Energy Aware Threshold based Efficient Clustering (EATEC) for Wireless Sensor Networks

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Abstract—This paper presents a new protocol called Energy Aware Threshold based Efficient Clustering (EATEC) which aims to reduce energy consumption within the wireless network. Efficiency of a wireless network depends on mainly of energy consumption. In cluster based protocols, changing of cluster and cluster head also consume more energy. So, in this proposed protocol, we are reducing the wastage of energy while selecting or changing the clusters/cluster heads. We evaluate both LEACH and EATEC through simulations using NS-2 simulator which shows that EATEC performs better than LEACH protocol.

Index Terms—Clustering, Energy, LEACH protocol, EATEC, NS-2.

I. INTRODUCTION

A wireless Sensor Network (WSN) consists of spatially distributed autonomous devices called sensors, and a base station to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at different locations. Sensor nodes can be networked to gather sensory data and each sensor performs two main responsibilities, namely, (i) sensing activities, and (ii) routing the sensed data to the base station or a controller.

Wireless sensor networks are attracting great interest in a number of application domains concerned with monitoring and control of physical phenomena, as they enable dense and effective deployments at low cost. However, application development is still one of the main hurdles to a wide adoption of WSN technology. In current real-world WSN deployments, programming is typically carried out very close to the operating system, therefore requiring the programmer to focus on low-level system issues. This not only distracts the programmer from the application logic, but also requires a technical background rarely found among application domain experts.

II. CLUSTERING

Grouping sensor nodes into clusters has been widely pursued by the research community in order to achieve the network scalability objective. Every cluster has a leader, often referred to as the cluster-head (CH). The cluster membership may be fixed or variable. Of the benefit, clustering may conserve communication bandwidth since it limits the scope of inter-cluster Cluster-based routing, originally proposed in wire line networks, are well-known techniques with special advantages related to scalability and efficient communication. As such, the concept of cluster-based routing is also utilized to perform energy-efficient routing in WSNs. In the architecture, higher energy nodes can be used to process and send the information while low energy nodes can be used to perform the sensing in the proximity of the target. This means that creation of clusters and assigning special tasks to cluster heads (CH) can greatly contribute to overall system scalability, lifetime, and energy efficiency [4].

The members which are connected to the cluster head will sense the physical environment and transmit it to the cluster head according to some time intervals. Aggregated data is compared and the mean data is generated at the cluster head. The mean data generated at the cluster head will be sent to the base station through the discovered path.

III. LEACH PROTOCOL

Low Energy Adaptive Clustering Hierarchy (LEACH) is the first hierarchical cluster-based routing protocol for wireless sensor network which partitions the nodes into clusters, in each cluster a dedicated node with extra privileges called Cluster Head (CH) is responsible for creating and manipulating a TDMA (Time division multiple access) schedule and sending aggregated data from nodes to the BS where these data is needed using CDMA (Code division multiple access). Remaining nodes are cluster members.
LEACH Protocol can be divided into two phases:

1. Setup phase
2. Steady phase

In the setup phase, the clusters are formed and a cluster-head (CH) is chosen for each cluster. While in the steady phase, data is sensed and sent to the central base station. The steady phase is longer than the setup phase. This is done in order to minimize the overhead cost.

B Architecture

LEACH was developed to monitor remote environment. Since individual nodes’ data are often correlated in a micro-sensor network, the end user does not require all the redundant data, rather the end user needs a high-level function of the data that describes the events occurring in the environment.

The motivation behind LEACH protocol is to correlate data among nodes that are close to each other by using data aggregation techniques to reduce the amount of raw data, this is mostly done by the elected cluster head before transmission to the base station. The architecture of LEACH protocol is shown in fig.2.

IV. Eatec Protocol

The proposed Energy Aware Threshold based Efficient Clustering (EATEC) protocol differs by the variables on which the criteria of changing the cluster head depend. In LEACH the clustering and the process of cluster head selection totally depends on time. Whereas, in our proposed technique the change of cluster head totally depends on the energy variable. The cluster head is only changed whenever the current cluster looses down its energy below that of the threshold value.

