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An Optimized Selective Forwarding Algorithm for Maximizing the Lifetime of Wireless Sensor Network

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***Abstract*—Wireless Sensor Network (WSN) is comprised of large number of sensor nodes interconnected by means of wireless link. The primitive objective of WSN is to answer queries by gathering the sensed data from the deployed sensors. Clustering algorithms are utilized to form hierarchical network topology, which is a most common method in WSN. In this paper energy efficient Random Selective Forwarding (RSF) and Transition State Switching (TSS) Algorithms are proposed. The performance metrics such as data rate, energy consumption and residual energy are plotted using Network Simulator 2. The simulation results depicting the performance of RSF and TSS shows that the proposed algorithms provides better results than the existing algorithm and it also reduces the power consumption of sensor nodes .**

Keywords—Energy saving, RSF, TSS, Wireless sensor network

I. INTRODUCTION

Wireless sensor network (WSN) refers to a collection of sensor nodes for supervising and storing the physical conditions of the environment and effective management of the collected data at a central location [1]-[2]. Sensor nodes in WSN technology are small electronic devices which have low processor speed, small memory size, low computation and low communication power.

The sensor node equipment includes a radio transceiver with an antenna, a microcontroller, an interfacing electronic circuit, and a battery. The price of sensor node varies from a few pennies to hundreds of dollars depending on the functionality parameters of a sensor. WSN were designed to facilitate military operations but its application has since been extended to health, traffic, and many other consumer and industrial areas. Low-cost deployment is one acclaimed advantage of sensor networks [3]. Limited processor bandwidth and small memory are two challenges in sensor networks, which will disappear with the development of fabrication techniques.

A WSN can be defined as a network of devices, denoted as nodes, which sense the environment and communicate the information gathered from the monitored field by wireless links. The sensed data is forwarded, possibly via multiple hops, to a sink through a gateway. The rest of the paper is organized as follows. Related work in section II. Section III describes the RSF and TSS. Section IV deal with simulation parameters and methodology. Section V presents the results and discussions. Conclusions are shown in section VI.

II. RELATED WORK

The lifetime of a sensor network depends on the power consumed at each sensor node. An efficient power management scheme will provide a longer network lifetime. Several methodologies have been proposed to deal with power management [4], a variety of Dynamic Power Management (DPM)techniques have been Proposed to reduce the power consumption in sensor nodes [5]-[6], by selectively shutting down the components, Dynamic Voltage Scaling (DVS) [6] [7], and Dynamic Voltage and Frequency scaling [7], In Low Energy Adaptive Clustering Hierarchy Protocol (LEACH) [8]-[9], nodes organize themselves into clusters and the cluster head transmits the data to remote base station, the cluster head are more energy intensive than non cluster head nodes. The cluster heads collects the data from the other nodes, cluster head are chosen randomly, but all nodes have a chance to become a cluster head, to balance the energy spent by each sensor nodes, it uses TDMA based MAC protocol. LEACH randomly selects cluster heads in each round to form a cluster network, which cause additional power consumption and inability to maintain the routes for data transmission. Multi-hop LEACH [10] is another extension of LEACH routing protocol to increase energy efficiency of the wireless sensor network, like LEACH in Multi-Hop LEACH some nodes elect themselves as cluster-heads and other nodes communicate themselves with the cluster-head to complete cluster formation in setup phase. When the distance between the cluster head and the base station is large then inter-cluster communication takes place. Hybrid Energy Efficient Distributed Clustering (HEED) [11] it is a multi-hop clustering algorithm for wireless sensor networks. The main objectives of HEED is to minimize energy consumption during cluster head selection phase and to minimize the control overhead of the network. A Balanced Clustering Algorithm with Distributed Self-Organization for Wireless Sensor Networks (DSBCA) [12] is based on the connectivity density and distance from the server. The purpose of DSBCA is to generate clusters with less energy consumption and avoid creating more clusters with many nodes. The clusters near the base station also forward the information from further clusters and as we all know, too many members in a cluster may bring about more energy consumption. Hence, based on the above concerns, DSBCA algorithm considers the connectivity density and the location of the node, to form a balanced clustering structure. It generates clusters in non-uniform distribution with less energy consumption, thus it overcomes other existing clustering algorithms.

III. DESCRIPTION

A. RSF

The objective of the proposal is to integrate WSN and Internet by implementing a SN (Sensor Network) discovery algorithm between WSN node and SN node for SN node selection and thereby improving the life time of the sensor node. WSN node is connected by means of a bridge called Internet SN which acts as a platform for providing Internet access to the WSN node.

