one part of existing method to select CHs.

```
%Election of Cluster Heads
if(temp_rand<= (p/(1-p*mod(r,round(1/p)))))
            countCHs=countCHs+1;
            packets_TO_BS=packets_TO_BS+1;
            PACKETS_TO_BS(r+1)=packets_TO_BS;
```

Figure 7. *Methods Select CHs in LEACH Protocols.*

In this context, we propose our improvement routing protocol for Wireless Sensor Networks (WSN) based on

LEACH existing approach. Our approach it based to improvement the algorithm LEACH protocol, exactly to minimize a distance between BS and cluster head and minimized number of dead nods far than BS.

Our method consists to locating the select cluster heads of the nodes that are far from BS at half the topology of the network.

Our Objectives is to avoid the death of the nodes which are very far from the base station and give luck to the node located at the half of the topology and base station so that they become CHs. The threshold equation becomes

$$T3(n)=T(n)*dmoy/d \qquad (3)$$

Where $d_{moy}= (d_{max}+d_{min})/2$, d is the distance between the node and the base station, d_{max} is the maximum distance between the base station and a node, and d_{min} is the minimum distance between the base station and a node.

The figure 8 bellow shows one part of our method to select CHs in LEACH Protocol.

```
%Improvment Election of Cluster Heads
if(temp_rand<= (p/(1-p*mod(r,round(1/p))))*dmoy/distance)
            countCHs=countCHs+1;
            packets_TO_BS=packets_TO_BS+1;
            PACKETS_TO_BS(r+1)=packets_TO_BS;
```

Figure 8. *Our Methods Select CHs in LEACH Protocols.*

6. Simulation of Our Method and Discuss Results

To make the comparison between our improved method and the results existing method how we simulated in section IV, we choose the same parameters presented in table TABLE 2 to simulate our approach improvement.

6.1. Results Simulation Proposed Approach with BS in L1 (150m, 50m)

The both figure bellow(Figure 9 and figure 10) shows the simulation results of our approach method representing respectively the state of the nodes after simulation and the number of node dead after number of rounds with BS in location (150m, 50m).

The yellow triangle in figure 9 represents the dead node after finally simulation with BS in location (150m, 50m).

6.2. Results Simulation Proposed Method with BS in L2 (175m, 50m)

The both figure bellow(Figure 11 and figure 12) shows the simulation results of our approach method representing the state of the nodes after simulation and the number of node dead after number of rounds with BS in location (175m, 50m).

The yellow triangle in figure 11 represents the dead node after finally simulation with BS in location (175m, 50m).

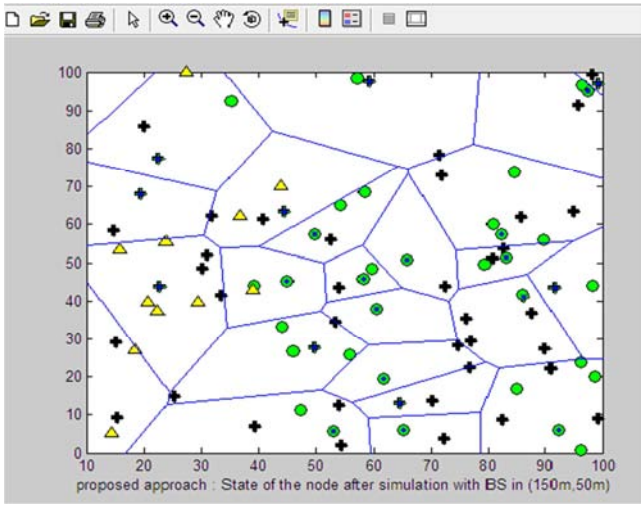

Figure 9. *State of the nodes after 100 rounds with BS in location (150m, 50m) Using Proposed Approach LEACH.*

