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Analyzing the Comparison in terms of Optimal Base Station Positions and Network Lifetime of the Benchmark Protocols in Wireless Sensor Network: Homogeneous and Heterogeneous LEACH with HEED

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ABSTRACT: A wireless sensor network (WSN) comprises of numerous autonomous tiny devices called sensor nodes spread in a particular area. The nodes are capable of monitoring the ambient conditions and then passing the related data through the network from various different locations to a main location. The efficient energy utilization is one of the important performance factors for wireless sensor networks survivability as the nodes operate with limited battery power. In this paper, we have given a comparative study of three clustering based benchmark protocols called LEACH-homogeneous, LEACH- heterogeneous and HEED for wireless sensor networks on the basis of base station position and network lifetime.

Keywords: Wireless Sensor Network, Homogeneous, Heterogeneous, LEACH, HEED, Clustering Algorithm, Residual Energy, Node degree

I. INTRODUCTION

A wireless sensor network consists of various small nodes that are deployed in some geographical region. The purpose of the network is to sense the environment and report what is happening in the area in which it is deployed. These sensor nodes consist of sensing, data processing and communicating components [1]. The sensing electronics measure ambient conditions related to the environment surrounding the sensor and transform them into an electric signal. Processing such a signal reveals some properties about the objects located and/or events happening in the vicinity of the sensor [2]. Sensors have the ability to communicate either among each other or directly to an external base-station. Despite the innumerable applications of WSNs, these networks have several restrictions, e.g., limited energy supply, limited computing power and limited bandwidth of the wireless links connecting sensor nodes. The main constraint in designing a routing protocol in WSNs is the limited power of sensor nodes that mandates the design of energy-efficient communication protocol. Many routing protocols have been proposed for wireless networks. In this paper, we analyze different energy efficient clustering algorithm for WSN. We first describe the benchmark protocols, LEACH (homogeneous [8] and heterogeneous) and HEED and then we provide simulation results of their comparisons in MATLAB [5], determining the performance analysis of each of the protocol. We have marked the results by changing the position of the base station (BS) or sink at different points in the network area for the algorithms. Further network lifetime for the networks has been studied for all the cases.

The paper is organized as follows. Section 2 summarizes the related previous works. Section 3 discusses the basic radio energy model. Section 4 describes the assumptions of the clustering algorithms. Simulation results are presented in section 5. Conclusions and suggestions for future work are given in section 6.

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II. RELATED WORK

Routing is the way of determining a path or route between source and destination upon request of data transmission. Various protocols have been proposed to enhance the life of WSNs and for routing the data to the base station. Battery power of individual sensor nodes is an important resource in the WSN [3]. When the battery power at a sensor node expires, the node is called as a dead node and the sensor node cannot contribute further in the network.

Sensors organize themselves into clusters or groups and each cluster has a leader called as cluster head (CH) and the low energy nodes called cluster members (CM) are used to perform the sensing in their region of deployment. The cluster head coordinates the communication among the cluster members and manages their data [9].

Low-energy adaptive clustering hierarchy (LEACH) is a popular energy-efficient adaptive clustering algorithm that forms node clusters based on the received signal strength and uses these local cluster heads as routers to the base station [6]. LEACH utilizes randomized rotation of local cluster heads to evenly distribute the energy load among the sensors in the network [3]. LEACH involves local coordination and control for cluster set-up and operation, and local compression to reduce global communication. LEACH clustering terminates in a finite number of iteration. We have taken LEACH in terms of two variations in the type of sensor networks: homogeneous and heterogeneous. In homogeneous network, all the sensor nodes are identical in terms of battery energy. On the other hand, in a heterogeneous sensor network, two or more different types of nodes, advanced nodes and normal nodes, with different battery energy and functionality are used.

