ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
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International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 12, April 2018

A NOVEL ROUTING PROTOCOL FOR WIRELESS SENSOR NETWORK USING AN ENERGY AWARE HETEROGENEOUS RING CLUSTERING (EA-HRC) METHOD

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Abstract

Energy saving to prolong the network life is an important design issue while developing a new routing protocol for wireless sensor network. Clustering is a key technique for this and helps in maximizing the network lifetime and scalability. Most of the routing and data dissemination protocols of WSN assume a homogeneous network architecture, in which all sensors have the same capabilities in terms of battery power, communication, sensing, storage, and processing. Recently, there has been an interest in heterogeneous sensor networks, especially for real deployments. This research paper has proposed a new energy aware heterogeneous ring clustering protocol (EA-HRC) for heterogeneous wireless sensor networks. Heterogeneity is introduced in EA-HRC by using two types of nodes: normal and advanced. In EA-HRC cluster heads for normal nodes are elected with the help of a probability scheme based on residual and average energy of the normal nodes. This will ensure that only the high residual normal nodes can become the cluster head in a round. Advanced nodes use a separate probability based scheme for cluster head election and they will further act as a gateway for normal cluster heads and transmit their data load to base station when they are not doing the duty of a cluster head.

Keywords: Wireless Sensor Network, Heterogeneous Ring Clustering, Energy Aware, Cluster Head.

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1. Introduction

Wireless sensor network consists of a large number of tiny sensors and a sink or base station. Sink generally acts as a gateway for other network [1] [2] [3]. Sensors not only sense the region, but also able todo computation, storage and communication to other sensors, including remote located basestation by using a wireless medium. A tremendous amount of research activities has been goingon in sensor networks due to their vital importance to a number of civilian and militaryapplications. Wireless sensor networks are used for battlefield surveillance, for monitoring andtracking of nuclear plants and hazard locations [4],[5],[6],[7],[8],[9],[10]. Sensors are batteryoperated devices therefore it is crucial that they utilize their energy in an effective manner toincrease the life of the network.

WSNs are usually deployed in a random way without any pre planning and exposed to terrible and dynamic environments. Sensor networks have to work for years without any attention fromthe external world. As a result, conventional algorithms which are suitable for other wirelessnetworks like MANET (Mobile Adhoc Network) and cellular system cannot be applied directly toWSN. Effective organization of the nodes to form clusters can save a significantamount of network energy. In hierarchical or cluster based routing high energy nodes do the data processing and transmission while low energy node sense the region. It is an effective way toreduce the energy consumption of the network by performing data aggregation or data fusion todecrease the number of transmissions to base stations [11], [12]. Sensor network are of twotypes: homogeneous and heterogeneous. When all the sensors of the network have the samecapacity in terms of energy, storage and computation it is known as a homogeneous sensornetwork. However when the sensor nodes differ from each other in terms of energy, storage andcomputation it creates a heterogeneous network. Heterogeneity in sensor network helps inincreasing the network lifetime and reliability. In this paper an energy aware clustering protocol isproposed to maximize the network lifetime. The protocol suggests a novel technique for clusterheads election and introduces a gateway concept for advance

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nodes to transfer the data load ofnormal cluster heads to base station. To save the energy of the network further, a sleep state issuggested for some sensor nodes.

2. Architecture of Energy Aware Heterogeneous Ring Clustering (EA-HRC) Method

The architecture for the proposed EA-HRC protocol for energy efficiency uses the Radio Model and Network Model to increase the overall lifetime of the network andreduce the energy consumption of the network. Radio Model is used to calculate theenergy dissipated in transmission and receiving of sensed data and communicationbetween nodes. Network Model gives the overall strategy and layout of the proposedEA-HRC nodes distribution and efficient mechanism for the routing of sensed data andinformation communicated over the network.

2.1 Radio Model

The assumptions about the energy dissipation in transmit and receive modes, will change the advantages which different protocols bring to provide the energy efficiency.The proposed EA-HRC protocol operation uses Heinzelman et al radio model for energyconsumptions of the messages. There exists a great deal of research in the area of lowenergyradios.

According to the first order radio energy model, energy consumed in transmitting a message is given by:

$$E_{tx} = K\,(E_{elec} + \in_{amp}\, d^{\lambda})$$

Where, K is the length of the message, d is the transmission distance between thetransmitter and the receiver; E_{elec} is the energy consumed by electronics of the node, $\in_{amp}$the transmitter amplifier and is λ is the path loss component.

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

$$E_{tx} = K\,.\,E_{elec}$$

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Based on the first order radio energy model, it can be inferred that, with thereduction in size and number of messages being exchanged and reduction in distantcommunication, energy consumption is reduced.

2.2 Network Model

Data gathering is a typical application in wireless sensor networks:this protocol aims at the study of the problems that involve in this kind of application.To explain thearchitecture of the Network Model some basic assumptions are made to hypothecate theproblem and analyze the proposed resultant outcome. The Proposed Network Modelprotocol assumes that a number of sensor nodes are randomly scattered in a twodimensionalsquare field, and the sensor network has the following properties:

1. The network is a static and densely deployed.

2. The nodes are immobile.

3. There exists only one base station.

4. Base station is stationary and is located outside the periphery of the WSN.

5. The battery used in the sensor node is irreplaceable.

6. The sensor nodes are location-unaware.

Despite the tremendous potentials and its numerous advantages provided by the different techniques already in existence - namely distributed localized computing,communication in which failure of one part of the network does not affect the operation inother part of the network, longer area coverage, extreme environment area monitoring, ithas seldom been used to improve or address the challenges faced by WNS.

