International Journal of Computing and Digital Systems
ISSN (2210-142X)
Int. J. Com. Dig. Sys. 6, No.1 (Jan-2017)
http://dx.doi.org/10.12785/ijcds/060101

Balanced Energy Efficient Grid Based Clustering Protocol for Wireless Sensor Networks

Asmaa Amer[1], Abd Elwahab Fawzy[2], Mona Shokair[3], Waleed Saad[4], Said El-Halafawy[5]and Ahemd Elkorany[6]

[1,2,3,4 5,6]*Department of Electronics and Electrical Communications, Faculty of Electronic Engineering, Menoufia University, Menouf, Egypt.*

Received 21 Jun. 2016, Revised 8 Sep. 2016, Accepted 1 Nov. 2016, Published 1 Jan. 2017

Abstract: Due to the limited power of sensor nodes of Wireless Sensor Networks (WSN), routing in WSN becomes a hot topic for researchers to provide us several routing protocols for achieving minimum usage of power. Cluster size has a great effect on saving energy and enhancing the network lifetime in Cluster-Based Routing Protocols (CBRP). Energy consumption is increased either when the cluster is very large or very small. Therefore, optimum cluster size must be determined to enhance the Cluster-Based Routing Protocols performance. In this paper, authors will provide a mathematical analysis to calculate the optimum cluster size which is not clarified until now. On the basis of optimum cluster size, Balanced Energy Efficient Grid based Clustering protocol (BEEG) will be introduced. MATLAB will be used for evaluating the performance of our protocol. Simulation results show that proposed BEEG enhances the network lifetime and throughput more than other protocols such as LEACH, DCHS, K-LEACH, MOD-LEACH and Energy-LEACH.

Keywords: Wireless Sensor Networks, Grid based clustering protocols, optimum cluster size, BEEG.

1. INTRODUCTION

Huge progress in Micro-Electro-Mechanical Systems (MEMS) technology allows an unionized structure which is comprised an enormous number of wireless sensor nodes and the base station. This structure is called WSN [1]. It is Tel-monitoring network which has several applications such as battlefield surveillance, patient monitoring, temperature calculation, and fire exposure and flood detection [2]. Efficient energy consumption of limited battery capacity of the sensor node is the main future trend in WSN. Routing protocols play a vital role in energy saving. In fact, efficient, secure and reliable routing protocol is a hot topic in WSN for researchers and scientists. The routing algorithms are classified into three main types: Direct transmission technique, Multi-hop transmission technique and clustering based algorithms [3]. In Direct Transmission (DT), Sensor nodes used single hop transmission to send the generated sensed data to BS. As power loss is related to distance, DT is efficient for small coverage area network, but in large area networks, farthest nodes from BS depleted their energy very quickly causing not monitored area. That phenomenon is called energy hole problem. In Minimum Transmission Energy routing (MTE), sensors used the multi-hop transmission to send the generated sensed data from the sensor nodes to BS. The minimum transmission energy route was selected for data flow. Sensors near the BS worked as relays for far sensors, so they depleted their energy faster than far nodes causing energy hole problem. When an energy hole problem in DT and MTE appears, some regions of the network will not be communicated with the BS..Therefore, the sensing process of the field will not be good overall networks lifetime [4]

E-mail address: asmaaamer2015@el-eng.menofia.edu.eg, abdelwabfawzy@el-eng.menofia.edu.eg, mona.sabry@el-eng.menofia.edu.eg, waleed.saad@el-eng.menofia.edu.eg, elhalafawysaid@yahoo.com and elkoranyahmed@yahoo.com

Clustering in [5] had been considered one of most efficient manner for reducing the energy consumption of sensor nodes. The benefits of using clustering are as follows:

 saving energy by performing data compression at cluster heads.

 Cluster heads collect data from one hop neighbors, therefore reducing global communication into local communication.

 Reducing multi-hop, which gives rise to more energy consumption.

Clustering based routing protocols have two types: dynamic clustering in which clusters are combined and diminished dynamically and static clustering in which cluster are formed at the beginning of network operation and remain constant over network lifetime. Static clustering is better than dynamic due to no overhead owing cluster formation in each round. In these protocols, Cluster size plays a vital role in reducing energy consumption through the network. whilst the cluster size is extremely large; most of the sensor nodes should transmit their data very far and drain their energy quickly. On another hand small cluster size will reduce energy saving owing to data compression and the network may require a number of cluster more than an optimum number of cluster. Therefore there is a trade-off in obtaining the optimal cluster size which achieves the least amount of transmission. In this paper, authors make mathematical analysis between direct transmission and multihop transmission to obtain threshold cluster size bound which allows least amount of energy for data transmission while more node are going to sleep mode, Therefore, Considerable energy provision can be obtained and propose Balanced Energy Efficient Grid based Clustering protocol (BEEG) Which depends on the optimum cluster size.

Authors are focusing on three enhancement network lifetime, load balancing and energy efficiency. The distinctive features of BEEG are:

 In each round, equal cluster head number is used.
 Cluster heads are disturbed uniform through the sensing field.
 All clusters are equal in size. Therefore, balanced energy consumption is assumed within each cluster.

 Using multi-hop communication between CHs and sink to avoid direct communication between far cluster heads and sink.

The remainder of this paper is organized as follows: Section II introduces related work. System model will be presented in Section III. The proposed approach will be made in Section IV. Simulation and discussions will be investigated in Section V. Finally, conclusions will be done in Section VI.

