Energy Efficient Routing Protocol for Wireless Sensors Network

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***Abstract*—In this approach, We put forward an energy-efficient routing protocol for Wireless Sensor Networks (WSNs) by means of a Gateway Node. Based on the location of the sensors in the sensing field it is being divided into four logical regions. Installation of the Base Station (BS) is away from the sensing area and at the center of the sensing area gateway node is been installed. The node uses direct communication if the distance of a sensor node from Base Station or gateway is less than predefined threshold distance,. Rest of the nodes are divided into two equal regions whose distance is beyond the threshold distance. Cluster head (CH) is selected in each region which is independent of the other region. These CHs are selected on the basis of a probability. Performance of this approach is compared with LEACH (Low Energy Adaptive Clustering Hierarchy). Performance analysis and statistic results show that the proposed protocol perform better in terms of residual energy, network lifetime and throughput.**

Keywords: Wireless Sensor Networks, clustering, gateway

I. INTRODUCTION

Wireless sensor networks have been one of the most important and interesting topics of discussion in the area of network technologies due to their ability to perform tasks without a communication infrastructure. A sensor network is consist of a very large number of sensor nodes and a base station which collects the data . The BS processes and stores the information it accepts from the nodes, it is an access point for the sensors on its network and if required, it may relay data to a central server for monitoring. A sensor node, despite its limited energy, calculation capability and memory, collaborates with the other sensor nodes and queries the physical quantities (heat, light, moisture, gas, etc.) of the environment, compiles the received data and transmits them to the base station.

Nodes are the building block of WSN –as shown in the figure these node May range from few to thousand number and are also interconnected to each other. Each of these sensors are part of an entire network which manages a particular region. Nodes usually contains the following : a microcontroller an inbuilt antenna a battery all embedded in one single circuitry sensor nodes vary in size from the size of shoebox to a size of grain it acts as functioning “bits” . they are also very powerful in nature . These sensor nodes are similarly variable in case of pricing it might cost from a few to hundreds of dollars, based on the difficulty level of the individual sensor nodes. These might result in constraints on resources such as energy, memory level , calculation speed and transportations bandwidth. The topology also varies from simple star topology to even multihops network. The propagation technique between the hops of the network can be routed else it might get flooded.

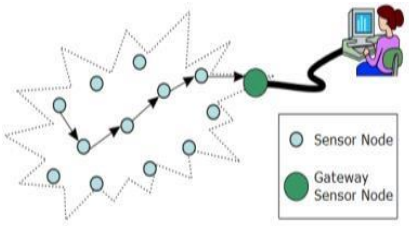

Fig.1 Sensor network

The intense deployment of WSN makes it quite difficult to recharge node batteries. Therefore, a key subject for WSNs is to restrain power expenditure of sensor nodes to extend network lifetime. In [3] [4] many clustering based routing protocols are suggested. Clustering protocol network energy consumption is well accomplished by minimizing the broadcast range of the sensors. Sensor nodes do not transmit data directly to the BS instead CHs receive the whole group messages, aggregates and sends it towards the BS resulting CH manages the group communication with the BS.

All nodes in cluster transmit their data to its corresponding CH. Time Division Multiple Access (TDMA) schedule for its member nodes to avoid collision by the CH. Each member node transmits its data to CH only in defined allocated time slot hence, sensor nodes turn off their transceivers otherwise. TDMA scheduling encourages saving energy of sensor nodes and these nodes stay alive for very long period. As a rule, each member node transmits its data to nearby CH therefore; a minimum amount of energy is necessary for data transmission. CHs perform calculation on collected data and strains out the redundant bits; it reduces the amount of data that has to sent to the BS. Accordingly, transmission energy of sensors reduce to significant amount in this approach, we implement an energy-aware multi-hop routing protocol using a gateway node.

The energy consumption of sensor nodes is considerably reduced by logically dividing the network into four regions. Different communication hierarchy in different regions has been used. Nodes closer to the BS and gateway node use direct communication. In other two regions nodes use clustering hierarchy i.e. sensor nodes transmit their data to

gateway node through their CHs. Gateway node define clusters and issues a TDMA schedule for CHs. Every Cluster Head issues TDMA schedule for its member nodes.