3. Working Model of Proposed EA-HRC Protocol

The flow diagramin Figure 1, describes the overview of the protocol, initially the user has to give the input which is in the form of number of nodes. For the

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nodesgenerated, their positions are randomly assigned and displayed. Once the nodes aredeployed, every node uses the neighbor discovery algorithm to discover its neighbor nodes.Using the cluster head selection algorithm, cluster heads are selected among the nodes. Theadvertisement message is broadcasted to all its neighboring nodes by the cluster heads andthus clusters are formed with a fixed bound size. Each node in the cluster maintains routingtable in which routing information of the nodes are updated. DRAND (distributedrandomized time slot assignment algorithm) method is used; it allows several nodes toshare the same frequency channel by dividing the signal into different time slots. Thecluster head aggregates the data from all the nodes in the cluster and this aggregated data istransmitted to the base station.

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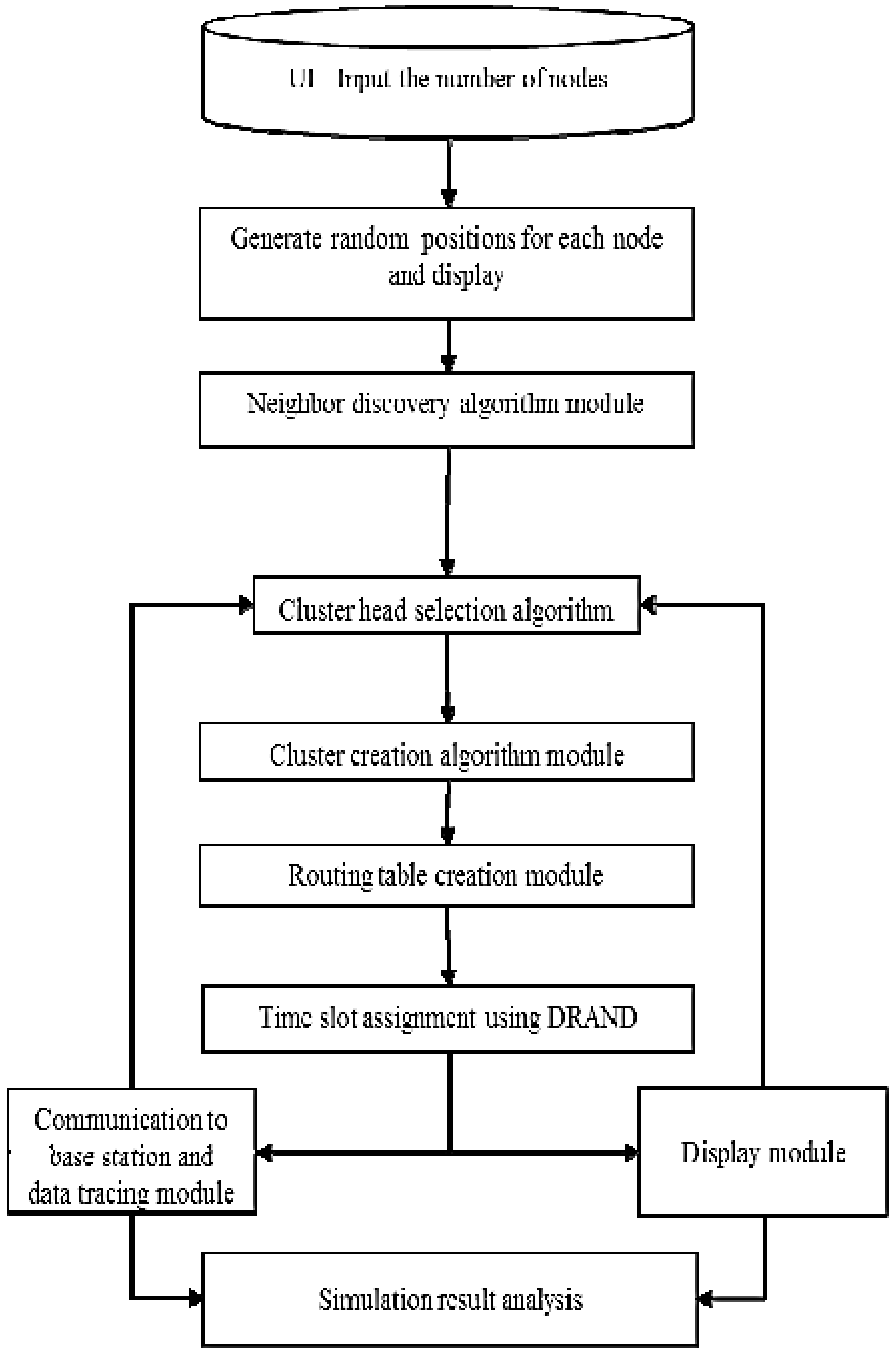

Figure 2: Flow Diagram of EA-HRC Protocol

Following are the three phases, after the node deployment:

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1. Neighbor Discovery

2. Cluster Head Selection

3. Cluster Formation

3.1 Neighbor Discovery

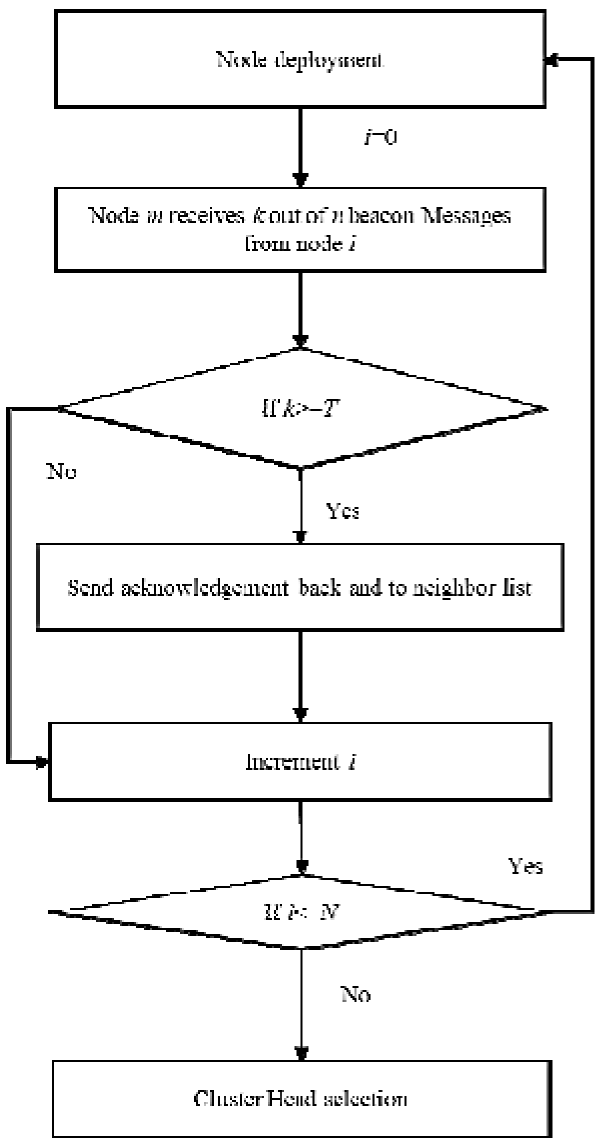

Figure 3: Flow Diagram of Neighbor Discovery

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The neighbour discovery phase takes place after the node deployment, where each node transmits number of beacon messages to its neighbouring nodes. Upon receivingthese beacon messages the node checks whether the total number of beacon messages are greater than the threshold value. Finally the node sends back an acknowledgment to thesource node and then the neighbour list in the source node is updated. The steps is shownbelow:

1. Create node deployment where each node transmits beacon messages to the neighbor nodes

2. Choose a node ‘i’ that transmits ‘N’ beacon messages with its ID

3. For each node ‘m’ , the node receives ‘k’ out of ‘N’ beacon messages from node ‘i’

4. If beacon messages selected is greater than or equal to the threshold, then send acknowledgment back and add to the neighbor list and increment the node ‘i’ otherwise, increment the value of node‘i’.

5. If node ‘ i ‘ is less than or equal to total number of beacon messages, then go for cluster headselection, otherwise, initialize node ‘i’ to 0 and repeat from step 2.

Where,N- total number of beacon messages, i-node transmitting the message, k number of beacon messages that are being selected. m- node which receives the messages.T- Threshold value.

3.2 Cluster Head Selection

After the required percentage of cluster heads are selected, each cluster head broadcasts the ADV+budget message to its one hop neighbor. If it is the first ADVmessage the neighboring node has received, then the neighbor is added to the minimal pathlist and heuristic value is calculated, else the neighbor is added to the alternative path listand the heuristic value is calculated. Finally the receiving neighbor sends back anacknowledgement message to the cluster head and broadcasts the

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ISSN 2394-3785 (Online)
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advertising message toits one hop neighbor. This process is continued till the budget exhausts.

During the cluster formation every node that comes under a cluster consumes one spot from the budget assigned to it. Similarly, they divide the rest of the budget allotted tothem among their one hop neighbors randomly. Apart from the advertisement message thatis sent there are other information like budget allotted, minimum number of hops to reachthe cluster head, traffic information through the node, average energy of the path andenergy of the node with the least energy along the path is also sent. The steps are shownbelow:

Input: number of nodes

Output: Cluster Head

Step 1: 'P' is initialized by the user

Step 2: The threshold equation T(n) is given by :

$$Node\ i\ computes\ T(n) = \begin{cases} \dfrac{P}{1 - P * mod\ (1/P)}, & if\ n \in G \\ 1\ , & Otherwise \end{cases}$$

where G-Set of nodes that have not been CH for last 1/P rounds, r-current round.

Step 3: Choose a random number between 0 and 1 using, assign t = rand().

Step 4: IF random number is greater than threshold value, the current node becomes the CH.

Step 5: ELSE node does not become the CH.

Step 6: INCREMENT node 'i'.

Step 7: END IF

Step 8: IF (node 'i ' < total number of beacon messages (N)), Return to Step 2.

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Step 9: ELSE go for timed cluster formation

Step 10: END IF

Where,

P- desired percentage of CH

r- current round

G- set of nodes that has not been CH in the last 1/P rounds

T(n)- threshold value.