II. RELATED WORKS

There are a number of Cluster-Based routing protocols for WSN have been introduced: Low Energy Adaptive Clustering Hierarchy protocol (LEACH) was discussed in [4]. It is considered as parent clustering based routing protocol. The cluster head is chosen based on the desired number of cluster head for the network and the number of the round in which node has not been chosen as a cluster head. The manner of choosing of cluster head appears many drawbacks such as:

- The cluster head is selecting without considering its residual energy. If its energy is low, it will die in short time.
- Non-uniform distribution of CHs is considered over network area. Therefore, unbalanced energy consumption appears.
- Overhead exists due to calculating the threshold and random number for all nodes during cluster head selection at all rounds.

Plentiful research works are done for overcoming these drawbacks. In Energy LEACH [6], the main parameter which decides whether the node will be cluster head or not is the remaining energy of the node. In LEACH-DCHS [7], the ratio between residual energy and initial energy of the node is taken as a part in the probability of selecting cluster head. Therefore, the node with high residual energy has more chance to become CH than a node with low energy node. Thus, LEACH-DCHS prolongs stability period by node energy aware. In Ref. [8], K-LEACH becomes as the same as LEACH. The main difference is that the threshold equation is modified. The optimum number of clusters and the remaining energy of a node is taken as a part of threshold equation. For MOD-LEACH in [9], Cluster size depends on its distance from the BS. Far clusters have a smaller size than near ones, as it consumed larger energy in the transmission process. Grid based clustering protocols are widespread owning to their simplicity and uniform distribution of nodes [10]. In GAF [11], cluster size is done such that allowing any two nodes in adjacent clusters becomes in the same transmission range. In [12, 13], the cluster size is reduced for allowing nodes in diagonal clusters in the same transmission range. The best transmission range in two-dimensional network was done in [14-15] and for one-dimensional network [15].

III. SYSTEM MODEL

For a fair comparison between all the previous protocols, the radio model in [7] will be used. In this model a contention free MAC protocol for both transmission and receiving model is used, therefore interference from simultaneous transmission maybe avoided and neglected. Figure 1 shows system model for transmitting a k-bit message from the transmitter (TX) to the receiver (RX).

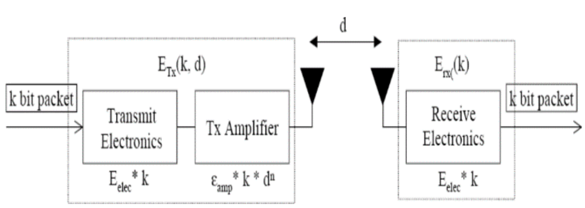

Figure 1. Radio power dissipation model.

The required energy by TX for transmitting a k-bit message a distance (d) is given by [1],

$$E_{Tx}(k,d) = \underbrace{k.E_{elec}}_{\substack{Dissipated\ power \\ in\ electronic\ circuit}} + \underbrace{k.E_{amp}.d^{p}}_{\substack{dissipated \\ energy\ in\ the\ amplifier}} \quad E_{Tx}(k,d)$$
$$= \begin{cases} \underbrace{k.E_{elec}}_{\substack{Dissipated\ power \\ in\ electronic\ circuit}} + \underbrace{k.\varepsilon_{fs}\ .d^{2}}_{\substack{Free\ space\ dissipated \\ energy\ in\ the\ amplifier}} & , \quad if\ d < do \\ \underbrace{k.E_{elec}}_{\substack{Dissipated\ power \\ in\ electronic\ circuit}} + \underbrace{k.\varepsilon_{amp}\ .d^{4}}_{\substack{Multipath\ dissipated \\ energy\ in\ the\ amplifier}} & , \quad if\ d \geq do \end{cases} \tag{1}$$

where the characteristic distance is $do = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{amp}}}$, E_{amp} amplification energy may be ε_{fs} free space amplification energy or ε_{amp} multi path amplification energy and E_{elec} electronic circuit energy.

The required energy by RX to receive this message is denoted by,

$$E_{Rx}\ (k) = E_{Rx-elec}\ (k) = k\ .E_{elec} \tag{2}$$

If an intermediate node between TX and RX is used for relaying data between them, the intermediate node's radio expends to:

$$E_{Fx}(k,d) = E_{Rx}(k) + E_{Tx}(k,d)$$
$$= \begin{cases} 2 * k * E_{elec} + k * \varepsilon_{fs} * d^{2} & , \quad if\ d \leq do \\ 2 * k * E_{elec} + k * \varepsilon_{amp} * d^{4} & , \quad if\ d > do \end{cases}$$
(3)

when cluster head contains m_i member nodes (where i =1, 2,…, L). The dissipated energy is appeared by CH in accepting cluster members message, aggregation the accepted message and sending the aggregated data to the BS which is given by Eq.(4); where E_{DA} is the data aggregation consumed energy, d_{i-toBS} is the distance between the i^{th} CH node and BS.

$$E_{CH}(i,k,d) = $$
$$\begin{cases} k.E_{elec}.m_i + k.E_{DA}.(m_i+1) + k.E_{elec} + \varepsilon_{fs}\ .k.d^{2}_{i-toBS} \\ \quad ,if\ d_{i-toBS} < do \\ \underbrace{k.E_{elec}.m_i}_{\substack{receiving\ signal\ from \\ member\ nodes}} + \underbrace{k.E_{DA}.(m_i+1)}_{\substack{aggregating\ (m_i+1) \\ signal}} + \underbrace{k.E_{elec} + \varepsilon_{amp}\ .k.d^{4}_{i-toBS}}_{\substack{transmitting\ the\ aggregated \\ signal\ to\ BS}} \\ \quad ,if\ d_{i-toBS} \geq do \end{cases}$$
(4)

IV. PROPOSED APPROACH

It's preferable to use direct transmission not multi-hop transmission inside the cluster. However, direct transmission is more energy efficient than multi-hop transmission below the threshold distance, therefore threshold distance defines the maximum direct distance between the cluster head and the farthest node. The optimum cluster size is designed based on this threshold distance which will be analyzed in the following:

A-Deduction of Threshold Distance

Figure 2 displays linear network with N sensor nodes mounted along a road from source to its cluster head. Linear application likes expressway traffic using the linear network. When a source node wants to send its data to its cluster head. It should specify efficient transmission policy. In this Section, authors make analysis to offer general equation for threshold distance $d_{threshold}$ that is used as a judging metric to specify the efficient transmission manner.