Hybrid Energy-Efficient Distributed Clustering (HEED) is an iterative clustering protocol that uses information about the nodes' remaining energy and their communication costs in order to select the best set of cluster head nodes. At the beginning of the clustering phase, a node with higher remaining energy has a higher probability CHprob of becoming a tentative cluster head. If the node becomes a tentative cluster head, it broadcasts a message to all sensor nodes within its cluster range to announce its new status. All nodes that hear from at least one tentative cluster head choose their cluster head nodes based on the costs of the tentative cluster head nodes. The cost of the tentative cluster heads in determined by another parameter known as node degree. Node degree is the number of nodes attached to a particular cluster head. The CH with minimum node degree has the least cost. During each iteration, a node that is not covered by any final cluster head can elect itself to become a new tentative cluster head node based on its probability CHprob. Every node then doubles its CHprob and goes to the next step. Once the node's CHprob reaches 1, the node can become a final cluster head, or it can choose its cluster head as the least cost node from the pool of final cluster head neighbors. If the node completes HEED execution without selecting its final cluster head, then it considers itself uncovered and becomes a final cluster head for the upcoming round.[4] Once the clusters are formed, all sensors send their data to the cluster head, where the data are aggregated into a single packet. Finally, the cluster head routes the data packets to the sink.

III NETWORK AND ENERGY CONSUMPTION MODEL

We assume that the energy consumption of the sensors is due to data transmission and reception. Cluster head consumes energy for the data aggregation before it sends the data to BS. We use the same radio model as stated in [3] and shown in Figure 1. Using this model, the energy consumed in transmitting one message of size ***k*** bits over a transmission distance ***d***, is given by $\mathbf{E_{Tx}(k,d)=k(E_{elec} + E_{amp}\, d^{\lambda})= E_{elec}\, k + k\, E_{amp} d^{\lambda}}$,

where k=length of the message,

d=transmission distance between transmitter and receiver,

E_{elec}= electronic energy,

E_{amp}=transmitter amplifier, λ= Path Loss ($2<=\lambda<=4$),

Also, the energy consumed in the message reception is given by

$\mathbf{E_{RX}= E_{elec}\, k}$

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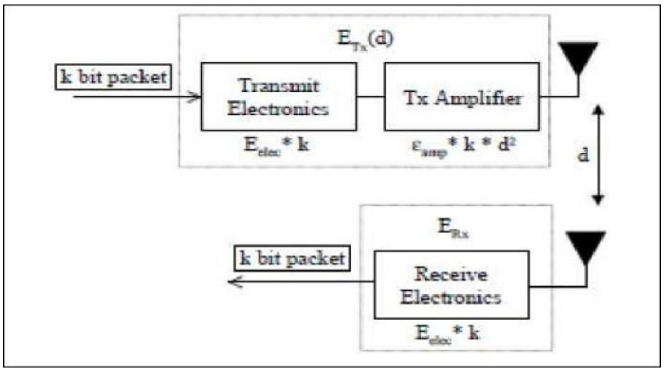

Figure 1: Energy Model for algorithm

IV BASIC ASSUMPTIONS FOR THE CLUSTERING ALGORITHMS

- Number of nodes in network are 100.
- The Base Station (BS) is fixed.
- All nodes can send data to BS.
- The BS has the information about the location of each node.
- Data compression is done by the Cluster Head.
- Data compression energy is different from the reception and transmission.
- Energy of transmission depends on the distance (source to destination) and data size.
- Nodes are uniformly distributed in network.

V PERFORMANCE EVALUATIONS

The performance analysis [7] of the routing protocols is evaluated with the MATLAB.

A. *Simulation Parameters*

TABLE I
SIMULATION PARAMETERS

Parameter	Values
Simulation Round	1500
Topology Size	200 X 200
Number of nodes	100
CH probability	0.1
Initial node power	0.5 Joule
Nodes Distribution	Nodes are uniformly distributed
Energy for Transmission (ETX)	50*0.000000001 Joule
Energy for Reception (ERX)	50*0.000000001 Joule
Energy for Data Aggregation	5*0.000000001 Joule

B. *Simulation Results*

The following figures show the network area with nodes deployed for different algorithms simulated in MATLAB.