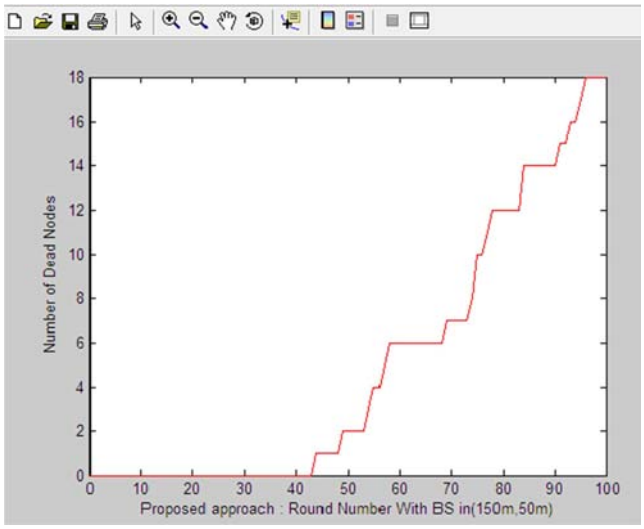

Figure 10. *Using Proposed Approach LEACH.*

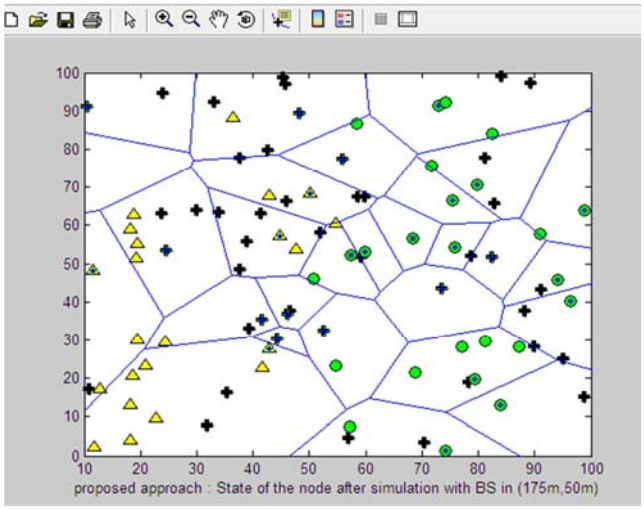

Figure 11. *State of the nodes after 100 rounds with BS in location (175m, 50m) Using Proposed Approach LEACH.*

6.3. Discuss Results Method Approach of LEACH Protocols

6.3.1. Simulation Result Proposed Method

The table 3 and figure 13 bellow gives a comparison between the simulation results between the existing approach and our proposed method for each base station position L1 and L2.

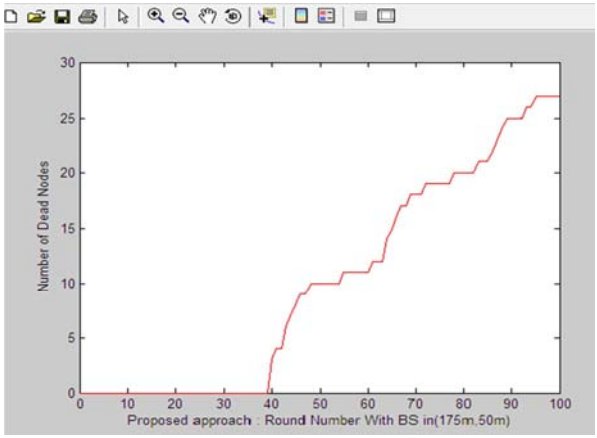

Figure 12. *Number of node dead after 100 rounds with BS in location (175m,50m) Using Proposed Approach LEACH.*

6.3.2. Discussion Results

The results of the simulation shown in the table 3 and figure 13 clearly show that there is an extension of the network lifetime, by applying our approach:

a) We decrease the number of dead nodes from 40 to 18 in the case where the base station is located at a distance of (150m, 50m).

b) We decrease the number of dead nodes from 58 to 28 in the case where the base station is located at a distance of (175m, 50m).

Finally in our approach we have succeeded in extending the network lifetime by 45% for Bs in (150m,50m) and 48 % for BS in(175m,50m).