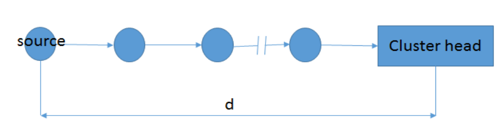

Figure 2. Linear network.

In general, the transmission energy for N-hop is given by,

$$E_{N\_Hop} = E_{MTE} = \underbrace{k.E_{elec} + k.E_{amp}.\left(\frac{d}{N}\right)^p}_{Source\ node\ transmission\ energy} + \underbrace{(N-1)(2.(k.E_{elec}) + k.E_{amp}.\left(\frac{d}{N}\right)^p)}_{consumed\ energy\ by\ the\ intermediate\ node} \quad (5)$$

In direct transmission (DT), the transmission energy is denoted by,

$$E_{DT}(k,d) = k.E_{elec} + k.E_{amp}.d^p \quad (6)$$

Direct transmission consumes less energy than multi-hop transmission if:

$$\Delta E = E_{DT} - E_{N-hop} \leq 0 \quad (7)$$

$$\Delta E = k.E_{elec} + k.E_{amp}.d^p - k.E_{elec} - k.E_{amp}.\left(\frac{d}{N}\right)^p - (N-1)(2.(k.E_{elec} + k.E_{amp}.\left(\frac{d}{N}\right)^p)$$

$$\Delta E = k.E_{amp}.d^p - N.k.E_{amp}.\left(\frac{d}{N}\right)^p - 2.(N-1)(k.E_{elec}) \leq 0$$

1-If $d < d_0$ then $\frac{d}{N} < d_0$ and $E_{amp} = \varepsilon_{fs}$

$$\Delta E = k.\varepsilon_{fs}.d^2 - N.k.\varepsilon_{fs}.\left(\frac{d}{N}\right)^2 - 2.(N-1)(k.E_{elec}) \leq 0$$

$$d \leq \sqrt{\left(\frac{2.(N-1).E_{elec}}{\left(1-\frac{1}{N}\right).\varepsilon_{fs}}\right)} \quad (8)$$

2- If $d_0 < d < 2.d_0$ then $\frac{d}{N} < d_0$ and $E_{amp} = \varepsilon_{amp}$.

$$\Delta E = k.\varepsilon_{amp}.d^4 - k.\varepsilon_{fs}\left(\frac{d^2}{N}\right) - 2.(N-1)(k.E_{elec}) \leq 0$$

$$d \leq \sqrt{\left(\frac{\frac{\varepsilon_{fs}}{N} \pm \left(\sqrt{\left(\left(\frac{\varepsilon_{fs}}{N}\right)\right)^2 + 8.(N-1).\varepsilon_{amp}}\right)}{2.\varepsilon_{amp}}\right)} \quad (9)$$

3-if $d > 2.d_0$ and $\frac{d}{N} > d_0$ then $E_{amp} = \varepsilon_{amp}$.

$$\Delta E = k.\varepsilon_{amp}.d^4 - k.\varepsilon_{amp}\left(\frac{d^4}{N^3}\right) - 2.(N-1)(k.E_{elec}) \leq 0$$

$$d \leq \sqrt[4]{\frac{2.(N-1).E_{elec}}{\left(1-\frac{1}{N^3}\right)\varepsilon_{amp}}} \quad (10)$$

From the previous analysis

Direct transmission consumes less energy than 2-hop transmission if:

$$D \leq \begin{cases} 2 * \sqrt{\left(\frac{A}{2.B}\right)} & , d \leq d_0 \\ \sqrt{\left(\frac{B \pm \left(\sqrt{B^2+8.C}\right)}{2.C}\right)} & , d_0 < d \leq 2 * d_0 \\ 2 * \sqrt[4]{\frac{A}{7 * C}} & d \geq 2 * d_0 \end{cases}$$

(11)

Where $A = E_{elec}$, $B = \frac{\varepsilon_{fs}}{2}$, $C = \varepsilon_{amp}$. Therefore, maximum direct distance $d_{threshold}$ that will be used in the cluster can be given by,

$$d_{threshold} = \begin{cases} 2 * \sqrt{\left(\frac{A}{2.B}\right)} & , \quad d_{threshold} \leq d_0 \\ \sqrt{\left(\frac{B \pm \left(\sqrt{B^2+8.C}\right)}{2.C}\right)} & , d_0 < d_{threshold} \leq 2.d_0 \\ 2 * \sqrt[4]{\frac{A}{7 * C}} & , \quad d_{threshold} > 2.d_0 \end{cases}$$

(12)

Authors can define the threshold distance as the upper allowable distance within the cluster itself; Therefore, the optimum cluster size is a size in which the distance between two possible far nodes in the same cluster is smaller than the threshold distance. According to the network design, the cluster shape may be square or circle or hexagonal based on the shape, the area and side are calculated according to the threshold distance. In our protocol, we assume cluster shape is square. Therefore, its area should be $\leq \left(\frac{1}{2}\right) \ d_{threshold}{}^2$ and its side $\leq \sqrt{d_{threshold}{}^2/_2}$.

