ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

MULTI-HOP CHAIN ROUTING ALGORITHM USING A DYNAMIC COORDINATOR IN WIRELESS SENSOR NETWORKS FOR MINIMUM ENERGY CONSUMPTION

Sukanya Varshini K., C. Jothi Kumar and P. John Paul
Department of Computer Science and Engineering, SRM University, India
E-Mail: sukanya.varshini@gmail.com

ABSTRACT

Wireless Sensor Networks (WSN) comprise of a large number of sensor nodes that have very limited energy in them. The sensor nodes are deployed in certain places in order to monitor Temperature, Pressure, Sound and other environmental conditions also. Wireless Sensor Networks are widely used in various fields such as medical, industrial monitoring, military surveillance and much more. The nodes in the network need to transfer data continuously to the Base Station and they have very limited energy in them. As a result of which the energy of the nodes decreases as the data gets transferred. It is not an easy task to replace the batteries of the nodes at all times, hence energy efficiency plays a very important role in Wireless Sensor Networks in order to increase the lifetime of the nodes present in the network. This paper deals with the energy efficiency in Wireless Sensor Networks to minimize energy consumption of the nodes. The Multi-hop Chain Routing Algorithm using a Dynamic Coordinator (MCRA-DC) considers various factors like transmission distance, data volume that needs to be transmitted and the energy residue of the nodes to select the path for transferring data from the nodes to reach the Base Station (BS). This algorithm also ensures that the network is available for a longer time by a frequent update of the Cluster Head (CH) and the path to reach the BS. The proposed technique thus increases the entire performance of the network in aspects of increasing the lifetime of sensor nodes.

Keywords: wireless sensor networks, energy efficiency, routing protocols, cluster head.

INTRODUCTION

Wireless sensor network consists of a group of distributed autonomous devices communicating with each other through a wireless connection. The sensor nodes present in the network are small, lightweight and portable. These nodes comprise of transducer, microcomputer, transceiver and power source. The main application of Wireless Sensor Network using sensors includes monitoring the physical or environmental conditions like temperature, humidity, pressure, etc. One of the major issues in Wireless Sensor Network is energy consumption. To increase the lifetime of the devices in the network, sensor node power should be used effectively, especially when routing data from the source node to the BS. For routing the information from the source node to the destination node many routing protocols are available in WSN [1]. The routing protocols include Flat based routing protocol, Hierarchical based routing protocol, Localization based routing protocol and QOS based routing protocol. The hierarchical based routing protocol can also be stated as cluster based routing. In Hierarchical routing, the nodes present in the network will be batched together in order to form clusters. For every cluster, a Cluster Head will be selected and information gets routed by the Cluster Head to the Sink. Cluster Head's main responsibility is to collect data from every node present in the respective clusters, and thus the name cluster based routing. The various types of hierarchical routing protocols include single-hop clustered routing, multi-hop clustered routing, multi-hop chain routing and multi-hop grid-based routing [2] [3]. Some of the protocols in the above hierarchical routing include the following:

- Single hop clustered routing - LEACH, LEACH-C, Enhanced LEACH-R
- Multi-hop clustered routing - TEEN, APTEEN, HEED, EEUC
- Multi-hop chain routing - PEGASIS, GSTEB, PEDAP
- Multi-hop grid-based routing - GDBB, TTDD, VGA

Scalability and energy efficient routing are some of the main advantages of these types of Wireless Sensor Networks [4]. Nodes in the network, which has the maximum amount of energy responsible for transmitting the information to the destination whereas the others nodes with less energy search for the target node situated in the network. The main idea behind the cluster formation is to manage energy efficiently, thus leading to increase in the lifetime of the nodes present in the network. Data which are being transferred by the nodes to the Base Station are being fused together such that the total number of messages that need to be transmitted gets reduced to a great extent. Cluster formation and data transmission are divided into phases according to the function performed. The first phase usually consists of selecting Cluster Head for each cluster present in the network followed by the data transmission in the second phase.

