Clustering based Energy Efficient Protocol for Wireless Sensor Network Comparison Study

Meenakshi Yadav
Research Scholar
CSE Department
Banasthali University

C. K. Jha, PhD
Head of Department
CSE Department
Banasthali University

ABSTRACT
In last decade the utilization of wireless sensor network in various fields is growing enormously. These WSNs applications are used where human access and monitoring cannot easily handled. Due to this sensor nodes are deployed randomly in unattended area, where these nodes form a network in an adhoc manner. In addition, battery of deployed sensors cannot be charged, so it is desirable that network should be energy efficient. By considering above mentioned issue, many energy efficient routing protocols have been proposed. This paper presents an overview of routing protocols those are based on clustering technique. These protocols are used to increase network lifetime.

General Terms
Wireless Sensor Network,, LEACH, Energy efficient protocols.

Keywords
Wireless Sensor Network, Hierarchical clustering, Sensors, Cluster Heads (CH), Base Stations (BS), Energy, Network lifetime

1. INTRODUCTION
First wireless sensor network was designed in middle of the 70s. This network is used for military applications. There are some problems in that network like large size, energy consumption etc. Since then lots of energy efficient protocols has been developed for WSNs. Each protocol has characteristics which are depending on applications and network architecture. Hierarchical clustering protocols are used to solve the energy consumption problem. Clusters are the group of sensors. Each cluster has their cluster head and used as a gateway between nodes and base station. Sensor nodes collect information and send to CH than CH send this information to base station. There are various parameters of clustering like number of clusters, Intracluster communication, Node and CH mobility, Nodes types and roles, Cluster formation methodology, cluster head selection, algorithm complexity, multiple levels and overlapping. Two common classification of clustering is clustering algorithm for homogeneous or heterogeneous network and centralized or distributed clustering algorithm. First one is based on the characteristics and functionality of the sensor in cluster and second one is based on method to form a cluster. Most of clustering algorithm can be categories as probabilistic clustering algorithm and Nonprobabilistic clustering algorithms. Main contribution of this paper is to provide a survey on energy efficient routing protocols those are based on clustering algorithm categories. Mostly protocols have their own cluster head selection method. The rest of the paper is organized as follows: In section 2 a literature survey is presented for various protocols. Section 3 concludes this paper.

2. LITERATURE SURVEY
In [1], the author presents a problem description regarding data movement in wireless sensor network. For the illustration they have presented architecture with two features; 1) Intra node router and 2) functional repartitioning. They claim that their architecture reduces traffic through router.

In [2], hundreds and thousands sensing nodes are available in a sensor network. It is essential that these nodes are cheap and energy efficient. The authors have presented an analysis of advantages and disadvantages of various existing protocol and have developed a low-energy adaptive clustering hierarchy technique that reduces the energy dissipation. LEACH having clustering setup phase and localized coordination between cluster head or base stations in rotation, for reducing global communication, local compression is used.

In [3], the sensors used are extremely small, low power device that programmed to sense the data. Now the challenge is how this sensed data or information collect and store within the sensor network. In this article author describe an architecture called SINA (sensor information network architecture). This SINA provides querying, monitoring and tasking facilities for sensor network. SINA works like middleware to organize the sensor information. Kernel of SINA is a set of configuration and communication primitives. IT provides scalable, robust and energy efficient organization of sensor network.

The first step of establishment of sensor network is deployment of sensor nodes. Low power hardware components and customized system architecture are necessary to create a network. In [4] the authors have introduced a concept to select the sensor nodes in such a way so that all monitoring area is covered completely. Author made mutually exclusive sets of sensor nodes only one set is active at a time. Simulation results show that by using only a set of sensor node energy saving is achieved.

A cellular network is collection of sensor network with more than one cluster. Cluster and cluster head is in cluster network and base station is in cellular network. For increasing life of sensor network authors in [5] have worked on relationship between bandwidth and energy consumption. Author propose a fine-grain variable bandwidth allocation with properly use of bandwidth. To reduce average power consumption a polynomial time slot is assigned to the algorithm for multiple cluster sensor networks.

