ISSN: 2321-8169
173 – 177

An Energy Efficient Clustering Routing Protocol using Twice Cluster Head Selection

Kaustubh L. Thakare
Department of E and TC
PCE, Nagpur
kaustubh.kt@gmail.com

Ashish B .Jirapure
Department of E and TC
PCE, Nagpur
ashish_ji2014@rediffmail.com

Dr. R. V. Kshirsagar
Department of Electronics Engg
PCE, Nagpur
ravi_kshirsagar@gmail.com

Abstract**--**A wireless sensor network contains many of these sensor devices that will to communicate either directly to the Base Station (BS) or each other. Usually, sensor nodes are scattered in the area, where we want to monitor some ambient conditions. Sensor nodes have to communicate among themselves to get information about the physical environment. Sensor nodes collect the information and then it is routed to the Base Station either directly or through other sensor nodes. The Base Station is a either a fixed node or mobile node, which is capable to connect the sensor network to an infrastructure networks. Routing protocol in wireless sensor networks (WSNs) are used for the less energy consumption. This paper introduces an energy efficient clustering algorithm for based on the LEACH protocol. The proposed protocol adds some feature to LEACH to support for nodes and also reduces the consumption of the energy network. The modified protocol is simulated and the results show a significant reduction in network energy consumption compared to LEACH.

Keywords *-Wireless sensor networks, base station, Leach protocol, network lifetime*.

*****

I. INTRODUCTION

Recently in micro-electro-mechanical systems and low power and highly integrated digital electronics have led to the development of micro-sensors. These sensors are well equipped with data processing and communication capabilities. The circuitry measures ambient conditions related to the environment surrounding the sensor and transforms them into an electric signal. Processing these a signal has some properties about objects located and events happening in the vicinity of the sensor. The sensor sends such collected data, usually via audio transmitter, to a command centre (sink) either directly or through a data concentration center (gateway). The decrease in the size and cost of sensors, resulting the advances, has fuelled interest in the possible use of large set of disposable sensors. Networking sensor nodes are expected to have significant impact on the efficiency of many military and civil applications such as combat field surveillance, security and disaster management. These systems process data gathered from multiple sensors to monitor events in an area of interest. On the military side, for example, the use of set of sensors can limit the need for personnel involvement in the usually dangerous reconnaissance missions. In addition, sensor networks can enable a use of landmines by making them remotely controllable and target-specific in order to prevent harming civilians and animals. Security applications of sensor networks include intrusion detection and criminal hunting. However, sensor nodes are constrained in energy supply and bandwidth.

Routing in wireless sensor networks is very challenging due to various characteristics that distinguish them from contemporary communication and wireless ad hoc networks. First of all, it is not possible to build a global addressing scheme for the deployment of sheer number of sensor nodes. Therefore, classical IP-based protocols cannot be applied to sensor networks. Second, in contrary to typical communication networks almost all applications of sensor networks require the flow of sensed data from multiple regions (sources) to a particular sink. Third, generated data traffic has significant redundancy in it since multiple sensors may generate same data within the vicinity of a phenomenon. Such redundancy needs to be exploited by the routing protocols to improve energy and bandwidth utilization. Fourth, sensor nodes are tightly constrained in terms of transmission power, on-board energy, processing capacity and storage and thus require careful resource management. Due to such differences, many new algorithms have been proposed for the problem of routing data in sensor networks. These routing mechanisms have considered the characteristics of sensor nodes along with the application and architecture requirements.

II. LEACH

All LEACH is the first hierarchical protocol in WSN. LEACH is an adaptive clustering routing protocol proposed by Wendi B. Hein Zelman. In many later literatures, it has been considered as the benchmark for other protocols. It has some distinctive characteristics like self-reconfiguration, adjustment of communication range according to distance, schedule of data transmission of individual nodes etc. In LEACH, the nodes organize themselves into local clusters, with one node acting as the cluster-head. All non-cluster-head nodes must transmit their data to the cluster-head, while the cluster-head node must receive data from all the cluster members, perform signal processing functions on the data (e.g., data aggregation), and transmit data to the remote base station. Therefore, being a cluster-head node is much more energy-intensive than being a non-cluster-head node. In the scenario where all nodes are energy-limited, if the cluster-heads were chosen a priori and fixed throughout the system lifetime, as in a static clustering algorithm, the cluster-head sensor nodes would quickly use up their limited energy. Once the cluster-head runs out of energy, it is no longer operational.

