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Cluster based Routing Algorithm to Minimize Energy Consumption in WSN

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***Abstract*—**Low energy consumption and increasing the network lifetime are key factors in proposing a wireless sensor network protocol. Clustering or hierarchical methods have been proven to be effective in decreasing the energy consumption. Clustering methods make use of cluster-heads in order to achieve the efficiency in wireless sensor networks. Gridding approach is used in clustering that divides the network layout into grid with nodes falling into the each grid. Cluster-head provides a hierarchy in the network, one between the nodes and cluster-head and second between the cluster-head and the base station. Cluster-heads aims at aggregating the data from sensor nodes and decrease the controlling data in the network. This idea increases the lifetime of the network by decreasing the energy consumed by the nodes.
In cluster based routing algorithm with mass-centre approach to minimize energy consumption in WSN, election of the cluster-heads is carried out based on two parameters, one is energy and the other is mass-centre of the sensor nodes. Threshold energy is selected and all the nodes that have the energy levels higher than the threshold energy qualify to be cluster-head. The second factor is the mass-centre of the nodes in which the weight of the node that lies near the centre of the grid is chosen to be the cluster-head for the current round.

***Keywords* —** *Clustering, Cluster-head, Threshold energy, Mass-centre.*

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I. INTRODUCTION

Wireless sensor network is a collection of miniature inexpensive low-powered sensor nodes that has the ability to sense and gather physical data, process the data and send it over a wireless medium. Sensor nodes have the ability to collect data independently and send it to other nodes or to the base station. Applications of these nodes can be for military surveillance, environment data gathering or industrial purposes. Deploying of the sensor nodes are not strictly planned and are usually in adhoc fashion.

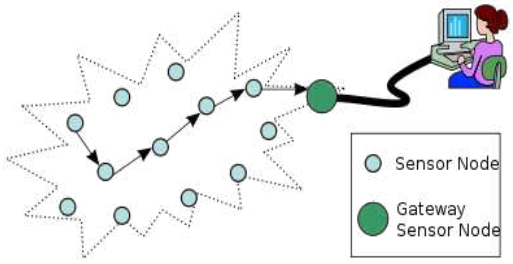

Fig.1: Wireless Sensor Network with the base station

On deployment, these nodes have the ability to organize themselves. Sensor nodes in the wireless network have a collaborative approach and work together to forward data to the required destination. Energy is provided to the sensor nodes using battery supply and in most of the cases the replacement of battery is not difficult or not possible. Depletion of sensor node's energy will make the sensor node incapable of operation. So Energy efficiency is an important parameter in designing routing algorithms for the wireless sensor network as the energy resources are greatly limited. Hence it requires effective method for data processing and forwarding. Even though various routing schemes have been implemented, there are shortcomings in terms of energy.

A sensor node will comprise of microcontroller, transceiver, memory, power source with one of more type of sensors.

Listed below are the features that make a wireless sensor network different from a traditional network.

- Restrictions in the hardware. Includes size and power supply and data processor.
- Large number of nodes work together
- Self organizing capability of the senor network's protocols.
- Broadcasting mechanism to send data
- Data oriented network
- Changes in topology

Designing of routing algorithms in wireless sensor networks is mainly concerned with the factor of energy. Increasing the network lifetime by making the most efficient of use of the available energy is the primary goal. Routing schemes for WSN's are mainly classified in three types - Block, Chain and Grid.
Clustering is network management technique, used to create clusters based on distance or proximity.
Clustering types include

- Static: fixed network parameters
- Dynamic: changing network parameters
- Single-hop and multi-hop
- Homogeneous clustering and heterogeneous clustering

Using clustering creates a hierarchical network over a flat network. This provides levels of hierarchy and an efficient way to choose cluster-heads. Cluster heads exist in each cluster and are responsible for sending data to the next cluster or to the base station. All communication of data goes through this cluster head elected by the member nodes or base station in the cluster based on certain parameters.

Base station in the wireless sensor network is the component that gathers data from the distributed sensor. Election of the cluster-head can be done in the following ways

- Centralized – elected by the base station to be the cluster-head.
- Distributed – elected by the member nodes in the cluster to

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be the cluster-head.
- Hybrid – both the base station and the member nodes of the cluster work together to be elect the cluster-head.

Another advantage of using cluster-heads is for data redundancy. Cluster heads have the ability to filter and aggregate data that is sent by the member nodes. Data filtering and aggregation will reduce substantial amount of data that has to be sent over the network and increase the bandwidth in the wireless sensor network.

