OSCH-LEACH: Optimum Secondary Cluster Head Selection for LEACH Protocol

Saad Hameed Abid*,Ph.D(Lecturer)

Abstract

A wireless sensor network consists of a bundle of sensor nodes which is using for monitoring and recording variety phenomenon's such as pressure, wind direction and speed, home security, machine failure diagnosis and biological detection. When the information collected and be together in an energy efficient manner help the sensor network to operate for long interval. The transmitted data between sensor nodes and Base station is as a result of fusion data in (WSN). And the LEACH (Low Energy Adaptive Clustering Hierarchy) protocol come with solutions for all data collection problems, when the clusters are arranged in self-organized manner, but it still suffering from some downside that can cause fatal problems.

To save the energy and based on the research of LEACH protocol, an optimum secondary cluster head low energy clustering protocol OSCH-LEACH is proposed in this paper. In the new protocol, in any round when the cluster head located in not good place -near the edge of the cluster and far away from many sensors - Cuckoo search algorithm is suggested to find the optimum secondary cluster head that take the role of the primary cluster head for those remote sensors i.e. aggregate data from those remote sensors and send the report to the primary cluster head. The experimental results show that OSCH-LEACH performs better than LEACH protocol. It not only extends the lifetime of the network, but also improves the energy efficiency by increasing the settle down and unsettle down period, number of alive nodes with time, and minimize energy consumption.

Keywords: LEACH protocol, clustering of WSN, optimization algorithms, power consumption of WSN.

*Al-Mansour University College

1. Introduction

A Wireless Sensor Network(WSN) is a network comprising a large number of wirelessly connected heterogeneous sensors which are spatially distributed across an interested field. The typical (WSN)consist of small low cost independent device ,the using and purpose of (WSN)is connection and communication with all other multi-hop wireless communication ,the (WSN)consist of nodes which it in turned contains one sensor embedded processors ,limited memory ,low power radio and it works with battery [1][2].The (WSN) has been widely use in our daily life and application in many areas and locations such as military aspect, pollution control, system, environment monitoring, target tracking, earthquake detection, patient monitoring system and vehicle motion control. The network works depended on monitoring and processing data by using (SN) in specific geographical area and resend it to the other forest location which it called the Base Station (BS)[3], see figure1. Each SN is responsible for sensing a desired event locally and for relaying a remote event sensed by other SNs so that the event is reported to the destination through base station BS. A major technical challenge for WSNs, however, lies in the node energy constraint and its limited computing resources, which may pose a fundamental limit on the network lifetime[4].
Clustering is helped to designing difference energy efficient protocol in Wireless Sensor Nodes (WSN).

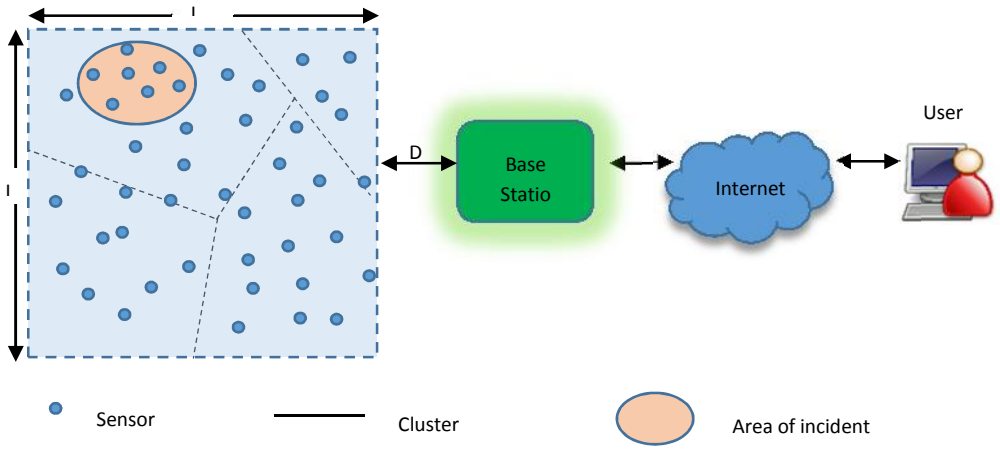

Figure 1. Wireless Sensor Network

LEACH is a well-known clustering protocol but it is still suffering from some unconstructive aspects that we tried to overcome in this research [5]. The rest of the research will arranged as follow: Section 2 gives a brief look of the previous work in the related area. Section 3 shows the LEACH protocol. Section 4 Cuckoo Search Optimization Algorithm. Section 5 take and addresses the destination OSCH-LEACH algorithm. Section 6 presents OSCH-LEACH simulation results. Section 7 shows the conclusion of the proposed work.