The operation of LEACH is broken up into rounds, where each round begins with a setup phase, when the clusters are organized, followed by a steady-state phase, when data transfers to the base station occur. In order to minimize overhead, the steady-state phase is long compared to the set-up phase. Initially, when clusters are being created, each node decides whether or not to become a cluster-head for the current round. This decision is based on the suggested percentage of cluster heads for the network (determined a priori) and the number of times the node has been a cluster-head so far. This decision is made by the node n choosing a random number between 0 and 1. If the number is less than a threshold T (n), the node becomes a cluster-head for the current round. The threshold is set as:

$$T(n) = \begin{cases} \dfrac{P}{1-P\left(r \bmod \dfrac{1}{P}\right)}, & \text{if } n \in G \\ 0, & \text{otherwise} \end{cases}$$

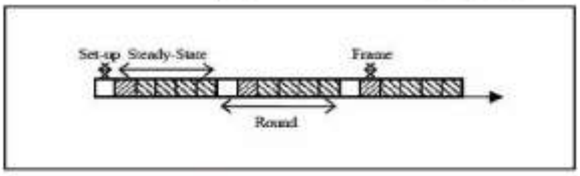


Figure 1: LEACH protocol phases

III. DESCRIPTION OF THE PROPOSED PROTOCOL

The proposed protocol is based on distributed clustering. In this protocol, all the nodes which are deployed randomly in the required environment to be monitored will be capable of communicating to every other node in the scenario. Every node will advertise its energy levels to all other nodes. The energy level of every node will be checked individually by each node and the nodes which are having energy more than the average energy level of the network are nominated for Cluster Head. The nodes which are at the top ten levels will be selected as Cluster Head initially. These Cluster Heads will advertise their selection to every other node in the network. Those nodes which are not capable of becoming the Cluster Head will wait for the advertisement made by the CH. These nodes will send a join request to the CH which is nearest to them on the basis of received signal strength. The Cluster Head will accept the cluster members and will prepare a TDMA schedule so that each node can communicate to CH without any collision. This TDMA schedule will be sent to the cluster members. Since the nodes will always have data to be send to CH, there are chances that these data may be correlated. The data collected at Cluster Head after the completion of one TDMA Cycle will be fused and aggregated. Now the communication between CH and the Base station will take place with the help of Direct Spread Spectrum so that no collision of data takes place. One by one the CH will be sending the aggregated data to the Base station for monitoring. After one round the process will be repeated again.

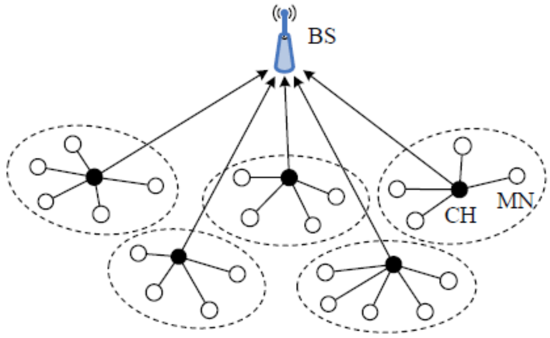


Fig: The Basic Topology of LEACH

IV. FLOW OF THE ROUTING PROTOCOL

There are two phases of the protocol. In the Phase 1 (Set Up Phase) every node will advertise its energy level to the other nodes in the network. An average energy level of the network will be calculated in every node. All those nodes which are having energy level greater than or equal to the average energy level will be selected for Cluster Head. After getting selected as cluster head, the CH nodes will advertise their selection and the rest of the non-Cluster head nodes will send join request based on the received signal strength of the advertisement of CH nodes to the nearest CH. The Cluster Head will accept their request and will prepare a TDMA slot and the member nodes will send data accordingly. This data will be collected at Cluster Head and it will aggregate that that and will transmit this data to the Base station for monitoring.

