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SZBC-HWSN: Stabilize Zone Balanced Cluster Head Selection Protocol for Heterogeneous Wireless Sensor Network

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Abstract

This paper presents a novel work to enhance stability of heterogeneous wireless sensor network (HWSN), with the protocol named as stabilize zone balanced Cluster head selection protocol (SZBC)-HWSN. SZBC-HWSN achieve better node connectivity in cluster and hence balancing energy consumption of the entire network. This work presents a solution to select high energy and low hop count node with base station from the zone to be cluster head (CH). In SZBC-HWSN Protocol, importance is given to initial energy, Residual energy and hop count for selecting cluster head based on regression analysis, with the nodes available from each zone of network. This approach gives better energy efficiency in HWSN compared to existing clustering protocol. For selecting cluster head towards the center of zone, boundary condition is also taken into consideration. The proposed method ensures that selected cluster head node is high energy or node near to base station. This approach reduces the possibility of selecting weak node to be cluster head, and to reduce the possibility of selecting cluster head at vicinity of network. The performance of the proposed protocol has been validated with two renowned existing protocols through simulation. The result shows that the proposed scheme outperforms than the existing protocols in terms of stability, throughput and energy remain in the network.

Keywords: Inhabitat, corona, super nodes, RSSI, averaging

1. INTRODUCTION

Wireless sensor network is very popular in remote applications due to Ad-hoc network approach for information collection. But, wireless sensor network is resource constraints in terms of sensing, computational, energy and link capability [1-3]. An energy constraint is main factor of all the said constraints. It means available energy (battery) is need to be utilized efficiently such that wireless sensor network can serve for long duration. Many researchers are tries to propose schemes to enhance energy efficiency of WSN, in the form of suggesting different energy conservation schemes and energy efficient routing scheme as [23-25, 46, 60]. From the suggested solution energy efficient routing protocol is the best possible option to enhance the stability and hence prolong the lifetime of WSN. As there are wide applications proposed by most of the researchers as in scientific domain by the placement of nodes at appropriate place of mountain, near Glaciers field and at the bottom side of water dam, it is possible to predict the accurate forecast for future [5-7, 9, 39, 41]. In industrial domain we can place sensors in bindings of electrical machine for monitoring the status [9, 10, 34, 39]. Sensor nodes can be used, in power plant monitoring to update administrator about the status of the system. Most of the above said applications are unattended by human being [11]. In such a scenario, WSN must serve for longer span of time. Though there are constraints of randomly deployed sensor nodes against uniformly deployed nodes in systematic applications such as weather forecasting, biological laboratory and **in habitat** monitoring. Agriculture, forests, coal mines, monitoring of rail tunnels, monitoring of solar photovoltaic cell in a grid, etc. [2, 12–14, 18, 32]. As randomly deployed sensor nodes is the main target of researchers, because main motive of WSN is in unattended operation. In all the above said applications there is the valuable data transfer from sensor nodes to Base station (BS) for analysis, which is normally placed at center of the network field or away from network. In WSN, BS is rich in resource in terms of energy, processing capability, communication and storage capability. On the contrary sensor nodes are limited in all the above said capability. Design energy efficient routing protocol to transfer collected information to base station (BS), is a challenging task if there is regular changes in positions of sensor nodes or if there is any early death of sensor nodes than the rated time[13,16-18]. Other possibility if any node is dead then there is need to update all the respective members from the placed zone, for this energy efficient routing scheme need to be lively present in the network. In WSN single hop or direct communication is used for transferring data to BS, sometimes there can be congestion and hence energy loss can be occurred. This communication found to be worst in large coverage area. Other alternative can be with multihop communication, but the problem is early death of nodes nearer to BS. In all the above approach, routing the information over the network with minimal energy is a challenging issue. Clustering is the solution for routing the information inside the network. Clustering improves the lifetime of WSN by greater than two times than the existing single hop communication [22]. Main aims of clustering is to offer load balancing and minimize energy consumption of entire network, minimize the interference of signal and hence possibility of collision. Available energy from the network is systematically utilized by the approach of clustering to stabilize the network, and hence prolong the lifetime [24-28, 43]. Clustered WSN can follow communication path as direct (single hop) or multihop [16, 19, 31, 32]. Clustered WSN consist of entity as cluster head (CH), cluster member (CM) and base station (BS) a rich resource element. In clustered WSN all cluster member collects (sense) and update it to CH. CH adapts strategy of TDMA format for information collection, which reduce the traffic inside a network. Every cluster member send their collected information in respective allotted time slot on TDMA frame, Sleep and Wakeup strategy reduce energy consumption of sensor nodes in WSN [13, 16, 17, 29, 30]. In clustered WSN CH works as relay element to forward collected and aggregated data to base station [11]. As basically WSN is categorized as homogeneous WSN and heterogeneous WSN. Features, objectives and outcomes of HWSN are different than homogeneous WSN, like it match with real time sensing mechanism and offers better performance matrices. Hence design requirement of clustering protocol for HWSN is different from homogeneous WSN. As former clustering protocol of homogeneous WSN is less compatible to HWSN. Researcher of homogeneous WSN clustering uses the strategy of single hop communication for inter cluster activities as e.g. LEACH [16], LEACH-DT [17], HEED [35], etc. While some of those uses multi-hop communication for enhancing energy efficiency inside large area network [1, 19, 31], in which distance of communication is greater than safe distance or threshold distance [17, 33, 34]. Multihop communication also supports scalability and in the network, where base station is away from the sensor network [33-35]. Researchers propose multihop communication scheme inside WSN for better inter-cluster communication and to enhance energy efficiency of the network as EDUC [26], Multi-hop LEACH [36], EADC [37], etc. are some such protocols. As in real time environment no network system continued as homogeneous WSN, because after deployment or after least number of rounds WSN becomes heterogeneous in terms of energy. To prolong stability and lifetime of HWSN, energy efficient clustering scheme is highly demanded.Popular HWSN clustering protocols are EEHC [4], SEP [38], DEEC [49], DDEEC [40], EDEEC [41], EDDEEC [42-43] and BEENISH [44]. These proposed routing protocols uses network model with different energy level nodes, as level 2 with first four protocol, level 3 nodes with very next 2 protocol and level 4 heterogenite nodes in last protocol. Energy heterogeneity is followed in all the above said HWSN protocol with random deployment of nodes. Though there are different other types of heterogeneity available i.e. processing, link, storage and sensing heterogeneity. This paper presents a novel scheme of cluster head selection based on Node Index (NI) or Node Quality Index (NQI), the new parameter introduced from our side. The main part of this proposed scheme is cluster head selection phase in which we are using ratio of initial energy to hop count and compared it with available residual energy of the node for finding node quality index and the node who have high value of node quality index is selected as CH. This scheme also uses boundary condition to confirm selected CH is off the vicinity from network zone. This protocol reduces internal overhead from the network and hence enhances energy efficiency of WSN. It results in enhanced performance measures of this scheme as compared to existing protocol of clustering. Further this research paper is arranged as Section 2 is for reviews of published literature in the form of literature survey, section 3 presents the motivation for this work, section 4 presents assumptions and constraints followed for network model in the form of preliminaries, section 5 gives brief about node energy consumption model utilized for the proposed protocol, section 6 presenting HWSN model and proposed protocol HWSN system model. Simulation results are presented from simulation setup and discussion of retrieved results from simulated network is presented in section 7 followed by compilation of this proposed protocol in the form of conclusion in section 8 and finally future scope for the proposed work.