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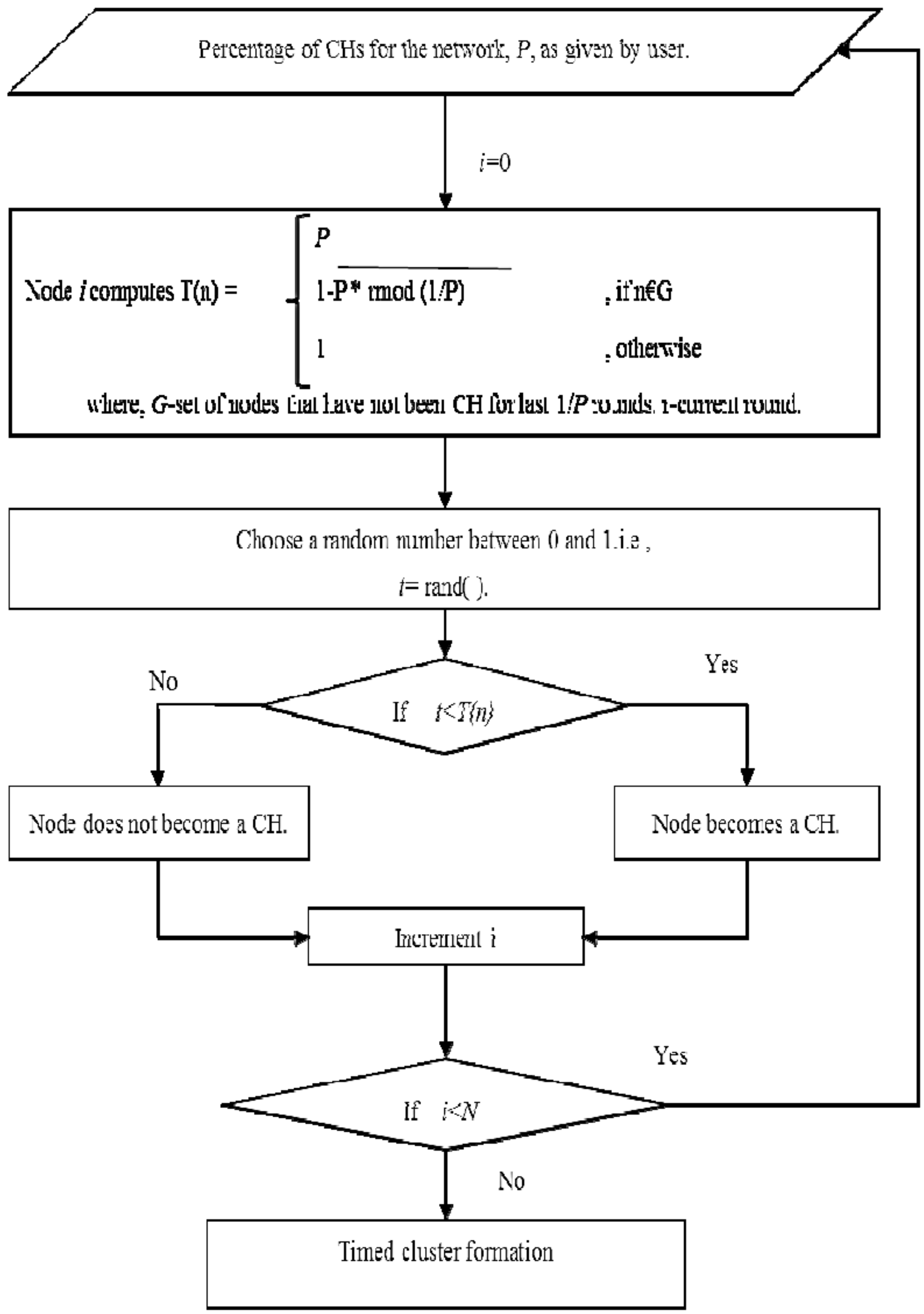

Figure 4: Flow Diagram of Cluster Head Selection

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3.3 Cluster Formation

After the required percentage of cluster heads are selected, each cluster head broadcasts the ADV+budget message to its one hop neighbor. If it is the first ADVmessage the neighboring node has received, then the neighbor is added to the minimal pathlist and heuristic value is calculated, else the neighbor is added to the alternative path listand the heuristic value is calculated. Finally the receiving neighbor sends back anacknowledgement message to the cluster head and broadcasts the Advertising message toits one hop neighbor. This process is continued till the budget exhausts.

During the cluster formation every node that comes under a cluster consumes one spot from the budget assigned to it. Similarly, they divide the rest of the budget allotted tothem among their one hop neighbors randomly. Apart from the advertisement message thatis sent, there are other information like budget allotted, minimum number of hops to reachthe cluster head, traffic information through the node, average energy of the path andenergy of the node with the least energy along the path is also sent. The steps shown below:

Step 1: CH broadcasts the advertisement and budget to its one-hop neighbor.

Step 2: The neighbor node ‘i’ receives first message.

Step 3: Add one-hop neighbor to ‘M’ and calculate ‘H’ .

Step 4: Otherwise, add one-hop neighbor to ‘A’ and calculate ‘H’

Step 5: Then send Acknowledgement back to the node from where it has received.