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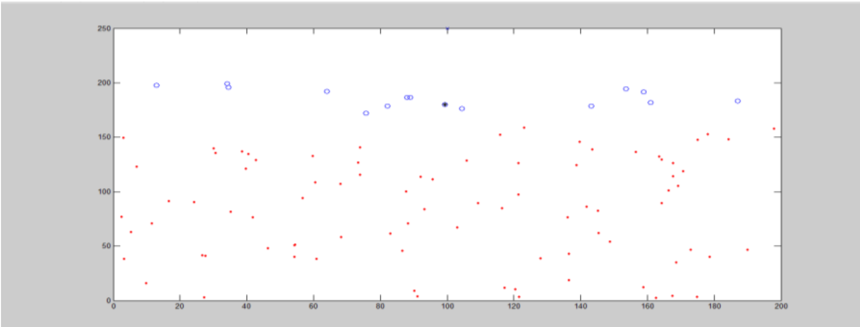

Figure 2. LEACH- Homo with BS(100,250)

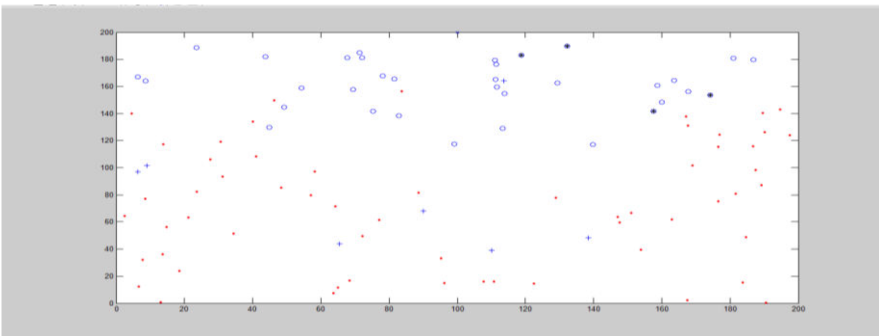

Figure 3. LEACH- Hetero with BS(100,200)

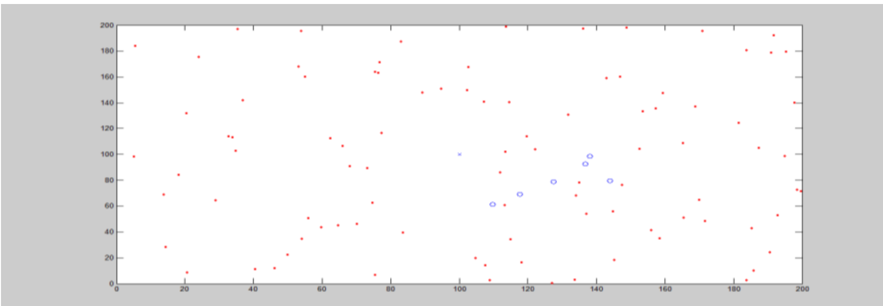

Figure 4. HEED with BS(100,100)

1) Network Lifetime (when first node dies): We simulated the algorithms for 5 times and determined the round number when the first node becomes dead in the network.

The Tables 2-4 give the values of the round numbers recorded and graphs in Figures 5-7 show the difference in lifetimes of the network in the three protocols, i.e. the first node dies at earlier round numbers in LEACH homo and hetero as compared to in HEED. The simulations have been made by changing the base station positions.

TABLE 2
ROUND NUMBER WHEN FIRST NODE DIES AT BS(100,250)

Simulation Run	LEACH homo	LEACH hetero	HEED
1	189	188	415
2	205	170	454
3	188	165	386
4	190	181	473
5	199	182	407

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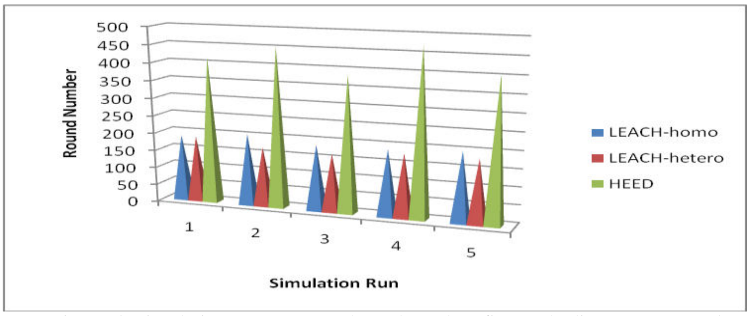

Figure 5. Simulation Run vs Round number when first node dies at BS(100,250)

TABLE 3
ROUND NUMBER WHEN FIRST NODE DIES AT BS(100,200)

Simulation Run	LEACH homo	LEACH hetero	HEED
1	286	298	370
2	273	296	420
3	271	292	451
4	256	316	390
5	306	331	415