In [6], authors have proposed a new threshold algorithm to improve network lifetime. The main idea of this algorithm is to select a new cluster head so that it can reduce the lower energy node to become cluster head. Threshold has been modified for selecting CH at next level. Different threshold

compare with random number and greater probability nodes elect as cluster head.

At the lower level of a network means near to sink, sensor nodes need to handle network traffic because these nodes deplete their energy very soon. There is imbalance of work load in network which is called hotspot problem. The authors in [7] have proposed an algorithm EAMTR for solving hotspot problem. EAMTR is energy aware multi-tree routing. In high density sink-type network EAMTR gives energy balancing, extension of network lifetime and reliability using route redundancy.

In article [8], author explains clustering techniques in detail. Clustering is a grouping of sensor nodes. Each cluster has their head in hierarchical structure. These cluster heads performs important tasks like fusion and aggregation. Sensors nodes senses data and send it to CH. Cluster head aggregates that data and send it to base station. Because CH sends the data to base station and some time with higher distance CH spends their energy rapidly. So the solution of this problem is re-elect new cluster head in each cluster. Data processing point is Base station. Base station is generally fixed at a distance from sensor network. CH is a gateway between sensor nodes and base station. Hierarchical clustering concept is useful for that application those require scalability. Scalability is related to load balancing and efficient resource utilization.

Adaptive clustering algorithm is one of the ways to reduce the energy consumption of wireless sensor networks. Authors in [9] have proposed a new energy aware clustering algorithm by using Ant colony optimization technique. The authors use a cost function that is implemented on base station and minimize the distribution cost of long distance transmission. Using ACO algorithm cluster heads have been selected and change the distance dynamically between CHs and distributed clusters.

In [10], the author analysis the LEACH shortcomings like cluster head selection and neglecting of node's residual energy. Based on these shortcomings author propose a new balanced LEACH protocol. In LEACH-B cluster head selection is based on residual energy of node at second round.

In [11], the authors introduce a cross layer approach and propose a cooperative LEACH protocol. Cooperative LEACH has M cluster heads in a cluster. These M cluster heads send data to sink or higher layer cluster heads. This scheme is most likely multipath routing scheme. Cooperative LEACH protocol reduces high energy consumption.

In [12], authors mainly consider the end to end latency and energy efficiency. The study of various energy efficient and time critical routing protocols like TEEN, APTEEN, SPEED, RAP, RPAR is presented. TEEN is threshold-sensitive energy efficient sensor network protocol used for time critical data sensing application in term of energy efficiency. Main drawback of TEEN is CH will not have information when the sensor nodes die. APTEEN is adaptive sensitive energy efficiency sensor network protocol. APTEEN is used for periodic collection of data and critical events. Drawback of APTEEN is that it requires additional complexity. Stateless Non-deterministic Geographic forwarding protocol maintains immediate neighbor's information for minimizing memory requirements. For removing congestion backpressure rerouting techniques has been used. RAP is a real-time architecture for communication in large scale wireless sensor network. RAP provides query and event services. RPAR is real-time power-aware routing in WSN. Main purpose of this protocol is to increase the number of packets which meets their deadline. RPAR also maintain properties of WSN like loosy links limited memory bandwidth.

In [13], the authors have introduced a spare selection phase into LEACH and propose a new protocol called LEACH-SM. Spare node strategy has been used for improving network life. There are active and passive nodes for efficient usages of energy. Nodes become in active node when awaking spare time is over and previously active node reached their exhausted limit.

One of popular routing scheme of WSN is convergecast. In which every sensor node sends the packet to the base station using configured routing paths. For saving energy convergecast routing technique send a single packet in which all received data has been merged along with own data. The authors in [14] propose a chain routing with even energy consumption protocol. IN CREEC a centralized control at BS has been processed for longer lifetime. Calculation of routing path and schedules throwing is done by BS. Throwing is a technique in which packet directly transmit to the base station. CREEC uses two main rules one is fairness of energy distribution and another one minimize the total energy consumption. Feedback mechanism is also used for energy distribution. The base station calculates the energy of each node. According to that energy level chain is re-build. Lower energy node will get light roles. CREEC implement two types of transmission Throwing and forwarding.