2. LITERATURE SURVEY

Research work proposed by different researchers in the area of clustering is for selecting cluster head depends on available initial energy [4,11,23,45,46], residual energy [4,20,23,26,40,47,48] and based on random approach [6, 15, 34, 45, 46]. Distance of communication can be added with the above said option, to improve the quality of clustering. If selected CH is considered as fix for the network (static approach), then selected CH have to serve for entire life. The selected CH after certain round may have low energy than the cluster member available from the zone, it may result early death of CH node. It reduce the stability of the network. To balance the energy consumption evenly and to prolong the stability and lifetime, CH role can be rotated among the sensor node. A Pole star routing protocol to initiate clustering in

WSN is low-energy adaptive clustering hierarchy (LEACH) protocol [34]. It follows the approach of load balancing by rotating the role of CH among the sensor nodes. This protocol follows random approach of CH selection, has less assurance for best CH and is less suitable for scalable networks. Lots of work with reference to LEACH protocols has been devised since from last more than one and half decade for improving lifetime of WSN are such as LEACH-DT [17] or a multi-hop variant of LEACH, called as M-LEACH [1]. Other strategy than the former LEACH is hybrid energy-efficient distributed (HEED) proposed in [18], this protocol select CH according residual energy and inter-cluster communication cost with respect to others. HEED supports scalability and prolong the lifetime of network. But, there is the issue of early death of nodes nearer to BS. QLEACH [56] and EE-LEACH [55] protocols proposed by the researchers to enhance energy efficiency and to improve lifetime of WSN. Researchers of clustering protocol for HWSN proposed a novel clustering protocol in the form of [38]. This protocol use the network model, which consist of two types of nodes as advanced and normal nodes. In this protocol CH selection is based on initial energy of the node and not to consider global energy of the network. Due to this advanced nodes are getting elected as CH, though they have less energy than normal nodes. This scheme offers more stability to the network and hence improves lifetime of the network. But, with this scheme there is always a punishment to advanced nodes, which results death of the same. Other protocol from HWSN with different approach is the distributed energy efficient clustering algorithm (DEEC) in [39], CH selection in this protocol is based on weighted probability of residual energy of the node to the average energy of the network. In this energy efficient scheme there is periodic rotation of CH for distributing energy evenly over the network. But, in this protocol punishment continues for advanced nodes compared with normal node. Different methods devised by researchers for avoiding early death of nodes and especially high energy nodes and to enhance lifetime of WSN. There are different approaches proposed by researchers to overcome the problem of (complete energy depletion of node) black hole as in [7], like corona model follow NP hard mechanism. Very first approach is cluster assistant, for selecting final cluster head and serve on behalf of final CH [51,64,65], e.g. TTDD as given in [52] scheme support scalability and higher throughput with multiple mobile sink with query fetching approach with low overhead, consist of high energy level nodes for relaying information from normal nodes towards BS, this scheme reduce the possibility of early black hole problem and reduce the energy consumption, hence enhance the lifetime of the network. Other type of approach is selecting CH at the center of cluster, such that better connectivity is achieved and hence gives better stability and lifetime [61-63]. Next type of approach is distributing nodes such that better connectivity among nodes and BS is achieved with non-uniform distribution [8, 53-55]. Node can follow distribution function as given in [56], for improving performance measures of clustered WSN. Last approach is based on varying transmission range, with adaptive data propagation model support for dynamic stability. The [7, 51, 57, 66] varying transmission energy level from BS results in enhanced lifetime of the network. Other option can be deployment of high energy (energy heterogenite nodes) nodes towards BS station or can be at regular distance to support for clustering in hierarchical WSN [66].

3. MOTIVATION

As there is there is always punishment to advanced nodes in SEP [38] and DEEC [39], as their probability of CH selection is greater than normal nodes. In EEHC [4] and E-DEEC [41], CH selection is preferably for super nodes and after certain round with advanced nodes. Still there is punishment is for high energy nodes. Though in both case after depleting energy level of high energy nodes, they have same energy level as that of normal nodes. Due to this CH selection criteria no longer work properly and hence there is early death of CH node, hence life of the WSN is lower than expected. It means that, it is not the optimal way of selecting CH and balancing energy consumption inside HWSN. SZBC-HWSN suggest a non-probabilistic way of selecting CH, such that stability and hence lifetime get prolong.

4. PRELIMINARIES

SZBC-HWSN is the novel clustering protocol presented here with three level node heterogeneity. Network assume for the implementation consists of '**n**' number of randomly deployed sensor nodes as $M \times M$ sensing field. All the nodes and the base station are static after deployment. The network consists of nodes that are heterogeneous in energy and BS is at the center network, and its location is assumed to be known to each node. The nodes are unaware of location and can calculate distance based Receive signal strength indicator (RSSI), the links are assumed to be symmetric [58, 59]. The selected final CH can forward collected data directly to BS. Data and control messages are transmitted through wireless links.