NETWORK MODEL

this model, radio energy consumption Eelec= 50 nJ/bit to run the transmitter for data transmission or receiver circuitry for data reception and the energy consumption of the radio caused by running the transmit amplifier equals εamp= 100pJ/bit/m2. A d^2 path loss due to free space propagation model is used. The energy consumption for transmitting a p-bit packet over a distance d is given by:

$E\_Tx\ (m,d)=E\_ele*p+\varepsilon\_fs*d^2$

The energy taken to receive an m-bit message is calculated by:

$E\_Rx=E\_ele*p$

RELATED WORK

GSTEB

General Self-Organized Tree-Based Energy-Balanced Routing Protocol is a multi-hop chain routing protocol [5]. The data reaches the Base Station from the nodes through multiple hops forming a chain-like structure, thus the name multi-hop chain routing. For every round, the Base Station changes the root node and intimates the new selection of root node to all other nodes present in the network with the broadcast ID and other information. Subsequently, every other node present in the network selects its own parent node considering information about self and the neighboring nodes only. Parent nodes are used to communicate with the root node. The nodes present in the network send information to the parent node and the parent node, in turn, forwards the data to the root node. The root node receives the data from the various parent nodes present across the network and aggregates the data together and forwards it to the Base Station. The node with the highest energy is selected as the root node. The main advantage of GSTEB is workload balance and to reduce energy consumption. Drawback includes larger delay as sink needs to select the root node at periodic intervals.

EECRU

Energy-Efficient Clustering method using Random Update initially consists of the Initial Cluster Construction phase (ICC) and the latter phase includes the Update of Clusters (UC) [6]. Initial Cluster Construction phase divides the network into initial clusters based on the temporal and spatial correlation of the data. A dynamic update method along with the Cluster Head rotation method is used to update the clusters. This is processed in the Update of Clusters phase. Here the rate of change of data and the residual energy is considered to attain energy efficiency. The update frequency is found to be higher as the rate of change of data in the network is high. The frequency of update in the network depends on the rate of data change in the nodes. The Cluster Head is selected based on the data frequency in the node present in the network. Higher the data frequency of the node, the higher is the chances of it to be selected as the cluster head. The next phase, which involves the data transmission phase includes the sampling rate control method in order to increase the data sampling efficiency and also network reliability is guaranteed. Cluster Head is selected wisely by combining the Cluster Head rotation scheme and the random update method resulting in a balanced energy level in the nodes across the network.

MCRA-DC

The Base Station receives the information of all the nodes regarding the distance and energy of the nodes. The Base Station after computing the received data, it assigns the single coordinator. The node which is nearer to the Base Station and which have the high energy level will be considered as the coordinator. The elected coordinator's information will be communicated to all the nodes in the network by the Base Station. The network then forms the clusters based on any of the cluster splitting algorithms. The topology seems like a tree structure, where it communicates with the coordinator to transmit the data to the sink. The coordinator is dynamic based on the number of rounds. The communication takes place from the nodes to the coordinator and then from the coordinator to the sink. The system deploys specific threshold to select the Cluster Head based on the energy of the nodes. The data aggregation takes place in the Cluster Head and sends the aggregated data to the sink. The Cluster Head changes over time based on the residual energy of the nodes. After 'n' rounds if none of the nodes satisfy the threshold, then the nodes form a chain to transmit data to the sink. The nodes communicate with each other based on the transmission distance, data volume and the energy of the transmission nodes. The communication takes place in a chain fashion. The nodes communicate with the intermediate nodes where it aggregates the data and sends to the Base Station. Figure-1 gives the topological representation of MCRA-DC.