A Algorithm

Initialization: There are number of sensor nodes which are spatially distributed in a network as shown in fig. 3. The information of locations of all nodes will be stored in the base station.

Fig. 4: Sensor Nodes Sending their Energy to BS

Cluster Formation: The node which is having the highest energy will be elected as a cluster head by the base station.

Fig. 5: Cluster Heads are Selected by the BS
Node which gets chance to become cluster head initially sends a hello message to the nodes which are there in a range (R0). The neighboring nodes which get the hello message will respond to the message and becomes the members for the respective cluster head. Similarly, the procedure is repeated until all clusters are formed. Formula for Range of a node is being given as follows:

\[ R_0 = \frac{\text{Total Area to be covered}}{X \times \text{Number of Clusters}} \times \text{Total Number of Nodes} \]

The process of changing the cluster head in a cluster is shown in fig. 6.

If any node which not being a member of any cluster or a node being a cluster head but no nodes in its cluster, will wait for a specified amount of time and then starts advertising themselves to become a member of any nearby cluster to it. Similarly all the nodes will become the member for one or the cluster. This way all the initial clusters are formed by the base station.

Cluster Reformation: The process of cluster reformation or changing the cluster head will occur only when the cluster head’s energy is reduced below that of the threshold energy value. The threshold value is manually changed. The steps of changing the cluster head are mentioned below

1. The process is initiated when the energy of the cluster head is less than that of the threshold value.
2. As soon as the energy of the cluster head goes down the threshold, the information is conveyed to the base station.
3. The base station will be responsible for the change of the cluster head of all the clusters.
4. Base station having all the information about the location of the nodes, will take the information of the residual energy of the nodes which are near to the present CH.
5. Then depending on the energy again the new cluster head will be selected by the base station.

Routing and Data Aggregation: The process of routing and data aggregation is same as that of the LEACH protocol. The new cluster head will attempt to get a path to reach the base station. Routing may be of single-hop or multi-hop as per the distance between the cluster head and base station. The route path between two nodes or base station will be stored in the routing tables of all the nodes.

V. SIMULATION AND RESULTS

NS2 is used as a simulation platform. NS is a discrete event simulator, where the advance of time depends on the timing of events which are maintained by scheduler. NS simulator is based on two languages: C++, and a OTcl (an object oriented tool command language) interpreter used to execute users command scripts.

Simulations for both LEACH and EATEC were done by keeping the number of nodes, clusters and simulation time constant. Numbers of trials were considered and the mean of all the trials was considered to fetch the required results. The simulation parameters are as shown in table 1.
Simulated result is compared with cluster based LEACH protocol. Energy consumed by EATEC protocol is less when compared to LEACH protocol. The following fig. 7 explains the same. The fig. 8 and 9 represent the comparison between LEACH and EATEC with respect to the total number of data packets transmitted and the number of alive nodes after every intervals of time with respect to simulation time respectively.

Both the protocols are compared with same simulation time and equal number of nodes. Ten trials were taken and the mean of those were taken and our proposed protocol EATEC was found to be more efficient. Efficiency was increased by 32.15% with respect to LEACH protocol. Energy used by the individual nodes is comparatively less. The nodes can be alive for longer time and will not die soon. Thus we can say that the protocol uses less amount of energy when compared to the other protocols.
VI. CONCLUSION

In this work an attempt has been made to enhance the network lifetime. The process of clustering plays a very important role in utilizing the energy. So, we have attempted to change the criteria and process of clustering and cluster head rotation.

An improvement over LEACH has been proposed by incorporating energy parameter in the cluster head selection process. In this proposed protocol (EATEC) the process of changing the cluster head is managed based on the energy criteria. The cluster heads will be reformed by the base station if any of the cluster heads energy goes below the preset threshold. The simulations were carried out in NS 2.34. It is observed from the simulation results that EATEC achieve 32.15% better energy efficiency than LEACH protocol. The node may or may not join the old cluster again.

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