International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2018): 7.426

Effective and Efficient Energy Based Data Collection and Routing in Wireless Sensor Networks Using Heed Clustering Technique

S. Subatra

Abstract: ***The journal examines with path is constructed between source and destination for data collection. From these queries we can answer by technique named as Mobile agent using HEED Protocol. Energy Aware routing is an main aim of minimizing the number of time slots required (schedule length) to complete an clustering based methodology, through this we can make of power control with effects of interference and show of power control helps in reducing transmissions of multiple frequencies of nodes with very effectively. In this journal, a energy efficient data collection is proposed using mobile agent methodology and HEED based clustering in wireless sensor networks, Sensor data in WSN is highly transferred, we proposed Enhanced Hybrid Energy Efficient Distributed Clustering (HEED) distributed based clustering algorithm, in here Cluster heads are selected from wireless sensor nodes based on the probability ratio using communication cost and energy. In such way the sensor nodes are with residual energy and lower intra communication cost made for Cluster Heads.***

Keywords: HEED, Energy Aware Routing, Mobile agent and Clustering

1. Introduction

The physical or natural circumstances, for example, temperature, weight, sound, and so forth., are checked by the Wireless sensor Networks (WSN) comprises of spatially scattered self-governing sensors and to the primary place it go their information by the system. The allowing screen of sensor activity and bi-directional are the additional ongoing systems. The military applications, for example, war zone supervision, it incites the upgrade of wireless sensor arrange, moreover modern process checking and control, machine wellbeing observing et cetera are the systems that are right now utilized in a significant calculation of mechanical and shopper applications. Each node is linked with one (or on occasion different) sensors, while WSN is create of "centers" from a couple to different hundreds or even thousand.

The radio receiver with an internal receiving relationship with an exterior gathering contraption, an electronic path example microcontroller for interfacing with the wireless sensors and an essentialness source are the two particular parts in the sensor frameworks and generally a power or an embedded kind of imperativeness gathering. Task "bits" of certified microscopic estimations still can't be formed, while a sensor center point may unique in size from that of a shoebox down to the range of a granule of buildup. The cost of wireless sensor node is moreover factor, made from a couple to several money, conditional upon the trouble of the individual wireless sensor nodes. Size and cost objectives on sensor center points result in related confinements on sources, immediate, memory, computational speed, energy and correspondences information exchange limit. The topology of the WSNs can differentiate from a fundamental star framework to an advanced multi-bounce wireless work organize. The spread strategy among the rebound of the network can be steering or flooding.

On a sensor networks is a static wireless Ad hoc system comprising of several sensor nodes conveyed on the fly for unattended task. Every sensor node is outfitted with a detecting device, a low computational limit processor, a short go wireless transmitter-beneficiary and a constrained battery provided energy. Sensor nodes screen some encompassing ecological marvel, process and the information got to forward towards a construct station situated with respect to the outskirts of the sensor organize. Base station(s) gather the information from the sensor nodes and transmit this information to some wireless control station.

2. Literature Survey

In the journal "On the Design of MAC conventions for Low Latency Hard Real Time Discrete Control Applications Over 802.15.4 Hardware" the creator Krishna Kant Chintalapudi Lakshmi Venkatraman expressed that Discrete occasion control circles in cutting edge machines of-ten contain an extensive number of sensors (50-200) answering to a controller.

Numerous discrete control applications must take into account hard constant prerequisites i.e., sensors must convey the event of basic occasions to the controller inside an ongoing due date (for the majority part 5-50ms) indicated by the control framework's plan necessities. Messages came to after this due date is viewed as lost. In case of activity blasts where a few sensors may endeavor to speak with the PLC in the meantime, messages from every one of the sensors must reach inside the predetermined due date.

The metric for execution in such frameworks is then the likelihood that a message from every one of the sensors prevails with regards to being gotten at the controller inside this due date. Further, for such answers for be feasible, the sensors should keep going for quite a long while without requiring change of batteries. In our study we look at the potential for utilizing 802.15.4 based radios for remote detecting in low-idleness hard ongoing discrete occasion control applications.