A. SETUP PHASE

The setup phase consists of three parts i.e. Cluster Head Election, Cluster Formation and Schedule Creation. In the Cluster Head Election, nodes having energy level greater than the average energy level of network are nominated and then elected as Cluster Head on the basis of larger energy level. In the Cluster Formation, Non Cluster Head nodes join cluster head based on received signal strength and form the cluster. In the Schedule Creation, the Cluster Head prepares a TDMA schedule for its cluster members for data transmission. A node in the network checks whether it is selected as Cluster Head or not. If the node is not selected as Cluster Head, It will wait for the announcement to be made by the Cluster Head nodes. If the node is selected as Cluster Head, It will advertise its selection to the other nodes in the network so that the Non Cluster Head nodes can join it to become the cluster members. The Cluster Head after getting the responses from the nodes will then prepare a TDMA schedule for its members and will again advertise this schedule only to its cluster members. This schedule will be saved by the cluster members and will send data on the basis of the allotted TDMA slot. After this the steady phase comes into play and after the completion of a round this process will be repeated again. In this way a complete round takes place.

 ISSN: 2321-8169
173 – 177

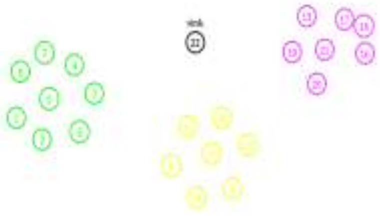


Figure 2: Setup Phase of Proposed Protocol

B CLUSTER HEAD ELECTION

In this phase, each node in the network advertises its energy level to the every other node of the network. After this advertisement every node gets the energy level of each and every node of the network. Now every node will arrange the received energy level of other nodes in the ascending order. The average energy of the network can be calculated as follows:

Those nodes whose energy level is less than the average energy level of the network will be discarded from the Cluster head nomination criteria. Now every node will match its ID with the top ten nodes having the highest energy level. If the ID matches, the node is selected as the Cluster Head. If the ID does not match, the node will wait for the Cluster Head announcements.

4.1.1. Cluster Formation

After the selection of Cluster Head, CH nodes will advertise their selection and the rest of the non-Cluster head nodes will send join request based on the received signal strength of the advertisement of CH nodes to the nearest CH for the current round. Now the Cluster head will advertise a Join Request message to all other nodes using a non-persistent carrier sense multiple access (CSMA) MAC protocol. This message consists of the Node ID and the Header of this message will be different from normal data messages. Each and every node which is non Cluster Heads will wait for this Join Request Message. The Cluster head will wait for the response for a time period known a prior. Every node will receive this announcement. Received Signal Strength is chosen because larger the received signal strength, more the node closer to it unless and until there is an obstacle in between the nodes. The nodes will check which Cluster Head is nearer to it i.e. whose received signal strength is strongest. And will select that Cluster Head. Now the node needs to inform the Cluster Head about its selection. The node will send a Join Response message which will consist of Node ID and a header differentiating it from data messages using a non-persistent carrier sense multiple access (CSMA) MAC protocol back to the closest Cluster Head. The Cluster Head will accept the Response and add the node as its cluster member.

1.2 STEADY STATE PHASE

This phase is the second phase of the proposed protocol. The steady phase consists of Data collection & Aggregation along with Data Transmission

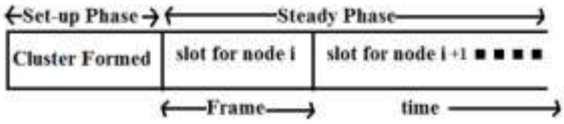


Figure3: steady phase

In Data collection, the cluster head gather data from every cluster member and fuse the data so that no redundancy left. In the data transmission, the Cluster Heads transmit the data one by one to the Base Station for monitoring.