Scalability and simplicity is the characteristics of energy aware geographic routing scheme for WSN. Geographic routing provides the pure location information rather than global topology information to route data packets. This location information feature makes it efficient, simple and scalable. There are two modes of working in geographic Greedy mode and Detouring mode. Packet delivery is not sure in detouring mode is common error in geographic protocols. The authors in [15] propose a new energy-aware interference sensitive geographic routing (EIGR) protocol. EIGR consider two points, total energy conservation and interference reduction. EIGR used an anchor list to provide the guidance to deliver the data. For data delivery greedy forwarding scheme is used. An energy-efficient relay region has been introduced. This relay region is beneficial for energy conservation.

A device wastes a big amount of energy if their battery discharging is not managed. So the study of battery behavior is important for improving network life. The author in [16] has presented a scheme called BAR (battery-aware scheme). This scheme is independent to any routing protocol. Nickel cadmium or Lithium-ion are power provides for wireless devices. Author divides the time into fixed-length durations, so that it will fit into packet-switched network. Author also gives online model for computing battery capacity. For prioritizing services of BAR an enhanced scheme developed called PBAR. BAR scheme is used in PBAR.

In [17], for improving network life by routing techniques there are two main problems occurs first one is routing overhead is very high and second is route maintenance scheme is not suitable for energy efficiency. Therefore author proposes a new metric for link cost for finding energy efficient routing path and a protocol for improving path setup transmission, performance and energy consumption. PEER quickly search the energy-efficient path and maintains route active for respond to topology. PEER protocol's route request packet having two information one hop count and energy

consumption. These information will update after receives to an intermediate node, then the packet will rebroadcast if one of the following conditions occur. A new packet or it comes from shorter path and path is same and best path but energy consumption is lower. First Conditions is for shortest path and second one is minimum energy consumption.

In [18], wireless sensor network is used to collect data from multiple sensors. So this type of application requires multiple sources to collect data and multiple sinks. When we are having such type of application that required multiple sources and sinks for data collection, single sink protocols are ill-suited. There is various protocols having single sink. To solve above mentioned problem author develop MUSTER protocol having many to many communication in WSNs. MUSTER having distributed path merging and load balancing features. MUSTER doubles the lifetime of WSNs.

In [19] almost all existing energy-efficient protocol selects the minimum energy path and lowest energy consumption for transmission of packets. This is main reason of unbalance distribution of residual energy in sensor nodes. By consideration of this author propose an algorithm called Energy-Balanced Routing Protocol (EBRP). Author uses physics concept and construct a potential field with respect of depth, energy density and residual energy. Packet move to sink using dense energy and residual energy. Topology, applications, routing are the reasons of imbalance in energy distribution. Deployment optimization, topology control, mobile sink/relay nodes, data aggregation and energy balanced routing are the possible solution to balance energy consumption.

In [20], Authors propose a method to find out the specifications of network resources. Network specifications are number of available nodes; sensing range and spatial sensing coverage etc. after that author develop novel criteria by considering SSC as the WSN effective operation criteria. Life time-aware routing and the desired sensing spatial coverage of the field of interest are the two main challenges in WSN. Author's work is focused on network layer and routing algorithm FA proposes for optimize the lifetime and sensing coverage of network. FA algorithm will increase the monitoring and sensing coverage ability and the lifetime of network.

Hotspot is a location where traffic is very heavy. That area node depletes energy very quickly. This problem is also affects CH node because CH also has lots of burden. So for balancing CH load it should be in rotation among all nodes. The authors in [21] propose an algorithm called energy efficient clustering. EC algorithm calculates cluster size that depends on hop distance to sink. Authors also propose a data collection protocol to check EC effectiveness. Simulation results show that EC algorithm increases network lifetime.

