Technique to Balance Energy Efficient Clustering with Data Transmission in Large Scale Sensor Network

Jyothi A.P, Usha Saktivel
Research Scholar,,Asst.Prof,Dept of ECE,Prof. & HOD:Dept. of Computer Science RRCE, Bangalore
jyothi_arcot@yahoo.co.in, sakthivelusha@gmail.com

ABSTRACT : Clustering has always been playing an essential role in energy efficiency over wireless sensor network. There are various studies that have been focused on resolving energy issues using various techniques where each technique have their own limitations. Hence, this paper presents a unique technique of clustering exclusively targeting large scale wireless sensor network by introducing a novel communication technique, clustering technique followed by selection of cluster head. The technique is also found to maintain a good balance between energy efficiency and data transmission in wireless sensor network. The study outcome shows proposed system offers better clustering performance with respect to most frequently adopted energy efficient protocol with respect to network delay, throughput, and energy conservation.

Keywords- Clustering, Energy Consumption, LEACH, Network Life Time, Wireless Sensor Network.

I. INTRODUCTION

A wireless sensor network is globally used for collecting information from human inaccessible geographical location. Although, the concept of wireless sensor network has shown multi-dimensional application in theory but it really doesn't even exists in commercial markets. It is interesting as there are massive research papers on wireless sensor network since last two decades, but it has never met the utility of common people very largely. A wireless sensor network consists of sensors that perform extraction of physical data from human inaccessible locations. Normally, sensors are low-powered electronic devices with low availability of resources, which are meant to capture environmental data e.g. heat, smoke, temperature, moisture, motion etc. In order to balance the tradeoff of energy consumption and network performances in a resource constraints network, it is essential to organize a multihop network into clusters. Fundamentally clustering includes two processes, one to decide the membership of participating node to a cluster family in each communication cycle and another to elect one of the nodes as a Cluster Head (CH). The selection of optimal cluster is a NP-complete problem and resembles the closeness to the "minimum dominating set problem" [1]. Energy efficiency issues are vast in literature and the reader is suggested to refer an extensive review work by the authors [2] namely "Trends and Technologies used for Mitigating Energy Efficiency Issues in Wireless Sensor Network". The prime reason behind this is a sensor node still suffers from energy problems that are the root cause of majority of other problems e.g. routing [1][2], bandwidth [3], security [4]. From the trends of existing research, one thing is very much clear that clustering is one of the most suitable factors that positively or negatively affects the network lifetime of wireless sensor network. The transmission distance of the CH is higher as compared to the other nodes, due to which they consume more energy. In order to balance this energy consumption a periodic re-cycling of CH election is adopted. A typical direct transmission from CH to base station and CH to CH as a multi-hop communication schematic is shown in the Fig.1. A direct transmission will have higher Communication overhead; it may introduce latency as well as it is not scalable for the large scale wireless sensor network as sensor could not support communication at long-haul.

The multihop communication from CH to CH having larger advantages to cope with scalability, increased life time and energy efficiency. Apart from routing based on clustering there are other secondary benefits of clustering which includes localization of the route inside the cluster so that the size of routing table within an individual node is minimized. The bandwidth utilization balancing and minimization of control message exhibit additional benefit on the overall traffic due to clustering. Irrespective of the associated advantages of clustering, the challenge of prolonging the network lifetime is crucial and still an open research problem as with multiple constraints, it is not trivial to achieve the goal by traditional approaches of clustering. The design prospect of cluster based routing protocol must include the application robustness along with secure communication, Synchronization and finally data aggregation [3].

At present, there is various energy efficient routing as well as clustering techniques introduced by various researchers till date [5]. However, all the clustering technique seriously lags inclusion of cost effective optimization (although there are various studies focusing on iterative and computationally expensive optimization theory [6] [7] in wireless sensor network). Hence, this paper discusses about a unique optimization technique called as clustering approximation that contributes to enhancing the network lifetime by providing multiple attributes for selecting cluster head. Section II discusses about the prior research work carried out in the area of energy efficient clustering in wireless sensor network followed by Section III that

briefs about the problems identification. The proposed contribution is discussed in Section IV followed by algorithm implementation in Section V. The result analysis is done in Section VI followed by summary of the paper in Section VII as conclusion.