2. Related Work

Centralized LEACH (LEACH-C)[6]: The same authors Hienzelman at al., proposed a centralized clustering approach LEACH-C,The clustering of information gets in the Base Station which is is receved information from nodes including it is location and energy level. Then the Base Station colculate the rate of the energies. The nodes with low energy rate will not be selected as CH for the current around. The Base Station boradcasts the nods ID of the CH to all nodes in the internet work when the Base Station selected the CHs for the current round, while the nodes are not selected by Base Station joint with the nearest CH. LEACH-C has the scalability problem because of this centralized architecture[7].

Threshold sensitive Energy Efficient sensor Network (TEEN): Manjeshwar and Agrawal[8] proposed TEEN as multi-hop event-based forwarding protocol which is generated according to a threshold related to sensory data, which is set by the application. TEEN protocol is work to put the sensor node in the highest level of the hierarchy, In this hierarchy build, the data passed first by sensor nodes to the cluster head, when the data passing it is collect aggregate and transmit to a higher level in cluster head to reach Base Station. For the evently distribute. The energy consumption, the cluster head are periodically changed inside the cluster head.

Adaptive Threshold sensitive Energy Efficient sensor Network (APTEEN): The same authors Manjeshwar and Agrawal[9] improved The comperehansive of information happen when APTTN provied TDMA with information in each cluster head ,then each nodes work to transmisson information again to the cluster head . Moreover, When and how the hard thershold and soft thershold valu control send the data, the event-base and monitoring can be the solution. While APTEEN has a complexity of enforces some overhead by implementing the threshold function, the count time, and the practical problem of centralized CH election.

Power-Efficient Gathering in Sensor Information Systems (PEGA-SIS): Lindsy and Ragharvendral [10] proposed (Power -Efficient -Cathering in Sensor

Information System) (PEOA-sis) chain-base-multihop protocol, Which is has two main objects first: confirming the network longevily and uniform energy consumption among the nodes. Second : lessing interception between source and Base Station (B.S)

Concentric Clustering Scheme (CCS): is an extension on PEGASIS proposed by Jung et al.[11],The idea of CCs including improvment the performance and to prolong the lifetime of network by study the location of B.S .The network in CCs divided into levels ,each level has a head of chain and chain which it using agreedy alogarithm when the chain in each levels put up from the farest node in B.S like DEGA sis

CLUBS: Is alogarithm proposed by Nagpal and Goov [12],In CLUBS clusters formed through local broadcast and gether in time suitable for local desting of nodes .

In CLUBS cluster formtion based on three characteristics:

• In network every node must be connected to a cluster.
• The diameter of all cluster should be same in the network.
• The nodes in the cluster must be able to communication and connect with each other which it is knows as intra-cluster communication.

3. Low Energy Adaptive Clustering Hierarchy (LEACH):

In LEACH protocol the clustering is a daptive and self-origanized, which it work to make equally distribution of energy load among the sensor nods in the WSN, The operation of LEACH divides into rounds, inturn each round is divided into tow phases: setup phase and steady -state phase, The comparaion between set-up and steady-state phases is always long to decrases overhead. A local cluster is a result when the sensor nodes arrange and origanized themself in LEACH protocol. Cluster head called when one node acting as a leader, While other nodes stay as ordinary nodes. The high-energy cluster head has a random rotation in the LEACH protocol. And local data fusion to transmit a mount of data from cluster head to the base station. And that will effect to prolong the life-time of the network. The energy of cluster head effected if the space between cluster head and base station is far and the communication of cluster head with base station will be directly. The cluster setting is different for different time interval because it is depend on the amount of energy that left in the sensor node[13].

According to energy model, when sending m bit data over a distance d, the total energy consumed by a node is given by:

$$E_{Tx}(m,d) = E_{elec} * m + £_{amp} * m \quad (1)$$

$$E_{Rx}(m) = E_{elec} * m \quad (2)$$

Where $E_{Tx}(m,d)$ is the energy consumption of transmitter, and $E_{Rx}(m)$ is the energy consumption of receiver. E_{elec} is the energy consumption of electronics per bit in the transmitter and receiver sensor nodes. ε_{amp} is the energy consumption of amplifier in transmitter sensor nodes, which can be calculated by:

$$£_{amp} = \begin{cases} \varepsilon_{fs} * d^2 & when\ d < d_0 \\ \varepsilon_{mp} * d^4 & when\ d \geq d_0 \end{cases} \quad (3)$$

Where d_0 is the threshold distance, if the distance between the transmitter and receiver is less than a threshold d_0, $£_{fs}$ is the free space communication energy parameter is used, otherwise, the multipath $£_{mp}$ model will be applied[1].