Imbalance of energy consumption in network is basically a energy hole problem. Nodes those are close to sink is spend their energy very soon due to heavy work load. The author in [22] divides the network into several layers and those layers divided into clusters. Lower level CH send the data to upper layer cluster heads and due to less distance between layers cluster heads energy consumption is improved. LEACH mobile, LEACH-mobile-enhances and CBR-mobile are existing cluster based mobile routing protocols those consider only the energy efficiency but reliability of routing protocol is also important factor to find out data link failure, recover sensor node and transmission path.

The authors in [23] propose an energy efficient and reliable protocol location-aware and fault tolerant clustering protocol for mobile WSN. A special packets sent by the sensor nodes to cluster head when these nodes do not have any data to sensed. Main objective to send these nodes are to find out mobility and failure of member nodes in cluster. Proposed protocol has less-end to end delay with respect to other protocols. In LFCPMWSN author selects CCH who is having least mobility factor due to this energy factor has not been improved.

In [24], the authors have proposed a new routing scheme QLEACH which is the combination of Q-DIR and clustering model in LEACH. Q-DIR is quadrant based directional routing. Q-DIR uses location based routing and restricted flooding. Q-DIR selects the broadcast region where destination and source node are placed. Q-DIR is reactive routing protocol for reducing routing overhead and power consumption through limited flooding. Location information of source and destination node is publicized via route request packet. Destination nodes respond this RREQ by replying RREP via the same path taken by source node. Individual nodes calculate their distance and forwarding zone information. These techniques reduce the number of participating nodes in RREQ and reduce energy consumption.

Data confidentiality, security, authenticity, availability and integrity must be maintained for WSN. Because of WSN limitation it is hard to maintain security in WSN. The author in [25] provides security parameters to LEACH protocol without affecting network performance. Using this protocol only authorized node will join and communicate with the network. Author delete the idle listening and overhearing using new protocol and save the energy to increase network life.

Clustering-based protocols based on principle of divide and conquer and it is best for heterogeneous WSN. Most of existing clustering protocols consider homogeneous WSNs. Homogeneous means all sensor nodes having same battery energy whereas heterogeneous means two or more different type of sensor nodes with different energy levels. Energy saving scheme designed for homogeneous networks are not performing well for heterogeneous networks. So author in [26] proposes a new energy scheme especially for heterogeneous networks. S-EECP and M-EECP are two proposed clustering algorithms based on single hop and multi hop respectively.

In [27], an exhaustive survey on energy-efficient routing protocols for WSNs is presented. WSN classified into four categories network structure, communication model, topology based and reliable routing scheme.

Most clustering algorithm selects cluster heads and this CH simultaneously works as a relay node to transfer the data to sink node or other node. Now this is inefficient with respect of energy efficiency. The author in [28] proposes a new distributed algorithm called scalable energy efficient clustering hierarchy (SEECH). In this algorithm CHs and relays selects separately between sensor nodes. This is based on the condition of nodes. High nodes are selected as CHs and low energy nodes are selected as relay nodes. Simulation results shows that SEECH is best suitable for large scale network and have better CH distribution.

Reliability and connectivity in WSNs has to be ensured by clustering protocol. Transmission of messages, data control packets are the main reason of energy consumption. Three

main adjustment parameters for cluster heads election are energy consumption adjustment degree and exact distance that each data traverses to reach the BS. Sensor nodes having three main components, sensing subsystem for data acquisition, processing subsystem for local data processing and wireless communication subsystem for transmitting necessary data. In [29] the author has proposed an energy efficient hierarchical cluster based routing algorithm for WSN. The Main idea of this protocol is selection of CH that is based on local information at the time of construction of routing tree. In selection of CH residual energy of node and its distance to base station is considered. Author use routing and clustering scheme number of control packets would be reduced and power of nodes is saved. Imbalanced load distribution between CHs is the main reason of random deployment. To solve this problem proposed protocol opt next node by considering residual energy in an area where density is very low.

