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IMPROVED ARCHITECTURE FOR MAXIMIZING SYSTEM LIFETIME OF WIRELESS SENSOR NETWORK USING CLUSTERING ALGORITHM

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Abstract - Real time implementation of Ad-hoc Wireless Sensor Network has increased with great potential. Application areas of WSN's are military warfare, disaster management, battle field, forest fire detection and other several monitoring area. Key challenge in WSN is to minimize the use of limited battery resources. Several energy efficient routing algorithms have been proposed till date. LEACH (Low-Energy Adaptive Clustering Hierarchy), a clustering protocol that divides the network into logical clusters and keeps rotating the cluster head selection to send data to sink. In this paper we propose a new technique of cluster formation based on organizational setup structure. New Network structure proposed will show an efficient increase in minimizing the node energy dissipation of signal transmission and will lead to maximize the system lifetime. We also propose a mix of Round-Robin algorithm into the cluster head selection for data transmission to base station. We compare the newly proposed clustering algorithm with the traditional LEACH algorithm.

Keywords - LEACH, Clustering, Cluster Head (CH), Round-Robin algorithm, residual energy.

I. INTRODUCTION

An Ad hoc network has a characteristic of non central administration network in which all nodes function as routers or user and self-organize to form a dynamic network. Basic part of a Wireless ad-hoc sensor network consist of sensor nodes which may be installed in remote areas for sensing and collecting the information from places which are not easy in reach by human being. Micro Electronic Mechanical Systems (MEMS) and wireless communication have emphasized on the development of tiny, low-cost, low-power and multi functional smart sensors. These smart sensor nodes are deployed in several areas for monitoring purpose for example sensor nodes have huge application in military area for battled surveillance, may be deployed in border areas or hilly regions to monitor any unwanted physical activity or any disastrous natural phenomenon, in traffic control to detect presence of high speed vehicle, in security systems to detect any unwanted motion. Sensor networks also have environmental application like forest fire detection, green house monitoring, landslide detection, flood detection. Key challenge in wireless sensor network is to minimize the power dissipation of the battery as it could be impossible or inconvenient to recharge the battery, because nodes may be deployed in a hostile or unpractical environment. Various routing algorithms have been proposed with a motive to maximize the system lifetime some of them are Minimum total energy routing (MTE), minimum hop routing (MH), Minimum residual energy path routing [1], flow redirection algorithm (FR) [2], flow augmentation algorithm (FA) [3], etc. Some of the examples of Hierarchical routing algorithms are LEACH [4] (Low-Energy Adaptive Clustering Hierarchy), HEED [5]

(hybrid energy efficient distributed clustering), EEDC (Dynamic clustering and energy efficient routing), etc. In our algorithm we use the concept of clustering the whole sensor network into three different levels based on function of minimum residual energy, after selection of cluster heads at different level we manage the round robin scheduling between the cluster heads at their own level for transmission of data from lower level cluster head to the upper cluster head or to base station.

The rest of the paper is organized as follows. In section 2, we review the existing LEACH routing protocol, in section 3, we review the related work over LEACH. In section 4, we discuss the newly designed architecture using clustering algorithm proposed by us.

II. OVERVIEW OF LEACH

In [4], communication protocol based on Low Energy Adaptive Clustering Hierarchy (LEACH) is first proposed by MIT's Heinzelman, Chandrakasan & Balakrishnan designed for wireless sensor network. LEACH is a self-organizing, adaptive clustering protocol that uses randomization to distribute the energy load evenly among the sensors in the network. If the process of cluster head selection was static and fixed throughout the system lifetime, then it is easy to see that the unlucky sensors chosen to be cluster head would die quickly, ending the useful lifetime of all nodes belonging to that cluster. Thus LEACH includes randomized rotation of the high-energy cluster-head position such that it rotates among the various sensors in order to not drain the battery of a single sensor. A LEACH protocol runs several rounds where each round consists of two phases: Set-up Phase and Steady state Phase.

In set-up phase clusters are organized and selection of cluster head was done, followed by the steady state phase in which schedule for communication with the cluster head was created and data transmission to the base station will takes place. In order to minimize the routing overhead of broadcasting request messages steady state phase is longer than setup phase. Set-up phase consist of: Advertisement phase and Cluster setup phase.

Advertisement Phase: Initially all the sensor nodes are randomly deployed in the network. Now nodes have the turn to decide whether it will become the cluster head for that particular round or not. A random number will be generated by each node between 0 to 1. If the number generated is less than a threshold value (T_n) then the node will become a cluster head in that particular round. The Threshold value may be calculated as:

$$T(n) = \begin{cases} \frac{p}{1 - p * (r \bmod \frac{1}{p})} & n \in G \\ 0 & n \notin G \end{cases}$$

where p is the desired percentage of cluster heads, r is the current round, and G is the set of nodes that have not been cluster-heads in the last $1/p$ rounds. Each node that has elected itself a cluster-head for the current round broadcasts an advertisement message to the rest of the nodes. For CH_ADV_MSG, the cluster-heads use a CSMA MAC protocol, and all the cluster-heads transmit their adv_msg using the same transmit energy. The leaf nodes must keep sensing the messages during the setup phase to hear the advertisement. After this phase completed, each non-cluster-head node decides to join the cluster head to which it belong for this round.

A. Cluster Setup Phase:

Leaf node will sense the adv_msg from the cluster head nodes and will decide to become the member on the basis of received signal strength of message. Node receiving the adv_msg from largest signal strength will become the cluster member under that particular cluster. After the decision made by the leaf node to become the member of cluster, each node will send information back to the cluster head using CSMA MAC protocol.