Table 3. *Number dead node in existing method and our method for leach protocol.*

Position of Base Station	Number of dead node in Existing Method for LEACH	Number of dead node in Our method For LEACH	Percentage increase live node
BS in (150m, 50m)	40	18	45 %
BS in (175m, 50m)	58	28	48 %

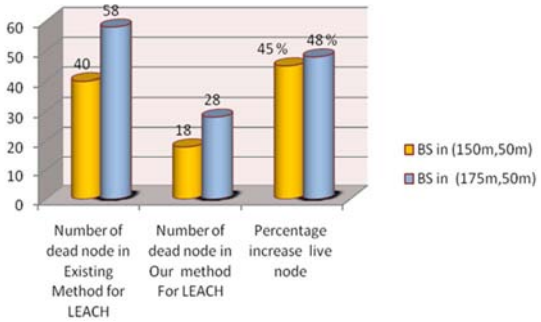

Figure 13. *Number node dead in each approach for each position BS.*

7. Conclusion and Perspective

In this paper we introduce wireless sensor networks routing algorithms using cluster based approach and we have proposed and detailed our new improvement method of clustering based on existing method LEACH protocols to minimize energy consumption in wireless sensor network, the simulation results show that our approach ensures the low energy consumption and improves the network lifetime, so we have succeeded to maximizing the lifetime of networks up to 45% compared to existing method studied in this paper.

As perspective this work can be used in different directions in our future works to propose a protocol with better consumption of energy and increase more the lifetime of Wireless Sensor Network.

References

[1] G. Arumugam, T. Ponnuchamy, (2015), ”EE-LEACH: development of energy-efficient LEACH Protocol for data gathering in WSN”, EURASIP Journal on Wireless Communications and Networking 2015:76, DOI 10.1186/s13638-015-0306-5.

[2] Hassan Oudani,Salahddine Krit,Lahoucine Elmaimouni and Jalal Laassiri, (2016, September)”Comparative Study and Simulation of Flat and Hierarchical Routing Protocols for Wireless Sensor Network”, International Conference In Engineering & MIS (ICEMIS), IEEE, (pp. 1-9).

[3] J. Jia, J. Chen, G. Chang, Y. Wen and J. Song, “Multi-objective optimization for coverage control in wireless sensor network with adjustable sensing radius”, Elsevier, Computers and Mathematics with Applications, vol. 57, (2009), pp. 1767-1775.

[4] T. Qiu, F. Xia, L. Feng, G. Wu and B. Jin, “Queueing theory-based path delay analysis of wireless sensor networks”, Advances in Electrical and Computer Engineering (AECE), vol. 11, no. 2, (2011).

[5] X. Zhang, X. Ding, S. Lu and G. Chen, “Principles for Energy-Efficient Topology Control in Wireless Sensor Networks”, WiCom '09. 5th International Conference on Wireless Communications, Networking and Mobile Computing, IEEE, (2009) September 24-26.

[6] Jong-Shin Chen.“Efficient Cluster Head Selection Methods for Wireless Sensor Networks”. Journal of Networks, Vol.5, No.8, AUGUST 2010.

[7] C. Li, H. Zhang, B. Hao and J. Li, “A Survey on Routing Protocols for Large-Scale Wireless Sensor Networks,” Sensors, Vol. 11, No. 4, 2011, pp. 3498-3526.

[8] Al-Karaki, J. N. and Kamal, A. E., “Routing Techniques in Wireless Sensor Networks: A Survey,” IEEE Wireless Communications, Vol. 11, pp. 6_28 (2004).

[9] E. Royer, and C. Toh, “A Review of Current Routing Protocols for ad hoc Mobile Wireless Networks”, IEEE Personal Communication, Vol. 6, pp. 46_55 (1999).

[10] Wafaa Ibrihich, Krit Salah-ddine, Jalal Laassiri, and Said El Hajji, "Recent Advances of Hierarchical Routing Protocols for AdHoc and Wireless Sensor Networks: A Literature Survey*" International Journal of Informatics Technologies- Ijit, Vol.:9, issue: 2, May 2016.