VOL. 12, NO. 23, DECEMBER 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

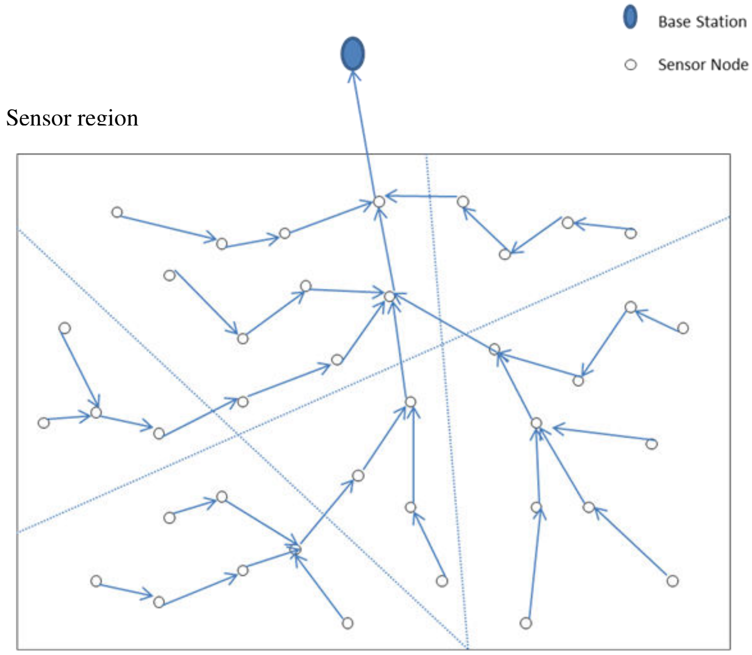

Figure-1. Topological representation of MCRA-DC.

Data clustering phase

The Base Station present in the network retrieves the various information such as the energy of the nodes and the distance between the nodes from the Base Station [7] [8]. Based on the details received from the nodes, the Base Station elects a coordinator from the list of nodes present in the network. The coordinator selected changes dynamically. The Base Station receives node information at regular periodic intervals and based on the details received the coordinator is elected. Once the coordinator is selected, the Base Station sends the coordinator information to all the nodes present in the network. Then the cluster formation takes place in the network. Based on the cluster splitting algorithm, the clusters are formed. After the formation of clusters, Cluster Head is selected for each cluster. Data are transmitted from each node to the Cluster Head and from the Cluster Head to the coordinator and finally from the coordinator to the Base Station. Data aggregation takes place at each node. When the data is forwarded from the Cluster Head, it aggregates the data and the number of messages being transmitted gets reduced. The formula for data aggregation is given as

$$X = \sum_{i=0}^{n} Xi/n + k$$

The main advantage in cluster formation is that the message overload is reduced to a great extent as a result of which maximum energy optimization is achieved. Figure-2 gives an overview of MCRA-DC protocol.