II. RELATED WORK

This section briefs the studies being completed towards tending to energy problems in various forms of wireless sensor system. Our earlier study has investigated an existing method for solving the power issues [8]. Most as of late, utilization of Voronoi chart for vitality productivity was seen in the work of Gautam et al. [9]. The author has likewise utilized bio-inspired system for enhancing the lifetime of the network. Yu et al. [10] have exhibited uneven grouping mechanism for energy conservation on groups with unequal number of nodes. There are likewise sure studies that give one of a kind bunching system e.g. utilization of Hausdorff separation based clustering system presented by Zhu et al. [11]. Unfortunately, the results of such works are never observed to be benchmarked. Udompongsuk et al. [12] have introduced a study that performs selection of clusterhead in light of moving normal, a factual based system. Be that as it may, the study experiences versatility issue and its tradeoff with energy effectiveness. Pei et al. [13] have displayed a study where the creators have enhanced the ordinary LEACH calculation researched over intellectual radio in wireless sensor system. In any case, the system finds less convenience after some time and mission based applications in wireless sensor system. Aside from these, there are additionally different enhancement system which depends on swarm insight e.g. dolphin swarm optimization, elephant swarm optimization [14], microorganisms searching calculation [15], BAT calculation [16]. Albeit all the aforementioned studies are centered on homogenous systems, there are additionally concentrates on devoted to address vitality issues and bunching issues relating to heterogeneous system. Thinks about directed by Meenakshi [17] and Patil [18]. Albeit, all the aforementioned methods give superior rules for future examination, however every one of them is conceivably connected with issues. Brief exchange of such issues in made in next segment.

III. PROBLEM IDENTIFICATION

The past section has talked about different energy effective procedure to moderate the system lifetime and a percentage of the standard clustering techniques, which has gotten a wide acknowledgment in past. In any case, the greatest problem with every one of the systems is pretty much the same. Dominant part of the procedure considers the position of the base station at the centroid of simulation area, which prompts most extreme of routing overhead. The second issue in existing studies is selection criteria of clusterhead, which is just based on residual energy. However, a few studies have streamline energy utilizing bio-inspired procedures, yet complexities of such algorithms concerning handling time and memory utilization is missing from the latest literary works. The third issue in the latest work is the way the advancement is performed. Larger part of the cases, it is done on just single level, be that as it may, there is a reasonable probability of performing optimization utilizing different levels considering different parameters included in information aggregation of remote sensor organize separated from leftover energy. The fourth problem explored in the existing studies is consideration of uncertain knowledge about the communication behaviour of the sensors. Thus, the issue articulation of the proposed study can be characterized as - "It is a computationally difficult to build up a multi-level clustering in grouping strategy for upgrading the system lifetime in wireless sensor applications". The following segment presents around a novel method that addresses the issues.

IV. PROPOSED SYSTEM

The prime purpose of the proposed system is to develop a novel technique of clustering that can directly contribute to enhancing the network lifetime. The secondary objective of the proposed system is to ensure a well balance scheme between energy efficiency and data packet delivery. Energy efficiency is maintained by introducing a novel clustering algorithm and data delivery is maintained owing to a very unique communication model in large scale wireless sensor network. The technique introduces a concept of collection of aggregated data packets from the cluster head using multiple numbers of extra nodes called as auxiliary nodes that are assumed to be multiple sub-base stations for large scale wireless sensor network. The justification behind this is one base station will not be enough for monitoring large scale network and hence multiple base stations are used in real-time. We are bringing out novelty in the concept by introducing RF transceivers to be a part of auxiliary nodes that is mainly responsible for two task i.e. i) collecting the aggregated data from the cluster heads in proximity and ii) performing syncing with each other to identify redundant data (in order to discard them). We assume here that the RF transceivers have abundant resources and are a replacement of multihop routing in sensor network. Hence, the proposed technique offers a novel clustering technique. The technique also discusses about a simple method of cluster head selection process which is based on two parameters remnant energy and distance between nodes. The next section discusses about the research methodology that is adopted in the proposed system.