Introduction of grids in the clustering algorithm and using cluster-heads in each of the clusters for sending and aggregating network will boost the network lifetime. Sensor network operation can be in any environment and the sensors work with in a collaborative approach for sending the data to the base station. One of the advantages of the sensors is that there is no specific structure the sensors have to follow. Sensors are usually placed where human interference in minimal and inaccessible most of the times. Sensors have the ability to monitor the environment and transmit it over long distances. The transformation of the electric signals to digital and transmission of the processed data is done by the equipment on the sensor node. Transmission of the processed data is carried out by transforming it into radio waves. Hence, sensors have three capabilities built within – Transformation of electric signals to digital, processing and filtering capability and finally sending the processed information to the base station.

In designing of the Wireless sensor networks, two considerations are of great importance. The first consideration is the ability to exchange large amounts of information between the nodes and the base station. The second consideration is minimizing the energy consumed by the nodes to transmit the information to the base station. These considerations show the importance of energy efficiency in the routing protocol. Clustering routing or hierarchical routing protocols have been proven to be a success in the design of energy efficient protocols. As mentioned earlier, hierarchical routing involves a multi layer approach in sending the data to the base station. One layer is concerned with selection of the cluster head and second layer is concerned with routing data to the base station by the cluster head.

Energy consumption is main factor in this work and the energy level of each node in the wireless sensor node is of particular interest, since the energy level of each node is limited and replacing the battery source or node is not practical. An accurate and effective visualization tool would provide a quick and accessible means to view the energy level of each node in the field to support the development of routing algorithms that minimize energy consumption.

II. RELATED WORKS

A lot of effort has been undertaken for the designing energy-efficient protocols for Wireless Sensor Networks. LEACH was one of the first cluster based routing protocols based on energy. LEACH stands for Low Energy Adaptive Clustering Hierarchy (LEACH) and is one of most famous clustering algorithms. LEACH is a distributed, proactive, dynamic algorithm that forms clusters based on strength of the received signal and makes use of local Cluster-heads to send data to the sink or the base station. The selection of the Cluster-head is performed among nodes within a cluster is done based on the remaining energy levels of the sensor nodes. The number of nodes that has to be active in the sensor network and the number of clusters in the network are the parameters defined in the node set. Low Energy Adaptive Clustering Hierarchy (LEACH) comprises of two phases and the two phases work in each round. First comes the set-up phase and then the steady-state phase. In the first phase, selection of the cluster-head is performed. Selection of the Cluster-Head in the cluster is based on the threshold T (n).

Threshold T (n) is specified by:

$$T(n) = \begin{cases} \dfrac{p}{1 - p * (r \mod \frac{1}{p})} & if \quad n \in G, \\ 0 & otherwise \end{cases} \tag{1}$$

In the equation given, G is the node that have not been cluster heads in the last 1/p rounds, p shows the predetermined percentage of cluster-heads and r shows the current round. On the selection of the cluster head, a broadcast message is advertised over to the other nodes. Each node then selects the cluster-head it to belong to depending on the signal strength of the advertised message. LEACH works with TDMA (Time division multiple access) that assigns each node with a time slot to send data to the cluster head. In the steady-state phase, data collection and data aggregation is carried out by the cluster-heads and data is transmitted over to base station. Because of the cluster-head selection is based on probability, there are chances of nodes with low energy to be elected as cluster-heads. This will make the depletion of the energy in the sensor node and makes it dysfunctional [1]. Moreover, LEACH uses single hop communication and is not suitable for large scale networks.

HEED stands for "Hybrid Energy-Efficient Distributed" and this clustering has been introduced by Younis and Fahmy. The main goal of HEED is to increase network life. The primary difference between HEED and LEACH is cluster head selection and cluster head selection in HEED is not random. Two factors are important in HEED, primary factor is the energy level of the node and the secondary factors are topology features such as node degree, neighbors distance that are used to break the tie between all the candidate nodes having high energy levels [2].However, Disadvantage is that massive overhead is created due to multiple rounds and energy consumption is not balanced.

DWEHC introduced by P. Ding, J. Holliday, and A. Celik stands for "Distributed Weight-based Energy-efficient Hierarchical Clustering scheme". In this scheme each of the nodes will first locate its neighbor, calculation of its weight is done which is based on its remaining energy and distance to its neighbors to the node. The largest weight node in a

neighborhood is a eligible candidate in becoming a cluster head. Cluster head hierarchy is then joined by the Neighboring nodes. Clustering is performed based on iterations and is not dependent on network properties [3]. Results show that there is less energy consumption than HEED but it has certain limitations. Due to large control message, there is an extra overhead compared to other schemes and lower energy efficiency with the use of single hop intercommunication [6].