The activity of a few cutting edge control frameworks, for example, computer numerically controlled (CNC) machines,

vehicles, fabricating robot clusters and so forth depend on discrete occasion control. In a discrete occasion control framework, sensors pass on the event of basic occasions (as opposed to tested estimations of ceaseless physical wonders) to a controller. The controller at that point, in view of these contributions from the sensors, instigates the fundamental incitation to control the framework.

For instance, proximity sensors at a welding unit may recognize and tell the landing of another work-piece to the controller. The controller may then actuate an automated arm to lift the piece up and put it on the welding stage. In another model, a few sensors may identify a conceivable oil/gas spill and upon warning, the controller may require closing down a few segments of the framework.

The run of the mill cutting edge discrete occasion control-based CNC machine or a vehicle traverses 3-15 mts along its biggest measurement (controller to sensors) and houses 50-200 sensors. For a substantial number of discrete occasion control-based frameworks the control circle must oblige hard constant necessities i.e., the detecting (location of the occasion), correspondence (sensor to controller and controller to actuator) and activation must happen inside a pre-indicated due date.

Given fixed detecting and actuating delays, such due dates can for the most part be converted into correspondence postpone due dates. A message that does not achieve its goal before this due date may make the machine go into a mistake condition that requires its impermanent stopping or resetting. In machines today, sensors and actuators impart to the controller by means of links and take into account hard continuous correspondence latencies going from 5-50ms relying upon the specifics of the machine.

Intrinsic to most discrete occasion control frameworks is the eccentric bursty nature of the movement i.e., it is difficult to foresee when, what number of, or which sensors will be activated to convey in the meantime to the controller. This is on the grounds that the correspondence is essentially occasion driven and usually difficult to anticipate the occasions and nature of event of outside occasions.

By and large, activity blasts are regular in most discrete occasion frameworks since, I) a solitary occasion may prompt a few sensors activating in the meantime and ii) in excess of one occasion may happen in the meantime (or "close enough occasions"). In whatever is left of the journal we will allude to such occasion driven blasts as sensor blasts. In case of a sensor blasted, at that point, messages from every one of the sensors must achieve the controller inside the predetermined due date since the controller can make fitting move just after accepting every one of the data sources. Disappointment of receipt of a message from even one sensor may prompt eccentric disappointments in the framework constraining it into an error recovery state.

Consider a production machine of 100 sensors that produces a finished product every 10sec. Assume that the assembling of every item triggers a normal of around 50 sensor burst events. A communication failure probability of 1ppm (1 in 106) translates to an expected time among breakdowns of about 2 days ((10^{6})/86400(50/10)).

A failure will lead to a decreased production throughput and hence significant financial losses. Probability of failure (or now and again expected time between disappointments) is in this way, maybe the most vital execution measure in most creation frameworks. Disappointments in machines, for example, vehicles may prompt graver outcomes including loss of life and property.

As anyone might expect, in modern day machines, sensor-actuator-controller correspondence is led by means of correspondence links (transports or wires conveying simple signs). The plan of present day machines requires watchful de-freedom for directing the links from different areas inside the machine to the controller. Dispensing with the links cannot just give the capability of empowering minimal and basic mechanical plans by dodging unwieldy cabling; yet additionally give extra advantages regarding simplicity of establishment and upkeep.

Furthermore, cables are often subject to wear and tear, especially when they are drawn from moving parts within the machine and require frequent maintenance. Each maintenance cycle translates to decreased usage and increased maintenance costs. Elimination of link wear and tear occasions converts into less support consumption and less down periods. Further, the likelihood of wireless sensors supports the plan of frameworks with a bigger number of detecting focuses for more effective control.

The actuators are typically anticipated that would initiate mechanical activities, for example, lifting a section or turning a fast penetrate. Actuators in this way, can't be un-tethered and require control links to be steered to them. Making the controller-actuator correspondence remote does not offer huge points of interest since controller-actuator correspondence links can be "packaged" up alongside the electrical cables without critical overhead. Sensors, then again, have modest power prerequisites, and can be made "completely wireless", working just on batteries.

Supplanting batteries in many sensors in a machine, in any case, can be a tedious, work serious employment. Visit battery changes bringing about upkeep downtime can counterbalance the increases offered by a remote detecting framework. Considered that the lifetime of commonplace assembling machines or vehicles is 10 years, it will be normal that remote sensors must work for something like two years on batteries before requiring battery substitution.