This paper is ordered as follows: segment 2 briefly reviews the related work. Segment 3 describes the network model. Proposed algorithm is explained in segment 4. In segment 5, we define the performance parameters and the performance of our proposed protocol is shown by simulations and is then compared with LEACH. Finally, segment 6 gives conclusion.

II. RELATED WORK

The most important features in the design of the wireless sensor network is Energy consumption and network lifetime. So to overcome this we use clustering based routing for WSNs. In clustering based protocol, the data from the sensor nodes are aggregated and sent to the BS which are placed at a distance.

LEACH is a protocol proposed by Wendi [1] in a seminal study on clustering-based routing. In LEACH, the entire network area is divided into clusters and each cluster has a CH. The sensor nodes that form the cluster send their data to cluster heads at certain periods. It is supposed that all the nodes always have data to send at data transmission time. If there is no data to send, the node sends the last data it senses. Such a case causes unnecessary energy consumption. The CH compresses the received data into a single signal and sends it to the base station. The CH is changed periodically.

Under PEGASIS protocol [6] Nodes form a peer to peer to transfer data from source to sink. In this formation process each node connects with next node. This topology is very difficult to be implemented as it requires global knowledge of sensor nodes.

Another clustering based protocol is HEED in which CHs are selected on the base of a probability.Here the residual energy decides the probability of a node to be elected as CH. Thus, it is possible that nodes with minimum residual energy acquire higher probability to become CH.

In improved leach protocol for indoor wireless sensor networks a new energy efficient protocol for data gathering and integration the sensor nodes are homogeneously organized in the rooms on the floors of a building. Each floor is assumed to be a cluster with static members in itself. The cluster heads are determined by selecting the node with the highest energy among the sensor nodes on the same floor. The lower and upper thresholds are determined for the values to be received. The values between these thresholds are sent to the cluster heads [4].

For homogenous large scale WSN and multi hop data delivery PASC is considered. It combines scheduling and clustering techniques to prolong the network lifetime. Based on the equivalence property of redundant nodes the network area is divided into a set of cells which are virtual, and are grouped into many disjoint subsets.

In Density controlled Divide-and-Rule (DDR), nodes are distributed uniformly. To control the density nodes are randomly distributed in different segments of network. With this the whole of network area is covered. Another vital point in DDR is that, clusters formed are static and number of clusters remains fixed. The number of clusters formed are near to optimum number. Thus energy is utilized efficiently and load is distributed uniformly.

III. MOTIVATION

Multiple level clustering hierarchy has following as its major drawbacks.

- One CH forward data to other CH which transmits data to BS. If the CH is far away, then high power transmission is necessary to forward CH.
- Nodes die early in clustering protocols, as member node decides itself whether to become CH or not. There is a high probability that some distant nodes are selected as CHs. Hence, excess of energy is consumed to forward data to BS.

In this approach, our prior motive is to design a gateway based energy aware multi-hop routing protocol. This approach also meets the following points.

- By dividing the Network Model into regions and with the aid of gateway node average transmission distance is reduced. Therefore, network energy is efficiently utilized and network lifetime is prolonged.
- In each region CH selection is independent of other regions so, there is definitely a CH exist in each region.

IV. NETWORK MODEL

In this work, S sensors which are installed randomly in a field to monitor environment is assumed. The *i-th* sensor is represented by si and the following sensor node set S= s1,s2,....., sn. The BS is installed faraway from the sensing field. After deployment the sensor nodes and the BS are stationary.

- At the centre of the network a gateway node is deployed in the same network field.
- After deployment the gateway node is stationary and rechargeable.
- The homogeneous sensor nodes with similar computational and sensing capabilities are used.
- A distinctive identifier(ID) is assigned to each sensor node.

A first order radio model is used. The energy dissipation of sensor nodes for transmitting, receiving and aggregating data is represented in this model. The transmitter dissipates more energy than receiver as it requires more energy for the transmitter electronics and amplifier. On the other hand, in receiver, only electronic circuit dissipate energy, as shown in fig 2.