B-Energy Efficient Routing Protocol:

Let us assume WSN is deployed in [X, Y] area with N nodes. The network designer calculates the threshold distance which is depended on the sensor node design parameter ($E_{elec}, \varepsilon_{amp}, \varepsilon_{fs}$) according to equation (12). Hence the optimum cluster size is known. optimum number of cluster is determined by dividing the field area by the optimum size of cluster. These clusters are uniformly distributed over the field like a grid and sensor nodes are equal and random distributed in each cluster as shown in figure.4.

Authors can introduce proposed protocol by the following steps:

Step 1*:* as soon as the nodes are deployed, they use CSMA/CA for sending a hello packet to BS which contains the location of the node and the residual energy. Figure. 3 shows the format of hello packet.

Step 2: BS selects only one cluster head for each cluster, which has the maximum residual energy.

Step 3: BS transmits the packet to each cluster head, which contains the following field: source ID, destination ID, MAC address of all its cluster members and the neighboring cluster heads.

Step 4: Each cluster head sends a message which contains source ID, destination ID, and cluster number to all its cluster members. CH uses Time Division Multiple Access (TDMA) in communication with cluster members when it receives messages from all nodes that should join to the cluster. It creates TDMA frame depending on the number of sensor nodes. Then it informs each node when to send data.

Step 5: Each cluster member sends its data and its residual energy to its cluster head.

Step 6: Cluster head processes and aggregates the received data and forwards it to sink.

Step 7: Each cluster head compares the residual energy of all its cluster member and chooses the cluster member has the maximum residual energy for being cluster head in the next round and informs the BS which node will be cluster head in the next round.

From Step 3 and Step 7 are done until the all nodes are dead.

The flow chart of our protocol is shown in Figure5.

Node ID	Node x position	Node y position	Energy level

Figure 3. format of a hello packet.

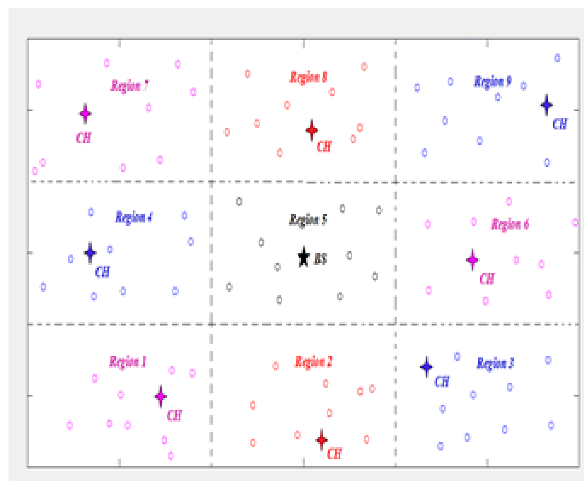

Figure 4. Network configuration.

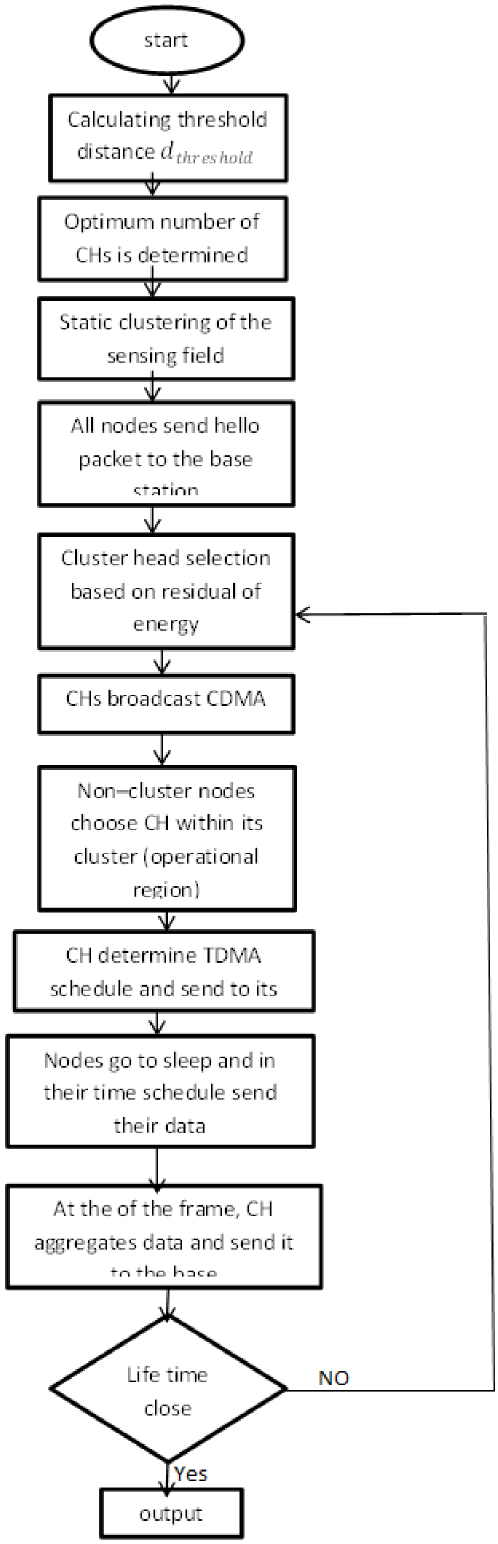

Figure 5. BEEG flow chart.

V. SIMULATIONS AND DISCUSSIONS

A- Network model

The following assumptions are fixed for all previous protocols and our approach:

1. The sink is unlimited resource device and is located on the border of the network.
2. As soon as the sensor nodes are randomly deployed, its location is maintained fixed.
3. All sensors nodes know its location using GPS or any other location determination device.
4. All sensor nodes are proactive (sense data periodically).
5. Close sensors have correlated data.
6. The symmetric communication channel (i.e. the energy cost for sending data between two nodes is the same for both directions).