There are subsequently, two measurements that totally catch the execution of a correspondence convention for low-latency hard real-time discrete event frameworks:

Probability of communication error - probability that somewhere around one sensor (among all sensors endeavoring to convey in case of a sensor burst) does not prevail with regards to transmitting its message to the controller inside the dead-line and, **Longevity of the system** - the normal future of wireless sensor nodes.

Communication cable based arrangements utilized in modern day machines normally give error rates of 1ppm (1 out of 106) or less. A wireless framework that replaces a current framework just to end up an execution bottleneck won't be acknowledged as a practical arrangement. In this journal we make the inquiry, "Can 802.15.4 based radios be utilized for wireless detecting in low-dormancy hard ongoing discrete control frameworks?" Rather than adopting a hypothetical strategy, in this journal, our methodology is to consider a normally utilized off-the-shelf radio - CC2420, (considering the acknowledgment it has gotten in the network) and endeavor to plan MAC conventions that can give 1ppm or less error probabilities inside due dates running in 5-50ms.

The trust is that this activity will prompt both subjective and quantitative speculations that can be utilized crosswise over other low-power radios dependent on the 802.15.4 standard also. Taking into account that in the average situations all sensors are inside 3-15 mts of the controller, in this journal, we confine ourselves to single hop MAC arrangements. Given that MAC conventions are extensively arranged into conflict free and dispute based conventions, in this journal they adopt a straw man strategy to planning and examining them deliberately.

In this Journal "Perma Sense: Investigating Permafrost with a WSN in the Swiss Alps" the creator Igor Talzi, Andreas Hasler, Stephan Gruber, Christian Tschudin expressed that Currently, there is an absence of standalone geo monitoring frameworks for cruel conditions that are anything but difficult to design, convey and oversee, while in the meantime clinging to science review quality prerequisites.

3. Background Study

3.1 Existing System

An infrastructure required for different mechanical and legislative associations to watch occasions happening in a physical world are given by sensor arrange. The WSNs comprises of unattended multi working sensors that are regularly conveyed in extensive amounts and in a high thickness way with restricted energy asset. These detecting nodes are connected by wireless medium by means of optical frequency band, infrared, or radio. These systems have different applications like surge and fire discovery in wireless zones, movement observation, airport regulation, et cetera. Sensors mutually accumulate encompassing condition data, for example, temperature, weight, and stickiness from their encompassing condition and forward it towards static information sink. In numerous situations, as nodes are conveyed in wireless and unsafe region, substitution of their batteries ends up unimaginable. So they should work without substituting their batteries for a long time.

Therefore control administration has turned out to be one of the crucial issues of WSNs. Utilizing a multi-bounce correspondence; it enables the deliberate information to be sent over a long separation to the primary area which is known as a sink. WSNs have been utilized for condition checking, human services, structure wellbeing observing, military, and numerous different applications. These sensor nodes depend on the utilization of little and constrained energy batteries to supply electrical energy to these gadgets. Batteries should be supplanted or energized frequently at whatever point it is drained. This standard support could without much of a stretch turn into the best expense of introducing a WSN for some applications [2]. Supplanting or energizing batteries isn't favored or unfeasible due to the increasing expense of customary upkeep when sensors are conveyed over a wide district. Furthermore, some of the time the nodes might be not reachable, that is, the point at which they are installed in building materials or sent in an unfriendly area for some military applications.

Amid the previous decade, the scientists proposed numerous answers for draw out the lifetime of system. One of these strategies utilizes obligation cycling technique where the diverse units of the nodes are turned off or entered low-control (rest) mode when they are idle [3, 4]. Another methodology is to plan energy mindful medium access control conventions (MACs) and directing conventions [5]. Information accumulation likewise diminishes the quantity of transmitted packets by expelling parcels that convey excess information for a similar locale [6, 7]. In spite of the way that past arrangements decrease energy consumption to broaden network lifetime or upgrade