Geographic Adaptive Fidelity has been introduced for clustering and this algorithm saves energy by identifying nodes that are necessary from a routing perspective and then turning off non-essential nodes. Only the source and sink nodes remain on while the intermediate nodes are responsible for monitoring the use of energy and balancing it. This scheme is based on adaptive fidelity that uses redundancy to save energy while conserving application fidelity to increase lifetime of the network. The major disadvantage is that it results in large traffic injection and delay is not fixed making it unsuitable of Wireless Sensor Network real time schemes.

PANEL stands for "Position based Aggregator Node Election Protocol". This particular scheme keeps up asynchronous sensor network routing contrary to other routing protocols. Position information is the leading component in the selection of the node aggregator. The notion is that the nodes are positioned in certain areas marked as topographical clusters. PANEL works based on predetermination of clusters before the network deployment. Each of its nodes are provided with the topological information. A position-based scheme is used for routing in the inter cluster data transfer. The idea of time-unit or epoch is used for cluster-head selection. Each node is made to a cluster-head in each epoch. In every cycle a different node is selected and made as the cluster-head for each epoch. This helps in load balancing of the network as each node has the equal opportunity in becoming the cluster-head. The major disadvantages are that the determination of geographical position data is not always possible and predetermination of clusters restricts its use in wireless sensor network.

This paper will concentrate on taking threshold energy as an eligibility criteria and mass-centre as the deciding factor for the eligible nodes in the cluster.

The paper is arranged in the particular format: in part 3, we have defined a methodology that defines the network and the energy model. Section 4, presents the algorithm description along with the algorithm. Section shows the simulation of the protocol and section 5 concludes the paper.

III. METHODOLOGY

A. Network Model

Network model has been proposed in the following manner:

- ✓ Base station is in a fixed position and the nodes have the ability to change
- ✓ Starting energy of all the nodes are set to be random.
- ✓ Deployment of the nodes is in a 2- Dimensional space.
- ✓ Every node contains the information of its coordinates, remaining energy and the cluster-head [7].

B. Energy Model

Energy is consumed by the sensor nodes while sensing, receiving and transmitting data. This paper proposes the first order radio model [1] for the energy model in the sensor network. This model includes the transmitter that the power control capability to dissipate minimum energy to transfer data to the receiver. To attain a welcoming signal-to-noise ratio (SNR), the transmitter's energy consumption is given as:

$$\begin{cases} E_{Tx}(n,d) = n(E_{elec} + \varepsilon_{fs} d^2) & d < d_0 \\ E_{Tx}(n,d) = n(E_{elec} + \varepsilon_{mp} d^4) & d \geq d_0 \end{cases} \quad (2)$$

In the equation,
n - Number bit of the message is given by n.
d - Distance.
Eelec - Energy dissipated/bit to run the transmitter
εfs , εmp - Energy dissipated /bit to run the transmit amplifier depending on the distance between the transmitter and receiver. If the distance is less than a threshold d0, the free space (FS) model is used, otherwise the multi path
(MP) model is used.

The energy consumption of the receiver is given by:

$$E_{Rx}(n) = n\,(E_{elec}) \quad (3)$$

The first order energy model is as same as the one used in LEACH [1].

IV. ALGORTIHM DESCRIPTION

We propose our cluster based mass-centre algorithm based on rounds. The algorithm is divided into set-up phase and steady-state phase. In the first phase, determination of cluster-head is done and structuring of the clusters is carried out. In the second phase, the steady-state phase involves transfer of data from the nodes to the cluster-heads and from cluster-heads to the base station.

A. Set-up Phase

This phase includes gridding the network layout, calculating the threshold energy and selection of cluster-heads among the sensor nodes.
The calculation of the threshold energy in the cluster is performed by using the equation:

$$E_\theta = \alpha * \left(\frac{1}{n} \sum_{i=1}^{n} E_i\right) \quad (4)$$

All those nodes that have higher energy than the calculated threshold are elgibile to be the cluster-heads for the current round.

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The second factor in determining the cluster-head is the mass-centre. The elgibile node with least mass-centre is selected to be the cluster-head for the current node. [8]
In order to calculate the mass-centre the following equation is used:

$$(x'_A, y'_A) = \left(\frac{1}{n}\sum_{i=1}^{n} X_i , \frac{1}{n}\sum_{i=1}^{n} Y_i \right) \quad (5)$$

B. Steady-state phase

In this phase, the emphasis is on the sending the data to the cluster-head and then from cluster-head to the base station. Once the cluster-heads collect and send data to the base-station, there is a decrease in the energy. In order to select the cluster-head for the next round, the energy of the cluster-head is calculated and if it falls below threshold then the next node from the sorted list is chosen.