The rotation will be when each node fletches to select a random number "T" between 0 and 1. In this threshold a node fletches a CH for the current rotation performed in the following threshold:

$$T(n) = \begin{cases} \frac{p}{1-p*\left(r \bmod \frac{1}{p}\right)} & if\ n \in G \\ 0 & otherwise \end{cases} \quad (4)$$

In the sensor population p is the required perecent of the CH, where r refers to the current round number .And G is the band nodes without CH in the last $1/p$ .Creating and mainpulating aTDMA schudule ,And sending aband of data from nodes to the B.S explained under CH responsibility and data need to using CDMA cluster number for the remmaining nodes . This protocol is divided in to rounds, each round consist of set-up phase and steady-state phase:

Set-up phase

The node has a decision to be independent wheather it become a CH or not. And the node elected as CH for the last time has a less chance, to take this decision in other mean (The node has not been

served as CH for long time has the right to elect itself than node that take it chance to be a CH last time). When an advertisement packet reach to the CH. It is work to unform their neighborhood about it ,while the advertisem pocket with the strong recived signal strength pick by non-CH nodes . After that, member nodes inform the CH that they become a member to that cluster with "join packet" contains their IDs. After the cluster-setup sub phase, the CH knows the number of member nodes and their IDs. Based on all messages received within the cluster, the CH creates and broadcast the TDMA schedule to cluster members, so that each regular node goes to sleep except in its time slot. TDMA protocol can be used also to avoid collisions. After that steady-state phase begins[13].

Steady-State Phase :

The transmission of data, when nodes send data, through their allocated TDMA slot and it use least amount of energy during transmission of data from nodes to the CH (Chosen- base on the recived strenghth of the CH advertisement. Also a minimum of energy is west in the nodes, when nodes allocated TDMA slot, the radio of each non-CH node can be stop. Then the CH received data and aggrerate it to resend for the BS[2][13].

4. Inspired Cuckoo Search (CS)

The idea of cuckoo search (CS)is taken from the parasitism of cuckoo bird species .These birds has the ability to producing quickly, and then leave eggs and the nest for the other coming birds ,the new host birds have a aggressively behave ,When it through the odd eggs upon discovering an intrusion ,while other birds chosen to leave and build a new nest[14] .In 2009 Xin-She Yang and Suash Den metaphor the idea of cuckoo eggs .In the following ,They represent each egg in the nest as solution ,And replace not so good solution with better solution was the aim to give a simple picture ,Each nest has one egg , But this idea in algorithm become complex which the nest has more than one egg to represent a set of solution (Cs) is based on the three following rules :

1)Each bird lays one egg in the same time this egg takes a place among other host birds randomly.

2)The egg get carried over to the nest generation when the nest represented by a highest fitness value.
3)The nest of the host birds has a fixed number.
And the host birds nest probability stands on fixed value of *pa* ∈ [0, 1] which means the host birds either leave the nest and build a new nest elsewhere or through the egg away. In the new solution generation, the random -walk is best perform made in using levy flights. The levy flight of cuckoo i is performed:

$$xi^{(t+1)} = xi^{(t)} + \alpha \oplus \text{lévy}\ (\lambda) \quad (5)$$

α > 0 represent size step which can be chosen by the user. And it should be related to the scales of the problem of the interest. And *α* = *O*(1) generality .In the equation for random walk (via L'vey) flight. And the step length is much longer in the long runs. And the result ⊕ refers to the entrywise multiplication mainly random walk provides y the L´evy flight and L´evy distribution provides the random step length[15].

$$\text{Levy} \sim u = t^{-\lambda}\ , (1< \lambda \leq 3) \quad (6)$$

L'evy distribution has an infinity distinction and means, The sequential jump /step of cuckoo mainly from random walk process with power-low step. Length distribution with heavy tail. The Cs has ability to find the success with high rate and universal optima.[16][17].

5. Proposed Optimum Secondary Cluster Head-LEACH Selection (OSCH-LEACH)

In spite of LEACH simplicity and even distribution of CH role, LEACH still suffering from some unconstructive aspects like:

- Many cluster heads can be located near the edges of the network.
- Adjacent nodes can become cluster heads.
- CH failure can cause some serious problems.

As shown in Figure 2 these features can cause high energy consumption since nodes have to transmit data over long distances to reach the cluster head. However, for a given round (r), if a cluster head is elected for a given round positioned in a suitable location, and there is no guarantee that in round (r+1) the cluster head will position in another good

location. This will not lead to minimum energy consumption during data transfer for all rounds [13].