ARPN Journal of Engineering and Applied Sciences

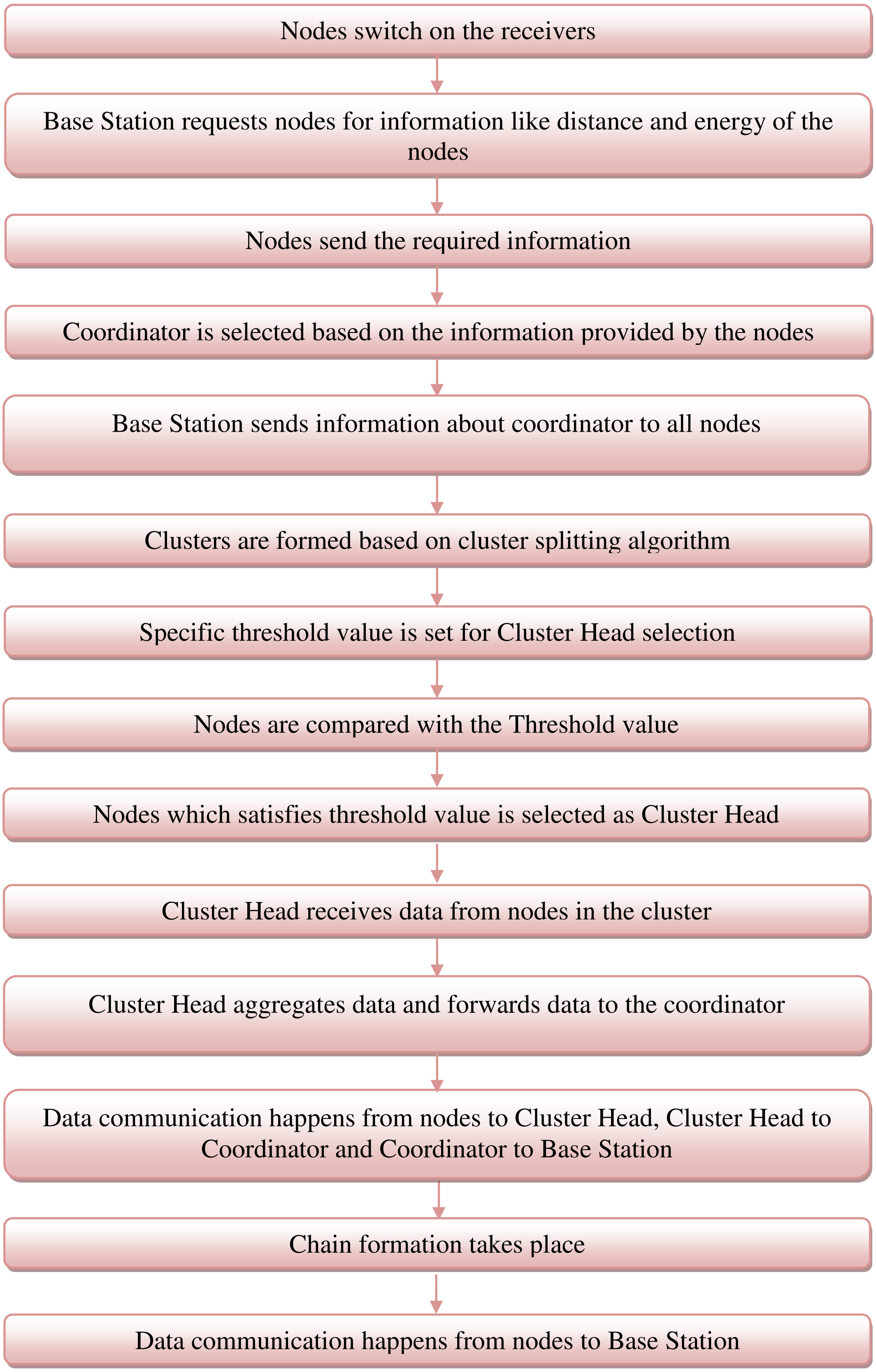

Figure-2. An overview of MCRA-DC protocol.

Chain routing phase

During the Cluster Head selection phase a specific threshold is set based on the energy of the nodes and the nodes only which satisfy the specified threshold will be elected as the Cluster Head [9]. The Cluster Head selection also happens periodically and the Cluster Heads

ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

are updated. Aftera certain number of rounds, when none of the nodes in the network satisfy the threshold value the chain formation takes place to send data to the Base Station. In the chain routing phase, the communication between nodes takes place in a chain fashion. The path to reach the destination is based on the distance between the nodes, data volume and the energy of the nodes. The data is passed from the node to another node, where the receiving node aggregates the received data and forwards it to the next node. The data thus gets forwarded to the Base Station from the nodes present in the network.

COMPARISON AND SIMULATION RESULTS

Simulation results shows the energy dissipation of the CH in MCRA-DC is less compared with GSTEB and EECRU Protocol with respect to total number of rounds. Figure 3 shows the residual energy of the nodes as the round proceeds.