B- Performance Measurements

The following parameters judge the efficiency of the routing protocol:

First Dead Node (FDN): The round at which the first node drains its battery. It is also called Stability period.

Half Dead Node (HDN): The round at which half of the nodes drain their batteries.

Last Dead Node (LDN): The round at which all nodes drain their batteries.

Network lifetime: the time period between the beginning of the network work and the last node death round.

Stability Period: the time period between the start of network operation till the first node death round.

Instability Period: The time interval between the FDN and LDN.

Number of CHs per round: the number of nodes per round, which will aggregate the sensed information from near nodes, then sent it to the BS directly.

Throughput: The total amount of data sent over the network. This includes the packets sent from normal nodes to either their CHs or BS, in addition to packets sent from CHs to the sink.

Average consumed energy: The average consumed energy for each node over network lifetime.

Residual energy: The residual energy of all nodes over the network life time.

c- Simulation Results

The proposed protocol is experimented extensively using MATLAB programs. Our simulation will use 90 sensor nodes with 0.5J initial energy, deployed randomly within a 225x225 m^2 sensor field. The length of message is 4000 bits. The parameters that are used in our simulation are shown in Table 1. There are two scenarios for suggested protocol are taken:

1-BS location becomes at center [112.5, 112.5].

2-BS location is at corner [225,225].

TABLE 1 SIMULATION PARAMETERS.

Parameters	***Values***
Network field	*(225,225)*
Number of nodes	*90*
Message Size	*4000 bits*
Do (threshold distance)	*87,7 m*
Initial energy of nodes E	*0.5 J*
Energy for data aggregation E_{DA}	*5 nJ/bit/signal*
Transmitting and receiving energy E_{elec}	*5 nJ/bit*
Free space amplification energy ε_{fs}	*10 PJ/bit/m2*
Multipath amplification energy for ε_{amp}	*0.013 PJ/bit/m4*

1-Network lifetime:

Figures 6 and 12 display the network lifetime, stability and instability period for LEACH [4], K-LEACH [8], DCHS [7], Energy-LEACH [6], MOD-LEACH [9] and BEEG, respectively for sink location at center and sink location at corner. Figure 7 and figure 13 show the FDN, HDN and LDN measures for sink location at center and sink location at corner. From the simulation results, our proposed protocol enhances the stability period and network life time as compared to LEACH, K-LEACH, DCHS, Energy-LEACH and MOD-LEACH.

Table 2 shows the percentage of enhancement of our proposed as compared to LEACH, K-LEACH, DCHS, Energy-LEACH, MOD-LEACH. To calculate the percentage of stability enhancement of our proposed protocol, authors use the following law:

$$\text{Stability enhancement } \% = \frac{\text{FDN OF OURPROPOSED} - \text{FDN OF THE PREVIOUS PROTOCOL}}{\text{FDN OF THE PREVIOUS PROTOCOL}} * 100 \qquad (13)$$

The proposed protocol has more stability period than these previous protocols as the sensor nodes able to work properly over longer time . when the sink at the corner, there is no percentage of lifetime enhancement stability. Therefore, table 2 does not contain lifetime enhancement when sink at corner. Furthermore, the remaining energy of all nodes in the network reduces more slowly than other protocols as shown in figure 8 and figure 14.

2-Throughput:

In addition to network lifetime, throughput is a vital metric that is used to judge the efficiency of the routing protocol. Throughput depends on network lifetime in a sense but not always. According to the result in figure 9, the maximum throughput is achieved by BEEG. Uniform distribution of CH over the sensing field and efficient CH selection of these CHs and enhanced network lifetime represent memorable reasons of increasing the throughput.

3-Cluster Head formation:

Figure 10 and figure 16 show the number of Cluster Heads chosen at each round. In LEACH, DCHS, K-LEACH and MOD-LEACH CHs, selection are based on the probability. So fixed numbers of clusters are not guaranteed. In our proposed protocol, the number of CHs is fixed over the network life time.

4- Energy consumption in different areas:

The relation between energy consumption and rounds in different areas in BEEG is shown in figure 17. the energy consumption is balanced over the sensing field.

TABLE 2 PERCENTAGE OF ENHANCEMENT OF OUR PROPOSED PROTOCOL.

Protocol	***Sink at center***		***Sink at corner***
	Stability	***Lifetime***	***Stability***
LEACH	*64.9%*	*46.5%*	*494.5%*
DCHS	*7.2%*	*57.2%*	*336.5%*
K LEACH	*345.4%*	*6.1%*	*2914.2%*
Energy-LEACH	*54.4%*	*108.6%*	*198.8%*
MOD-LEACH	*10.55%*	*41.3%*	*172.8%*

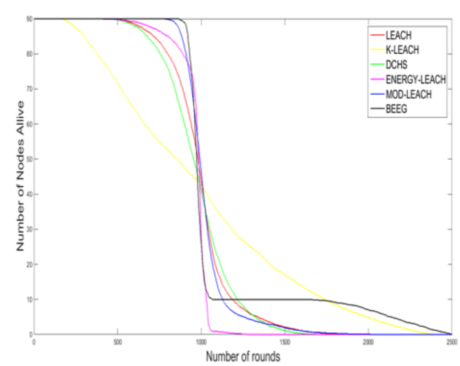

Figure 6. Network lifetime when sink at center.