5. NODE ENERGY CONSUMPTION MODEL

Transmitter section of sensor nodes required energy for running radio electronics and amplifier circuit, whereas the receiver section energy consumption is only in receiving data packet in radio electronics over the threshold distance '$\mathbf{d_0}$'. And also based on free space 'ε_{fs}' and multipath fading 'ε_{mp}' channel. If the communicating distance is lower than a threshold distance then free space model is used for energy consumption calculation, else multipath model is used[16,34]. When transmitting the L-bit data to a distance'd' the radio expends according to [44]. Data aggregation model used for CH packet transmission to BS is as [19, 34]

6. HWSN MODEL AND SZBC-HWSN PROTOCOL

For the implementations of this proposed protocol, we consider three levels HWSN model [43]. We are using three level energy nodes as normal nodes, advanced nodes and super nodes. SZBC-HWSN considers, normal nodes having energy level as 'E_0', advanced nodes with fraction of m and energy level '**a**' times more than normal nodes i.e. with energy level '$E_0(1+a)$'. At the last super nodes of fraction 'm_0' and energy levels greater than '**b**' times more than normal nodes as 'E_0 (1+b)'. As '**n**' is the number of nodes in the network, then '**nmm_0**', '**$nm(1-m_0)$**', and '**n(1-m)**' are the number of super, advanced and normal nodes in the network respectively.

Total amount of Energy imposed by three types of nodes is as follows:

Total energy of normal node is: $E_{normal}=n\,(1-m)\,E_0$

Total energy for advanced nodes is: $E_{advanced}=nm\,(1-m_0)\,(1+a)\,E_0$

Total energy with super nodes is: $E_{super}=nmm_0\,(1+b)\,E_0$

Total initial energy available in the network is calculated as:

$E_{Totalnetwork}=E_{normal}+E_{advanced}+E_{super}=nmm_0\,(1+b)\,E_0+nm\,(1+a)\,(1-m_0)\,E_0+n\,(1-m)\,E_0$

$E_{Totalnetwork}=n\,(1+m\,(a+m_0b))\,E_0$

It means that this network have energy level m $(a+m_0b)$ greater than normal nodes involved in network which have only normal nodes (Homogeneous Wireless Sensor Network).

6.1 SZBC-HWSN Protocol

Details of proposed protocol (SZBC-HWSN) are discussed here. This protocol components involved in CH selection criteria are initial energy, hop count and residual energy of the nodes.

Normally we can calculate the number of rounds supported by the network for complete life as [44];

$R=E_{Totalnetwork}/E_{Round}$

Where R is denoted as total round during the network lifetime. E_{Round} is the energy dissipated by the network for completing one round and can be calculated as:

$E_{Round}=K\ (2nE_{elec}+nE_{DA}+L\varepsilon_{mp}d^4_{to\ BS}+n\ \varepsilon_{fs}\ d^2_{to\ CH})$

Where K is the optimal number of clusters generated, E_{DA} is the data aggregation energy for CH, $d_{to\ BS}$ is the distance between CH to BS, and $d_{to\ CH}$ is the distance between cluster members to CH.

$d_{to\ BS}$ and $d_{to\ CH}$ is calculated as:

$d_{to\ CH} = M/\sqrt{2\boldsymbol{\pi}K}$, $d_{to\ BS}=0.765M/2$

By taking the derivative of E_{Round} with respect to k and equate it zero, gives optimum number of cluster heads K_{opt} and is calculated as:

$K_{opt}=\sqrt{n}/\sqrt{2\boldsymbol{\pi}}\ X\ \sqrt{\varepsilon_{fs}}/\sqrt{\varepsilon_{mp}}\ X\ M/d^2_{to\ BS}$

Proposed Network structure is divided in four equal zone, calculate the NQI for the nodes in each zone. By considering the boundary condition of zone from the network and the nodes with high node quality index is considered for CH selection. From each zone nodes with better node quality index is the competitor to become the final cluster head to transfer collected information to base station (BS) and all the other CH nodes from different zone of the network have to send their collected information to final CH. But, during this CH have to consider the distance between them and the BS and also with final CH, if distance between CH and BS is less than distance between final CH then zone CH can forward collected data to BS directly or on the contrary send the collected data to final CH to forward data to BS..

Node quality index is calculated as the ratio of initial energy to hop count and compared with reference to residual energy available with the node, with weight factor. The node whose value of quality index is better from zone selected as CH for that zone. Value of weight factor or constant is normally less than 1.This approach is followed at each zone to select CH along with the boundary condition. Then there is averaging of node quality index of all CHs from entire network and then the node which has better value of node quality index than the average value is selected as final CH for forwarding data on behalf of all the cluster heads from the network.

7. SIMULATION RESULTS

In this section we have shown results of our work with reference to existing protocols for three level nodes HWSN. Protocol for validations are SEP and DEEC. In our network model we consider BS is located in the center of network with coordinates as (100, 100) for 200 m X 200 m. For simplicity with the consideration that all nodes are stationary and omit the energy loss due to collision and interference. Evaluation of proposed protocol is possible by the following performance measures, those are explained in brief as follows:

7.1 Stability period

It is the time span in terms of cluster round spent by the network nodes before the death of very first node from network under operation. That is the span of cluster round, network to withstand against changing energy levels in the network without any loss [20, 23, 39-44].

7.2 Lifetime

It is the time span in the form of cluster round support by all the nodes from the network till the death of last node from the network [4, 9, 18, 23, 26, 33, 39-44].

7.3 Number of alive nodes per round

Number of nodes alive per cluster round of working network is normally referred as no. of alive nodes per round. This value gives indirect information of lifetime supported by the network [4,15,18,20,23,38-40,41,44,47-48,50,58].

7.4 Number of dead nodes per round

Number of nodes dead per cluster round is referred as number nodes dead per round [4,15,18,20,23,38,39,41,44,47-48,50,58]. We can also calculate node death rate from this performance metrics.

7.5 Throughput

Number of data packets transacted over the network from the CH on behalf of CM to the BS per cluster round is termed as throughput [4,6,20,23,38,39,41,44,47,48,50].

Parameter set used for simulation is presented in the form of table 1. Detailed discussion based on result is followed by table 1. Simulation is performed with i5 processor and 4GB RAM, with MATLAB R2007.