V. RESEACH METHODOLOGY

The proposed research work considers an empirical design approach for accomplishing an enhancement in network lifetime owing to novel clustering technique. The design of the proposed clustering mechanism is carried out using following modules:

- **Communication Model**: The proposed system considers a large scale simulation area of wireless sensor network with specific number of nodes distributed randomly. There are 4 types of sensors involved in the communication model e.g. i) cluster head, ii) member node, iii) base station, and iv) auxiliary node. The uniqueness in the proposed system is after the data being aggregated by the cluster head, it is forwarded to multiple auxiliary

nodes, which performs redundancy checks and then forwards the unique information to the base station. The scheme of communication model is represented in Fig.1.

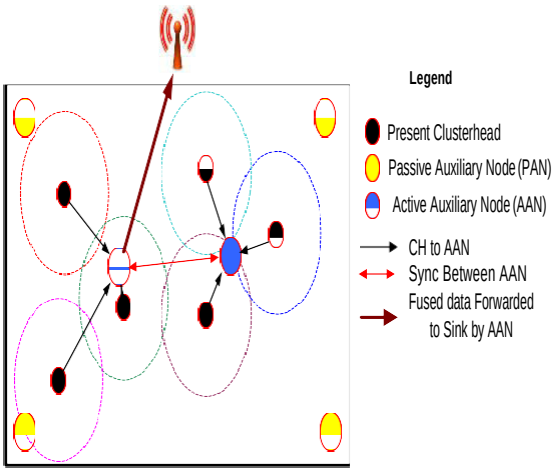

Fig.1 Proposed Communication Model

Fig.1 shows that there are two forms of auxiliary nodes i.e. i) Passive Auxiliary Node (PAN) and ii) Active Auxiliary node. Basically, an auxiliary node can be also thought as small base stations mounted in the surveillance area for coverage and connectivity extension in large scale wireless sensor network. For better energy efficiency, the system is able to identify the minimum number of such auxiliary nodes required for data aggregation from multiple spots. Hence, the technique switches of power of certain auxiliary nodes called as PAN and switches on only specific number of auxiliary nodes required called as AAN. However, with the progress of simulation, PAN and AAN toggle the switching on / off cases in accordance to coverage of present cluster head. Also the technique is also capable of performing syncing between all the AAN to ensure lower overhead in base station along with increment of data quality.

Fig.1 shows that there are two forms of auxiliary nodes i.e. i) Passive Auxiliary Node (PAN) and ii) Active Auxiliary node. Basically, an auxiliary node can be also thought as small base stations mounted in the surveillance area for coverage and connectivity extension in large scale wireless sensor network. For better energy efficiency, the system is able to identify the minimum number of such auxiliary nodes required for data aggregation from multiple spots. Hence, the technique switches of power of certain auxiliary nodes called as PAN and switches on only specific number of auxiliary nodes required called as AAN. However, with the progress of simulation, PAN and AAN toggle the switching on / off cases in accordance to coverage of present clusterhead. Also the technique is also capable of performing syncing between all the AAN to ensure lower overhead in base station along with increment of data quality.

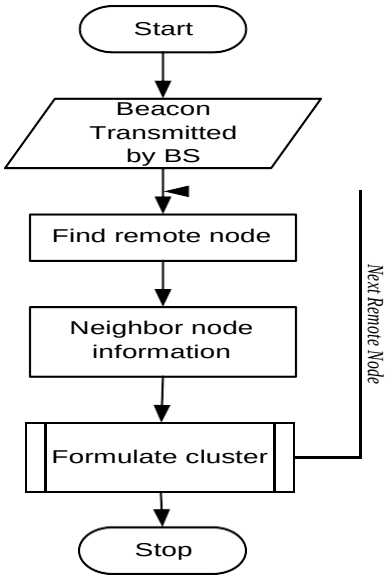

Fig.2 Proposed Clustering Techniques

VI. Algorithm Implementation

The design and development of the proposed system is carried out on the basis on 2 algorithms as discussed below:

a. Algorithm for Communication

This algorithm is responsible for performing communication in terms of data aggregation in wireless sensor network. The algorithm takes the input of *n* (total sensors), n_a (number of AAN), n_p (number of PAN), *sd* (shortest distance), *nd* (node density), bs (base station), which after processing forwards the fused data to base station. The algorithm initially performs random distributed of nodes and make uniform distribution of n_a and n_p. Using the second algorithm for the clustering, the algorithm aggregates the data from cluster head and forwards it to n_a. The selection mechanism of n_a is based on shortest distance between the cluster head and uniformly positioned auxiliary nodes. However, with a progress of simulation, it is quite possible that existing cluster head will be depleted of battery power and in that case possibly the older n_a will be not be enough to cover the range of new cluster head. Hence, we calculate the node density in order to check the positions of majority of nodes. The algorithm also re-calculates the distance between the newly elected cluster head with all n_p and n_a (which are reachable). The n_a which are in reachable distance are retained and other are replaced by new n_a which was previously n_p. After the complete collection of the data is accomplished, the communicating na will perform syncing with each other, which is basically an operation to find the message with similar timestamp. Such message are considered to be duplicated message and hence discarded. Finally, the data packets are fused together by anyone of the na which is forwarded to base station.

Table 1 Algorithm for Communication

Algorithm for Communication

Input: *n* (total sensors), n_a (number of AAN), n_p (number of PAN), *sd* (shortest distance), *nd* (node density), bs (base station)

Output: fused data forwarded to base station

Start

1. init rand(n), n_a, n_p
2. Apply Algorithm-2 for CH selection.
3. n_a ⌊_ sd(CH, auxiliary node)
4. If battery(CH)==0
5. Calculate n_d and sd[(newCH),(n_a, n_p)]
6. Select n_p ⌊_ new(n_a)
7. n_{ai} ↔ fuseddata(bs) ↔ n_{aj}
8. n_a ⌊_ filter(fuseddata) ⌊_ b_s.

End

The advantage of this algorithm is that it reduces the complexity operations over cluster head that results in maximizing the lifetime of the cluster head to 50%.

b. Algorithm for Clustering

The algorithm selects the input of *bs* (base station), *d* (distance), E_c (Energy Coefficient), and E_{rem} (remnant energy) and after processing gives the output of energy efficient cluster head. This algorithm is also used in previous algorithm of communication. This technique initiates with a base station bs to broadcast the route discovery information so that it can evaluate the position of other nodes from itself along with other status of explored nodes. The base station than uses Euclidean's distance between themselves and other nodes and then it selects the node with maximum Euclidean's distance, which means that this node is located in more remote area within the simulation area. We call it as last node that starts exploring the neighborhood nodes. It does so by using distance-based formulations i.e. if the transmission distance of the next node is found to be within the present node, the next node is considered to be neighbor nodes. The process is repeated for next node with lesser distance from the last node. Hence, a cluster is formulated where all the parent nodes *i* is transmitted with the data from the children node *j*. After the cluster is formulated the next emphasis is on the selection process of cluster head. A new variable called as energy coefficient E_c is computed to be remnant energy of each node divided by distance between the sensor and base station. The system than consider a node with the maximum value of E_c to be cluster head. This algorithm, when used with communication algorithm, ensures highest network lifetime along with delivery of quality data during the data aggregation process in wireless sensor network.

Table 2 Algorithm for Clustering

Algorithm for Clustering

Input: *bs* (base station), *d* (distance), E_c (Energy Coefficient), E_{rem} (remnant energy)

Output: Selection of clusterhead

Start

1. bs ⌊_ broadcast(beacon)
2. $d \rightarrow \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \; \forall (x_1\ y_1) \in {}^{n}(x_2\ y_2) \in bs$
3. For i=1:n
4. Last node ⌊_ max(d)
5. Last node ⌊_ find_neighbor_node
6. Next node ⌊_ [max(d)-a]
7. Next node ⌊_ find_neighbor_node
8. Repeat Line-5 until all nodes are covered.
9. Calculate energy coefficient

   $E_c = E_{rem} / d$
10. Clusterhead ⌊_ max(E_c)
11. End

End

Hence, it can be also seen that there are multiple points of n_a where the data aggregation takes place from cluster head to na and while multiple n_a sync with each other to delivery redundant free data to sink. Hence, data aggregation time may quite increase. So, we first compute the total time required to capture the data by all n_a for the purpose of enhancing the network lifetime. Hence, we develop a condition which ensures that data aggregation time from n_a should be minimized. As the existing cluster head is free from performing redundancy check or multi-hop operation, hence, it network lifetime is maximized. The next section discusses about the results accomplished from the study.