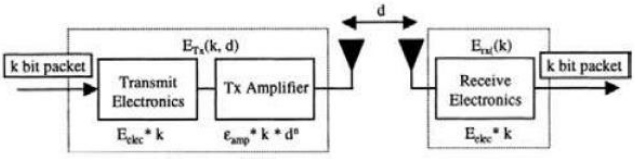

Fig.2.Radio Model

The energy required to transmit a data packet of k bits to a distance d and to receive a data packet of k bits, is given as:

ETx(k, d) = ETx−elec(k) + ETx−amp(k, d)……(1)
ETx(k, d) = Eelec × k + Eamp × k × d2……..(2)
ERx(k) = ERx−elec(k)ERx(k) = Eelec × k…….(3)
ERx(k) = Eelec × k ……..….(4)

V. METHODOLOGY

Here we present the details of the proposed protocol. Sensor nodes have large amounts of data, which the BS has to C

A. Initial Phase

In our protocol sensor nodes dispersed randomly are homogenous in nature. A HELLO packet is transmitted to the sensor nodes by the BS. The Sensor node in response transmits its location to BS. The distance of each node and all information of the sensor nodes are fed into data table after calculation by the BS. The node data table contains of unique node ID, residual energy of each node, position of node and its remoteness to the BS and gateway node.

B. Setup Phase

Based on the location of the node in the network, the network field is divided into logical regions. As a result, the nodes are divided into four distinctive logical regions by the BS.

Region-1: As the distance of these nodes from BS is very short. Nodes under region-one uses direct communication i.e transmit their data directly to BS Region -2: this is the region near the Gateway node the sensor nodes near gateway sends their data directly to gateway which aggregates data and forward to BS. These two regions are stated to as non-clustered regions. Region 3,4-All the other nodes away from the gateway node and BS are divided to two equal half regions. These are termed clustered regions. Sensor nodes in each clustered region organize themselves into small groups known as clusters.

C. CH selection

In the beginning the BS divides the network into logical regions. CHs are selected in each region distinctly. Let R_i represent the number of rounds to be a CH for the node Si. Each node elect itself as a CH once every $R_i = 1/p$ rounds. At the first round all the nodes have same amount of charge of battery life and chance of being the CH after which from the consecutive rounds on the basis of the remaining energy of sensor node and with a probability p the CHs are selected alike LEACH. It is essential to keep n x p CHs. In an epoch a node can become a CH only once and the nodes not elected as CH belong to the set .C.

In each round the probability of a node to be elected as CH increases. At the start of each round, a node Si belongs to set independently it chooses a random number between 0 to 1. If the generated random number for node Si is less than a predefined threshold T(s) value, then the node becomes CH in the existing round.

$$T(S) = \begin{cases} \frac{p}{1-p\times(r \bmod (1/p))} & \text{if } s \in C \\ 0 & otherwise \end{cases} \quad \ldots\ldots\ldots\ldots\ldots(5)$$

where P = the desired percentage of CHs and r = the present round, C = set of nodes that are not nominated as CH in present round. After CHs election of CHs in each region, they inform their role to neighbour nodes. Using a CSMA MAC protocol CHs transmits a control packet. An acknowledgement packet is transferred when a control packet is received at the node.

D. Scheduling

When all cluster formations are completed, each CH creates TDMA based time slots for its member nodes. In its private scheduled time slot the associated nodes transfer their sensed data to CH Else for which nodes are switched to idle mode. Transmitters of the node are turned on at the time of transmission. Resulting in energy dissipation of individual sensor node is decreased.

E. Steady-State Phase

In this phase, the sensor nodes broadcast their detected data to CH. Data is collected from member nodes, aggregated and forwards to gateway node by the CHs. Gateway node further accepts data from CHs, aggregates and is transmitted to BS.

VI. PERFORMANCE EVALUATION

A. Simulation Setting

In order to measure the performance of our proposed protocol, we simulated our protocol using MATLAB. We consider 100 nodes that are distributed randomly in 100m X 100m field. At the center of the sensing field a gateway node is deployed. The BS is situated away from the sensing field. Both gateway node and BS are stationary after positioning. A packet size of 4000 bits is considered. We compare our compare the proposed protocol with LEACH protocol. To measure performance of our protocol with LEACH, we ignore the effects affected by interference and signal collision in the wireless channel.