Table 1: Simulation parameters

Sr.No.	symbol	Parameter	Value
1	-	Network area	200mX200m
2	-	Location of base station	(100,100)
3	N	Number of nodes	200
4	E_0	Initial energy of nodes	0.5–1J
5	L	Data packet size	4000bytes
6	Eelec	Radio electronics energy	50 nJ/bit
7	εfs	Free space Energy	10 pJ/bit/m2
8	εmp	Energy for multipath fading	0.0013 pJ/bit/m4
9	EDA	Data aggregation energy	5 nJ/bit/signal
10	d_0	Threshold distance	87-87.5 m

A. SEP protocol

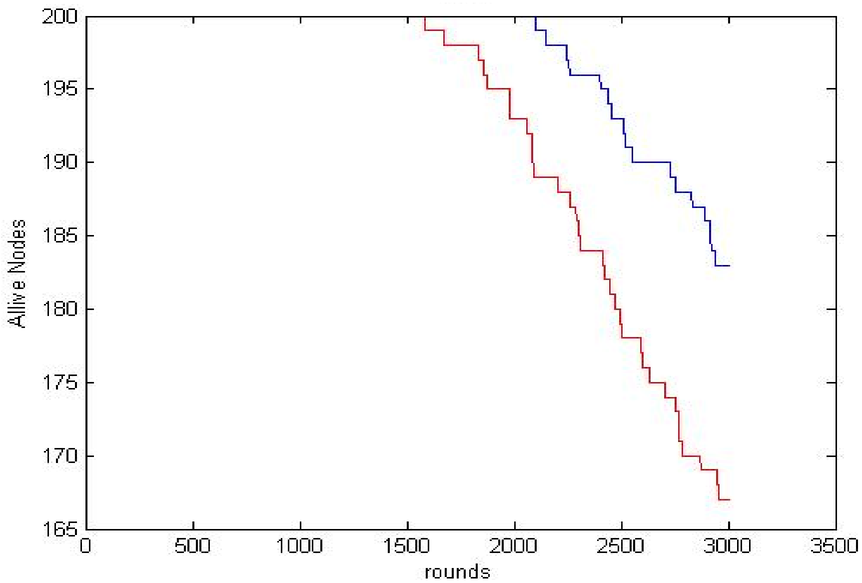

Figure 1(a). Alive nodes Vs No. of rounds

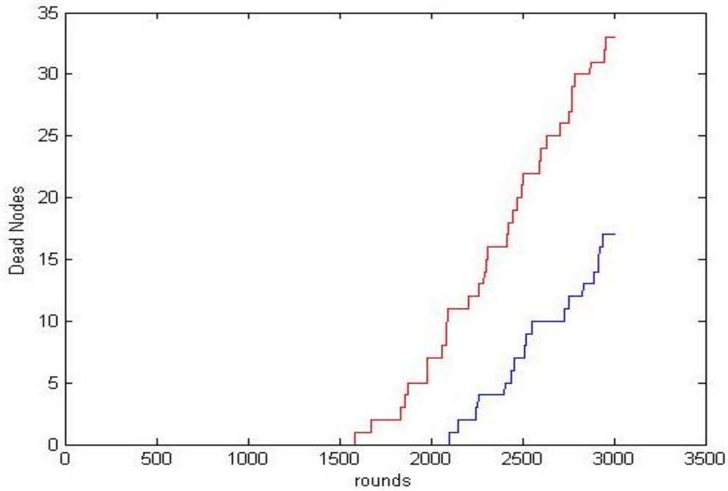

Figure 1(b). Dead Nodes Vs No. of rounds

Figure 1(a) presents a graph of alive node from the network Vs no. of cluster rounds and figure 1(b) depicts the dead nodes Vs rounds, it is found that our contributed protocol outperforms the former SEP protocol in the form of enhanced stability period, as stability period of our proposed protocol is 2097 and 1585 for former SEP. Hence stability period with proposed protocol is improved by 30% than the former SEP. With approach of better node to be CH for the initiated round utilized the energy from the network systematically and results in improved throughput of the network. As node with better connectivity and better the value of remaining energy and lower hop count is selected as CH. Selected CH is at or near the center of each zone or with final CH approach, throughput of the network get enhanced. Which is depicted in figure 1(c) and (d).

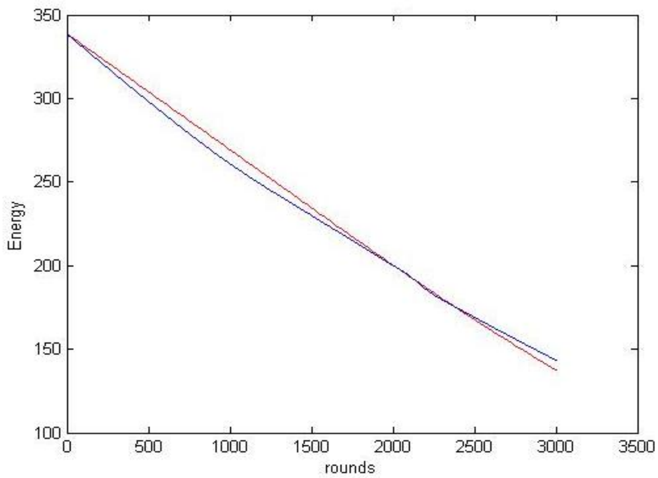

Figure 1(c). Energy remain in the network Vs rounds

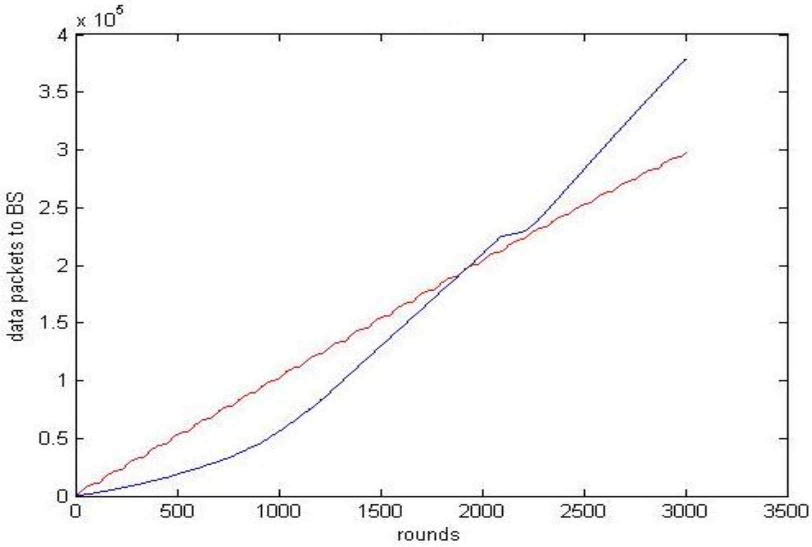

Figure 1(d). Data packets sent to BS Vs rounds

B. DEEC protocol

Figure 2(a) presents alive nodes from the network Vs no.of cluster rounds and figure 2(b) depicts the dead nodes Vs rounds, it is found that our contributed protocol gives better performance than the former DEEC in the form of stability period as 2345 and 1275 for former DEEC.