3.2. Need of the Research

The aim of this research is to propose an energy constituent-based model. Not only does modeling of constituents as single energy consumption units present many possible strategies for maximizing the network’s lifetime, it also has a few benefits when WSN is seen as a composition of these constituents. Figure 1-3 clearly shows how the energy of a node is consumed by tasks, operations, events, changes, demands and commands during its lifetime. This composition of constituents allows optimization of the energy consumption of a node if desired, permits optimization of a selected constituent for a specific application, and, more importantly, allows an overall optimization of the consumption of energy of whole network by taking into consideration the play off among constituents. Furthermore, the constituents can be modified to suit the required application. This research focuses on minimizing and optimizing energy consumption based on the energy consuming constituents as a general model for WSN deployment and development. The model deals with all common aspects of energy consumption in all types of WSNs. We believe designing wireless sensor networks with their energy constituents in mind will enable designers to balance the energy dissipation and optimize the energy consumption among all network constituents and maintain the lifetime of the network for the projected application.

Our aim is to propose a single overall formulation of the consumption of energy of the whole wireless sensor network. Another possible but more difficult formulation states the consumption of energy model as a non linear function of its constituents. This approach requires more extensive exploration, as we do not understand well enough the metrics associated with the energy of each constituent and we are unsure about the mathematical models that can

describe such a non-linear relationship. In this research we comprehensively model the components of each of the five energy elements of the structural design. The aim is to provide an accurate account of all functional aspects of a constituent and their salient energy-related parameters. These parameters will allow us to estimate the WSNs performance, optimize their operation, and design more energy efficient applications. In the second phase of our study, we aim for an optimization of each element and a general optimization with respect to a balance between the energy constituents. These optimizations will be confirmed by mathematical proof and simulation. Finally, we will use the outlines of the project to generate an algorithmic solution to minimize overall energy consumption and network performance.

4. Research Methodology

4.1. Proposed Work

1.4.1 Research Objectives and Scope

- Addressing the above-mentioned research questions, Figure 1-5 shows the steps that will be followed in this journal:
- Determine the impact of consumption of energy constituents and their pervasive parameters on entire WSNs consumption of energy.
- Obtain a quantitative measurement and modeling of the entire consumption of energy based on prevalent parameters.
- Propose a model which is applicable for all kinds of applications in sensor network.
- OPTIMISE overall energy consumption by optimizing the model.
- The model should cover the challenging problems: scalability, reliability, and collaboration

The overall model will offer the best approach to minimize the energy consumption by involving the prevalent parameters.

4.2. EEA-HEED

It is a distributed clustering algorithm created as an enhancement over LEACH. The upgrade is done in the CH selection strategy. EEA-HEED, chooses CH based on vitality and additionally correspondence cost. In EEA-HEED, every node is mapped to precisely one cluster. It is isolated into three stages:

4.2.1. Initialization Phase

Every sensor node sets the likelihood Cprobof getting to be CH pursues: Where Cprobis the underlying level of CH required in the system, Eresidualis the present energy of the node and Emax is the most extreme energy of the completely charged battery.

4.2.2. Repetition Phase

This is an iterative stage in which every node rehashes a similar procedure until the point that it discovers a CH to which it can transmit with minimum expense. In the event that any node finds no such CH, chooses itself to be a CH and sends the announcement message to its neighbors. At first sensor node end up conditional CH, it changes its status later on the off chance that it finds a lower cost CH. The sensor node ends up permanent CH if its CHprob has achieved 1.

4.2.3. Finalization Phase

In these stage nodes either chooses the least cost CH or itself turns into a CH. In spite of the fact that it is an enhancement over LEACH still it has a few hindrances like more CH are created than anticipated and it doesn't know about heterogeneity.

1) Configure the network - In this part the system will be design by heterogeneous nodes. There may me same sort or diverse kind of nodes which will organize in a system in arbitrary way. In proposed work we will take 300 no. of nodes and appoint a region of 150 x 150.
2) Formation of Clusters - In this part various clusters will appoint in the region in irregular way. Bunches will characterize in such a way, to the point that there will be least one node in a cluster and a most extreme of five nodes in a cluster. The nodes routinely refresh their arrangements of neighbors.
3) Selection of Cluster Head - Single cluster head will be chosen dependent on lingering energy and intra bunch correspondence. This cluster head will be capable to take data from different nodes and transmit to base station or other cluster head. The data might be of any sort for instance Pressure, humidity, sound, temperature and so forth.