Full coverage of sensing field is main objective of wireless sensor networks. The author in [30] develops a novel algorithm which covers whole sensing field and BS connectivity of sensor node, for this author use tree concept. Maximum connected load-balancing cover tree have two components first one coverage optimizing and second one probabilistic load balancing. By using MCLCT sensing and transmitted load will be shared between sensor nodes. Due to this energy consumption is evenly between nodes.

Mobile wireless sensor networks suffer from packet overhead and delivery ratio degradation. Due to this energy consumption is increased. The author in [31] proposed a crosslayer operation model for improving energy consumption and throughput of MWSN. Application, network, MAC, physical layer integrated into the proposed model. Location information is present into routing operation and used for route discovery process MAC layer is used to set transmission range. This information is used by the node and energy will be saved. Neighbor finding massage broadcast only in active node by proposed scheme, so that energy can be saved. This proposed model leads network to consume less energy and taking care of packet delivery ratio.

If an algorithm group the sensor node properly than the energy efficiency can be increase for WSN. Cluster head selection assignment and construction requires additional overhead. In [32] the author considers the isolated nodes and proposes a new regional energy aware clustering method. Weight is a main factor is this algorithm that represents residual energy of each sensor node. When the network designed improperly and distribution of nodes is not correct these isolated nodes are not in the range of CH. Because of this, these nodes took lots of transmission energy for communication. In proposed concept author calculate the distance between sensors and sinks and then check whether regional average energy and node energy is sufficient to send the data to sink or CH node. REAC-IN protocol solves the isolated node problem and improves CH selection process.

For achieving better system performance sensor deployment is best parameter. Author in [33] proposes a deployment scheme that satisfies the average detection probability requirements. Algorithm determines the number of sensors required for a local region. It minimizes the total number of sensors. Proposed algorithm optimizes the solution.

In [34], author proposes an algorithm that is based on the idea of structure compose of edge nodes. Random structure transformed into virtual circle. Greedy forwarding is used for transmission and overhead is also reduced. The virtual circle is used to reduce length of routing path and transmission delay. Proposed protocol gives high delivery ratio, short path length, less control packet overhead and energy consumption.

Geographic routing does not require global topology so it is good approach in large scale WSNs. Sensor node take routing decisions according to geographic locations. If a sensor do not have neighbor close to sink than geographic routing cannot calculate hop count. It is called local minimum problem. The author in [35] proposes a clustering technique named energyefficient homogeneous clustering that selects cluster heads according to residual energy. Author also consider the obstacles in cluster and proposed a technique to optimize the routing path. For this author use Dijkstra's shortest path algorithm.

A comparison table has been shown the various protocols for improving life of sensor network.

Table 1: comparison of various protocols

Clustering routing protocol	Mobility	Scalability	Distributed	Hop Limit	Energy Efficiency	Homogeneous	Use of localization
LEACH	X	Limited	√	Single	High	√	X
LEACH-A	X	good	√	Single	Very high	X	X
LEACH-B	X	good	√	single	Very high	√	√
LEACH-C	X	good	X	single	Very high	√	√
LEACH-Cell	X	Very good	√	single	Very high	√	√
LEACH- E	X	Very good	√	single	Very high	X	√
LEACH-EEE	X	Very good	√	Multi hop	Very high	√	X
LEACH-F	X	Limited	X	single	Very high	√	√
LEACH-K	X	Good	√	single	Very high	√	√
LEAC	√	Very	√	singl	Ver	√	√

H-M		good		e	y high		
LEACH-Multihop	X	Very good	√	Multi hop	Very high	√	√
LEACH-S	X	Good	√	single	Very high	√	X
LEACH-TL	X	Very good	√	single	Very high	√	X
LEACH-V	X	Good	√	single	Very high	√	X

3. CONCLUSION

Generally, clustering technique is efficient in terms of network life and energy consumption in WSNs. In this article we tried to summarize energy efficient protocols those are using clustering technique. Some of them have their own concept to select cluster head to reduce energy consumption and increase network lifetime. Most of protocols work on the issues of WSNs. Therefore for increasing network lifetime, data delivery and efficient power consumption we need to select proper routing protocol.