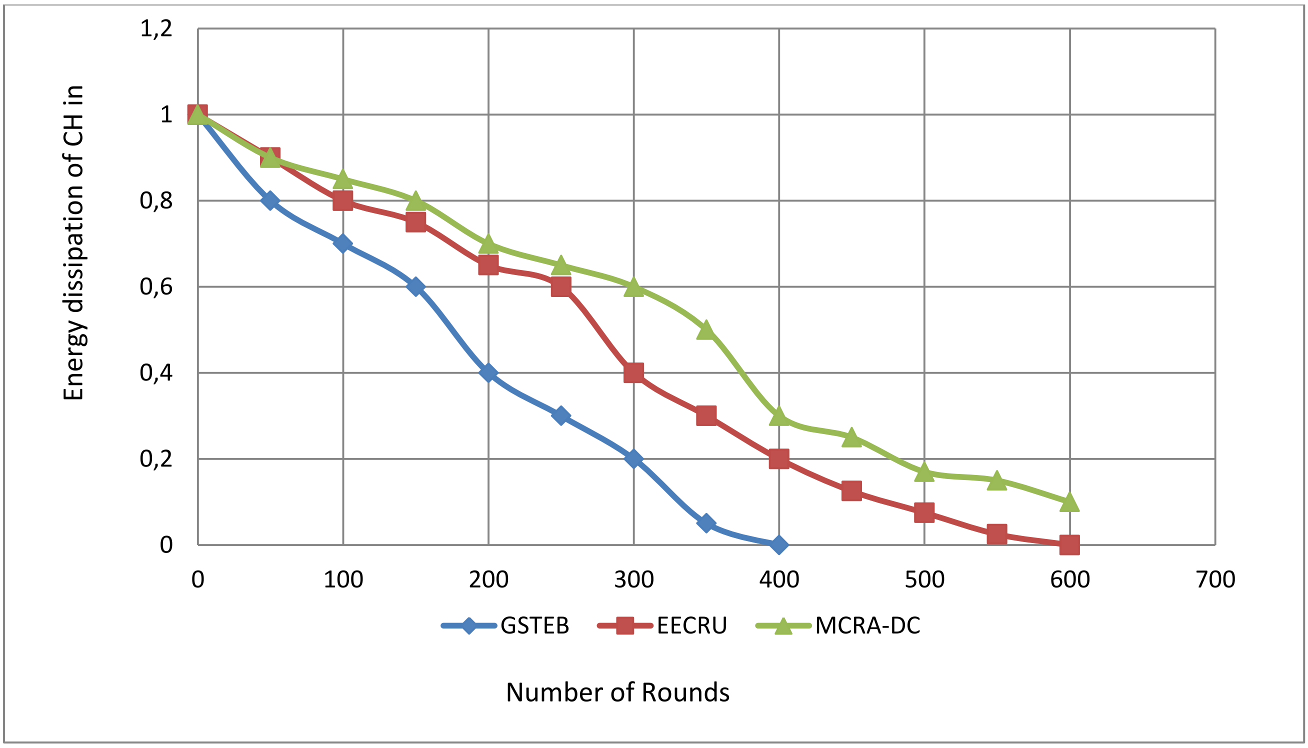

Figure-3. Residual energy of nodes as round proceeds.

The Figure-4 shows the comparison of first node dead with number of rounds for GSTEB, EECRU and MCRA-DC Protocol. The network lifetime of MCRA-DC is high compared with other given protocol.

ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

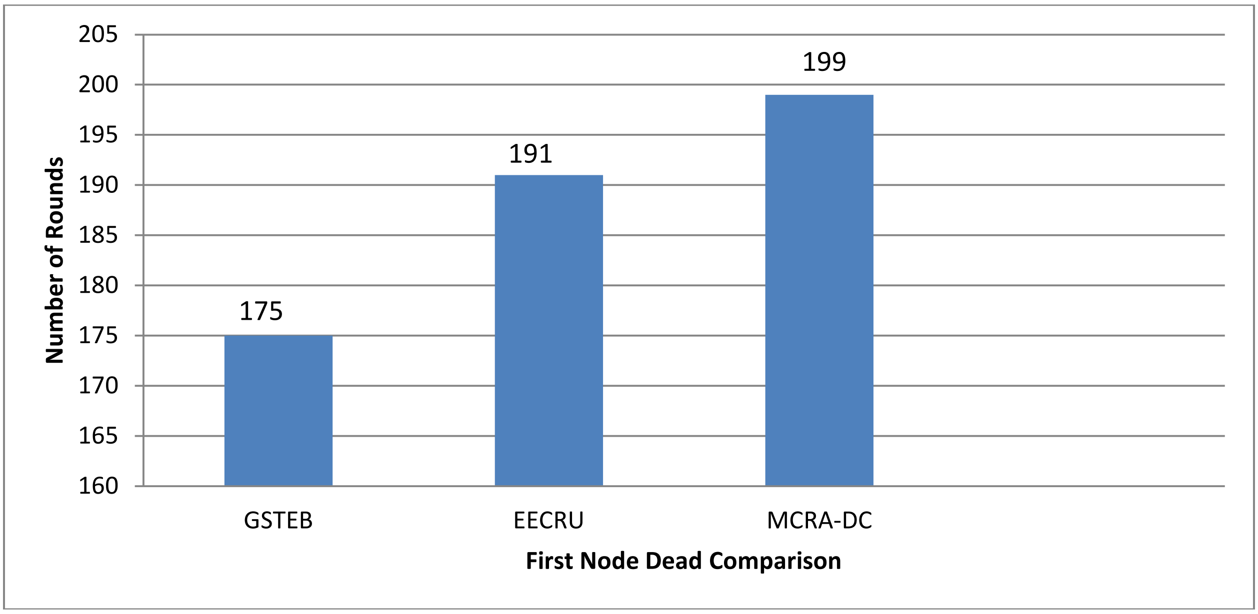

Figure-4. First node dead comparison of protocols.

CONCLUSIONS

This paper has proposed a new algorithm Multi-hop Chain Routing application using Dynamic Coordinator (MCRA-DC) for selecting the path effectively to transfer data from the sensor nodes to the sink. In the proposed algorithm, the path for transferring data takes place in two phases: Cluster formation phase or Chain formation phase. In Cluster formation phase, clusters are formed and the data gets transferred through cluster heads if the threshold is satisfied by the node. If the threshold is not satisfied, then chain formation happens for the data to reach the Sink. MCRA-DC considers various factors like transmission distance, data volume that needs to be transmitted and the energy residue of the nodes to select the path for transferring data from the nodes to reach the Base Station (BS). Thus the path for data transformation takes place efficiently thus reducing the energy utilization of the nodes to a great extent. The residual energy of the nodes is compared with the other protocols like GSTEB and EECRU and proved that MCRA-DC has better energy utilization. The first node dead comparisons with other protocols have also proved that MCRA-DC has better performance in saving energy to a great extent.

REFERENCES

[1] W. Heinzelman, A Chandrakasan and H Balakrishnan. 2002. An Application-Specific Protocol Architecture for wireless microsensor networks. IEEE Transactions on Wireless Communications. 1(4).

[2] C. Jothikumarand Revathi Venkataraman. 2016. A Review of Hierarchical Routing Protocol for Wireless Sensor Network. Indian Journal of Science and Technology. 9(32).

[3] Abdul Gani Khan, Abdur Rahman, Neeti Bisht. 2013. Classification of Hierarchical Based Routing Protocols for Wireless Sensor Networks. International Journal of Innovations in Engineering and Technology, Special Issue - ICAECE.

[4] Jyoti Kumari; Prachi. 2015. A Comprehensive Survey of Routing Protocols in Wireless Sensor Networks. 2nd International Conference on Computing for Sustainable Global Development (INDIACom).

[5] Zhao Han; Jie Wu; Jie Zhang; Liefeng Liu; Kaiyun Tian. 2014. A General Self-Organized Tree-Based Energy-Balance Routing Protocol for Wireless Sensor Network. IEEE Transactions on Nuclear Science. 61(2).

[6] Fan Wang; Sining Wu; Kunpeng Wang; Xiaopeng Hu. 2016. Energy-Efficient Clustering Using Correlation and Random Update Based on Data Change Rate for Wireless Sensor Networks. IEEE Sensors Journal. 16(13).

[7] Shreshtha Misra; Rakesh Kumar. 2016. A literature survey on various clustering approaches in wireless sensor network. 2nd International Conference on Communication Control and Intelligent Systems (CCIS).

[8] B Y Kushal; M. Chitra. 2016. Cluster based routing protocol to prolong the network lifetime through mobile sink in WSN. IEEE International Conference on Recent Trends in

Electronics, Information & Communication Technology (RTEICT).

[9] Yongchang Yu; Yichang Song. 2010. An Energy-Efficient Chain-Based routing protocol in Wireless Sensor Network. International Conference on Computer Application and System Modeling.