VII. RESULT DISCUSSION

The outcome of the proposed study was compared with all the standard energy efficient protocols e.g. LEACH [19], PEGASIS [20], ERP [21], HCR [22], and HEED [23]. These are the frequently used energy efficient clustering technique for wireless sensor networks. The accomplished outcomes of the study are discussed as follows:

A. Analysis of Energy Conservation

The amount of energy conserve is calculated by finding total amount of average residual energy retained by the nodes in 1000 simulation rounds. The outcome shown in Fig.3 highlights that proposed system offers better retention of energy as compared to existing system. HCR algorithm is designed using genetic algorithm for optimizing the energy efficient routes. Usage of genetic algorithm over longer iteration has extra computation of

fitness function and extracting the elite outcomes. Hence it includes more energy consumption just like LEACH. The performance of LEACH and ERP is degraded owing to overheads as clusters once selected as allowed to work until death. Moreover, as base station is always located at center, it incurs more loss of power in case of redundant data packets. The improvement of LEACH could be seen in PEGASIS; however, the chains don't supports extensive clustering mechanism with redundancy check on data packet.

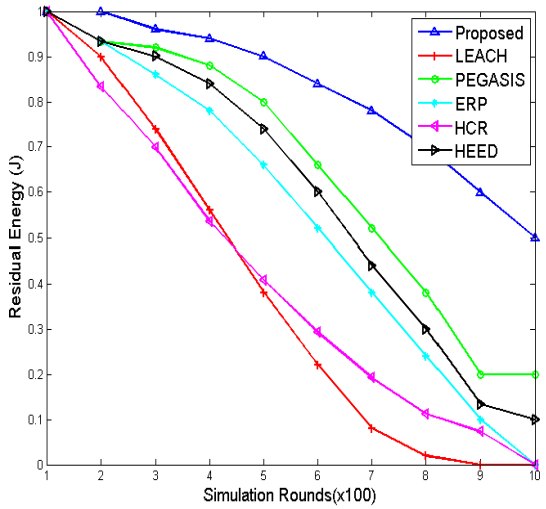

Fig.3 Energy Consumption Analysis

A. *Analysis of Throughput*

Throughput was estimate by calculating the size of data packet being processed (fused) and transmitted over certain specific period of time. Fig.4 shows that LEACH, HEED, and ERP doesn't have much better throughput performance. Owning to usage of conventional topology, the task of redundancy check (data fusion) has to be carried out by each cluster head. Hence, in case of dynamic wireless sensor network, the system for existing technique fails to perform intercommunication among the clusters in order to check for unique packets. As such algorithms don't supports multihop network, hence, a good amount of transmits energy was expended in order to maintain good coverage and communication performance in LEACH, HEED, and ERP. A closer look will also show that PEGASIS and HCR has nearly similar performance for throughput. The prime reason behind this is HCR uses round robin scheme and PEGASIS uses chain-based scheme for performing clustering. Being a part of hierarchical routing, PEGASIS and HCR scheme ensures better energy efficiency but it considerably takes time to construct the path which is a time consuming process especially for HCR which uses iterative evolutionary technique. Hence, proposed system excel better as it uses AAN and PAN, which acts as subsidiary base station for large scale network, for perform the complex computational work by synching with each other, which is just a replica of multihop communication system.