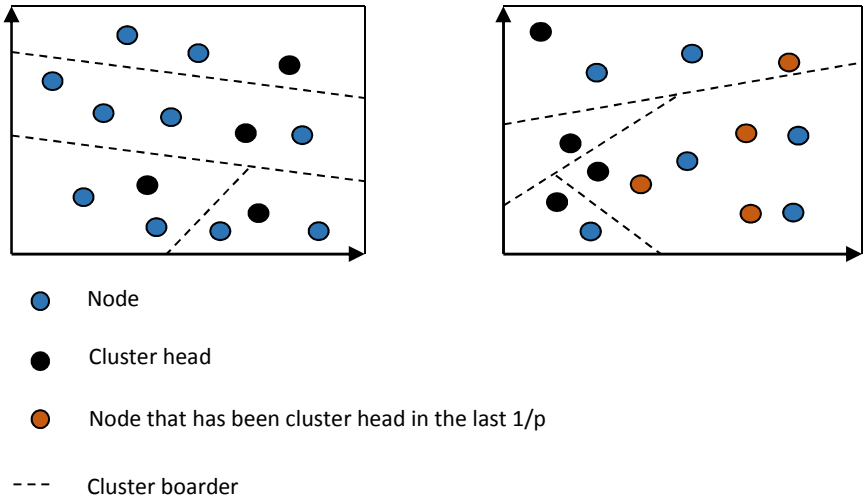

Figure 2 Cluster head position in two successive rounds

To overcome these problems, when a node announced itself as a CH, a number of sensors receive the signal and send a request to join the cluster, the CH receives the join request with their location (either by using GPS or using localization), if the distance between the elected CH and a certain percentage of cluster members (*Per_d)* is greater than a certain distance threshold (*Dist_th*), the cluster head announced itself as a primary cluster head (*P_ch*), and send a request of a secondary cluster head for those remote sensors. The proposition os using cuckoo search optimization algorithm come to search and located the optimum sensor (with high residual energy and located in suitable position) from *G* to act as a secondary cluster head (*S_ch*) for the remote sensors. The optimum sensor will announce itself as a *S_ch*, as soon as the *P_ch* receive the *S_ch* announcement it sends a copy of TDMA schedule that *S_ch* will depend to receive her member reports, according to this TDMA the *S_ch* begins its duty of receiving its member data, aggregate the data and send a single report to the *P_ch*. By using this technique *P_ch* don't need to communicate with all remote sensors and loos its energy as well as the remote sensors don't need to send data for long distance to the remote

cluster head, this will preserve the precious energy of all sensors and prolong the WSN lifetime.

For the current round, if the *P_ch* loos its energy and couldn't accomplish its mission the *S_ch* will take all its responsibilities, communicate with the Base station (BS) and complete the dead *P_ch* mission, see figure 3.

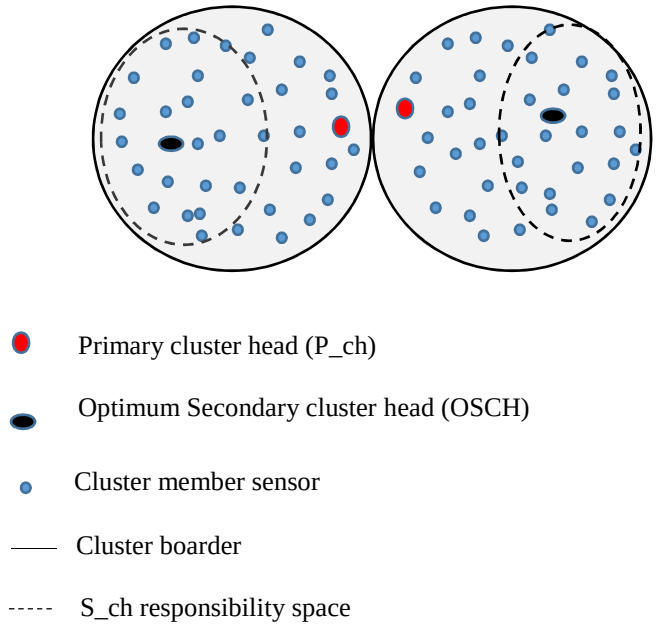

Figure 3 Optimum Secondary Cluster Head of LEACH protocol

5.1 OSCH-LEACH Algorithm Fitness Function

The goal of proposed algorithm fitness function goal is to low the power exhaustion in the sensor (s_i) in both transmitting a data packet to other cluster member that are in *S_ch* responsibility space, and to the primary cluster head *P_ch*, the fitness function given by:

$$F_1 = ETx * Packet_{length} + Efs * dist * packet_{length} \quad (7)$$

$$F_2 = \begin{cases} ETx * Packet_{length} + Efs * dist_1^2 * packet & if\ dist_1 < d_0 \\ ETx * Packet_{length} + E_{mp} * dist_1^4 * packet & if\ dist_1 \geq d_0 \end{cases} \quad (8)$$

$$F = F_1 + F_2 \quad (9)$$

Where *dist* refers to the distance (remote sensors, s_i), and $dist_1$ refers to the distance (s_i, Cluster head).