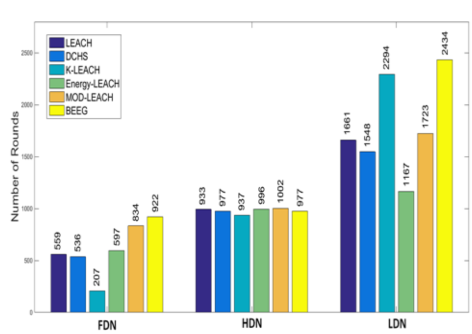

Figure 7. FDN, HDN and LDN when sink at center

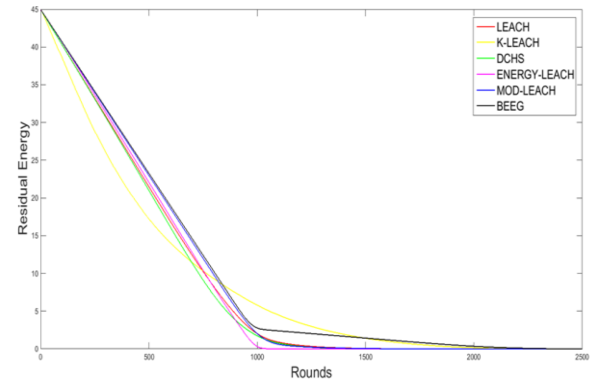

Figure 8 Remaining energy of all sensor nodes when sink at center

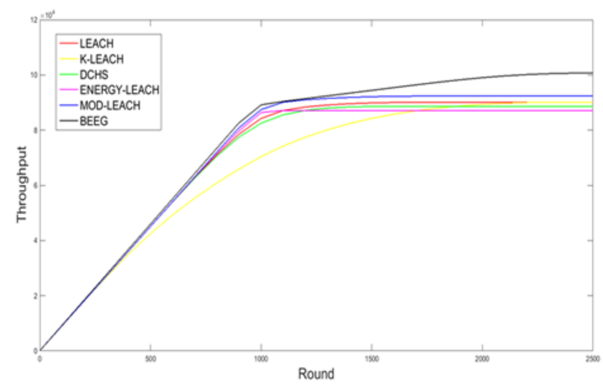

Figure 9. Received packets over round when sink at center.

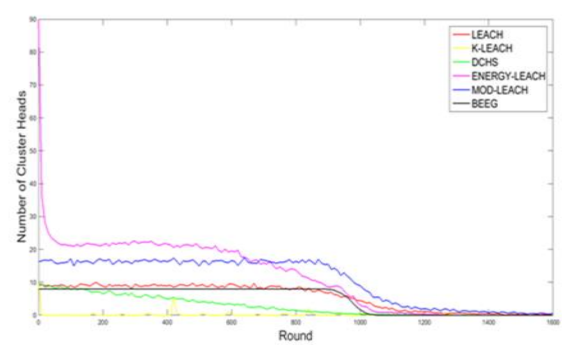

Figure 10. Number of Cluster Head over round when sink at center

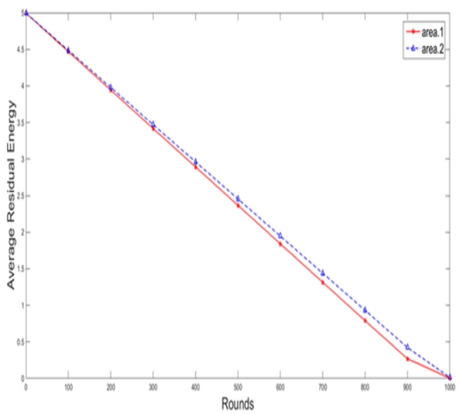

Figure 11. Energy consumption of BEEG in different areas when sink at center.

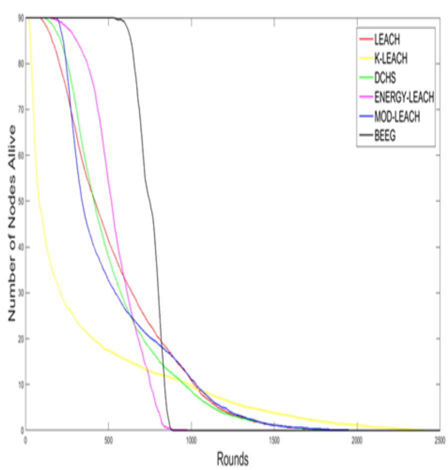

Figure 12. Network lifetime when sink at corner.

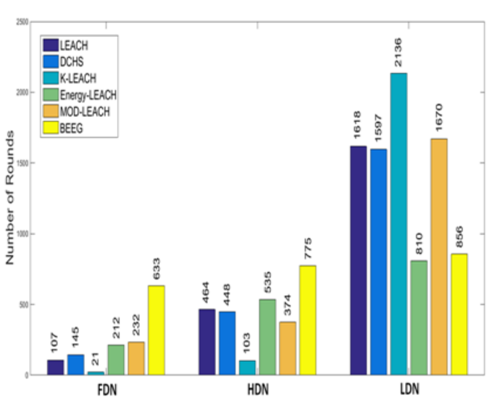

Figure 13. FDN, HDN and LDN when sink at corner.

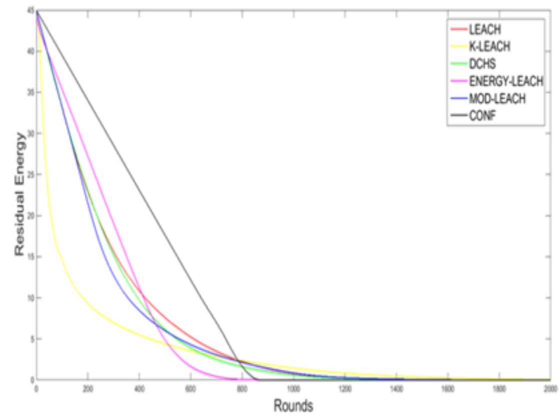

Figure 14. Remaining energy of all sensor nodes when sink at corner.