Algorithm for structuring of the cluster and selection of cluster-head

- If (mod (round-num, rmax) = 0
- Threshold energy

$$E_\theta = \alpha * \left(\frac{1}{n}\sum_{i=1}^{n} E_i \right)$$

- Mass-centre

$$\left(\frac{1}{n}\sum_{i=1}^{n} X_i , \frac{1}{n}\sum_{i=1}^{n} Y_i \right)$$

- For i =1 to n
- If Ei ≥ Eθ then
- Insert node i into Q set
- i (type) = candidate
- Distance (i) = sqrt $((X_i-X_{MC})^2 + (Y_i-Y_{MC})^2)$
- End
- Sort Q set in ascending order with less mass-centre
- Cluster-Head= min (Q)

For further rounds, based on rmax, select Cluster-heads based on less mass-centre in the Q list.

X and Y form the coordinates in the network layout that specify the location of the nodes.

Ei is the energy of every node in the network that checks with the threshold energy Eθ to be eligible for cluster-head selection.

Q is the queue that includes the list of the all nodes that are eligible in the ascending order of the mass-centre

V. SIMULATION

Simulation of the protocol in ns2 yields graphical results of the routing performance and performance analysis graphs.

Fig. 2: Routing Performance of Nodes

Graph in Fig.2 shows the network throughput, packet delivery ratio and delay which is much better than LEACH.

Fig. 3: Performance Analysis of Nodes

Graph in Fig.3 displays packets received and the corresponding packets dropped in the WSN that is better than the LEACH.

VI. CONCLUSION

In Wireless Sensor Networks, energy factor is one of the most important parameter considered while designing a protocol. In our Cluster based Routing Algorithm to minimize energy, it concentrates not only on the threshold energy factor but also the mass-centre. This two factor approach selects the best node to be the cluster-head in the cluster for the current round and also prepares a sorted list of nodes that can be chosen as cluster-heads for further nodes. Cluster-head aims at aggregating the data from the nodes of the entire cluster thus saving the energy by avoiding the nodes with low energy to send data to the base station and also by minimizing the controlling messages in the network. This proposed algorithm will yield low energy consumption in the cluster nodes and an increase the overall lifetime of the network.

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REFERENCES

[1] W.R.Heinzelman,A.Chandrakasan,H.Balakrishnan,"Energy efficient communication protocol for wireless sensor networks", In: Proceedings of the 33rd Hawaii International Conference on System Science, vol. 2, 2000

[2] 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, 2004

[3] P. Ding, J. Holliday, and A. Celik, "Distributed Energy-Efficient Hierarchical Clustering for Wireless Sensor Networks," in Proc. of the First IEEE international conference on Distributed Computing in Sensor Systems, pp. 322–339, 2005

[4] Y. Xu, J. Heidemann, and D. Estrin, "Geography-informed Energy Conservation for Ad Hoc Routing," in Proc. of the 7th annual international conference on Mobile computing and networking, 2001, pp. 70–84.

[5] L. Buttyan and P. Schaffer, "PANEL: Position-based Aggregator Node Election in Wireless Sensor Networks," in Proc. of IEEE Internatonal Conference on Mobile Adhoc and Sensor Systems, pp. 1–9, 2007.

[6] Gulbadan Sijender, Mohammad Haseeb Zafar "A Survey of Cluster-based Routing Schemes for Wireless Sensor Networks" in Smart Computing Review, vol. 3, no. 4, August 2013.

[7] A. G. Delavar, S. Shamsi, N. Mirkazemi, and J. Artin, "SLGC: A New Cluster Routing Algorithm in Wireless Sensor Network for DecreaseEnergy Consumption," International Journal of Computer Science, Engineering and Application, vol. 2, no. 3, pp. 39–51, 2012.

[8] Arash Ghorbannia Delavar, Javad Artin and Mohammad Mahdi Tajari "RCSDN: A Distributed Balanced Routing Algorithm with Optimized Cluster Distribution Optimized Cluster Distribution" in International Journal of Computer and Electrical Engineering, Vol.4, No. 4, August 2012.

[9] Ameer Ahmed Abbasi, Mohammad Younis , " A survey on clustering algorithms for wireless sensor networks" Elsevier, computer communications 30 (2007) 2826-2841

[10] K. Akkays and M. Younis, "A Survey on Routing Protocols for Wireless Sensor Network." Elsevier Ad Hoc Network Journal, vol.3, no.3, May, 2005, pp. 325-349

[11] G. Ran, "Improving on LEACH Protocol of Wireless Sensor," Journal of Information & Computational Science, vol. 3, pp. 767–775, 2010.

[12] Arboleda LMC, Nasser N. Comparison of clustering algorithms and protocols for wireless sensor networks. In: Proceedings of the Canadian conference on electrical and computer engineering; 2006.p. 1787–92.