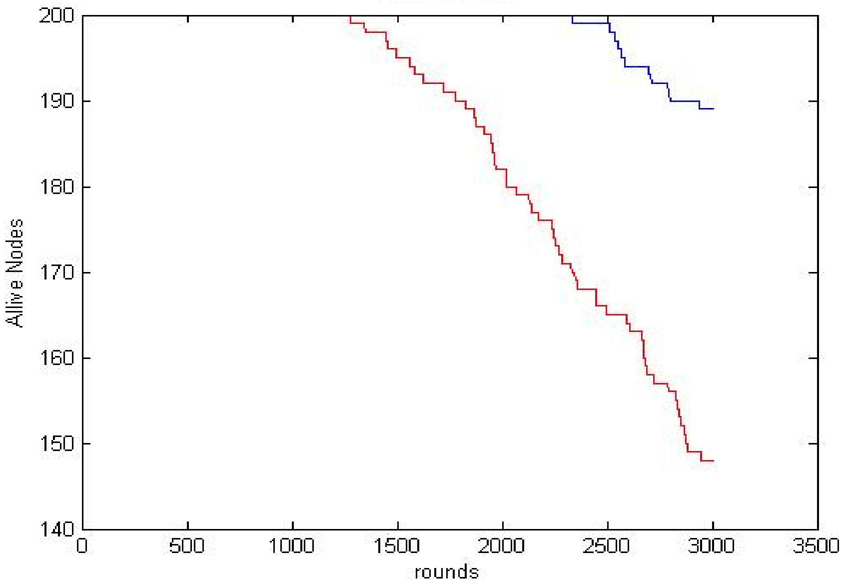

Figure 2(a). Alive nodes Vs No. of rounds

Hence stability period is get improved by the factor of 83% than the former DEEC protocol. As stability is improved, it indirectly enforce enhanced lifetime.