4.3 Cluster Head Selection

Cluster heads can use a routing protocol to compute inter cluster paths for multi-hop communication to the observer(s), as discussed. The following requirements must be met:

1) Clustering is completely distributed. Each node independently makes its decisions based only on local information.
2) Clustering terminates within a fixed number of iterations (regardless of network diameter).
3) At the end of each TCP , each node is either a cluster head, or not a cluster head (which we refer to as a regular node) that belongs to exactly one cluster.
4) Clustering should be efficient in terms of processing complexity and message exchange.
5) Cluster heads are well-distributed over the sensor field and have relatively high have range residual energy compared to regular nodes.

Cluster Head Selection Algorithm

SELECT_CLUSTERHEAD (n, S) Begin:
Step1. Let we have a set S of n nodes in a cluster viz. S= {S1 , S2 , S3… Sn}

Step2. Calculate the distance of one node to all nodes.
for i=1 to n
do for j=1 to n
do dij = distance from si to sj
end for
end for

Step3. Calculate the sum of all distance from one to all nodes.
for i=1 to n
do for j=1 to n
do Di=Di + dij
end for
end for

Step4. Calculate distance from BS to each node for all nodes.
for i=1 to n
do DBSi = Distance from BS to Si
end for

Step5. Calculate the net distance with base station for each node
for i =1 to n
do NDBSi=DBSi + Di
end for

Step6. Select the cluster head based on all NDBS values.
NDBSi =Min (NDBS1 , NDBS2 , NDBS3 , NDBS4… NDBSn)
And corresponding node will selected as cluster head.

Finalize of network clustering, the inter clustering depends on the network application. For example Cluster Heads (CH) are communicating with each other to aggregate the data through multiple hops. For multi hop communication between the cluster heads the range of selection may vary to ensure degree of connectivity into an control interference

For an cluster communication in inter cluster the connectivity gives on multihop based relationship between the inter-cluster nodes of transmission range, R_t, and the Intra cluster transmission range, R_c. The proof of theorem is defined through our algorithm and results and discussions. The density model provides an necessary algorithms and asymptotically multi-hop connectivity.

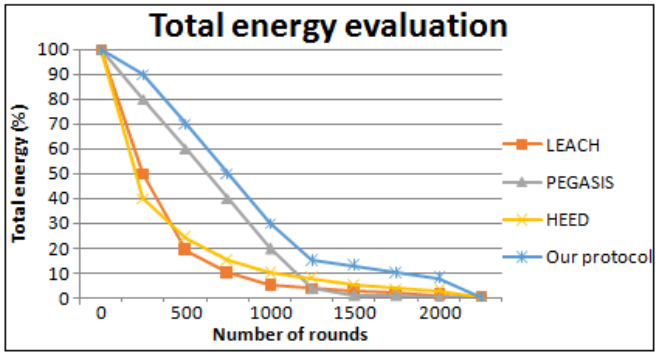
5. Results and Discussion

This EEA-HEED protocol is a good baseline for comparison because it has the following features:

1) EEA-HEED clustering is purely distributed and it is based on local information
2) Cluster Head selection are guaranteed to the nodes with an highest weight allocation to their clusters
3) Every node in network is associated with an cluster head of its own
4) Assumptions are about node dispersion in the field to make.
5) the "n" number of iterations in protocol is used by function of network that the diameter which is passing current clustering approach into an Ad hoc networks
6) The message and its time complexities are $\Theta (n)^2$ per node respectively
7) all those cluster heads are with neighbors, (i.e: Cluster Heads are well scattered in the field of networks).