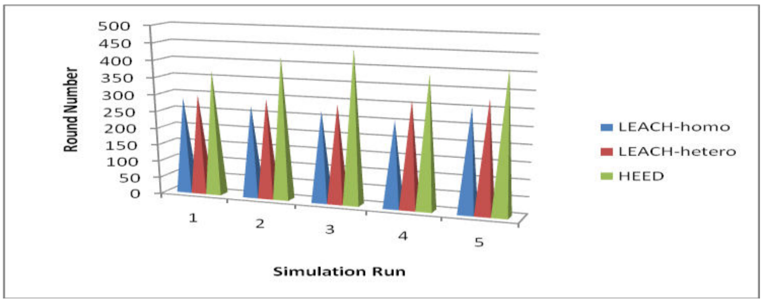

Figure 6. Simulation Rum vs Round number when first node dies at BS(100,200)

TABLE 4
ROUND NUMBER WHEN FIRST NODE DIES AT BS(100,100)

Simulation Run	LEACH homo	LEACH hetero	HEED
1	402	859	422
2	422	907	422
3	462	745	462
4	439	745	418
5	448	692	381

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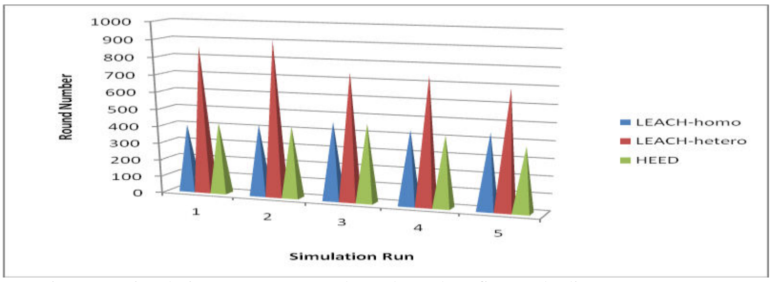

Figure 7. Simulation Rum vs Round number when first node dies at BS(100,100)

2) Network Lifetime (number of nodes dead) **:** We show both types of nodes for heterogeneous LEACH i.e. advanced nodes and normal nodes. The Tables 5-7 give the values of the number of dead nodes recorded after 500 rounds and the graphs in Figures 8- 10 show the difference in lifetime of network in the three protocols. There are maximum number of alive nodes in HEED at 500 rounds. At BS(100,100), the number of nodes dead in case of LEACH Hetero is nil as the nodes start to die after round number 700.

TABLE 5
NO. OF DEAD NODES AT BS (100,250)

Simulation Run	LEACH homo	Leach hetero		HEED
		A dead	N dead	
1	85	1	32	4
2	86	2	40	7
3	84	1	33	6
4	81	1	31	3
5	82	2	38	5

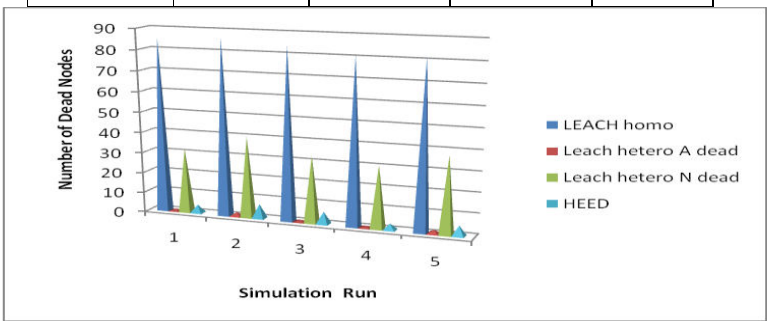

Figure 8. Simulation Rum vs Number of dead nodes at round no. 500 at BS(100,250)

TABLE 6
NO. OF DEAD NODES AT BS (100,200)

Simulation Run	LEACH homo	Leach hetero		HEED
		A dead	N dead	
1	67	0	15	4
2	56	0	18	2
3	60	0	16	3
4	64	0	14	5
5	58	0	17	4