Step 6: Node ‘i’ cascade the advertisement message to its next one-hop neighbor and increments the value of ‘i’

Step 7: If budget exhausts, the network formation is completed

With,Minimal path- M, Heuristic value- H, Alternate path- A

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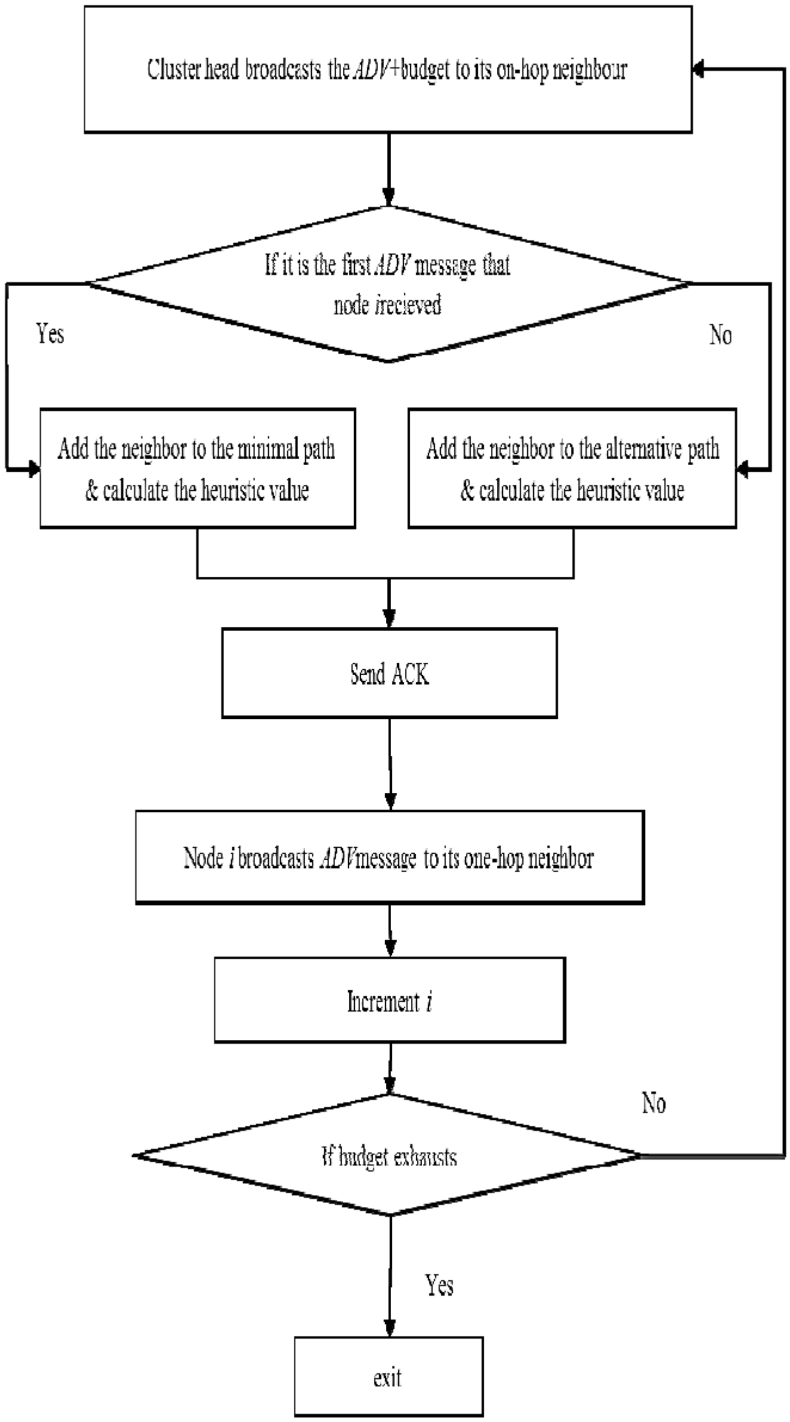

Figure 5: Flow diagram of Cluster Formation

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4. Implementation Result and Discussion

The parameters taken into consideration while evaluating are:

1. Round Number vs Number of Dead Nodes (with variation of probability)

2. Round Number vs Average Energy of Each node (with variation of probability)

Table 1: Simulation Details

Simulation Area	100*100 (sq.mt)
Base Station Location	(150,50)
Channel Type	Wireless Channel
Energy Model	Battery
Transmission Amplifier	10*0.000000000001
EfsEmp	0.0013*0.000000000001
Data Aggregation Energy	5*0.000000001
Transmission Energy,ETx	50*0.000000001
Receiving Energy,ERX	50*0.000000001

4.1 Simulation Analysis of Protocols at 0.05 Probability for the number of Dead Nodes

At 0.05 probabilities, the percentages of total nodes that can become cluster head are 5% of the total number of nodes. The simulation was conducted at 0.05 probabilities, Figure 6, 7, 8 and 9 shows results.Comparison, of the simulation results at the 0.05 probability for the EA-HRC protocol and LEACH protocols, is performed and as shown in Figures 6, 7, 8 and 9 represents the number of dead nodes against the round number elapsed for the different intervals at 50,100,150 and 200 nodes respectively. Also it is

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observed that the simulation at 50 nodes, the number of dead nodes of EA-HRC protocol is almost as comparable to number of dead nodes in the LEACH protocol, as presented in figure 6. However as the number of nodes increase, weobserve that EA-HRC protocol results in lesser number of dead nodes after the completionof 100 rounds when compared to LEACH, as shown in the Figures 7, 8 and 9 taken from simulation results.