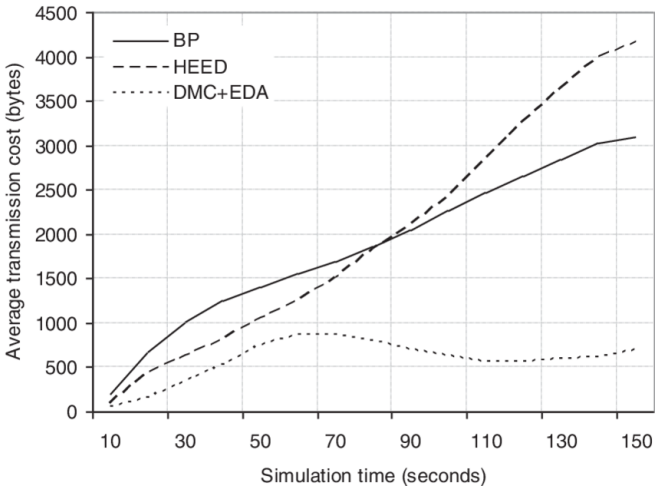
5.1. Energy Consumption Result Analysis

In order to give performance, below figure clearly shows that the proposed routing algorithm makes us energy consume than existing system. Minimum energy consumption of nodes makes through clustering.



Above figure 5.1 shows that energy decrease of proposed protocol EEA-HEED than other protocols such as LEACH, HEED and PEGASIS, because our EEA-HEED selects the Cluster head according to the residual energy and to its minimum energy, from its previous Cluster Head than random probability and it extends network lifetime. The throughput ratio of previous cluster head it rather than cluster head nodes according to the total number of packets, its greater value of throughput of better performance protocol.

5.2. Number of Packets Received For Sink



From the above analysis in figure 5.2, the average transmission cost is contribute for our proposed EEA-HEED divergence measure clustering, we also add more data aggregation such as DMC (Divergence Measure based Clustering) and EDA (Entropy based data aggregation) along with the hybrid energy efficient distributed clustering, also compared with Belief propagation technique. DMC + EDA gives an good factor for EEA-HEED. Compare by individually it makes an HEED as good one, if we add DMC and EDA to HEED it makes an EEA-HEED (Enhanced Energy Aware – Hybrid Energy Efficient Distributed Clustering Protocol)

6. Conclusion

One of the most important issues in Wireless Sensor networks is to preserve the limited energy resources of sensor nodes available in it. Data generated from adjacent nodes are highly interrelated thereby formulating the sink node to lose its energy for processing those interrelated data. In order to minimize the data packets broadcasted to sink, data aggregation is a method to combine the data either at the sensors or at the intermediate nodes.

In our proposed work, wireless sensor networks are finding its application through Clustering process by EEA-HEED protocol. The battery energy is an very scarcest among Wireless sensor network. Our work gives an optimization and control of power through intelligent techniques of using DMC and EDA into HEED, using this EEA-HEED is designed. The correlated reliable routing methods find the path of its destination by predicting the best nodes in their path. The packet loss mechanism retransmits away and the energy is reduced here.

The NS2 simulator is used for implementing the system design. The performance mechanism is evaluated with high energy consumed, sampling rate and end to end delay mechanism. When it is compared to previous LEACH protocol energy consumption is reduced.

7. Future Work

Clustering is an one of efficient methodology in networks to improving energy of wireless sensor nodes, through this we made hierarchical clustering approach, in future the clustering made from hybrid methodology called from optimal distance from sink nodes. The position of cluster heads consumes less energy compare to approach.

Data transmission also make an topology wise, through this we make an balanced network analysis and the enhanced EEA-HEED is given. Through extensive analysis and simulations, we found that EEA-HEED outperforms other algorithms in terms of stability period. In addition, we also deduced that the predefined cluster-head percentage correlates with the node number of a network, and this contributes to determining a proper number of cluster heads for a network

In future, the network lifetime is enhanced by implementation of data aggregation algorithm to re allocate task of sink to another node when its residual energy sink node drops.