Therefore, the distance and energy is tow related parameters which the fitness function compound from it and as a result, the total communication power is decreased when minimizing this function causing WSN lifetime prolonging.

5.2 Optimum Secondary Cluster Head-LEACH (O*SCH-LEACH*) Selection algorithm

In this section Cuckoo Search Optimization algorithm (CSO) is used to find (Optimum Secondary Cluster Head) (OSCH) of (LEACH) protocol in WSN. Input and output are tow parameters where the input represents the set of all sensor in the cluster that lies far away from the clusters. And output refers to the sensor with least power exhaustions on data transmission from sensor to the CH.

Algorithm *Optimum Secondary Cluster Head for LEACH (OSCH-LEACH)*
Input : *S1* = {s_1, s_2, …, s_n}, n is the number of remote sensors in the cluster
Output: Optimum secondary cluster head node

Begin

1. Generate a host nest *xi* (i=1, 2, 3, ,n) ;
2. Repeat

Get a sensor randomly (say k);
Evaluate its quality/ fitness F_k;
Choose a sensor among n (say k1) randomly;
If ($F_k < F_{k1}$),
Substitute by the new solution (sensor);

end
Replace a fraction (pa) of worse sensors by new sensors;
Keep the best solution;
Rank the solutions and store the present best solution an array *best_ch*

Until stop criterion true
endfor

3. Rank the array *best_ch* and return the best sensor (minimum power consumption)
4. End

6. Optimum Secondary Cluster Head-LEACH (OSCH-LEACH) Simulation

Matlab using simulate proposed algorithm with regular and consider in using the same simulation parameters in LEACH clustering protocol comparison the assumption of the network model is based on the following points:

1. The base station take the center place in the sqared regionand N sensor are vanished within field of interest A=M*M randomly .
2. Each sensor node using one localization service to recognized position.
3. Through each node can be detect the location of base station. the B.S and sensor are stationary, while each sensor can directly connect with base station if it has enough energy
4. All nodes are confirming, with same capabilities.

Table 1 shows the parameters assumption of our simulation

Table1. OSCH-LEACH simulation parameters

Parameter	Value
Sensing area (M*M)	200*200 m^2
Number of nodes (*N*)	500
Initial energy of nodes (E_0)	0.3joules
Electronics energy (E_{elec})	$5*10^{-8}$joules
Position of BS	100,100

Packet size	4600 bits
Amplification energy for free space model (ε_{fs})	10^{-11}joules
Amplification energy for multipath model (ε_{mp})	$13*10^{-17}$ joules
Threshold distance (d_0)	87m
Distance threshold (*Dist_th*)	60 m

Optimum secondary cluster head simulation program performed using Matlab, it starts with 500 sensors that distributed in a field of 200*200 m^2 randomly. The network sensors clustered and some of the cluster heads lie near the boarders of the cluster. The purpose of using cuckoo search optimization procedure is to knows the optimum located of sensor to act as second cluster head *S_ch*. A comparison is made between LEACH and OSCH-LEACH scenario to clear the conduct of CSO according to the simulation outcomes. Figure4 shows the start of our simulation with a network of 500 nodes deployed randomly in 200*200 m^2.

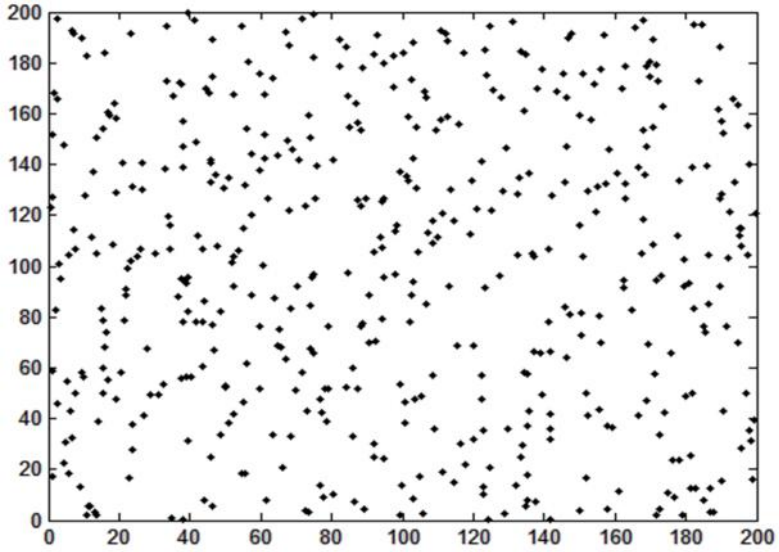

Figure 4 Random WSN nodes deployment

Figure 5 Shows the network arranged in 8 clusters (each cluster appears in different color), each cluster has a cluster head (labeled with a circle). The figure shows that four cluster heads appears in the boarder of the clusters (red, yellow, magenta, and cyanic).