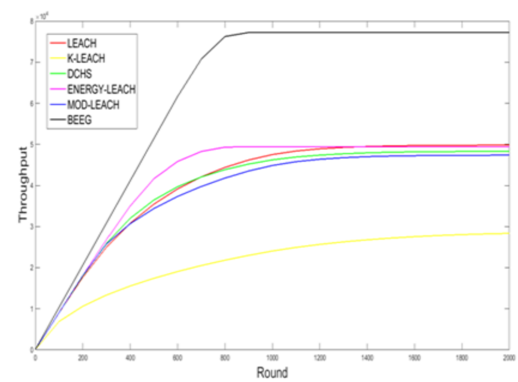

Figure 15. Received packets over rounds when sink at corner.

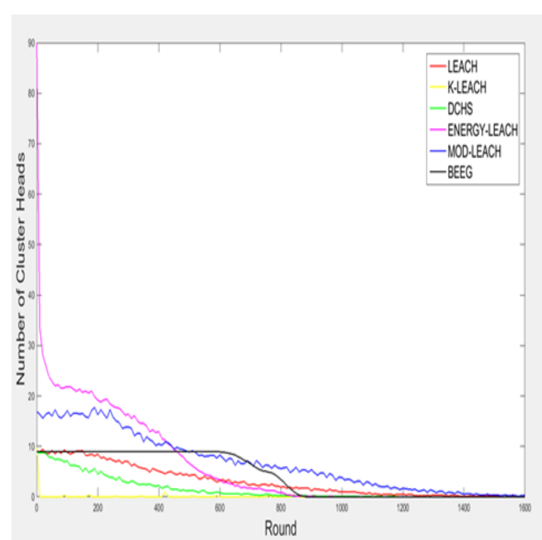

Figure 16. Number of cluster Head over round when the sink at corner.

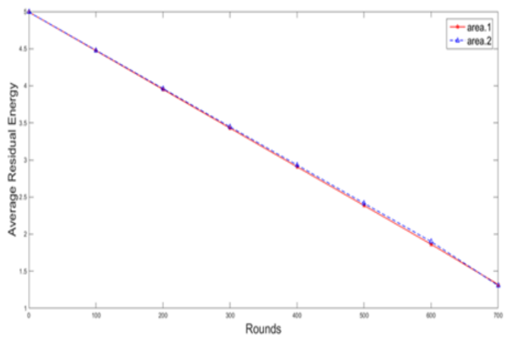

Figure 17 Energy consumption of BEEG in different areas when the sink at corner.

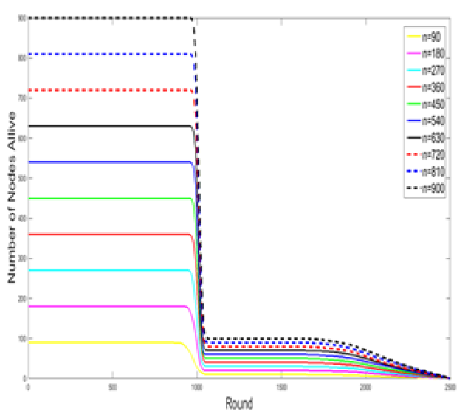

Figure 18 Energy consumption of BEEG in different areas when sink at corner.

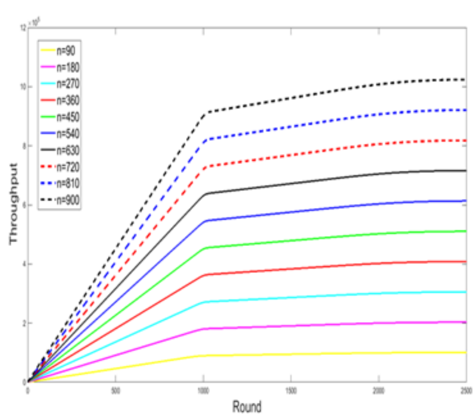

Figure 19 Scalability effect on throughput.

SCALABILITY ANALYSIS

We also analyze the scalability of our protocol by changing the number of total nodes. We compare the number of alive nodes and packets sent per round in each scenario. The simulation results are shown in Figures 18 and 19. Varying the number of nodes can vary the delay of packets reception. Therefore, by increasing the number of nodes, it can increase the delay because if TDMA is used, then most of the nodes must wait for their turn to send the data. This increment in delay is crucial for time critical applications. But, in our case, we have an only considerable number of live nodes and number of packets sent to BS per round. It also can be seen that the changing the number of nodes doesn’t affect the number of live nodes and number of packets sent per round.

CONCLUSIONS

Owning to Cluster size plays a vital role in enhancing the Grid based clustering routing protocol performance. Comprehensive analysis on the maximum allowable cluster size was done and based on this analysis, authors present proposed clustering based routing protocol to enhance the network lifetime and to reduce energy consumption. BEEG avoids far direct transmission which quickly drains the node energy, balances energy consumption over the network due to uniform distribution of cluster heads and cluster head selection based on energy aware of node. Simulation results showed that BEEG has larger network lifetime and energy efficient as compared to other protocols such as LEACH, DCHS, K-LEACH, MOD-LEACH and Energy-LEACH.

FUTURE WORK

Authors want to apply optimum cluster size in dynamic clustering and take the distance from the base as parameter in cluster head selection.

REFERENCES

[1].N. A. Pantazis, S. A. Nikolidakis and D. D. Vergados, "Energy-Efficient Routing Protocols in Wireless Sensor Networks: A Survey," in *IEEE Communications Surveys & Tutorials*, vol. 15, no. 2, pp. 551-591, Second Quarter 2013.

[2]. A. Abbasi and M. Younis, “A survey on clustering algorithms for wireless sensor networks,” Computer Communications, vol. 30, pp. 2826–2841, 2007.