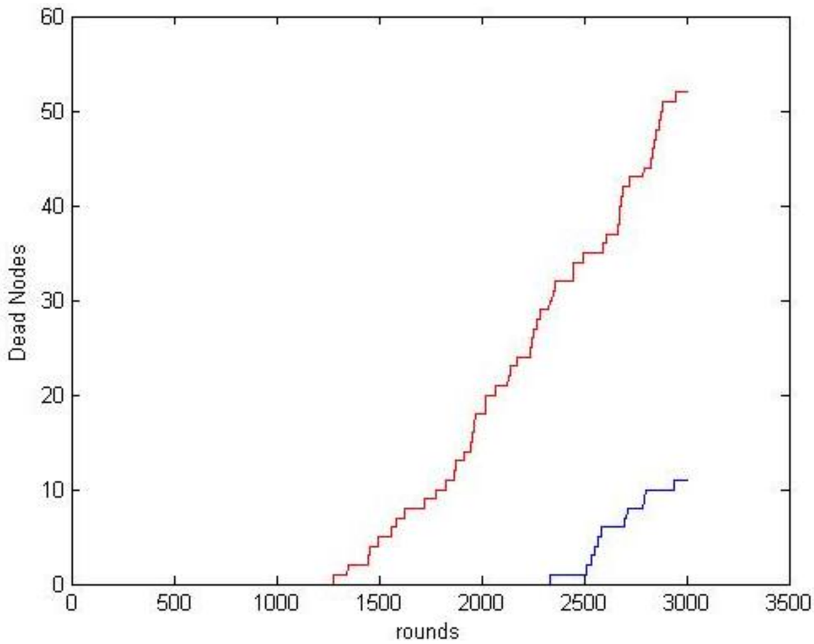

Figure 2(b). Dead Nodes Vs No. of rounds

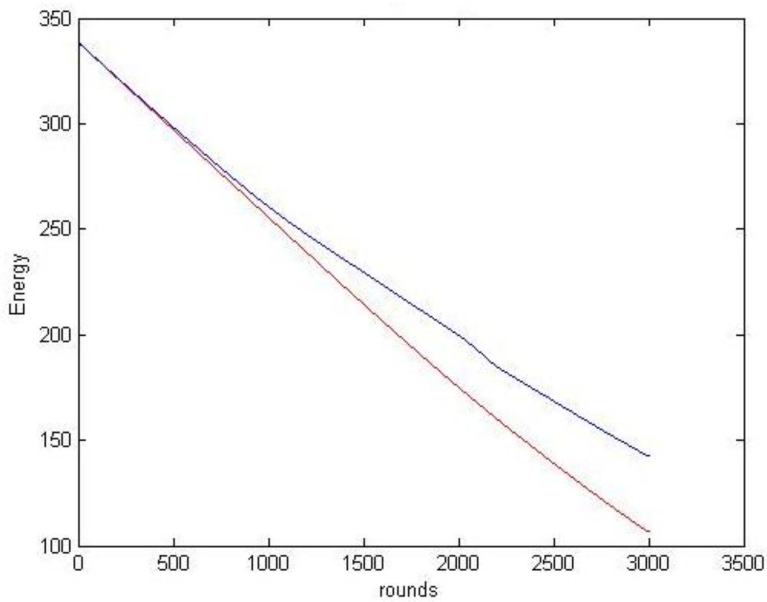

Figure 2(c). Energy remain in the network Vs No. of rounds

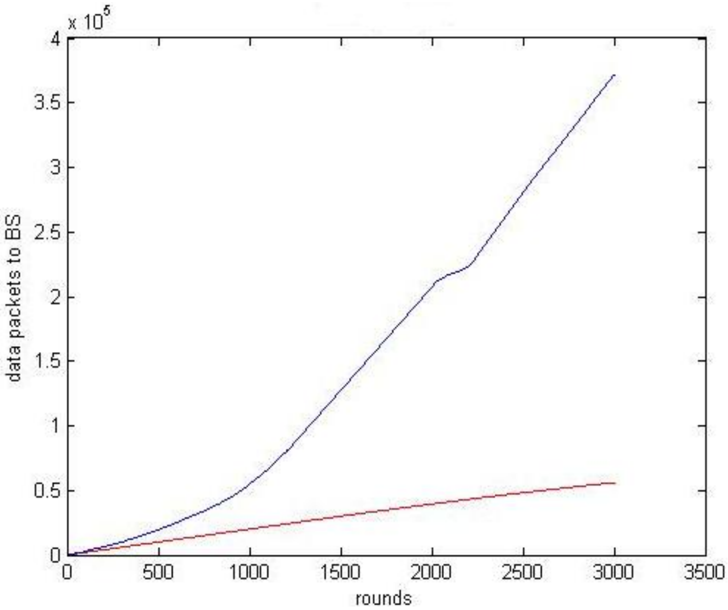

Figure 2(d). Data packets sent to BS Vs No. of round

As the node which have better value of NQI and boundary condition is the probable selected CH. Hence residual energy utilization found to be better than the former DEEC and hence throughput is better than the former DEEC. Our proposed protocol not using the base of probability for CH selection, and boundary condition is taken into consideration force best CH to be the head of zone. With averaging strategy force better node as relay node for data packet transfer, hence available energy is utilized systematically and throughput is improved. Hence stability with this faithful CH is better than former approach of CH selection. With proposed protocol selected CH have better connectivity with cluster member and hence energy remain in the network is about to be linearly exponential, it also enhanced packet transfer towards BS. Final outline from the above discussion is that, with the network partitioned in four equal zone and BS is at center reduce the internal overheads of network management.

8. CONCLUSION

This paper offers different propositions from our side as best suitable node is CH from each zone and suitable node to be final CH, with the consideration of boundary condition and node quality index. With the additional factor of distance between selected final CH and BS, if distance is longer than the distance between final CH transfer all collected data packet information to final CH otherwise forward all collected data packet to BS. Non-probabilistic CH selection approach is exploited in this work in the form of ratio of initial energy to hop count and compared with residual energy. This scheme gives assurance of better utilization of available energy and balancing the load evenly in the zone or over a network. Hence it improves the stability of the network and prolongs the lifetime of HWSN.

9. FUTURE SCOPE

We try to implement and simulate the said system for better CH selection using different automata techniques. So that stability gets prolonged than this scheme and results in better lifetime of HWSN for different level nodes. Second option can be to deploy BS away from the network field and improve the optimum value of cluster count.

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REFERENCES

[1] V. Mhatre and C. Rosenberg, 2004, "Homogeneous vs. heterogeneous clustered networks: a comparative study," Proc. IEEE, ICC6, pp. 3646–3651.

[2] C.Y. Chang and H.R. Chang, "Energy aware node placement, topology control and MAC scheduling for wireless sensor networks," Comp. Netw. 52 (2008) 2189–2204.

[3] X. Gu, J. Yu, D. Yu and G. Wang, Y. Lv,2014, "ECDC: an energy and coverage-aware distributed clustering protocol for wireless sensor networks, " Comp. Electr. Eng.40 (2014) 384–398.

[4] D.Kumar, T. C. Aseri and R.B. Patel, 2009, "EEHC: Energy efficient heterogeneous cluster scheme for wireless sensor networks," Elsevier computer communication, pp.662-667.

[5] A.A.Kazerooni, H. Jelodar and J.Aramideh, 2015, "LEACH and HEED

Clustering Algorithms in Wireless Sensor Networks: A Qualitative Study," Advances in Science and Technology: Research J., Vol.9, No.25, pp.7-11.

[6] Y.Yao, Q. Cao and A. V. Vasilakos, 2015, "EDAL: An Energy-Efficient, Delay-Aware, and Lifetime-Balancing Data Collection Protocol for Heterogeneous Wirel. Sensor Netw.," IEEE/ACM J. on Networking, Vol.23, No.3, pp.810-823

[7] C. Song, M. Liu, J. Cao, Y. Zheng, H. Gong and G. Chen, 2009, "Maximizing network lifetime based on transmission range adjustment in wireless sensor networks, " Comp. Commun. 32, pp.1316–1325.

[8] S. Olariu and I. Stojmenovic, 2006, "Design guidelines for maximizing lifetime and avoiding energy holes in sensor networks with uniform distribution and uniform reporting," INFOCOM 2006. Proc. of the 25th IEEE International Conference on Computer Communications. pp. 1–12.

[9] M. N. Brazil, C. J. Ras and D. A. Thomas, 2013, "Relay Augmentation for Lifetime Extension of Wireless Sensor Networks," IET Wirel. Sensor Systems, Vol.3, Issue.2, pp.145-152.

[10] S. A. Nikolidakis, D. Kandris, Dimitrios, D. Vergados and C. Douligeris, 2013, "Energy Efficient Routing in Wireless Sensor Networks Through Balanced clustering," Algorithms **2013**, 6(1),pp.29-42

[11] F. boutekkouk, F. Taibi and K. Meziani, 2015, "A hybrid approach to extend the lifetime of heterogeneous wireless sensor networks," The 6th International Conference on Emerging Ubiquitous System and Pervasive Networks, " Procedia Computer Science (2015), Vol.63, pp.136-141.

[12] J. Mao, Z. Wu and X. Wu, "A TDMA scheduling scheme for many-to-one communications in wireless sensor networks," Comp. Commun. 30 (2007) 863–872.

[13] P. Ayona and A. Rajesh, 2016, "Investigation of energy efficient sensor node placement in railway systems," Eng. Sci. Technol. Int. J.19, pp.754-768.

[14] V. Kaundal, A.K. Mondal, P. Sharma and K. Bansal, "Tracing of shading effect on underachieving SPV cell of an SPV grid using wireless sensor network, " Eng. Sci. Technol. Int. J. 18 (2015) 475–484.

[15] H. Tan, X. Hao, Y. Wang, F. C. M. Lau and Y. Lv, 2013,"An Approximate Approach for Area Coverage in Wireless Sensor Networks," The 4th International Conference on Ambient Systems, Networks and Technologies (ANT-2013), SciVerse Science Direct, Procedia Computer science, Vol.19,

pp.240-247.