4. REFERENCES

[1] Paul Lettieri and Mani B. Srivastava: A QoS-aware, Energy-efficient Wireless Node Architecture: IEEE international workshop on mobile multimedia communication, pp. 252-261, 1999.

[2] Wendi Rabiner Heinzeleman, Anantha Chandrakasan and Hari Balakrishnan: proceeding of the IEEE 33rd international conference on System Sciences 2000.

[3] Chavalit Srisathapornphat, chaiporn jaikaeo, chien-Chung Shen: Sensor Information Networking Architecture: IEEE International workshop on parallel processing, pp. 23-30, 2000.

[4] Sasa Slijepcevic, Miodrag Potkonjak: Power Efficient Organization of Wireless Sensor Network: IEEE international conference on communication, Vol. 2, pp. 472-476, 2001.

[5] SeongHwan Cho, Kee- Eung Kim: Variable Bandwidth Allocation Scheme for Energy Efficient Wireless Sensor Network: IEEE international conference on communication, Vol. 5, pp. 3314-3318, 2005.

[6] Chen Xuhui, Yang Zhiming, cheng Huiyan: Unequal clustering Mechanism of LEACH protocol for wireless Sensor Network: world congress on computer science and information engineering, IEEE computer Society 2009.

[7] H. Fariborzi, M. Moghavvemi: EAMTR : energy aware multi-tree routing for wireless sensor networks: IET communication Vol. 3, Iss 5, pp. 733-739, 2009.

[8] Basilis Mamalis, Damianos Gavalas, Charalampos Konstantopoulos, Grammati Pantziou: Clustering in wireless sensor network: Zhang/RFID and Sensor networks, pp 323, 2009.

[9] Morteza Ziyadi, Keyvan Yasami, Bahman Abolhassani: Adaptive Clustering for Energy Efficient Wireless Sensor Networks based on Ant colony optimization: IEEE 7th annual communication networks and services research conference 2009.

[10] Mu tong, Minghao Tang: LEACH-B AN improved LEACH protocol for wireless sensor network: IEEE 6th international conference on wireless communication networking and mobile computing, 2010.

[11] Asaduzzaman, Hyung Yun Kong: Energy Efficient Cooperative LEACH Protocol for Wireless sensor networks: Journal of communication and networks, Vol. 12, No. 4, August 2010.

[12] D. Baghyalakshmi, Jmimah Ebenezer, S.A.V. Satymurty: Low Latency and Energy Efficient routing protocols for wireless sensor networks: IEEE International conference on wireless communication and sensor computing, 2010.

[13] Bilal Abu Bakr, Leszek Lilien: Extending Wireless Sensor Network Lifetime in the LEACH-SM Protocol by Spare Selection: 5th international conference on Innovative Mobile and Internet Services in Ubiquitous Computing IEEE computer society 2011.

[14] Jisoo shin, Changjin Suh: CREEC: Chain Routing with Even Energy Consumption: Journal of communication and networks vol. 13 no. 1, February 2011.

[15] H.Huang, G. Hu, F.Yu, Z. Zhang: Energy-aware interference-sensitive geographic routing in wireless sensor networks: IET communication, Vol. 5, Iss. 18, pp. 2692-2702, 2011.

[16] Chi Ma, Yuanyuan Yang: A Battery-Aware Scheme for Routing in Wireless Ad Hoc Networks: IEEE transactions on vehicular technology, Vol. 60, no. 8, October 2011.

[17] Jinhua Zhu, Xin Wang: Model and Protocol for Energy-Efficient Routing over Mobile Ad Hoc Networks: IEEE transaction on Mobile computing, Vol 10, no.11, November 2011.

[18] Luca Mottola, Gian Pietro Picco: MUSTER : Adaptive Energy-Aware Multisink Routing in Wireless Sensor Network: IEEE transaction on Mobile computing, Vol. 10, no. 12, December 2011.

[19] Fengyuan Ren, Jiao Zhang, Tao He, Chuang Lin, Sajal K. Das: EBRP: Energy-Balanced Routing Protocol for Data Gathering in Wireless Sensor Networks: IEEE transaction on parallel and distributed systems, Vol. 22, no. 12, December 2011.