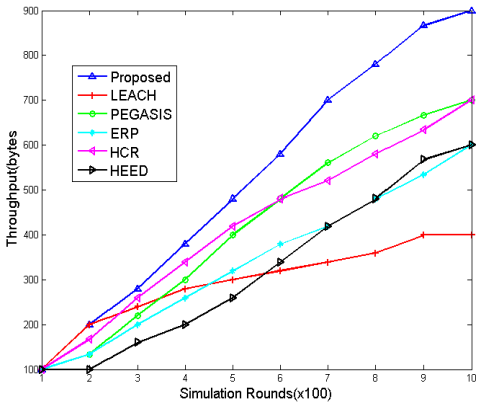

Fig. 4 Throughput Analysis

B. *Analysis of Network Delay*

Network delay is computed by the time difference between the packets being relayed to packets being received. It can be easily computed by the observing the timestamps of packets in transmitting state and receiving state. Fig.5 highlights the analysis of the network delay, where it can be seen that PEGASIS has been witnessed with more network delay. The prime point of issue in the chain structure, which is good for energy efficiency but is not mean to meet the communication objectives of time critical applications in wireless sensor network. The next better performance of delay was seen in trend of ERP and HEED due to usage of optimization principle. Better delay performance was also observed for HCR that uses genetic algorithm. However, it was not found energy efficient.

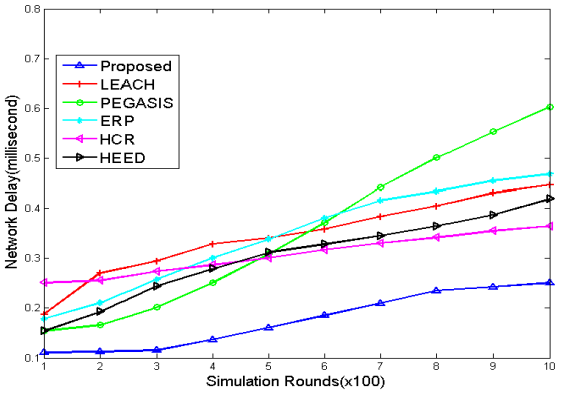

Fig.5 Network Delay Analysis

Therefore, the outcome clearly shows that proposed system is capable of ensuring minimization of energy drainage, maximization of data delivery, and with highly reduced network delay.

VIII. CONCLUSION

Energy is constantly the uncommon resource in any applications on vast scale remote sensor framework and grouping is the most as often as possible utilized procedure to ensure the life range of the sensor hubs. Till 10 years prior, there have been tremendous abstract works towards vitality change in bunching. Out of such rules research responsibility, a couple of systems have gotten a basic affirmation and are comprehensively packed in association with vitality powerful gathering instrument.

Regardless, such existing models encounters i) nonappearances of more broad degree of progression, ii) utilization of an over the top measure of complex count that impacts correspondence execution and life range of sensors, and iii) openness of lesser number of energy capable grouping measures. The best pitfalls of existing clustering methodologies is its absurd suspicions i.e. i) determination of sink on the premise of leftover vitality, ii) constraining the base station in the point of convergence of recreation territory (i.e. position reliance), iii) nonattendance of supportability of multihop correspondence in vitality effective methods. Hence, this paper addresses all such basic issues by showing a novel batching method that performs potential streamlining. Various criteria have been point by point for decision of aggregator center point, which gives better edge to vitality insurance. Using first demand radio model, the energy assessment shows that proposed grouping change technique ensure perfect life range of a sensor hubs when contrasted with existing framework

REFERENCES

[1] M. Ghaffari, "Near-optimal distributed approximation of minimum-weight connected dominating set", In Automata, Languages, and Programming, Springer Berlin Heidelberg, pp. 483-494, 2014

[2] L. Atzori, A. Iera, and G. Morabito, "The internet of things: A survey",Computer networks, Vol. 54(15), pp.2787-2805,2010

[3] H. Jiang, L. Chen, J. Wu, S. Chen, and H. Leung, "A reliable and high-bandwidth multihop wireless sensor network for mine tunnel monitoring", Sensors Journal, IEEE, Vol. 9(11), pp.1511-1517,2009

[4] G. Padmavathi, and Shanmugapriya, "A survey of attacks, security mechanisms and challenges in wireless sensor networks", arXiv preprint arXiv:0909.0576, 2009

[5] S.K. Singh, M.P. Singh, and D.K. Singh, "A survey of energy-efficient hierarchical cluster-based routing in wireless sensor networks",International Journal of Advanced Networking and Application (IJANA), Vol. 2(02), pp.570-580,2010

[6] K. Selvarajah, and V. Kadirkamanathan, "Energy efficient sink node placement in sensor networks using particle swarm optimization", In Ant Colony Optimization and Swarm Intelligence, Springer Berlin Heidelberg,pp. 510-511, 2006.