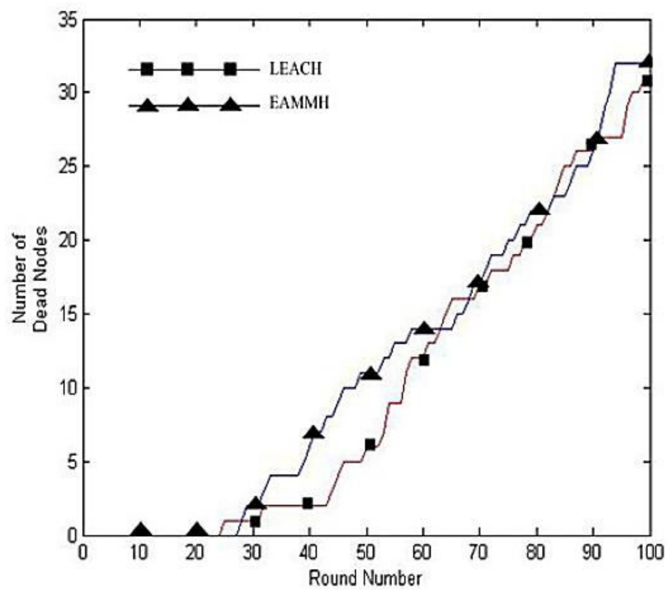

Figure 6: Simulation results for 50 nodesat 0.05 Probability for the number of Dead Nodes

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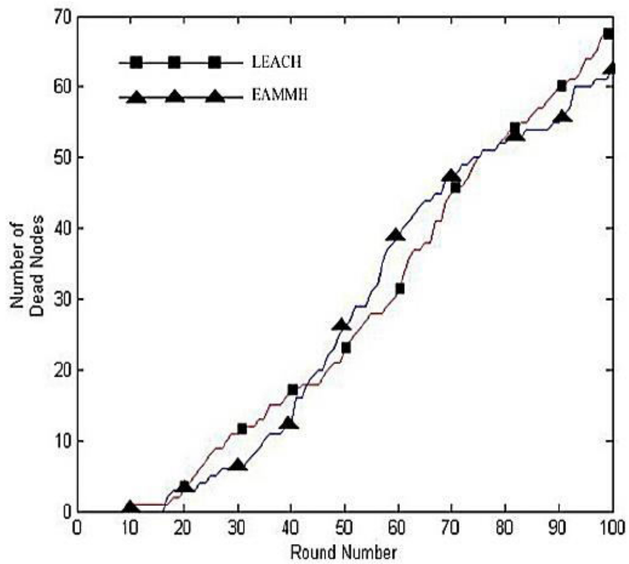

Figure 7: Simulation results for 100 nodesat 0.05 Probability for the number of Dead Nodes

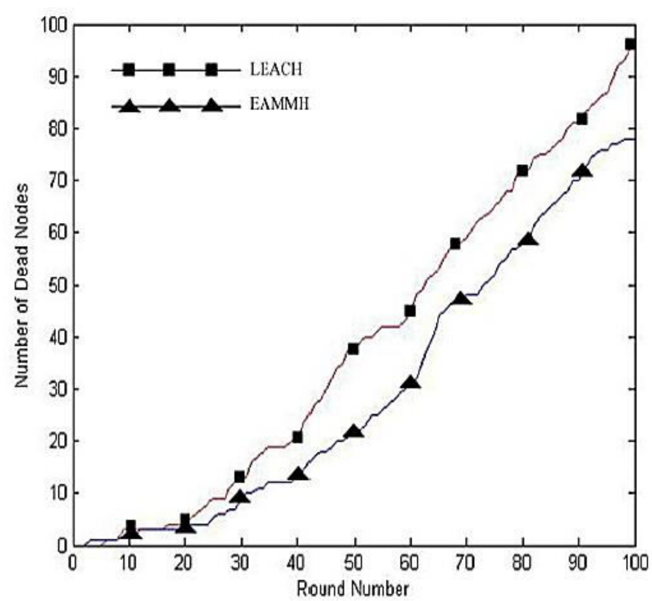

Figure 8: Simulation Result for 150 nodes at 0.05 probability for the number of dead nodes

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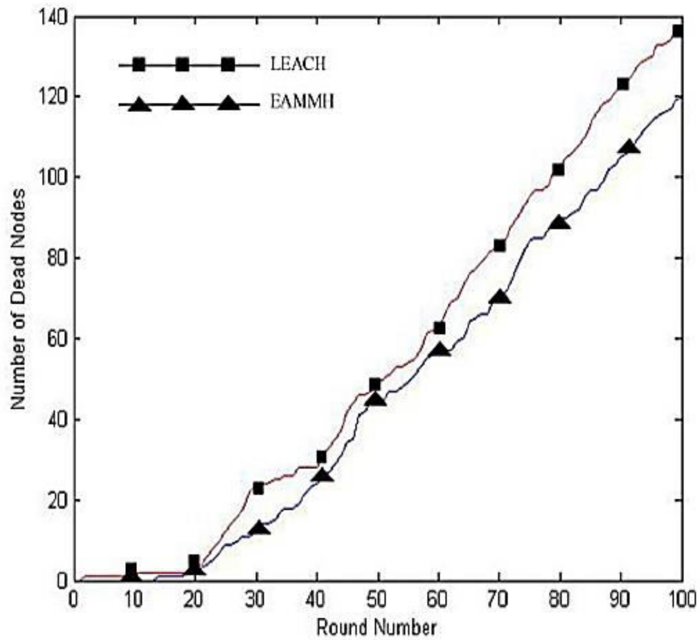