Table 1 presents the radio parameters.

Parameter	Value
E_0	0.5J
E_{elec}	5nj/bit
E_{fs}	10pj/bit/m^2
E_{mp}	0.0013pj/ bit/m^4
E_{da}	5pj/bit
Packet Size	4000bits

B. Performance Parameters

1) Network Lifetime: In fig 2, the results of the network lifetime are observed. After consuming 0.5 joule energy the nodes are considered dead.

2) Throughput: To evaluate the performance of throughput, comparison is made for the nodes between the data sent by the nodes to the BS and that recived n by the BS.

3) Residual Energy: The residual battery energy of network is considered in order to examine the energy consumption of nodes in every round. Residual energy ensures agile degradation of network life.

A. Simulation Results and Analysis

Here we present the simulation results. We run wide simulations and compare our results with LEACH. Next paragraphs give detail of each objective

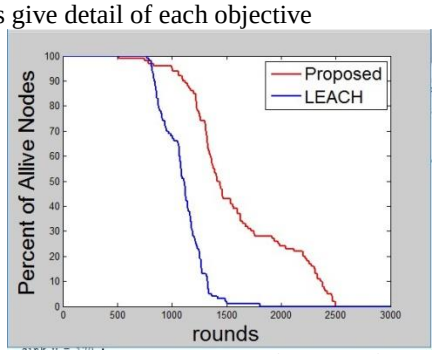

Fig-3:Interval plot- Analysis of network lifetime

1) *Network Lifetime:* In fig 3, the results of the network lifetime are observed. After consuming 0.5 joule energy the nodes are considered dead. Our protocol achieves the longest network is divided into logical regions and further two of them are sub divided into clusters. Energy consumption among sensor nodes is balanced in our topology. In LEACH, nodes die quickly because the period of stability in the network ends. It is not obvious that appointed CHs in LEACH are spread consistently all over the network field. Thus, there is a prospect that the selected CHs will be focused in one region of the network. This can result that some nodes will not have access to any CHs around it. Thus the protocol which we proposed perform statically different and well performed.

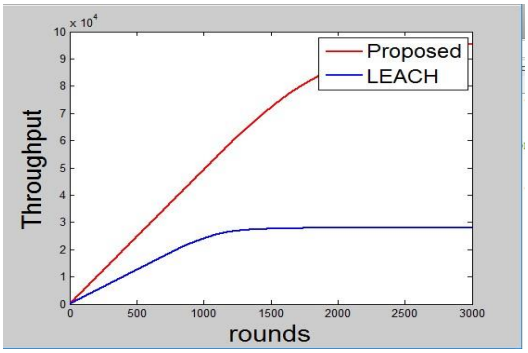

Fig. 4: Interval plot- Analysis of Throughput

2) *Throughput:* Extensive simulations are used to assess the average packet sent to BS. Simulation results of our protocol demonstrate improved throughput. Interval plots of our protocol and LEACH is shown in fig 4. To examine throughput, assumption is made that CHs can transfer easily with gateway node. throughput of 5 times than LEACH improvement is shown in simulation results show, this is because, the information sent by the sensor nodes that are closer to the gateway node transmits its data to the gateway node directly and then it aggregates and forwards to the BS. Nodes in the other two regions i.e. the clustered region consumes very less power as a result the nodes stay alive for a very long period.

3) *Dead Node:* As shown in the fig 5 it is observed that the consumption of the battery life of nodes in the network is less in our proposed protocol is less than that in LEACH hence in the end of each round the number of dead nodes are reduced considerably to that of LEACH .