B. Steady state phase:

This phase involves two rounds schedule creation and data transmission. In schedule creation phase the cluster head will create a schedule for data transmission for all their leaf nodes based on TDMA scheduling. This schedule will be then broadcast back to leaf nodes. In data transmission phase, leaf node or non-cluster head member will transmit the data to cluster head in particular time slot allotted to them. After a certain time interval which is decided earlier, the next round starts for selection of new cluster head.

Limitations of LEACH Protocol:

Cluster head selection criteria in LEACH are random and depend upon some probability instead of minimum residual energy of node or any cost function or path function i.e. distances between the node and the base station or sink node.

III. RELATED WORK

A lot of routing protocols have been proposed to prolong the lifetime of WSN by making some improvement in cluster head selection criteria and cluster formation process. In order to overcome the shortcomings of LEACH, Heinzelman presents LEACH-C protocol. LEACH-C (LEACH-Centralized) is a protocol that uses a centralized clustering algorithm to produce better clusters. This protocol has the same steady-state as LEACH, while it select CHs considering information of node location and energy lever to determine the near-optimal clusters. In [5], nodes belong to the same cluster form a chain, where nodes only communicate with their nearest neighbors. The mechanism is a combination of Leach and PEGASIS but it is only a simple combination and lack of the consideration of the energy consumption of the chain. In [6], Two modified LEACH protocols: energy-LEACH protocol and Multihop-LEACH protocol are presented Energy-LEACH protocol considers residual energy in the phase of cluster head selection. Multihop-LEACH protocol adopts multi-hop communication between cluster and sink. Simulation results show that energy-LEACH and Multihop-LEACH protocols have better performance than LEACH protocol. In [7], partition-based LEACH (pLEACH) algorithm was explained that ensure the consistent number and uniform distribution of cluster heads. The pLEACH algorithm achieve significant improvement in terms of collision in cluster head set-up phase, the variance of residual energy consumption, the number of survival nodes and the quality of communication. . In [8], Time-based Cluster-Head Selection Algorithm (TB-LEACH) was explained which modifies the cluster-head selection algorithm of LEACH to improve the partition of cluster. In TB-LEACH, competition for cluster-heads (CHs) no longer depends on a random number as in LEACH, and a random time interval instead. Nodes which have the shortest time interval will win the competition and become cluster heads. In order to obtain a constant number of cluster-heads, a counter was set. When the number of the counter has reached specified value, nodes no longer continue competition for cluster-heads.

IV. PROPOSED ARCHITECTURE

In this section, we shall explain our network and assumptions made, which will be used in the simulation section. In the wireless sensor network we assume that a large no of sensor nodes are randomly

deployed in the square field to continuously monitor the area. Main assumption of the network is that energy level of battery of all the sensor nodes are known in priori. $T(\text{sys})$ denotes the system lifetime which is equivalent to the lifetime of the node having minimum residual energy $E(\text{min})$ in the whole network. The proposed algorithm also works in two phase: Set-Up Phase and Steady state Phase

Steps involved in Set-Up Phase: The given steps are to be followed in the beginning of each round.

- In our proposed system we divide the whole network into three different levels based upon minimum residual energy of node. The three levels are local cluster level, zonal level, network level. There will be three types of cluster head: local cluster head (LCH), zonal cluster head (ZCH) and network cluster head (NCH). The necessary condition for the given model is given below: $E(\text{LCH}) < E(\text{ZCH}) < E(\text{NCH})$, $E(\text{NCH}) =$ The node having highest residual energy in the network.
- Node having highest value of residual energy level will be selected as Network cluster head (NCH) for that particular round.
- Now network will be divided into four different zones depending upon the geographical location of the sensor nodes as well as node density (assumptions).
- Now node having highest value of residual energy level within that particular zone will be selected as Zonal cluster head (ZCH) also now ZCH will not participate into the cluster formation at lower level.
- At the lowest level logical clusters will be created, where each cluster will have a cluster head and limited no of nodes belongs to that particular cluster. Local cluster head (LCH) selected should have more residual energy as compare to all leaf nodes.

Fig. 1 : Data flow chart

Steps involved in Steady state Phase:

Once the formation of cluster was completed, the process of data sensing and transmission started. Nodes which are deployed in remote areas for some specific purpose will start sensing the information. Now node within a cluster will transmit the data to its own cluster head, where local cluster head will receive the data from nodes on the basis of TDMA scheduling. Similarly, ZCH will receive the data from all LCH's on the basis of TDMA. Again, NCH follow the same process as that of ZCH. NCH will be responsible for transmitting data to sink node.

The process of new NCH, ZCH and LCH selection was repeated every time after the completion of time interval decided at the starting of the algorithm.

Also if condition occurs of more than one node having energy value equal to value of cluster head at their level then round-robin scheduling algorithm will take places so that the load distribution among the nodes having high value of residual energy will take places and there will be less probability of single node drainage from the system

Fig. 2 : 3D Data flow diagram

Fig. 3 : Ideal Data flow diagram

Fig 1 shows the step by step data flow chart and fig 3

shows the flow of data step by step from lower level to the upper level.

V. CONCLUSION & FUTURE WORK

A new network model for WSN based on clustering algorithm was proposed which may tends to maximize the system lifetime by minimizing the energy dissipation of nodes for data transmission. This newly proposed algorithm would be compared with the traditional LEACH algorithm and the results would be analyzed. In future, simulation of the proposed architecture on WSN will be performed using ns-3(network simulator version 3) and pros and cons of the algorithm would be analyzed, so that the algorithm may be used for highly scalable network with more reliability and hence overall lifetime of the system increases. In addition encryption can be done during different level of data transmission to make the algorithm more secure and efficient.

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