[16] W.B. Heinzelman, A. Chandrakasan and H. Balakrishnan, 2000, “Energy efficient communication protocol for wireless microsensor networks,” Proc. 33rd Hawaii International Conference on System Sciences (HICSS’00),” pp. 8020–8029.

[17] S.H. Kang and T. Nguyen, 2012, “Distance based thresholds for cluster head selection in wireless sensor networks,” IEEE Commun. Lett. 16 (9), pp. 1396–1399.

[18] O. Younis and S. Fahmy, 2004, “HEED: a hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks,” IEEE Trans. Mobile Comput. 3 (4), pp. 366–379.

[19] S. Bandyopadhyay and E.J. Coyle, 2003, “An energy efficient hierarchical clustering algorithm for wireless sensor networks,” IEEE INFOCOM, pp. 1713–1723.

[20] Ye M., Li C., Chen G. and Wu, J.,2005, “EECS: An Energy Efficient Clustering Scheme in Wireless Sensor Networks,” In Proceedings of the 24th IEEE International Performance, Computing, and Communications Conference (IPCCC), Phoenix, AZ, USA, pp.535–540.

[21] S. Soro and W.B. Heinzelman, “Cluster head election techniques for coverage preservation in wireless sensor networks,” Ad Hoc Netw. 7 (2009) 955–972.

[22] A.F. Liu, W.X. You, C.Z. Gang and G.W. Hua, 2010, “Research on the energy hole problem based on unequal cluster-radius for wireless sensor networks,” Comp. Commun. 33, pp.302–321.

[23] R. Sheikhpour, S. Jabbehdari and A. Khadem-Zadeh, 2011, “Comparison of energy efficient clustering protocols in Heterogeneous wireless sensor networks,” Int. J. of Advanced Science and Technology, pp. 27-40.

[24] S. Dehghani, M. Pourzaferani and B. Barekatain, 2015, “Comparison on energy-efficient cluster based routing algorithms in Wireless Sensor Network,” The Third Information Systems International Conference, Science Direct, Procedia Computer science, Vol.72, pp.535-542.

[25] C. K. Sendhilkumar, R. Sukumar and M. Nageswari, 2013, “Sensors lifetime enhancement techniques in wireless sensor network,” IRACST- Int. J. of Computer Science and Information Technology and Security, Vol.3, No.2, pp.159-164.

[26] J. YU, Y. QI and G. Wang, 2011, “An energy-driven unequal clustering

protocol for heterogeneous wireless sensor networks," J Control Theory Appl., pp.133-139.

[27] S. Ganesh and R. Amutha, 2013, "Efficient and Secure Routing Protocol for Wireless Sensor Networks through SNR Based Dynamic Clustering Mechanisms," J. communications and Networks, Vol.15.No.4,pp.422-429.

[28] N. G. Praveena and H. Prabha, 2014, "An efficient multi-level clustering approach for a heterogeneous wireless sensor network using link correlation," Springer: EURASIP J. on Wirel. Commu. and Netw. pp.1-10.

[29] N. Vlajic and D. Xia, 2006, "Wireless sensor networks: to cluster or not to cluster?," IEEE Computer Society's Proceedings of the 2006 International Symposium on a World of Wireless, Mobile and Multimedia Networks (WoWMoM'06), pp.1-9.

[30] M. Liu, J. Cao, G. Chen and X. Wang, 2009, "An energy aware routing protocol in wireless sensor networks," Sensors 9, pp. 445–462.

[31] V. Mhatre and C. Rosenberg, 2004, "Design guidelines for wireless sensor networks: communication, clustering and aggregation," Ad Hoc Netw. 2 (1), pp. 45–63.

[32] M. Perillo, Z. Cheng and W. Heinzelman, "On the problem of unbalanced load distribution in wireless sensor networks," Proc. of IEEE GLOBECOM Workshops on Wireless Ad hoc and sensor networks, Dallas, TX, 2004, pp. 74–79.

[33] B. Tavli, 2009, "Energy-efficient relaying in wireless networks," Int. J. Electron. Commun.63, pp. 695–698.

[34] W.B. Heinzelman, A. Chandrakasan and H. Balakrishnan, 2002, "An application-specific protocol architecture for wireless microsensor networks," IEEE Trans. Wirel. Commun. 1 (4), pp. 660–670.

[35] R.C. Carrano, D. Passons, L.C.S. Maglhaes and V.N. Albuquerque, 2014, "Survey and taxonomy of duty cycling mechanisms in wireless sensor networks," IEEE Commun. Surv. Tut. 16 (1), pp. 181–192.

[36] F. Xiangning and S. Yulin, 2007, "Improvement on LEACH protocol of wireless sensor network," Proc. of International Conference on Sensor Technologies and Applications (Sensor Comm.) pp. 260–264

[37] J. Yu, Y. Qi, G.Wang and X. Gu, 2012, "A cluster-based routing protocol for wireless sensor networks with non-uniform node distribution," Int. J. Electron. Commun. 66, pp. 54–61.

[38] G. Smaragdakis, I. Matta and A. Bestavros, 2004, "SEP: A Stable Election Protocol for clustered heterogeneous wireless sensor network," In 2nd Int. Workshop on Sensor and Adhoc Network Protocols and Applications, pp.1-6.

[39] L. Qing, Q. Zhu and M. Wang, 2006, "Design of a distributed energy-efficient clustering algorithm for heterogeneous wireless sensor network," Elsevier, Computer Communications, Vol.29, pp. 2230- 2237.

[40] B. Elbhiri, S.Rachid, S. E. Fkihi, S. and D. Aboutajdine, 2010, "Developed Distributed Energy- Efficient Clustering (DDEEC) for heterogeneous wireless sensor networks," 5th International Symposium on I/V Communications and Mobile Network (ISVC), pp. 1-4.

[41] P. Saini and A. K. Sharma, 2010, "E-DEEC- Enhanced Distributed Energy Efficient Clustering Scheme for heterogeneous WSN," 1st International Conference on parallel, Distributed and Grid Computing (PDGC - 2010), pp. 205-210.

[42] N. Javaid, T. N. Qureshi, A. H. Khan, A. Iqbal, E. Akhtar and M. Ishfaq, 2013, "EDDEEC: Enhanced Developed Distributed Energy-Efficient Clustering for Heterogeneous Wireless Sensor Networks," Int. workshop on body area sensor networks (BASNet -2013), pp.914-919.