[11] Hetal Rana, Sangeeta Vhatkar, Mohommad Atique, "Comparative Study of PEGASIS Protocols in Wireless Sensor Network", IOSR Journal of Computer Engineering (IOSR-JCE) e-ISSN: 2278-0661, pISSN: 2278-8727, Volume 16, Issue 5, Ver. I (Sep – Oct. 2014), PP 25-30.

[12] Mahnaz Esmaeeli, Seyed Ali Hosseini Ghahroudi, "Improving Energy Efficiency using a new Game Theory Algorithm for Wireless Sensor Networks", International Journal of Computer Applications (0975 – 8887) Volume 136 – No.12, February 2016.

[13] Y. Wang, C. Hsiao Tsai and H. Mao, "HMRP: Hierarchy-Based Multipath Routing Protocol for Wireless Sensor Networks', Tamkang Journal of Science and Engineering, Vol. 9, No 3, pp. 255-264 (2006).

[14] Y-F Chen, X-G Fan, B Xu, Cluster head optimization strategy for WSN based on LEACH. Comput Eng. 22, 026 (2011).

[15] D Guo, L Xu, LEACH Clustering Routing Protocol for WSN, in Proceedings of the International Conference on Information Engineering and Applications (IEA).

[16] Kanishka Raheja, Sunil Kr Maakar, "A. Survey on Different Hybrid Routing Protocols of MANET ",(IJCSIT) International Journal of Computer Science and Information Technologies, 5512-5516, Vol. 5 (4), 2014.

[17] Ali Jorio, Sanaa El Fkihi, Brahim Elbhiri,and Driss Aboutajdine1 "An Energy-Efficient Clustering Routing Algorithm Based on Geographic Position and Residual Energy for Wireless Sensor Network ", Journal of Computer Networks and Communications Volume 2015, Article ID 170138, 11 pages http://dx.doi.org/10.1155/2015/170138.

[18] P. T. V. Bhuvaneswari and V. Vaidehi, "Enhancement techniques incorporated in LEACH- a survey", Indian Journal of Science and Technology, Vol.2 No 5 (May 2009).

[19] Nisha yadav, Sunil Kumar Yadav, Implementation of Wire Sensor Network using MATLAB Simulator.

[20] Madhupreetha L. Rajaram, Elias Kougianos, Saraju P. Mohanty, and Uma Choppali," Wireless Sensor Network Simulation Frameworks: A. Tutorial Review", IEEE Consumer Electronics Magazine, April 2016.

[21] Mourad Hadjila,Hervé Guyennet,Mohammed Feham," A. Chain-Based Routing Protocol to Maximize the Lifetime of Wireless Sensor Networks", Wireless Sensor Network, 2013, 5, 116-120, http://dx.doi.org/10.4236/wsn.2013.55014.

[22] Gopi Saminathan Arumugam1 and Thirumurugan Ponnuchamy2," development of energy-efficient LEACH Protocol for data gathering in WSN Arumugam and Ponnuchamy EURASIP Journal on Wireless Communications and Networking (2015) 2015:76 DOI 10.1186/s13638-015-0306-5.

[23] Mustapha Kabrane, Lahoucine Elmaimouni, Salahddine Krit, and Jalal Laassiri.(2016, September). Urban mobility in smart cities using low-cost and energy-saving wireless sensor networks. In International Conference In Engineering & MIS (ICEMIS), *(pp. 1-7)*. IEEE.

[24] M. Kabrane, S. Krit, K. Bendaoud, M. Elasikri, H. Oudani, H. El Bousty, K. Karimi and L. Elmaimouni "Smart Cities: Energy Consumption in Wireless Sensor Networks for Road Traffic Modeling Using Simulator SUMO" International Conference on Engineering &MIS 2017 (ICEMIS2017 submission 50), 08-10 May, Monastir 2017, Tunisia.