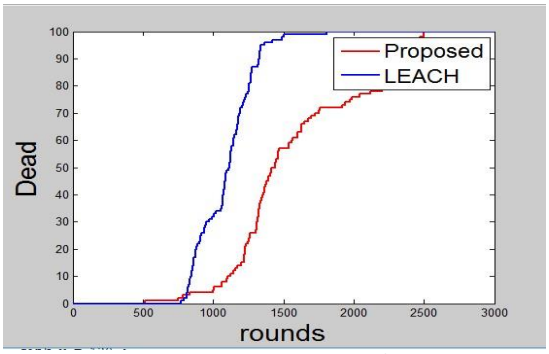

Fig-5:Interval plot- Analysis of dead nodes

4) *Residual Energy:* Average residual energy of network per round is as shown in fig 6. Assumptions are made that a node has 0.5 joule energy. 100 node network has total energy of 50 joules. Our protocol produces minimum energy consumption than compared to that of LEACH. Fig 6 clearly depicts that our protocol overtakes LEACH routing protocol in terms of energy consumption per round. minimum energy consumption and high probability of CHs in all regions is ensured by deployment of gateway node at the centre.

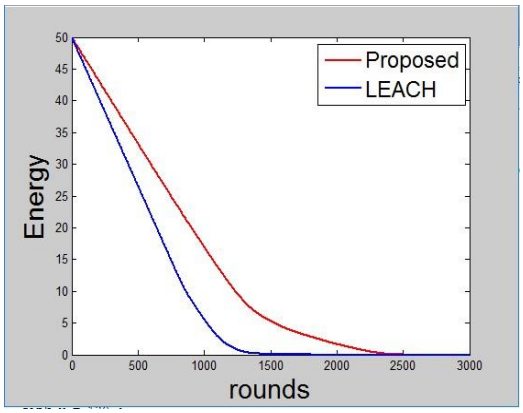

Fig 6-Interval plot-Analysis of remaining energy

VII. CONCLUSION

We describe an energy-efficient routing protocol using gateway node to minimize energy consumption of sensor network. Here network is divided into logical regions. Each having different communication order. Two of which uses direct communication topology and other regions are further sub-divided into clusters and uses multi-hop communication. Each node in a region elects as a CH independent of other regions. This system enhances better distribution of CHs in the network. Simulation outcomes show that our proposed protocol performs well compared to LEACH. Three performance objectives are assessed: Network lifetime, Residual energy and throughput.

REFERENCES

[1] Mainwaring, Alan, *et al*. "Wireless sensor networks for habitat monitoring." Proceedings of the 1st ACM international workshop on Wireless sensor networks and applications. ACM, 2002.

[2] Burrell, Jenna, Tim Brooke, and Richard Beckwith. "Vine yard computing: Sensor networks in agricultural production." Pervasive Computing, IEEE 3.1 (2004): 38-45.

[3] Ye, Mao, et al. "EECS: an energy efficient clustering scheme in wireless sensor networks." Performance, Computing, and CommunicationsConference, 2005. IPCCC 2005. 24th IEEE International. IEEE, 2005.

[4] Li, Chengfa, *et al*. "An energy-efficient unequal clustering mechanism for wireless sensor networks." Mobile Adhoc and Sensor Systems Conference, 2005. IEEE International Conference on. IEEE, 2005.

[5] Heinzelman, Wendi Rabiner, AnanthaChandrakasan, and HariBalakrishnan. "Energy-efficient communication protocol for wireless micro sensor networks." System Sciences, 2000. Proceedings of the 33rd Annual Hawaii International Conference on. IEEE, 2000.

[6] Lindsey, Stephanie, and Cauligi S. Raghavendra. "PEGAS IS: Powerefficient gathering in sensor information systems." Aerospace conference proceedings, 2002. IEEE. Vol. 3. IEEE, 2002.

[7] Younis, Ossama, and Sonia Fahmy. "HEED: a hybrid, energy efficient, distributed clustering approach for ad hoc sensor networks." Mobile Computing, IEEE Transactions on 3.4 (2004): 366-379.

[8] Smaragdakis, Georgios, Ibrahim Matta, and AzerBestavros. "SEP: A stable election protocol for clustered heterogeneous wireless sensor networks". Boston University Computer Science Department , 2004.

[9] Loscri, V., G. Morabito, and S. Marano. "A two-levels hierarchy for low-energy adaptive clustering hierarchy (TL-LEACH)." IEEE Vehicular Technology Conference. Vol. 62. No. 3. IEEE; 1999, 2005.