References

[1] C.Y. Chong and S.P. Kumar, “Sensor networks: evolution, opportunities, and challenges,” In Proceedings of IEEE, pp. 1247-1256, 2003.
[2] K. Sohrabi, J. Gao, V. Ailawadhi, and G.J. Pottie, “Protocols for self-organization of a wireless sensor network,” IEEE Personal Communications, vol. 7, pp. 16-27, 2000.
[3] A.M. Zungeru, L.M. Ang, and K.P. Seng, “Classical and swarm intelligence based routing protocols for wireless sensor networks: A survey and comparison,” Thesis of Network and Computer Applications, vol. 35, pp. 1508-1536, 2012.
[4] B.A. Attea and E.A. Khalil, “A new evolutionary based routing protocol for clustered heterogeneous wireless sensor networks,” Applied Soft Computing, vol. 12, no. 7, pp. 1950-1957, 2012.
[5] M. Shokouhifar and A. Jalali, “A new evolutionary based application specific routing protocol for clustered wireless sensor networks,” AEU-International Thesis of Electronics and Communications, vol. 69, no. 1,pp. 432-441, 2015.
[6] N. Vlajic and D. Xia, “Wireless sensor networks: to cluster or not to cluster,” In Proceedings of the International Symposium on a World of Wireless, Mobile and Multimedia Networks, pp. 258-268, 2006.
[7] W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, “Energy-efficient communication protocol for wireless microsensor networks,” In Proceedings of the 33rd International Conference on System Science (HICSS’00), Hawaii, USA, pp. 1–10, 2000.
[8] A. Wang, D. Yang, and D. Sun, “A Clustering Algorithm Based on Energy Information and Cluster Heads Expectation for Wireless Sensor Networks,” In Proceedings of International Conference on Computers & Electrical Engineering, pp. 662-671, 2012.
[9] J. Jia, Z. He, J. Kuang, and Y. Mu, “An energy consumption balanced clustering Algorithm for wireless sensor network,” In Proceedings of the IEEE International Conferences, pp.1-4, 2010.
[10] M. Saadat, R. Saadat, and G. Mirjalily, “Improveing threshold assignment for cluster head selection in hierarchical wireless sensor networks,” In Proc. Int’l Symposium on Telecommunications, pp. 409-414, 2010.
[11] S.H. Kang and T. Nguyen, “Distance based thresholds for cluster head selection in wireless sensor networks,” IEEE Communications Letters, vol. 16, no. 9, pp.1396-1399, 2012.
[12] Y. Liu, K. Xu, Z. Luo, and L. Chen, A reliable clustering algorithm based on LEACH protocol in wireless mobile sensor networks, In Proc. IEEE ICMET, pp. 692-696, 2010.
[13] S. Hussain, A.W. Matin, and O. Islam, “Genetic algorithm for hierarchical wireless sensor networks,” Thesis of Networks, vol. 2, no. 7, pp. 87-97, 2007.
[14] M. Shokouhifar and A. Hassanzadeh, “An energy efficient routing protocol in wireless sensor networks using genetic algorithm”, Adv. Environ. Biol., vol. 8, no. 21, pp. 86-93, 2014.
[15] I. Gupta, D. Riordan, and S. Sampalli, “Cluster-head election using fuzzy logic for wireless sensor networks,” In Proceeding of the 3rd Annual Conference on Communication Networks and Services Research, pp. 255-260, 2005.
[16] J.S. Lee and W.L. Cheng, “Fuzzy-logic-based clustering approach for wireless sensor networks using energy predication,” IEEE Sensors Thesis, vol. 12, pp. 2891-2897, 2012.
[17] J.M. Kim, S.H. Park, Y.J. Han, and T.M. Chung, “CHEF: cluster head election mechanism using fuzzy

logic in wireless sensor networks," In Proceeding of the 10th International Conference on Advanced Communication Technology, pp. 654-659, 2008.
[18] G. Ran, H. Zhang, and S. Gong, "Improving on LEACH protocol of wireless sensor networks using fuzzy logic," J. Inf. Computational. Sci., vol. 7, pp. 767-775, 2010.
[19] I.S. Alshawi, L. Yan, W. Pan, and B. Luo, "Lifetime Enhancement in Wireless Sensor Networks Using Fuzzy Approach and A-Star Algorithm," IEEE Sensors Journal, vol. 12, no. 10, pp. 3010-3018, 2012 S. Lindsey and C. S. Raghavendra, "PEGASIS: Power-efficient gathering in sensor information systems," in Aerospace conference proceedings, 2002. IEEE, 2002, pp. 3-1125-3-1130 vol. 3.
[20] O. Younis and S. Fahmy, "HEED: a hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks," Mobile Computing, IEEE Transactions on, vol. 3, pp. 366-379, 2004.
[21] S. Cho, B. Shrestha, K.-H. La, B.-H. Hong, and J. Lee, "An Energy-Efficient Cluster-Based Routing in Wireless Sensor Networks," in Communication and Networking, ed: Springer, 2011, pp. 57-64.