2. LEACH-DC ROUTING PROTOCOL

In the network initialization, LEACH-DC uses the idea of LEACH-C in Nodes send their geographic formation to a sink. The sink calculates the maximum distance of each node to the centre of the region, and sends it to each node. Considering a single node energy ratio, add the current energy Ei-current and the initial energy Ei-total of the node i to the threshold formula of selecting cluster head. For a node consuming more energy, it reduces the values of T(n) and the probability of becoming cluster head. In contrast, for a node consuming less energy, it increases the values of T(n) and the probability of becoming cluster head. The threshold T(n)is calculated using the formula

$$T(n)=\begin{cases}\dfrac{p}{1-p(r \bmod (1/p))}*\dfrac{E_{i\text{-}current}}{E_{i\text{-}total}} & \forall n\in G\\ 0 & other\end{cases}$$

Adding the distance between the node and the region center into the threshold formula can make the area covered by the selected cluster head node as far as possible, and the cluster head as close to the regional center as possible, which shortens the distances of some nodes' data transmission and effectively saves energy. The cluster head selection threshold T(n) of LEACH-DC is calculated as in formula

$$T(n)=\begin{cases}\dfrac{p}{1-p(r \bmod (\frac{1}{p}))}*[(1-\rho)\dfrac{E_{i\text{-}current}}{E_{i\text{-}total}}+\rho\dfrac{d_{max}-d}{d_{max}}] & \forall n\in G\\ 0 & other\end{cases}$$

In formula, ρ, a constant, is the proportion of the node energy consumption ratio and distance ratio in T(n). *d*maxis the maximum distance between the edge node and the center of the region. *d*is the distance between a node and regional center. Formula is used for the first selection of cluster head in the twice cluster head selection strategy. LEACH-DC introduces the second cluster head selection on the basis of the first clustering, making the selected cluster head as close as possible to the centroid of the cluster member forested region and its energy more than the average of members' residual energy in the cluster. Since the energy consumption of transmitting a packet of k bits by each node to the cluster head depends on the distance between the node and the cluster head, if the cluster head is closer to the centroid, the free space model can be used to transmit data signals, thus can be greatly save energy to 40%-50%. Choosing a larger residual energy node as cluster head is basically to avoid the excessive death of cluster head due to low energy.

In the first cluster head selection process, when common node sends a request to join the cluster to the first selected cluster head node CHf according to the unique code in the cluster *code_* broadcasted by CHf, the common node also sends its residual energy value Ei-current, XN (node's X coordinate), and YN (node's Y coordinate) to CHf. CHf can calculates the energy average of the cluster nodes Eav, where N is the total number of the live node in the cluster. Comparing the energy value of each node in the cluster with Eav, if it is greater than Eav, put the node into the candidate cluster head set Eh. If finally the candidate cluster head set Eh is empty, the cluster head remains unchanged.

Arithmetic average is used to calculate the centroid position D(Xd, Yd) for simplicity, as shown in formula

$$D(X_d, Y_d) = \begin{cases} (\sum_{i=1}^{N} XN_i) / N \\ (\sum_{j=1}^{N} YN_j) / N \end{cases}$$

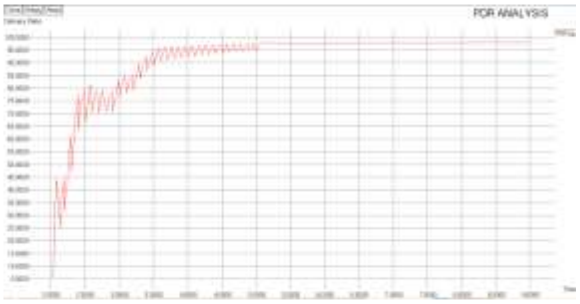
For each node in the candidate cluster head set Eh, calculate its distance to D(Xd, Yd) using formula, and
denoted the distance as D(i)

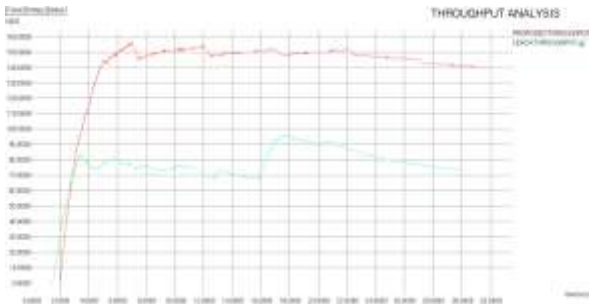
$$D(i) = \sqrt{(XN_i - X_d)^2 + (YN_i - Y_d)^2} \qquad i \in E_h$$