[10] Jafri, MohsinRaza, NadeemJavaid, AkmalJavaid, and Zahoor Ali Khan. "Maximizing the Lifetime of Multi-Chain PEGASIS Using Sink Mobility." World Applied Sciences Journal 21, no. 9 (2013): 1283-1289.

[11] M. Akbar, N. Javaid, A. A. Khan, Z. A. Khan, U. Qasim, "On Modeling Geometric Joint Sink Mobility with Delay-tolerant Cluster-less Wireless Sensor Networks", 4th IEEE Technically Co-Sponsored International Conference on Smart Communications in Network Technologies (SaCoNet'13) 2013, Paris, France.

[12] Tahir, M., *et al*. "On Adaptive Energy-Efficient Transmission in WSNs." International Journal of Distributed Sensor Networks 2013 (2013). [13]B. Manzoor, N. Javaid, O. Rehman, M. Akbar, Q. Nadeem, A. Iqbal, M. Ishfaq, "Q-LEACH: A New Routing Protocol for WSN", International Workshop on Body Area Sensor Networks (BASNet-2013) in conjunction with 4th International Conference on Ambient Systems, Networks and Technologies (ANT 2013), 2013, Halifax, Nova Scotia, Canada,Procedia Computer Science, Volume 19, 2013, Pages 926-931, ISSN 1877-0509,

[14] K. Latif, A. Ahmad, N. Javaid, Z. A. Khan and N. Alrajeh, " Divideand-Rule Scheme for Energy Efficient Routing in Wireless Sensor Networks", The 4th International Conference on Ambient Systems, Networks and Technologies (ANT 2013), 2013, Halifax, Nova Scotia, Canada, Procedia Computer Science, Volume 19, 2013, Pages 340-347, ISSN 1877-0509, http://dx.doi.org/10.1016/j.procs.2013.06.047.Procedia Computer Science.

[15] N. Javaid, M. Waseem, Z. A. Khan, U. Qasim, K. Latif and A. Javaid, "ACH: Away Cluster Heads Scheme for Energy Efficient Clustering Protocols in WSNs", 2nd IEEE Saudi International Electronics, Communications and Photonics Conference (SIECPC 13), 2013, Riyadh, Saudi Arabia

[16] Heinzelman, Wendi Rabiner, Joanna Kulik, and HariBalakrishnan. "Adaptive protocols for information dissemination in wireless sensor networks." Proceedings of the 5th annual ACM/IEEE international conference on Mobile computing and networking. ACM, 1999. [17]N. Javaid, S. N. Mohammad, K. Latif, U. Qasim and Z. A. Khan, M. A. Khan, "HEER: Hybrid Energy Efficient Reactive Protocol for Wireless Sensor Networks", 2nd IEEE Saudi International Electronics, Communications and Photonics Conference (SIECPC 13), 2013, Riyadh, Saudi Arabia.

[18] Heinzelman, Wendi B., Anantha P. Chandrakasan, and HariBalakrishnan. "An application-specific protocol architecture for wireless microsensor networks." Wireless Communications, IEEE Trans actions on 1.4 (2002): 660-670.

[19] Mcmullen, Sonya A. "Mathematical Techniques in Multi sensor Data Fusion 2nd Edition." (2004).

[20] Klein, Lawrence A. "Sensor and data fusion concepts and applications." Society of Photo-Optical Instrumentation Engineers (SPIE), 1993.

[21] N, Javaid. A, Khan. I. A, Djouani. K, "Performance study of ETX based wireless routing metrics," 2nd IEEE International Conference on Computer, Control and Communications (IC4-2009), Karachi, pp.1-7, 2009.

[22] Javaid, N.; Bibi, A.; Djouani, K., "Interference and bandwidth adjusted ETX in wireless multi-hop networks," GLOBECOM Workshops (G Wkshps), 2010 IEEE , vol., no., pp.1638,1643, 6-10 Dec. 2010.

[23] Javaid, N.; Ullah, M.; Djouani, K., "Identifying Design Requirements for Wireless Routing Link Metrics," Global Telecommunications Conference (GLOBECOM 2011), 2011 IEEE , vol., no., pp.1,5, 5-9 Dec. 2011.