In WSN, nodes move at random speed and direction which results in dynamic topology. As the overall infrastructure are said to be dynamic, it is necessary to witness the movement of nodes over the entire network. Internet SN node consists of 'n' number of SN nodes which are also said to be dynamic and hence they revolve to different positions at different periods of time. Every SN nodes has its own energy and mobility over the network. The WSN nodes broadcast the packets requesting for Internet access through the SN nodes. The SN nodes receive the packets from the WSN nodes and in turn the SN nodes broadcast the packet for providing Internet access to the WSN nodes. Every time when the SN nodes broadcast the packets requesting for internet access, the energy of the SN nodes gets decreased. As the SN nodes are also dynamic there is every chance that the node selected by the WSN node for accessing the Internet can be relocated and moved to different direction at certain interval of time.

When the node is relocated, then the internet access requested by the WSN node is denied. Hence it is necessary for the WSN node to choose a node which has high energy and low mobility. For selecting the node which has high energy and low mobility, selective forwarding SN selection algorithm using Time to live (TTL) is implemented, there by the life time of the SN can be improved. There are two criteria for improving the life time of the SN, they are mobility and energy. Mobility can be defined as the movement of nodes within the network and they are recorded in micro seconds in a topology. Energy can be defined as the residual energy of the gateway node which is responsible for the successful transfer of data over the network. During broadcasting, the energy of the gateway node gets reduced.

The cache table is present at every node which is responsible for storing the energy value and the mobility value of the SN nodes. Every time when the WSN nodes broadcasts the packet, the value of the energy and mobility of the SN nodes are updated simultaneously and hence the cache table gets updated at every interval of time. This Random selective forwarding algorithm offers less packet drop and more data rate when compared with the existing DSBCA. Let us consider two scenarios in the process of improving the life time of the SN which are described as follows:

Case 1:
When the SN node is in the same position (No Mobility), but the node energy is less than the threshold energy, check for the energy value of all other SN nodes in the network and choose the SN node which has highest energy and select that SN node for providing Internet access to the WSN node.

Case 2:
When the SN node is moved from its position (dynamic), then if the SN moves out of range, then it is necessary for the WSN node to check in the cache table and choose the next SN node which has high energy and low mobility and use that node for accessing the Internet.

Working principle of the Selective Forwarding SN Discovery Algorithm**:**
Steps for finding an alternate node:

1. Record all SN nodes initial energy and mobility.
2. Store the SN nodes mobility.
3. When an alternate SN node is required check for the nodes energy and mobility.
4. Select the second SN node based on the following:
   a. Node energy > Threshold energy
   b. Lesser mobility.
5. Compare the energy and mobility of all the nodes; choose a node which has high energy and low mobility among the selected nodes.
6. Broadcast from the source node to the SN node.
7. Check if the SN node is capable of reaching the destination; if it establishes the path to the destination, forward the request from WSN node to the destination node. If it doesn't reach the destination node, repeat steps from step 4.

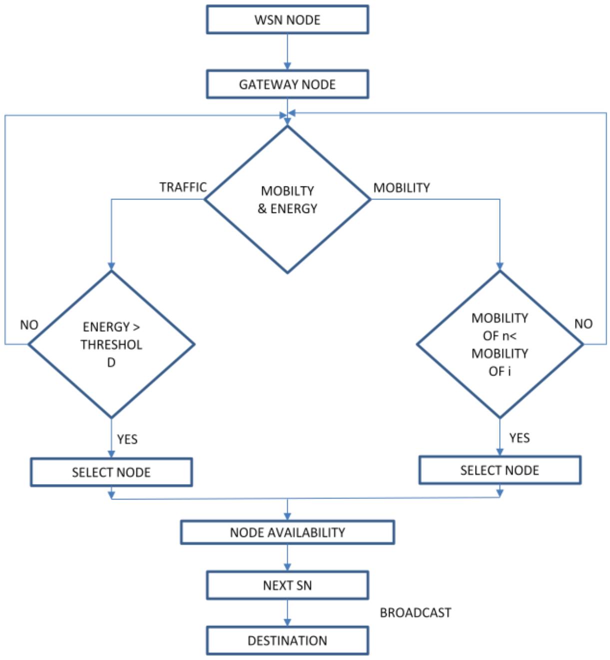

Fig 1. Flowchart description of the working of Selective Forwarding SN Algorithm

B. TSS

This approach is based on game theory. We apply Nash's multi state Equilibrium to switch and maintain a constant flow of data and energy conservation. The above approach can be integrated with any routing protocol to define its routing as energy efficient routing by default.