Figure 9: Simulation Result for 200 nodes at 0.05 probability for the number of dead nodes

4.2 Simulation Analysis of Protocols at 0.05 Probability for the Average Energy

Comparison of the average energy available at each node,during the process of cluster formation and network stabilization is performed, and are represented in Figures10, 11, 12 and 13.From the simulation analysis, we observe that, as the round progresses for the EAMMH and LEACH protocols, at the beginning the average energy of each node after100 rounds is almost equal for both the protocols as shown in Figure 10 and 11.However, as the no of nodes increases, the EAMMH protocol outperforms LEACHprotocol as represented in Figure 12 and 13.

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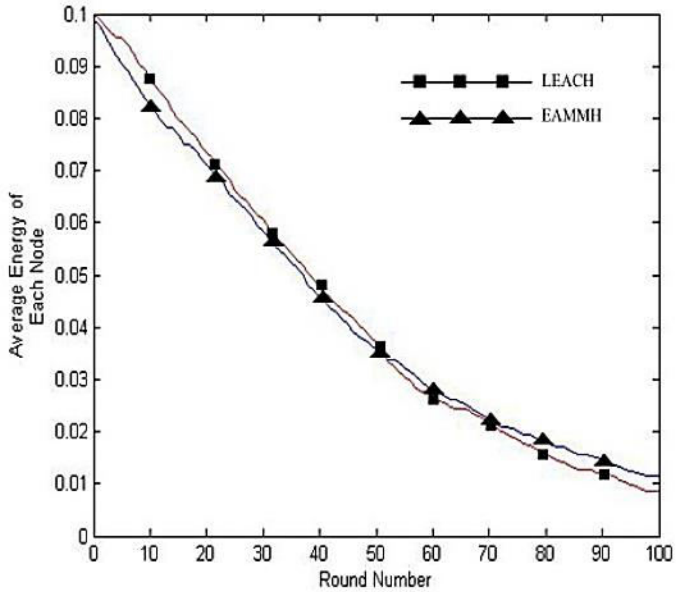

Figure 10: Simulation Results for 50 nodes at 0.05 Probability for Average Energy (units of Joules)

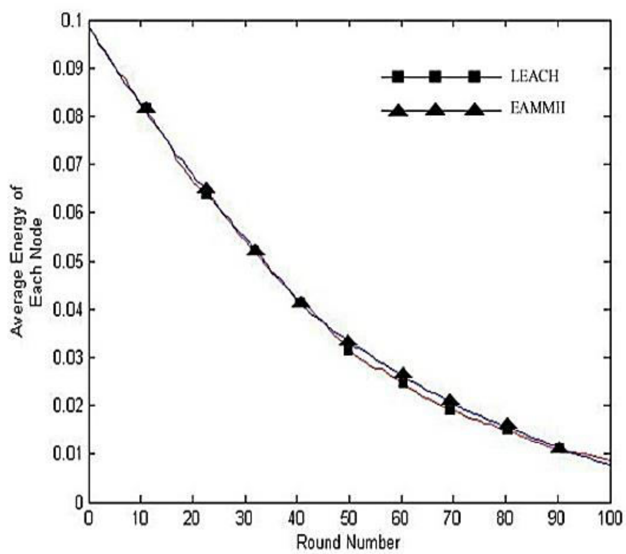

Figure 11: Simulation Results for 100 nodesat 0.05 Probability for Average Energy(units of Joules)

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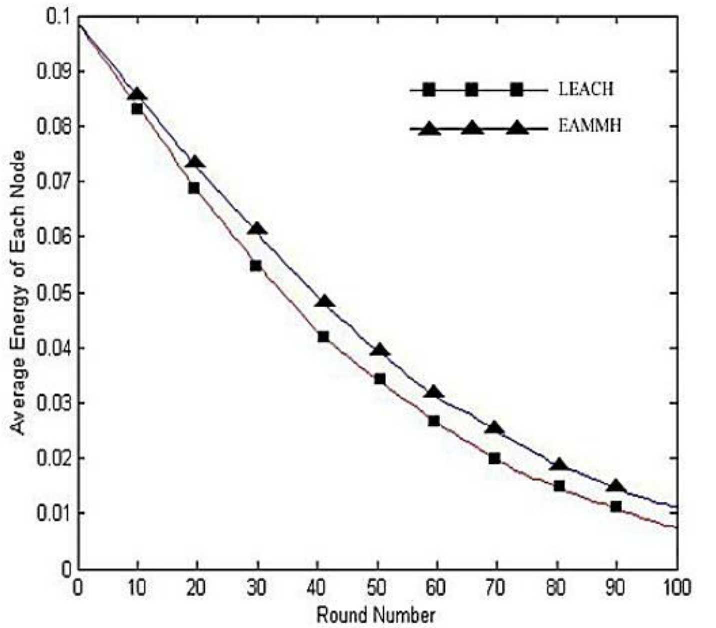

Figure 12: Simulation Results for 150 nodesat 0.05 Probability for Average Energy(units of Joules)