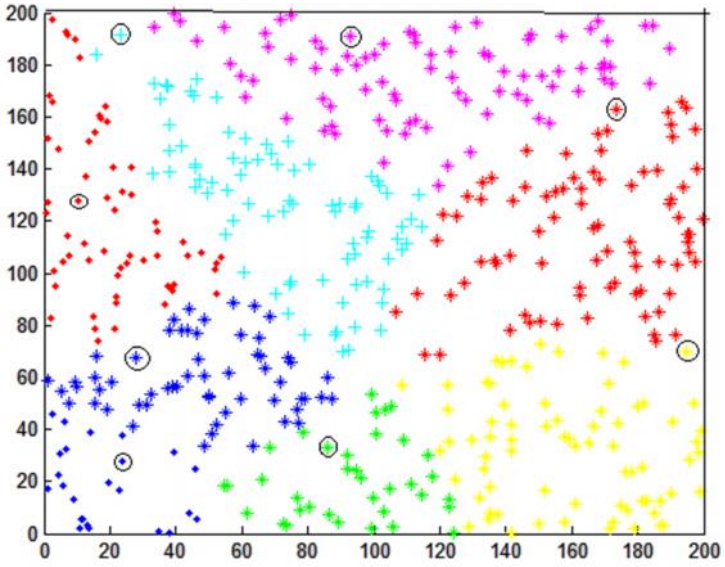

Figure 5 Clustered WSN

In our scenario when OSCH algorithm run to find the optimum sensor that is close enough to those remote sensors and with high residual energy to act as a secondary cluster heads. Figure6 shows four secondary cluster heads labeled with square for those four clusters.

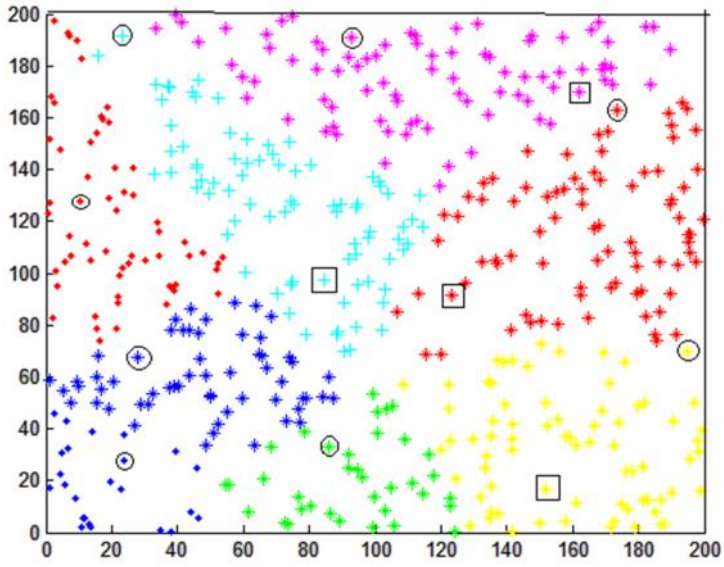

Figure 6 OSCH-LEACH simulation

Figure 7 shows that the performance of the OSCH-LEACH algorithm is more reliable than that of the LEACH in the clustering of wireless sensor networks of 500 nodes in an area of 200*200 m^2, because the settle down time period and unsettle down period for LEACH protocol in seconds is 370 second, while for OSCH-LEACH is 480 second, that is be inverted on the lifetime of the whole network.

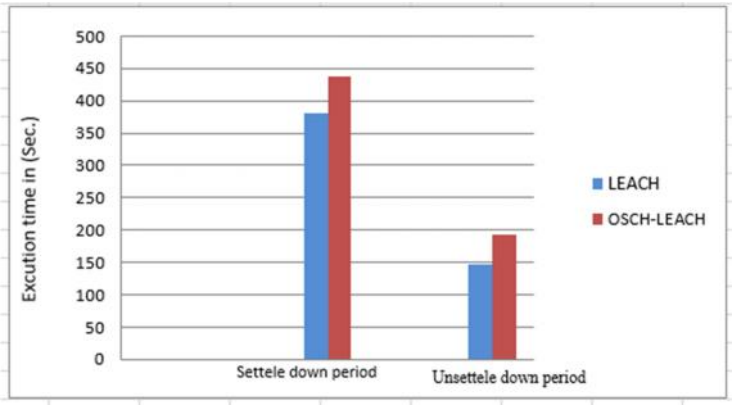

Figure 7 Settle down period and unsettle down period for LEACH and OSCH-LEACH

Figure 8 clear the number of lifetime nodes for LEACH through using the network lifetime metrics and the improved version. While after round 1480 of LEACH represent all the dead nodes. while in OSCH-LEACH scenario after 1780 rounds there are still alive sensors due to the selection of optimum secondary cluster head that eliminate the extra energy consumption because of remote sensors.