In Nash equilibrium, consider 3 levels of the node: high, mid and low level. Obviously, high level denotes the active, low level denotes the dead and mid level resembles the sleep state of a node. Usually a node drops from high level to low level. Using Nash's multi state framework, we introduce a mid level such that a node is returned to the high level once it falls below the mid state. The threshold value determines when the node must be carried to the high level.

Preliminaries:

The Initial energy of the node must be divided based on the number of transmission sequence/data it is capable of handling. The threshold level must be between mid level and low level. Increase in threshold value decreases the number of left out communications. When the number of left out communications is nil, then the node is considered to be dead.

Working Method:

Divide the node's Initial energy (IE) for 'n' data transfers. For every 'i' cycle, set the threshold value as 30% of the Transmitted power(TX) or Higher the TX and RX, higher is the threshold and lower the TX and RX, lower is the threshold. If in an 'i+j' th cycle, if the node reaches the threshold value, then increase the node's power with the reserved energy. The node switches to high state once energized. Note the maximum communications that occurred and the left out communications to be carried out.

The residual energy depicts the remaining energy of sensor nodes. When residual energy increases; the node does not fall down to the low level. If residual energy increases, the node can be tasked further; the collective residual energy increases the node's life time. When the number of services=0, the node attains the dead state. In this type of policies a dedicated computer is responsible for maintaining a global state of the system. Based on the collected information the central computer makes allocation decisions. For a large number of computers the overhead of such schemes become prohibitive and the central decision computer becomes the bottleneck.

We show that the Nash Bargaining Solution (NBS) provides a Pareto optimal operation point for the distributed system. We give a characterization of NBS and an algorithm for computing it. We prove that the NBS is a fair solution and we compare its performance with DSBCA and RSF algorithms. NBS guarantees the optimality and the fairness of allocation. This approach provides less energy consumption and steady residual energy for the nodes.

IV. SIMULATION

The simulation work is carried out using Network Simulator 2. A network with 40 numbers of nodes is designed. Wireless link is provided between the nodes. Constant Bit Rate (CBR) is considered this UDP based client-server application sends data from the client to a server at a constant bit rate. In this section, lots of simulation experiments are presented to demonstrate the effectiveness and superiority of the proposed new algorithm in comparison with the DSBCV algorithm.

In the simulation experiments, WSN nodes are randomly distributed in the 50 m × 50 m area. We compare RSF and TSS with the DSBCA, observing the network lifetime especially. In comparison, we make use of the NETWORK SIMULATOR 2 as simulation tool. The parameter setting for the experiments are illustrated in Table I. Parameters that are analyzed for evaluation includes data rate, energy consumption, and residual energy and delivery ratio.

Table I. SIMULATION PARAMETERS

Network Properties	
Simulation time	75s
Grid position X dimension topology Y dimension topology	 1343 645
Node deployment	Random
Network Topology	
No of nodes	40
Channel type	Wireless
Link data rate	1Mbps
TCP packet size	1500
CBR packet size	1000
Application	CBR
Protocols	
Routing protocol	DSR
MAC Protocol	MAC 802.11
Transport Protocol	TCP UDP

V. RESULTS AND DISCUSSION

A. Data rate analysis

The data rate analysis denotes the total number of bits transmitted per second. From Figure.3 it can be seen that RSF incorporated with wireless sensor network delivers better data rate, when compared with DSBCA incorporated network and TSS incorporated network. In RSF, the nodes receive a maximum data rate of 150 bytes, but in case of DSBCA it receive a maximum of 15 bytes as shown in figure 2 and in TSS it receive a maximum of 75 bytes as shown in figure 4. RSF checks the node mobility and energy before sending the packets, so it yields less packet drop and increased data rate. TCP is used as transport protocol .The graphs shows data rate at different nodes with respect with time in (ms), when comparing RSF shows better data rate.