[3] Fawzy A E, Amer A, Shokair M, El-Halafawy S, Waleed S. An Efficient Design of Cluster Size for Maximizing Outcomes of Direct Transmission in Cluster-Based Wireless Sensor Networks. Int. J. of Comp. and Dig. Sys. (IJCDS), vol.5, no.5, Sep. 2016.

[4]. O. Boyinbode, H. Le, A. Mbogho, M. Takizawa, and R. Poliah, “A survey on clustering algorithms for wireless sensor networks,” in Proc. 13th international conference on Network-Based Information Systems, pp. 358-364, 2010.

[5]. W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, “Energy-efficient routing protocols for wireless microsensor networks,” in Proc. 33rd Hawaii Int. Conf. System Sciences (HICSS), Maui, HI, Jan. 2000.

[6]. F. Xiangning and S. Yulin, "Improvement on LEACH Protocol of Wireless Sensor Network," *Sensor Technologies and Applications, 2007. SensorComm 2007. International Conference on*, Valencia, pp. 260-264,2007.

[7]. M. Abo-Zahhad, S. M. Ahmed, N. Sabor and S. Sasaki, "Mobile Sink-Based Adaptive Immune Energy-Efficient Clustering Protocol for Improving the Lifetime and Stability Period of Wireless Sensor Networks," in *IEEE Sensors Journal*, vol. 15, no. 8, pp. 4576-4586, Aug. 2015.

[8]. Parul Bakaraniya, Sheetal Mehta “K-LEACH: An Improved LEACH Protocol for Lifetime Improvement in WSN” International Journal of Engineering Trends and Technology (IJETT), Vol.4,2013.

[9]. M. Saadat, R. Saadat and G. Mirjalily, "Improving threshold assignment for cluster head selection in hierarchical wireless sensor networks," *Telecommunications (IST), 5th International Symposium on*, Tehran, pp. 409-414,2010.

[10]. Y. Zhuang, J. Pan and G. Wu, "Energy-Optimal Grid-Based Clustering in Wireless Microsensor Networks," *Distributed Computing Systems Workshops, 2009. ICDCS Workshops '09. 29th IEEE International Conference on*, Montreal, QC, pp. 96-102,2009.

[11]. Y. Yu, D. Estrin, and R. Govindan, “Geographical and Energy-Aware Routing: A Recursive Data Dissemination Protocol for Wireless Sensor Networks,” UCLA Comp. Sci. Dept. tech. rep., UCLA-CSD TR-010023, May 2001.

[12]. Zehua Zhou, Xiaojing Xang, Xin Wang and Jianping Pan, "An energy-efficient data-dissemination protocol in wireless sensor networks," *International Symposium on a World of Wireless, Mobile and Multimedia Networks(WoWMoM'06)*, pp. 10 -17, 2006..

[13]. Y. Zhuang, J. Pan and G. Wu, "Energy-Optimal Grid-Based Clustering in Wireless Microsensor Networks," *Distributed Computing Systems Workshops, 2009. ICDCS Workshops '09. 29th IEEE International Conference on*, pp. 96-102,2009.

[14]. R. Akl and U. Sawant, "Grid-based Coordinated Routing in Wireless Sensor Networks," *4th IEEE Consumer Communications and Networking Conference*, pp. 860-864,2007.

[15]. R. Vidhyapriya and P. T. Vanathi, “Energy efficient grid-based routing in wireless sensor networks,” International Journal of Intelligent Computing and Cybernetics, vol. 1, no. 2, pp. 301–318, Jan. 2008.

Asmaa Amer received her B.Sc. degree in electronics and electrical communications engineering from Menofia University, Egypt, in 2013. Currently, she is demonstrator at the Department of electronics and electrical communications engineering, Her major research interests include sensor Networks, mobile communications, and network Security.

Abd Elwahab Fawzy received his B.Sc. degree in electronics and electrical communications engineering from Menofia University, Egypt, in 2013. Currently, he is demonstrator at the Department of electronics and electrical communications engineering, His major research interests include sensor Networks, mobile communications, and network Security.

Mona Shokair received the B.E. and M.E. degrees in electronics engineering from El Menofia University, El-Menofia, Egypt, in 1993 and 1997, respectively. She received Ph.D. from Kyushu University, Japan, 2005. She was lecturer in El-Menofia University from 2006 to 2011. Since 2012, she is Associated Professor in El-Menofia University. She received VTS chapter IEEE award from Japan in 2003. Now her current research is in OFDM system, WIMAX system and cognitive radios.

Waleed Saad has received his BSc (Hons), M.Sc. and Ph.D. degrees from the Faculty of Electronic Engineering, Engineering, Menoufia University, Menouf, Egypt, in 2004, 2008 and 2013, respectively. He joined the teaching staff of the Department of Electronics and Electrical Communications of the same faculty since 2014. In 2005 and 2008.

Ahmed S. Elkorany received the B.Sc. degree in electronics and electrical communications (with honor degree) in May 2003 from faculty of electronic engineering, Menoufia University. He is appointed as a Demonstrator in Dec. 2003. In the same department. He received the M.Sc. and the Ph.D. in electrical communications (microwaves and antennas) in 2007 and 2011, respectively, both from the same faculty. Finally in December 2011 he was appointed as a Lecturer also in the same dept. systems, EBG structures and cognitive radio.

Said Elhalafawy received the B.Sc., and M.Sc. degrees in electronics engineering from Menoufia University, Menoufia, Egypt, in 1978, and 1984, respectively and journals.

He received the Ph.D. degree from Plzen, Czech Republic, in 1990. Presently, he is the dean and Professor at faculty of electronic engineering, Menoufia University. He has published several scientific papers in national and international conferences. He has published several scientific papers in national and international conferences and journals. His current research areas of interest include image processing, speech processing, digital communications and electromagnetic applications.