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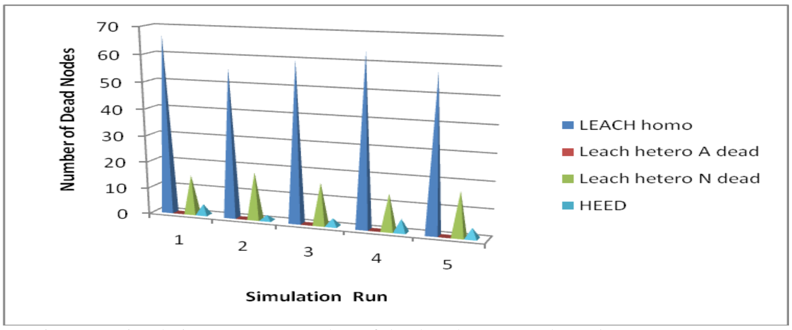

Figure 9. Simulation Rum vs Number of dead nodes at round no. 500 at BS(100,200)

TABLE 7
NO. OF DEAD NODES AT BS (100,100)

Simulation Run	LEACH homo	Leach hetero		HEED
		A dead	N dead	
1	34	0	0	1
2	23	0	0	5
3	31	0	0	6
4	28	0	0	4
5	29	0	0	2

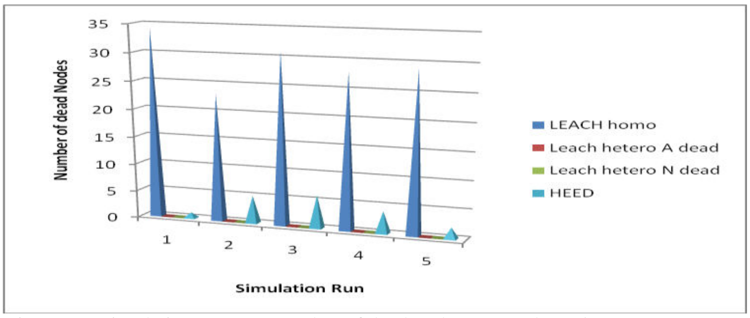

Figure 10. Simulation Rum vs Number of dead nodes at round no. 500 at BS(100,100)

3) Network Lifetime (when last node dies): We simulated the algorithms and determined the round numbers in which the last node dies i.e. when the whole network becomes dead as shown below. We have not recorded the values for LEACH hetero as the maximum rounds for which we have simulated the algorithms is 1500 and in this case, networks are alive for all the three base station positions till round number 1500.

TABLE 8
ROUND NUMBER WHEN LAST NODE DIES AT BS (100,250)

Simulation Run	LEACH homo	HEED
1	719	1024
2	738	1035
3	779	1069
4	886	1041
5	804	1078

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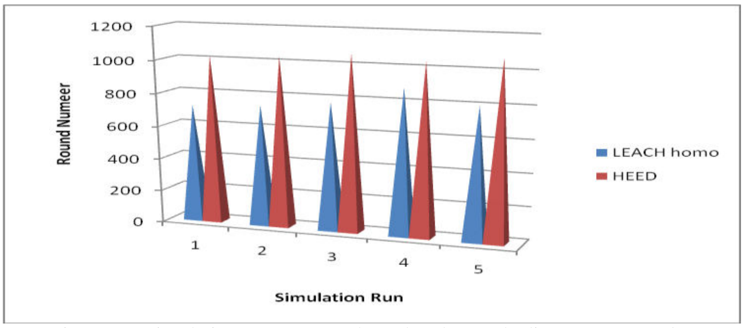

Figure 11. Simulation Rum vs Number when last node dies at BS(100,250)

TABLE 9
ROUND NUMBER WHEN LAST NODE DIES AT BS (100,200)

Simulation Run	LEACH homo	HEED
1	739	1041
2	807	1035
3	920	1069
4	839	1050
5	852	1058

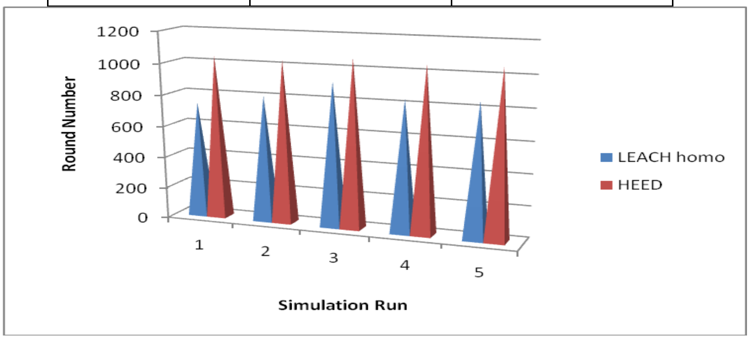

Figure 12. Simulation Rum vs Number when last node dies at BS(100,200)