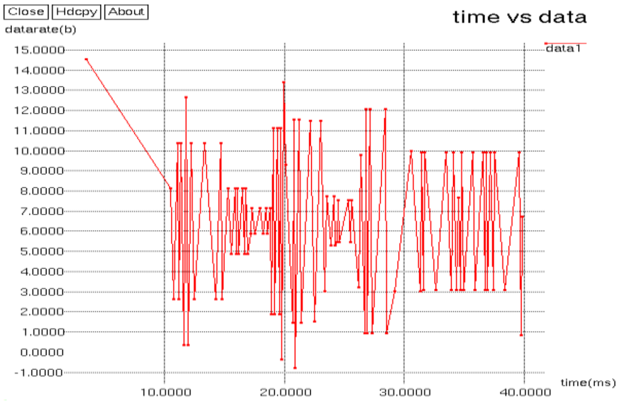

Fig 2. Data rate using DSBCA algorithm

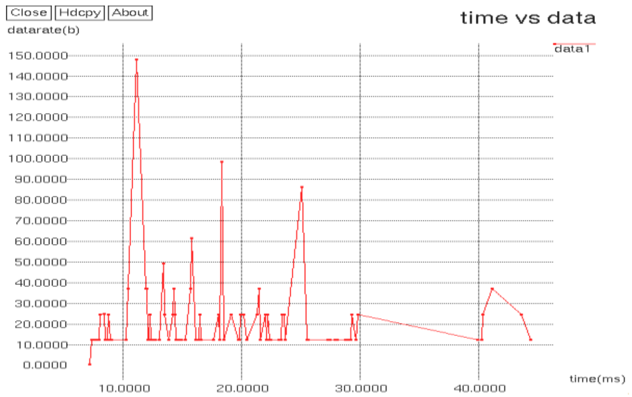

Fig 3. Data rate using RSF algorithm

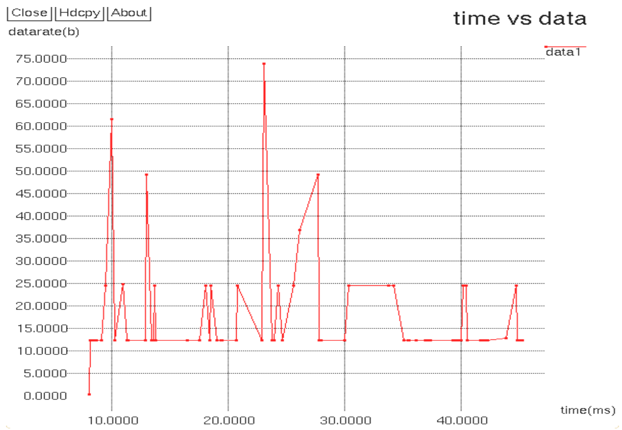

Fig 4. Data rate using TSS algorithm

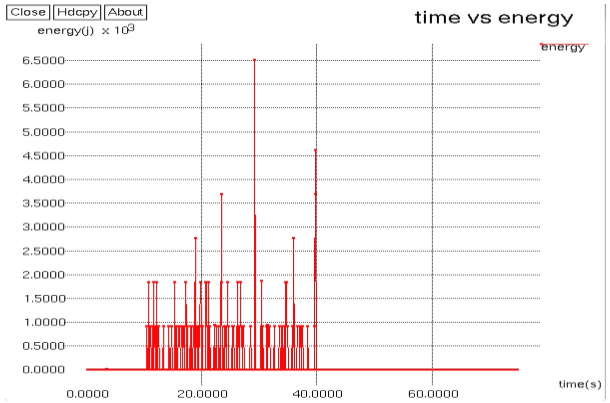

Fig 5. Energy consumption of nodes using DSBCA algorithm

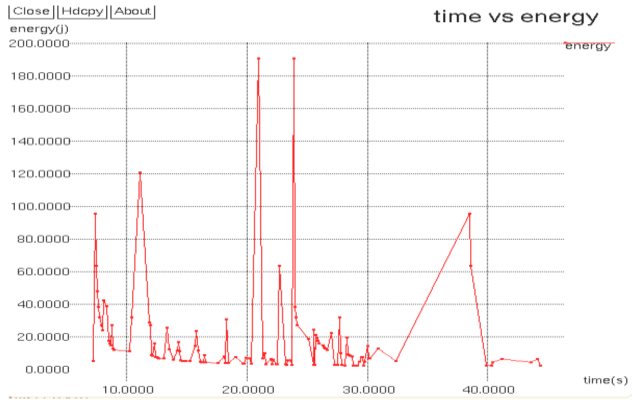

Fig 6. Energy consumption of nodes using RSF algorithm

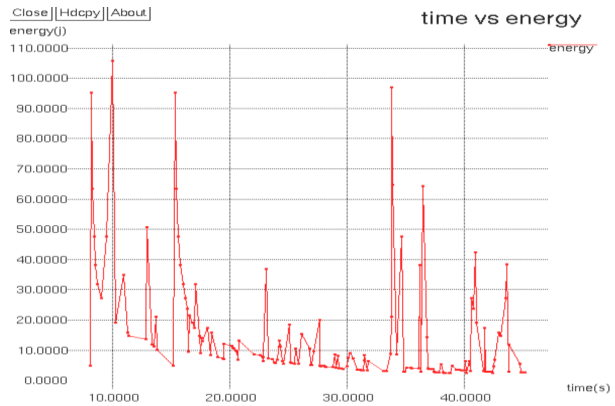

Fig 7. Energy consumption of nodes using TSS algorithm

B .Energy consumption analysis

The energy consumption of various nodes with respect time in seconds is analyzed. In TSS incorporated wireless sensor network a mid level is introduced such that a node is returned to the high level once it falls below the mid state. The threshold value determines when the node must switch to the high level. This method will reduce the energy consumption of nodes, from Figure 7 it can be seen that TSS incorporated wireless sensor network offers less energy consumption when compared with DSBCA and RSF incorporated wireless sensor networks as shown in Figure 5 and Figure 6 respectively. Therefore, the network using TSS consumes less energy.

C .Residual energy analysis

The residual energy of various nodes is calculated by subtracting transmission energy from the initial energy. The energy is analyzed for different nodes. In TSS incorporated wireless sensor network,30 nodes have a steady energy of 11.2 joules ,whereas DSBCA incorporated wireless sensor network 12 nodes have a steady energy of 12.4 joules, and in RSF incorporated wireless sensor network 21 nodes have a steady energy of 11.8 joules . Figure 10 it can be seen that TSS incorporated wireless sensor network delivers more nodes with steady residual energy when compared with DSBCA and RSF incorporated wireless sensor networks as shown in Figure 8 and Figure 9 respectively. Therefore, the network using TSS provides better residual energy.