[43] N. Javaid, M. Babar Muhammad, Imran, M. Guizani, Z. Ali Khan, T.A. Alghamadi and M.L.lahi, 2015, "An energy-efficient distributed clustering algorithm for heterogeneous WSNs," Springer: EURASIP J. on Wireless Communications and Networking, pp.3-11.

[44] T.N.Qureshi, N.Javaid, A.H.Khan, A. Iqbal, E. Akhtar and M. Ishfaq, 2013, "BEENISH: Balanced Energy Efficient Network Integrated Super Heterogeneous Protocol for Wireless Sensor Networks," Int. Workshop on Body Area Sensor Networks (BASNet-2013), SciVerse Science Direct, Vol.19, pp.920-925.

[45] D. P. Nudurupati and R. K. Singh, 2013, "Enhancing Coverage Ratio using Mobility in Heterogeneous Wireless Sensor Network ," International Conference on Computational Intelligence: Modeling Techniques and Applications, Science Direct, Procedia Technology, Vol.10, pp.538-545.

[46] G. Abdul-Salaam, A. H. Abdullah, M. H. Anisi, A. Gani and A. Alelaiwi, 2016, "A Comparative analysis of energy conservation approaches in hybrid wireless sensor networks data collection protocols," Telecomm. Syst, Vol.61, pp.159-179.

[47] H. Kour and A. K. Sharma, 2010, "Hybrid Energy Efficient Distributed Protocol for Heterogeneous Wireless Sensor Network," Int. J. of Computer Applications (0975-8887), Vol.4, No.6, pp.1-10.

[48] B. Elbhiri, R. Saadane and D. Aboutajdine, 2009, "Stochastic Distributed Energy Efficient Clustering (SDEEC) for heterogeneous wireless sensor networks," IGST-CNIR J., Vol.9, Issue 2, pp.11-17.

[49] G. S. Arumugam and T. Ponnuchamy, 2015, "EE-LEACH: development of energy-efficient LEACH Protocol for data gathering in WSN," Springer: EURASIP J. on Wirel. Commu. and Netw. , pp.1-9.

[50] B. Manzoor, N.Javaid, O.Rehman, M.Akbar, Q.Nadeem, A.Iqbal, and M.Ishafaq, 2013, "Q-LEACH: A New Routing Protocol for WSNs," Int. Workshop on Body Area Sensor Networks, SciVerse Science Direct, Vol.19, pp. 926-931.

[51] H.M. Ammari and S.K. Das, 2008, "Promoting heterogeneity, mobility, and energy-aware Voronoi diagram in wireless sensor networks," IEEE Trans. Parall. Distr. Syst. 19 (7), pp. 995–1008.

[52] F. Ye, H. Luo, J. Cheng, S. Lu and L. Zhang,2002, "A two-tier data dissemination model for large-scale wireless sensor networks, " Proc. of IEEE / ACM International Conference on Mobile Comp. and Netw., MOBICOM, pp.148–159.

[53] J. Lian, K. Naik and G. Agnew, 2006, "Data capacity improvement of wireless sensor networks using non-uniform sensor distribution," Int. J. Distrib. Sens. Netw. 2(2), pp.121–145.

[54] X. Wu, G. Chen and S.K. Das, 2008, "Avoiding energy holes in wireless sensor networks with nonuniform node distribution," IEEE Trans. Parall. Distr. Syst. 19 (5), pp. 710–720.

[55] G. Ma and Z. Tao, 2013, "A nonuniform sensor distribution strategy for avoiding energy holes in wireless sensor networks," Int. J. Distrib. Sens. Netw., pp.1–14.

[56] S. Halder, A. Ghosal and S.D. Bit, 2011, "A pre-determined node deployment strategy to prolong network lifetime in wireless sensor network," Comp. Commun. 34, pp. 1294–1306.

[57] A. Jerry, P. Leone, O. Powell and J. Rolim, 2006, "An optimal data propagation algorithm for maximizing the lifespan of sensor networks," Proc. IEEE International Conference of Distrib. Comput. Sens. Syst. LNCS 4026,

pp. 405–421.

[58] C. Li, M. Ye, G. Chen and J. Wu, 2005, "An energy efficient unequal clustering mechanism for wireless sensor networks," Proc. of IEEE International Conference on Mobile Ad-hoc and Sensor Systems (MASS), pp. 596–604.

[59] X. Min, S. Wei-ren, J. Chang-jiang and Z. Ying, 2010, "Energy efficient clustering algorithm for maximizing lifetime of wireless sensor networks," Int. J. Electron. Commun. 64, pp. 289–298.

[60] G. Abdul-Salaam, A.H.Abdullah, M. H. Anisi, A. Gani and A Alelaiwi, 2016," A comparative analysis of energy conservation approaches in hybrid wireless sensor networks data collection protocols," Springer: Telecomm. Syst. (61), pp.159-179.

[61] V. Pal, Yogita, G.Singh and R. P. Yadav, 2015, "Effect of Heterogeneous Nodes Location on the performance of clustering algorithms for wireless sensor networks, "Third International Conference on recent trends in computing (IRCTC-2015), science Direct: Procedia Comput. Science (57), pp.1042-1048.

[62] Y. Li, G. Xiao, G.Singh and R. Gupta, 2013, "Algorithms for finding best locations of cluster heads for minimizing energy consumption in wireless sensor networks, "Springer: Wireless Netw. (19), pp.1755-1768.

[63] C. Sevegi and A. Kocyigit, 2008, "On determining cluster size of randomly deployed heterogeneous WSN's,"IEEE Communications Letters, Vol.12, No.4, pp.232-234.

[64] H. Li, J. Liu, 2016, "Double Cluster Based Energy Efficient Routing Protocol for Wireless Sensor Network," Springer, Int. J. Wireless Inf. Networks, Vol. 23, pp.40-48.

[65] L.Wang, W. Bi and T. Lu and C. Zhang, 2010, "An Improved Energy-Efficient algorithm based on L-DCHS in WSN,"IEEE 2010, pp.312-316.

[66] M. Diwakar and S. Kumar, 2012, "An energy efficient level based clustering routing protocol for wireless sensor networks," International J. of smart sensor network systems (IJASSN), Vol.2, No.2, pp.55-65.