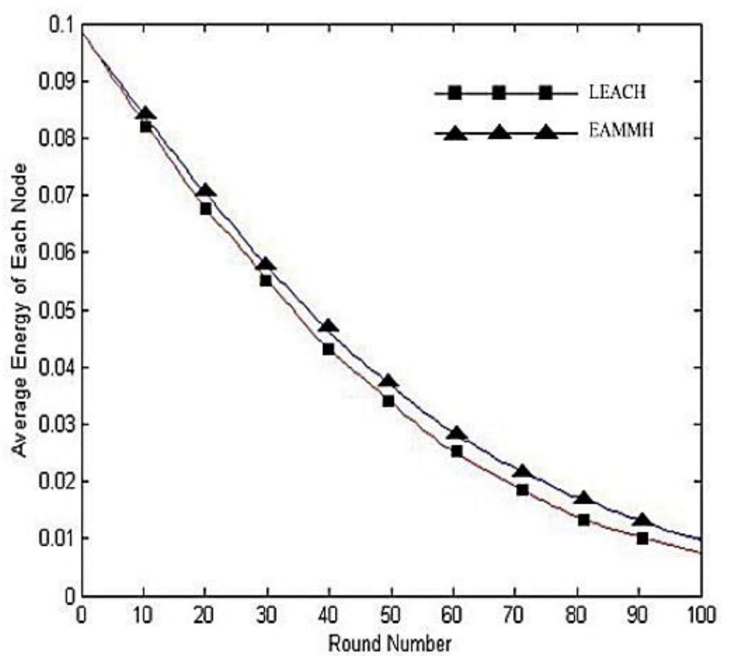

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Figure 13: Simulation Results for 200 nodesat 0.05 Probability for Average Energy (units of Joules)

5. Conclusion

In this research work routing protocols based on clustering protocols for selection of Cluster Head are developed for both Homogeneous and Heterogeneous WSNs. Throughthis research work, it has been proved that –Homogeneous protocols are a novel energyefficient data gathering protocols, where clustering is based on allocating the growthbudget to neighbors, multi-hop, multi-path. Whereas the EA-HRC algorithm, outcome ofthis research work, chooses the alternative path based on heuristic function values (routingtable information). EA-HRC protocol organizes the sensor nodes into clusters and forms amulti-hop intra-cluster network.

References

[1] W. B. Heinzelman, A. Chandrakasan, and Balakrishnan, (2002) "An Application-Specific ProtocolArchitecture for Wireless Micro-sensor Networks", *IEEE Transactions Wireless Communications,* Vol. 1, No. 4, pp. 660-670.

[2] S. Bandyopadhyay, E. J. Coyle, (2003) "An energy efficient hierarchical clustering algorithm forwireless sensor networks", *In INFOCOM 2003 Twenty-Second Annual Joint Conference of theIEEE Computer and Communications, IEEE Societies,* Vol. 3, pp. 1713-1723

[3] C. K. Liang, Y. J. Huang & J. D. Lin, (2008) "An energy efficient routing scheme in wirelesssensor networks", *In Advanced Information Networking and Applications-Workshops (AINAW2008), 22nd International Conference, IEEE,* pp. 916-921.

[4] J. N. Al-Karaki, A. E. Kamal, (2004) "Routing techniques in wireless sensor networks: a survey",*Wireless communications, IEEE*, Vol. 11, No. 6, pp. 6-28.

[5] A. A. Abbasi, & M. Younis, (2007) "A survey on clustering algorithms for wireless sensornetworks", *Computer communications*, Vol. 30, No. 14, pp. 2826-2841.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 12, April 2018

[6] Shio Kumar Singh, M. P. Singh, and D. K. Singh (2010) "Routing protocols in wireless sensornetworks–A survey", *International Journal of Computer Science & Engineering Survey,* Vol. 1,No. 2, pp 63-83.

[7] D. Bhattacharyya, Tai-hoon Kim &Subhajit Pal (2010) "A comparative study of wireless sensornetworks and their routing protocols", *Sensors*, Vol. 10, No. 12, pp. 10506-10523.

[8] X. Liu (2012) "A survey on clustering routing protocols in wireless sensornetworks", *Sensors*, Vol. 12, No. 8, pp. 11113-11153.

[9] M. Aslam, NadeemJavaid, A. Rahim, U. Nazir, Ayesha Bibi, and Z. A. Khan (2012) "Survey ofextended LEACH-Based clustering routing protocols for wireless sensor networks", *In HighPerformance Computing and Communication & 2012 IEEE 9th International Conference onEmbedded Software and Systems (HPCC-ICESS), 2012 IEEE 14th International Conference on,*pp. 1232-1238, IEEE, 2012

[10] S. Tyagi, & N. Kumar, (2013) "A systematic review on clustering and routing techniques basedupon LEACH protocol for wireless sensor networks", *Journal of Network and ComputerApplications*, Vol. 36, No. 2, pp. 623-645.

[11] Pantazis, A. Nikolaos, A. Stefanos, Nikolidakis, and Dimitrios D. Vergados (2013) "Energyefficientrouting protocols in wireless sensor networks: A survey", *Communications Surveys &Tutorials, IEEE* 15.2 (2013), pp. 551-591.

[12] S. Lindsey, & C. S. Raghavendra,(2002) "PEGASIS: Power-efficient gathering in sensorinformation systems", *In Aerospace conference proceedings, IEEE,* Vol. 3, pp. 1125-1130.