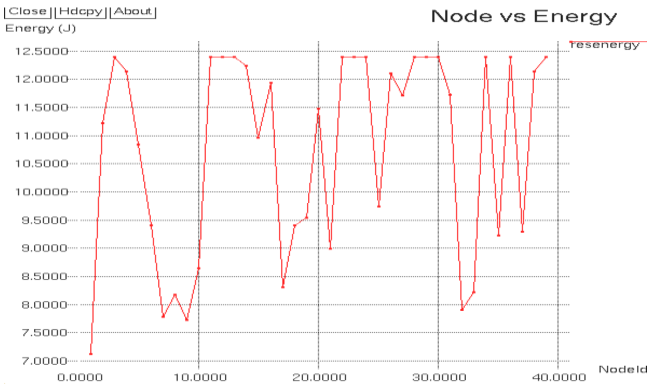

Fig 8. Residual energy of nodes using DSBCA algorithm

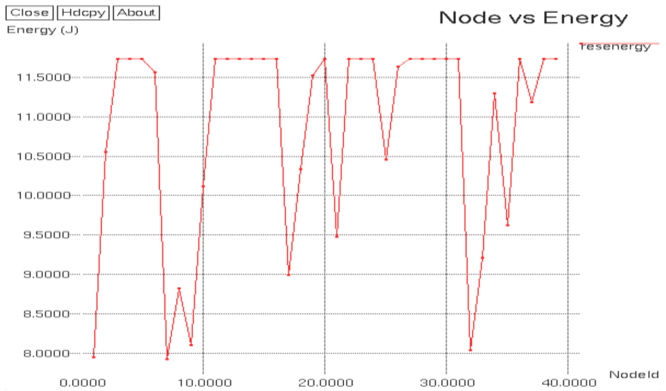

Fig 9. Residual energy of nodes using RSF algorithm

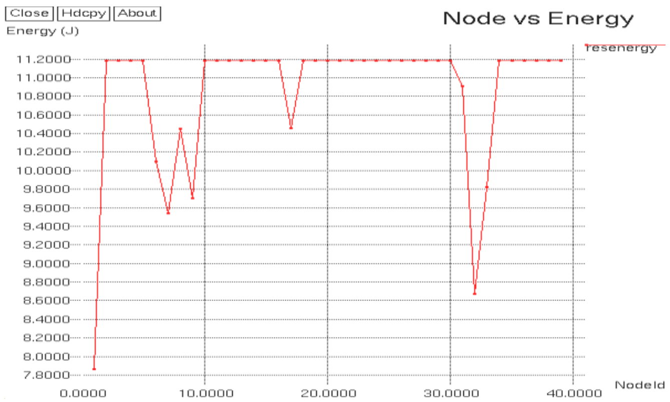

Fig10.Residual energy of nodes using TSS algorithm

Table II. INFERENCE

PARAMETERS	DSBCA	RSF	TSS
DATA RATE	15 Bytes	150 Bytes	75Bytes
ENERGY CONSUMPTION	6.5*10^3 J	190J	109J
RESIDUAL ENERGY	12.4J	11.8J	11.2J
DELIVERY RATIO	21.04	53.88	93.06

VI. CONCLUSION

In this paper, RSF and TSS algorithms are proposed, on comparing with existing DSBCA, we infer that our proposed RSF and TSS can form more stable and reasonable structure, it also improves the network lifetime significantly. In addition to that the proposed scenario is scalable and it works for different network sizes. The simulation result shows that the proposed algorithm is feasible and it has superior performance. As a future work we intend to study the performance of Random Selective Forwarding and Transition State Switching in real time applications.

REFERENCES

[1] Zhen Yu, Yong Guan, "A dynamic en-route filtering scheme for data reporting in wireless sensor networks," *IEEE/ACM Transactions on Networking*, vol. 18, no. 1, pp. 150-163, Feb 2010.

[2] P. S. Sausen, J. R. B. Sousat, M. A. Spohn, A. PerkusichO and A. M. N. Lima, "Exploring the switching energy effect in a dynamic power management technique for wireless sensor *networks*," *The 33rd Annual Conference of the IEEE Industrial Electronics Society (IECON)* Nov. 5-8, 2007, Taipei, Taiwan.

[3] Sajid Hussain, Abdul Wasey Martin, "Genetic algorithm for hierarchical wireless sensor network," *Journal of networks*, vol-2, nO.5, pp.87-97, Sept 2007.

[4] Mr. Sharad Saxena, Dr. Shailendra Mishra, Dr. Ashok Kumar Sharma, Dr. D. S. Chauhan, "Efficient power utilization techniques for wireless sensor networks – A Survey," *International Journal on Computer Science and Engineering (IJCSE)* vol. 3, no. 2, pp.905-925,Feb 2011.

[5] C.F Chiasserini, R.R. Rao, "Improving energy saving in wireless systems by using dynamic power management*," IEEE Transactions on Wireless Communications*, vol.2, Issue 5, pp. 1090-1100, September, 2003.

[6] A.Sinha, A.Chandrakasan, "Dynamic power management in wireless sensor networks,"*IEEE Design and Test of Computers*, vol. 18, Issue 2, pp. 62-74, March-April 2001.

[7] B.Calhoun, A. P. Chandrakasan, "Standby power reduction using dynamic voltage scaling and canary flip-flop structures," *IEEE Journal of Solid-State Circuits*, vol. 39, no. 9, Sept 2004.

[8] K.Ramesh, Dr.K.Somasundaram, "A comparative study of cluster head selection algorithms in wireless sensor networks," *International Journal of Computer science and Engineering survey (IJCSES)*, vol.2, no 4, pp.153-164, Nov 2011.

[9] Wernhuar Tarng, Hao-Wei Lin, and Kuo-Liang Ou "Cluster allocation and routing algorithm based on node density for extending the lifetime of wireless sensor networks," *International Journal of Computer sciencetechnology (IJCSIT)* vol. 4, no 1,pp.51- 62,Feb 2012.

[10] Muhammad Omer Farooq, Abdul Basit Dogar, Ghalib Asadullah Shah, "MR-*LEACH:* Multi-hop Routing with Low Energy Adaptive Clustering Hierarchy," 2010 *Fourth International Conference on Sensor Technologies and Applications*.

[11] O. Younis and S. Fahmy, "HEED*:* A hybrid, energy-efficient, distributed clustering approach for Ad Hoc sensor networks*", IEEE Transactions on Mobile Computing*, vol. 3, no. 4, pp. 366-379, Oct-Dec 2004.

[12] Ying Liao, Huan Qi, and Weiqun Li "Load balanced clustering algorithm with distributed self-organization for wireless sensor networks,"*IEEE sensors journal*, vol. 13, no. 5, May 2013.