[20] Hamid Rafiei Karkvandi, Efraim Pecht, Orly Yadid-pecht: Effective Lifetime-Aware Routing in Wireless Sensor Networks: IEEE sensors journal, Vol. 11, no. 12, December 2011.

[21] Dali Wei, Yichao Jin, Klaus Moessner, Rahim Tafazoli: An Energy-Efficient Clustering Solution for Wireless Sensor Networks: IEEE transaction on wireless communication, Vol. 10, no. 11, November 2011.

[22] Jin Ke-yin, Zhang Yao, Tian De-run: Based on the improvement of LEACH protocol for wireless sensor network routing: IEEE international conference on intelligent system design and engineering application, 2012.

[23] L. Karim, N. Nasser: Reliable location-aware routing protocol for mobile wireless sensor network: IET communication, Vol. 6, Iss. 14, 2012.

[24] J. Gnanambigai, N. Rengarajan, K. Anbukkarasi: Q-LEACH: An Energy Efficient Cluster Based Routing Protocol for Wireless Sensor Network: IEEE 7th international conference on intelligent systems and control, pp. 359-362,2012.

[25] Muneer Alshowkan, Khaled Ellidithy, hussain Alhassan: LS-LEACH: A New Secure and Energy Efficient Routing Protocol for Wireless Sensor Network: 17th IEEE/ACM international symposium on distributed simulation and real time applications 2013.

[26] Dilip Kumar: Performance analysis of energy efficient clustering protocols for maximizing lifetime of wireless sensor networks: IET wireless sensor systems, Vol. 4, Iss.1, pp.9-16, 2014.

[27] Nikolaos A. Pantazis, Stefanos A. Nikolidakis, Dimitrios, D. Vergados: Energy-Efficient Routing Protocols in Wireless Sensor Networks: A survey: IEEE communication survey and tutorials, Vol. 15, no. 2, 2013.

[28] Mehdi Tarhani, Yousef S Kavian, Saman Siavoshi: SEECH: Scalable Energy Efficient Clustering Hierarchy Protocol in wireless sensor network: IEEE sensors journal, Vol. 14, no. 11, November 2014.

[29] Maryam Sabet, Hamid Reza Naji: A decentralized energy efficient hierarchical cluster-based routing algorithm for wireless sensor networks: International journal of Electronic and communications, pp. 790-799, Elsevier 2015.

[30] Chia-Pang chen, Subhas Chandra mukhopadhyay, cheng-long chuang, Maw-yang Liu, Joe-Air Jiang: Efficient Coverage and Connectivity Preservation with Load Balance for Wireless Sensor Networks: IEEE sensors journal, Vol. 15, no. 1, January 2015.

[31] Marwan Al-jemeli, Fawnizu A. Hussin: An Energy Efficient Cross-Layer Network Operation Model for IEEE 802.15.4-Based Mobile Wireless Sensor Networks: IEEE Sesnor Journal,Vol. 15, no. 2, February 2015.

[32] Jenq-Shiou Leu, Tung-Hung Chiang, Min-Chieh Yu, Kuan-Wu Su: Energy Efficient Clustering Scheme for Prolonging the Lifetime of Wireless Sensor Network With Isolated Nodes: IEEE communication letters, Vol. 19, no. 2 ,February 2015.

[33] Hoon Kim, Sang-wook Han: An Efficient Sensor Deployment Scheme for Large-Scale Wireless Sensor Networks: IEEE communication letters, Vol.19, no. 1, January 2015.

[34] Dejing Zhang , Enqing Dong: A Virtual coordinator-Based Bypassing void routing for wireless sensor networks: IEEE sensors journal, Vol. 15, no. 7, July 2015.

[35] Hari Prabhat Gupta, S.V. Rao, Amit kumar Yadav, Tanima Das: Geographic Routing in clustering wireless sensor networks among obstacles: IEEE sensor journal, Vol. 15, no. 5, May 2015.