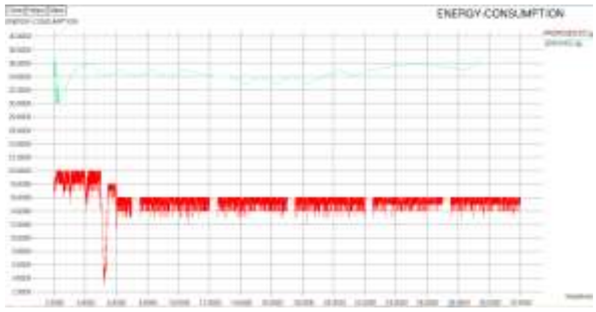
Select the node with the smallest D(i) as the final cluster
Head of the cluster, denoted as CHt. This ends the second cluster head selection process. Now CHf broadcasts in the cluster a message, which informs CHt selected and contains then unique code in the cluster *code_* when CHf was selected as the cluster head, to ensure that the cluster nodes are the original members. When a common node receives a CHt message, it checks the message against its saved code_, if they are equal, send a request to join the cluster to CHt; if not, abandon the message until receiving a correct message. Once the second cluster head selection finishes, and TDMA time slots has confirmed, the protocol enters data transmission phase.

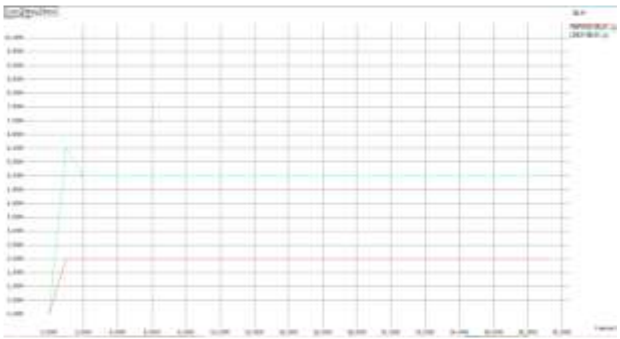
3. CONCLUSION

Considering the nodes' remaining energy and their distances to the regional center in a wireless sensor network makes the nodes with more remaining energy more possible to become cluster heads and these cluster heads will not appear at the edge of the region, so the cluster heads can cover larger area. Reselecting cluster head in the cluster makes the cluster head as close as possible to the centroid of the cluster area and its energy is greater than the average residual energy of nodes in the cluster, reducing the energy consumption for inside cluster communications. Simulation shows that LEACH-DC protocol improves LEACH protocol in the way that LEACH-DC protocol balances the energy consumption of nodes in the network, delays the nodes' death time, and prolongs the life time of the entire WSN effectively.









References:

[1] Mao Xiaofeng, Yang Min, et al., "SURVEY ON WIRELESSSENSOR NETWORK APPLICATIONS," Computer Applicationsand Software, Vol. 25, No. 3, 2008, pp. 179-181,doi:CNKI:SUN:JYRJ.0.2008-03-068 (in Chinese).

[2] Akkaya K., Younis M., "A survey on routing protocols for wirelesssensor networks," Ad Hoc Networks, Vol. 3, 2005, pp. 325-349,doi:10.1016/j.adhoc.2003.09.010.

[3] Heinzelman W., Chandrakasan A., Balakrishnan H., "Energyefficientcommunication protocol for wireless microsensor networks,"Proc. Of the 33rd Annual Hawaii

Int'l Conf. on SystemSciences(HICSS-33), Maui:IEEE Computer Society, 2000, pp. 3005-3014.

[4] Heinzelman W. B., Chandrakasan A. P., Balakrishnan H., "Anapplication-specific protocol architecture for wireless microsensornetworks," IEEE Trans on Wireless Communications, Vol. 1, No. 4,2002, pp. 660-670, doi:10.1109/TWC.2002.804190.

[5] Heinzelman W. B., Chandrakasan A. P., Balakrishnan H., "An application-specific protocol architecture for wireless crosensor networks," IEEE Trans on Wireless Communications, Vol.1, No. 4,2002, pp. 660-670, doi:10.1109/TWC.2002.804190.

[6] Wu Xinhua, Wang Sheng, "Performance Comparison of LEACH and LEACH-C Protocols by NS2," Proc.of the 9th International Symposium on Distributed Computing and Applications to Business, Engineering and Science(DCABES 2010), IEEE Computer Society, Aug. 2010, pp. 254-258, doi:10.1109/DCABES.2010.5