TABLE 10
ROUND NUMBER WHEN LAST NODE DIES AT BS (100,100)

Simulation Run	LEACH homo	HEED
1	740	1213
2	682	1042
3	658	1106
4	737	1074
5	697	1136

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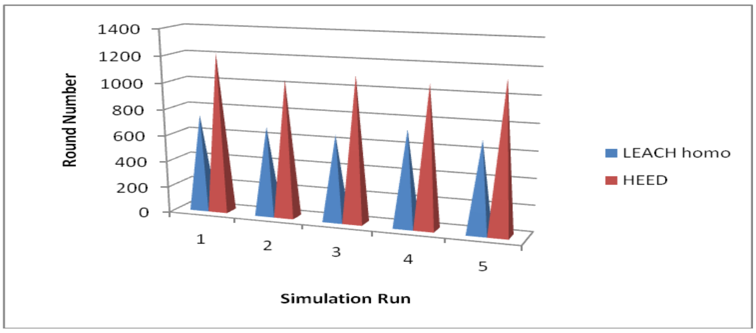

Figure 13. Simulation Rum vs Number when last node dies at BS(100,100)

VI.CONCLUSION AND FUTURE WORK

Energy consumption is the main design issue in routing of wireless sensor network, which ultimately effects the network lifetime. We analyzed and compared the homogeneous LEACH, heterogeneous LEACH and HEED in terms of network lifetimes by changing the Base Station positions in the network. The first node dies later in HEED for the BS(100,250) and BS(100,200) while the hetero LEACH overpowers it when BS is at (100,100). Further, there are maximum number of alive nodes in HEED at 500 rounds for BS(100,250) and BS(100,200) but at BS(100,100), the number of nodes dead in case of LEACH Hetero is nil as the nodes start to die after round number 700. Lastly, we recorded the values of round numbers when the last node dies in the network. LEACH hetero proves best, followed by HEED and LEACH homo in this case, as the maximum rounds for which we have simulated the algorithms is 1500 and for LEACH hetero, networks are alive for all the three base station positions till round number 1500.

The comparisons can also be made on various different parameters like changing the node deployment strategy, varying the number of nodes, etc. and analyzing their effect on the network lifetime.

REFERENCES

1. I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A Survey on Sensor Network", *IEEE Communication Magazine 40*, pp. 102-114, August 2004.
2. G. Martin, "An Avaluation of Ad-hoc Routing Protoco ls for Wireless Sensor Networks", Master's thesis,School of Computing Science, Newcastle Univer-sity upon Tyne, U.K., May 2004.
3. W.R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "An Application-Specific Protocol Architecture for Wireless Microsensor Networks" in *IEEE* Tmnsactions on Wireless Communications, vol. 1(4), pp. 660-670, October 2002.
4. Stanislava Soro,Wendi B. Heinzelman , "Cluster head election techniques for coverage preservation in wireless sensor networks" Department of Electrical and Computer Engineering, University of Rochester, Rochester, NY 14627, United States, Science Direct , Elsevier, Ad Hoc Networks 7, 955–972, 2009
5. www. Mathworks.com
6. J. Al-Karaki, and A. Kamal, "Routing Technique s in Wireless Sensor Net-works: A Survey", *IEEE Communications Magazine*, vol 11, no. 6, pp. 6-28, December 2004.
7. S. Taruna, Jain Kusum Lata, Purohit G.N. "Zone Based Routing Protocol for Homogeneous Wireless Sensor Network", International Journal of Ad hoc, Sensor & Ubiquitous Computing (IJASUC) Vol.2, No.3, September 2011.
8. Shio Kumar Singh, M P Singh, and D K Singh, "Energy Efficient Homoge-nous Clustering Algorithm for Wireless Sensor Networks", International Journal of Wireless & Mobile Networks (IJWMN), Vol.2, No.3, August 2010.
9. C.R. Lin, and M. Gerla, "Adaptive Clustering f or Mobile Wireless Net-works", *IEEE Journal on Selected Areas in Communication*, vol. 15, no. 7, pp. 11265-1275, September. 1997.

BIOGRAPHY

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