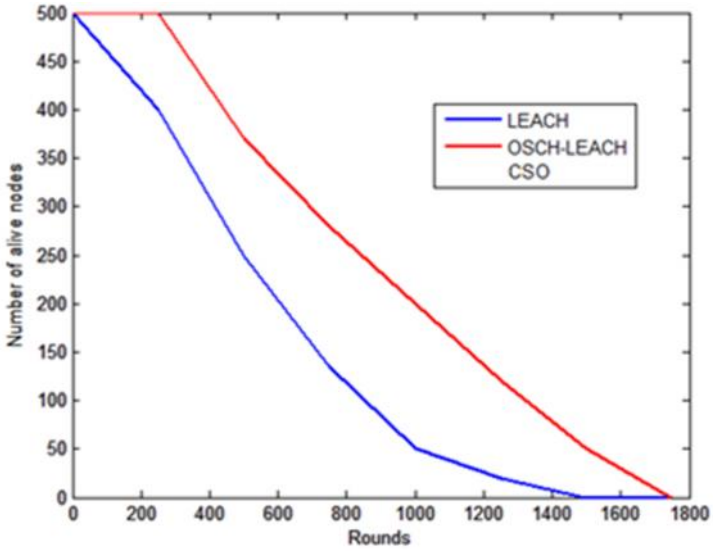

Figure 8 Number of alive nodes

Figure 9 shows another factor for the exhaustion energy of the network, in round (1225) for LEACH protocol the network lost it is energy but in OSCH-LEACH algorithm the network has energy to round (1790) with ability to works for many other rounds.

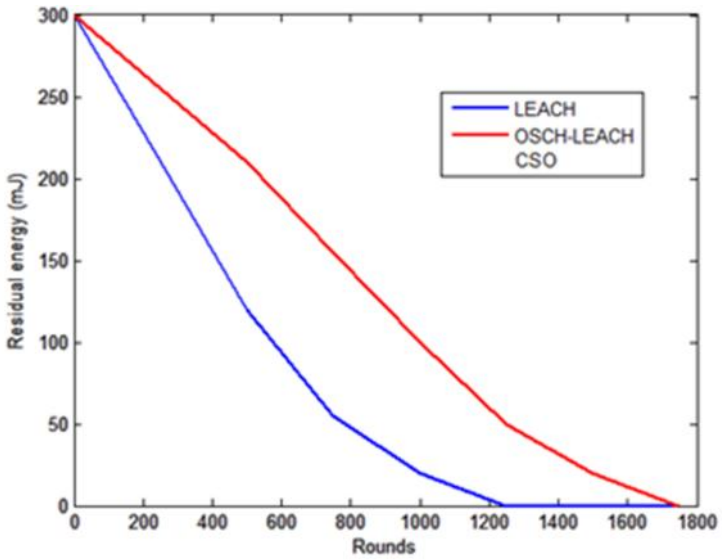

Figure 9 Network power consumption

7. Conclusion

In WSN, selection of cluster head node is very important and many researches focusing on minimizing energy consumption during the essential process of data. Clustering of WSN nodes can dramatically save the energy and prolong network lifetime. In this paper, OSCH-LEACH algorithm is presented to manage the problem of on boarder cluster head of LEACH protocol using cuckoo search optimization algorithm to find the optimum secondary cluster head for those remote sensors that performs the obligation of the cluster head and send its report to the primary cluster head. The results show that the suggested clustering algorithm can significantly give more robustness against LEACH according to network life metrics as number of alive node with rounds progress, energy exhaustion with rounds progress, settle down and unsettle down period.

References

[1] A. Hac', "Wireless Sensor Network Design", John Wiley & Sons(2003).

[2] I. F. Akyildiz, "Wireless Sensor networks", A John Wiley and Sons, Ltd(2010).

[3] P. Zheng, L.M. Ni, "Wireless Network Complete", Morgan Kaufmann (2010).

[4] K. Sohraby, D. Minoli and T. Znati, "Wireless Sensor Net- works Technology, Protocols, and Applications," John Wiley & Sons, Inc. Hoboken (2007).