[7] H. Safa, and F. Yassine, "Localization in large scale wireless sensor networks. In Telecommunications (ICT),2012 19th International Conference, pp. 1-6, 2012.

[8] A.P. Jyothi and U. Sakthivel. "Trends and Technologies Used for Mitigating Energy Effi-ciency Issues in Wireless Sensor Network", International Journal of Computer Applica-tions, vol.111, No.3, pp.32-40, February 2015.

[9] N. Gautam, S. Sofat, and R. Vig, "An Ant Voronoi Based Clustering Approach for Wire-less Sensor Networks", Springer Journals, Social Informatics and Telecommunications, 2014

[10] J. Yu, Y. QI, G. Wang, "An energy-driven unequal clustering protocol for heterogeneous wireless sensor networks", Springer Journal of Control Theory Application, 2011

[11] X. Zhu, L. Shen, and T-S Peter Yum, "Hausdorff Clustering and Minimum Energy Routing for Wireless Sensor Networks", IEEE

[12] Transactions On Vehicular Technology, vol. 58, no. 2, February 2009

[13] K. Udompongsuk, C. S. In, C. Phaudphut,, "MAP: An Optimized Energy-Efficient Cluster Header Selection Technique for Wireless Sensor Networks", Springer Journal, Advances in Computer Science and Its Applications, Lecture Notes in Electrical Engineering, 2014

[14] E. Pei, H. Han, Z. Sun, B. Shen and T. Zhang, "LEAUCH: low-energy adaptive uneven clustering hierarchy for cognitive radio sensor network", Springer- EURASIP Journal on-Wireless Communications and Networking, 2015

[15] M.A. Bharathi, B.P. Vijayakumar, D.H. Manjaiah, Cluster Based Data Aggregation in WSN Using Swarm Optimization Technique, International Journal of Engineering and In-novative Technology, Vol.2, Iss.12, June 2013

[16] M.A. Bharathi, M. Mallikarjuna, B.P. Vijaya Kumar, "Bio-Inspired Approach for Energy Utilization in Wireless Sensor Networks", Elsevier-International Conference On Model-ling Optimization And Computing, Vol.38, pp.3864-3868, 2012

[17] K. Seelam, M. Sailaja and T. Madhu, "An Improved BAT-Optimized Cluster-Based Routing for Wireless Sensor Networks", Springer Journal, Intelligent Computing and Ap-plications, Advances in Intelligent Systems and Computing, 2015

[18] D. Meenakshi and S. Kumar, "Energy Efficient Hierarchical Clustering Routing Protocol for Wireless Sensor Networks", Springer Journal, Social Informatics and Telecommunications Engineering, pp.409-420, 2012

[19] P. R. Patil and U. P. Kulkarni, "Energy-Efficient Cluster-Based Aggregation Protocol for Heterogeneous Wireless Sensor Networks", Springer-Journal, Intelligent Computing, Net-working, and Informatics Advances in Intelligent Systems and Computing, 2014

[20] W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy-Efficient Communication Protocols for Wireless Microsensor Networks", Proceedings of the 33rd Hawaaian International Conference on Systems Science (HICSS), 2000

[21] C.S. Raghavendra "PEGASIS: Power-Efficient Gathering in Sensor Information Systems Stephanie Lindsey",Work, Vol. 310, pp. 336-1686,2001.

[22] E. Ahvar, S. Ahvar, G.M. Lee, and N. Crespi, "An energy-aware routing protocol for query-based applications in wireless sensor networks, The Scientific World Journal, 2014

[23] S. Hussain, and A.W. Matin, "Energy efficient hierarchical cluster-based routing for wireless sensor networks", Jodrey School of Computer Science Acadia University Wolfville, Nova Scotia, Canada, Technical Report, pp.1-33,2005.