[5] A. Depedri, A. Zanella and R. Verdone, "An Energy Efficient Protocol for Wireless Sensor Networks" In Proceeding of the Autonomous Intelligent Networks and Systems, AINS'03, pp. 1-6(2003).

[6] W. Heinzelman, "Application-specific protocol architectures for wireless networks," Ph.D. dissertstion, Mass. Inst. Technol., Cambridge, 2000

[7]Dilip Kumar, "Performance analysis for energy efficient protocol for maximize lifetime of wireless sensor network", IET Wireless Sensor System, Vol. 4, Issue 1, 2014, pp.9-16.

[8]Manjeshwar A., Agrawal D., "Teen: a routing protocol for enhanced efficiency in wireless sensor networks", In: IEEE parallel and distributed processing symposium (IPDPS), San Francisco, USA, 2001, pp.2009–15.

[9]Manjeshwar A., Agrawal D., "Apteen: a hybrid protocol for efficient routing and comprehensive information retrieval in wireless sensor networks", In: IEEE parallel and distributed processing symposium (IPDPS), Florida, USA, 2002, pp. 195–202.

[10]Lindsey S., Raghavendra CS., K. M. Sivilingram, "Data Gathering Algorithms in Sensor Networks using Energy Metrics", IEEE Transactions on Parallel and Distributed Systems, Vol. 13, no. 9, 2002, pp.924-935.

[11] F. Tang, I. You, S. Guo, M. Guo, Y. Ma, "A chain-cluster based routing algorithm for Wireless Sensor Networks", journal of intelligent manufacturing 23 (4), 2012 1305.

[12]Nagpal R, Coore D., " An algorithm for group formation in an amorphous computer", In: International conference on parallel and distributed computing systems (PDCS), Louisville, Kentucky, USA; 1998.

[13] W. Heinzelman, A. Sinha, A. Wang, and A. Chandrakasan, "Energy-Scalable Algorithms and Protocols for Wireless Microsensor Networks," International Conference on Acoustics, Speech, and Signal Processing ICASSP, vol. 6, pp. 3722-3725, Istanbul, Turkey(2000).

[14]Xin-She Yang, Suash Deb, "Cuckoo Search via Levy Flights", World Congress on Nature and Biologically Inspired Computing (NaBIC 2009), IEEE Publications, USA, December 2009, pp. 210-214.

[15] X. S. Yang," Nature-Inspired Metaheuristic Algorithms", 2nd Edition, Bristol, U.K: Luniver, 2010.

[16] R. B. Payne, M. D. Sorenson, K. Klitz, "The Cuckoos", Oxford University Press, 2005.

[17] Yang, X.S. and Deb, S.," Engineering Optimization by Cuckoo Search. In: Int. J. Mathematical Modelling and Numerical Optimization", Vol. 1, No. 4, 2010, pp. 330-343.

OSCH-LEACH : اختيار امثل راس عنقود ثانوي لبروتوكول LEACH

م.د. سعد حميد عبد*

المستخلص

شبكه المتحسسات اللاسلكيه تتكون من عدد من عناقيد المتحسسات التي تستخدم في مراقبه وتسجيل عدد من الظواهر مثل الضغط، سرعه واتجاه الرياح، امنيه المنازل، تشخيص اعطال المكائن، و اكتشاف الاخطاء البيولوجيه. ان جمع المعلومات مع بعضها بطريقه كفوءه من ناحيه استهلاك الطاقه تساهم في اطاله عمر الشبكه. ان البيانات تنتقل على شكل اشارات بين المتحسسات والمحطه الرئيسيه . ان بروتول LEACH يعتبر من اشهر البروتوكولات من حيث كفاءه حفظ الطاقه ولكنه مازال يعاني من بعض المشاكل التي قد تسبب مشاكل كبيرة.
لغرض حفظ الطاقه بهدف اطاله عمر الشبكه لفترة اطول تم اقتراح اختيار امثل راس عنقود ليكون راس عنقود ثانوي حيث ان في اي دورة اذا كان راس العنقود الرئيسي في مكان غير مناسب- **قرب حدود** العنقود وبعيد عن كثير من المتحسسات- لذلك اختبرت خوارزميه طائر الوقواق لايجاد المتحسس الامثل لياخذ دور راس العنقود الرئيسي لهؤلاء المتحسسات البعيده حيث يقوم بجمع البيانات ويستخرج منها تقرير واحد يرسله الى راس العنقود الرئيسي. الخوارزميه المقترحه اظهرت نتائج افضل من حيث استهلاك الطاقه واطاله عمر الشبكه.

*كلية المنصور الجامعة